Theoretical and Empirical Essays on Strategic Behavior in Various Industries

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Boston College
The Graduate School of Arts and Sciences
Department of Economics

THEROTICAL AND EMPIRICAL ESSAYS ON STRATEGIC BEHAVIOR IN VARIOUS INDUSTRIES

A dissertation
by
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ABSTRACT

Caglar Yurtseven, Theoretical and Empirical Essays on Strategic Behavior in Various Industries. My Thesis Major Professor: Dr. Utku Unver

This dissertation consists of three theoretical and empirical essays. In all essays strategic behavior is a key factor. The first essay tries to explain certain pricing behaviors in cellular communication markets using social interactions as a basis for modeling. The second essay estimates the demand in the Turkish dishwasher market. It utilizes the complaint call rate for a firm as a new explanatory variable in the estimation process. The last essay examines the effects of market share restrictions on the cost reduction efforts of firms in a market.

The first essay develops a model of competition in cellular network markets. People’s choices are investigated in their social environments with differing utilities for different calls, which creates the distinctive part of this article. People get higher utilities from talking to people who are closer to them in the social environment.

In the constructed market, different tariff types, per unit pricing and two part tariffs are examined for the existence of non-monopoly equilibria. In the well-known papers of the literature, different prices for in-line and between-line calls are justified with different cost structures for in-line and between-line calls. This essay is different from the literature because it is able to explain price discrimination with customer necessities and without cost differences.
For per unit charging, assuming each firm has different costs which are larger than zero, the smaller cost firm gets a higher share with lower prices in the equilibrium. For two part tariffs with costs higher than zero and different from each other, a two firm equilibrium is reached in which the higher cost firm charges higher prices and a lower fixed fee, whereas the lower cost firm charges lower prices and a higher fixed fee.

The second chapter is the empirical essay of this dissertation. In demand estimations, unobserved characteristics like perceived quality or after-sale service quality of products have created omitted variable bias. In the essay, the complaint call rate for a product is offered as a proxy to solve the endogeneity problem that arises from unobserved heterogeneity. Using demand and supply estimations of the Turkish dishwasher market, the complaint call rate is shown to be a valid proxy to solve the problem.

Use of this proxy is possible under less restrictive assumptions than the popular instrumental variable method, which is also offered for the solution of the same problem. In addition, the model constructed in the essay has strong testable implications and is demonstrated to be consistent with a stable market of a leader firm and followers. Demand and supply elasticities of dishwashers are estimated for Turkey, which can help durable goods firms to use their investment and marketing resources more efficiently in emerging countries.

The third essay studies the effects of market share restrictions on research and development effects of firms in a market. Market share of firms are closely followed by
regulatory authorities and restrictions are applied in many cases around the world.

This essay investigates if these restrictions affect the cost reduction efforts of the firms in a market. The theoretical model constructed shows that under the no exit assumption, market share restrictions lower the level of competition and possible rewards from R&D efforts, therefore causing smaller levels of R&D efforts both for big and small firms in the market.
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CHAPTER 1.

A SOCIAL INTERACTION MODEL OF CELLULAR COMMUNICATION PRICING

1.1 Introduction

As human beings, we all live in social environments. In our daily lives, we socially interact with the people around us. In most of these interactions an ordinary person gets higher utility if the interaction takes place between him and a person who he feels himself closer to. Imagine two person who go to movies, travel for a vacation, seeing games and so on. Their utilities are, in ordinary conditions, higher if this two people are closer to each other. For closeness to have such an importance the interaction does not have to be as complicated. Even in a daily conversation closeness brings higher utility. It is not unusual for people who are socially apart from each other to find themselves easily in severe discussions. The rule applies to phone talks as well. An average person has more than 100 connections in his/her address book. However it is a well known fact that we rarely call many of those people. There are even people who we haven’t talked for years! Therefore, it is easy to make an observation at this point: A person’s social interactions give shape to his/her phone talk pattern as well. We cannot understand those patterns if we do not examine these people in their social environments. By observing utilities of people which are based on a "social distance" concept and the cost of calls, we’ll try to understand how people make decisions in the wireless network markets.
In a leading paper of the area by Laffont, Rey and Tirole (1998) equilibrium for a two firm wireless market is investigated. In their paper, they use a variety of the well-known Hotelling concept for the differentiation of firms. Consumers are located uniformly on a line segment \([0,1]\). The two networks are located at the two extremities of the segment, namely \(x_1 = 0\) and \(x_2 = 1\). In their paper, utility of consumers from phone calls are mainly determined by their distance to the relevant firm. However for the utility a person gets from a phone call, different from that paper, I believe, distance to a firm is not the only point that matters. To model a more realistic environment, in which people get higher utility from talking with their closer friends, relatives etc., I introduce the placement of consumers to a social circle according to their social features in the real world. That is, the distance between two consumers on the circle shows how consumers are socially close to each other. This social distance concept might have complicated the mathematics of this paper but I believe it makes the paper more realistic by differentiating between two talks duration of which are equal but the utilities are not, due to the different social closeness of the talking agents. Furthermore by choosing a circle rather than a line the continuity property of the social environment comes into the model which can be seen as a necessity. With all the modifications including the social distance concept, which provides the uniqueness of this paper in the literature, I am able to get more realistic results regarding firm choice and pricing decisions.

I need to mention a working paper by Mobius (2001) at this point. In that paper Mobius tries to explore diffusion process of new land-line firms in a former
monopoly land-line market. In this sense, there is no relation between this and his paper. But also, his work has the observation that urban markets subdivide into "islands" along geographical and socioeconomic dimensions: users are more likely to communicate with subscribers "inside" their island than with those "outside" it. Different occupations are represented in this paper’s social islands. This modeling type might be realistic for markets where the network firms have businesses as their customers. By removing this islands assumption I create a more proper environment for the personal market. One has to remember that cell phones do not have to be used for business purposes, in the contrary they are used more for personal communication. This communication mainly includes talks with friends and family and from a sociological perspective it is nearly impossible to make islands of considerable size for these personal connections. Therefore, I can say the social circle concept of this paper can be considered as a highly modified version of Mobius’s islands idea, but other than that there is no similarity between the areas, models and results of his and my paper. I believe without the social distance and continuity concept, I introduced in this paper, it is not possible to fully understand firm and consumer decisions like pricing and firm choice.

In this paper, I first study the case where there are two firms in the market and that the firms compete on a per unit time charge basis. (This has been the case for a long time in many countries like Turkey, Greece, Russia, Ukraine, etc.) I didn’t restrict cost structures of firms in my investigation; firms may have the same costs or may differ in that respect. In the model, firms are maximizing their profits and
consumers are maximizing their total utilities. I also hypothesize that, there is a marginal consumer who get the same utility from choosing either firm. Same kind of marginal consumer reasoning can be seen in the work of Bental and Spiegel (1995). In the case of per unit charge with two firms and differing costs, I find an equilibrium with two firms. However in a case where the cost difference is big enough there might be an equilibrium in which the market goes to a monopoly structure. And if the market has two equal cost firms the result that is reached is not surprising in the sense that both firms get equal, 50% share of the market.

After per unit time charge, the investigation of this paper continues with a different price scheme. For this scheme again a duopoly structure is assumed and the market, when one of the firms has lower cost than the other is examined. In that section I look for an equilibrium in two-part tariffs. Similar to the construction for two-part tariffs in Laffont, Rey, Tirole (1998) I assume there is a fixed fee that all the consumers have to pay and there is a charge according to time consumed which can be called as usage fee. Again with profit and utility maximization it is shown in that part that there is an equilibrium in which the low cost firm get higher share with higher fixed fee and lower prices. However an assumption should be noted at this point. For the sake of simplicity and considering it is close to real market phenomena, I assume, in two-part tariff competition, firms charge their marginal cost as their price for in-line talks. This is the case in which person you call is a customer of your provider as well. Firms are able to charge mark-up rates for between-line talks, that is, firms can make profits by their per-minute charges if the person you
call is a customer of the other firm.

The paper is structured as follows. The next section sets up the model. I make extensive use of graphs at the model introduction. After introducing the model, background definitions and assumptions, I present the conceptual results for the ‘pay as you talk’ pricing model. Having the results in hand, the paper proceeds with a different price scheme section in which the results for two-part tariff model are presented. It concludes with a brief discussion of the findings and provides the proofs for some of the results in the appendix part.

1.2 The Model

Consumers

Consumers get utility by using their cell phones to talk with other people. However, due to the fact that this paper's work is based on the "calling party pays" regime and for the sake of simplicity I assume; in a cell-phone conversation only the calling party gets utility. People get higher utility from talking with the persons who are closer to them. All the people in the model are placed on a circle (See figure 1.).\(^1\) At this placement social features of the persons are considered so that they get higher utility from talking to a person whose distance to him is shorter.

---

\(^{1}\)The distances are calculated as if the consumers are located on a straight line. The circumference of the circle is 2 units. Points that are shown as 0 and 1 are placed on the two extremes of the semi-circles and they don’t represent the locations of the points on the x-axis.
The question comes to mind at this point is that, then why does not he talk only to the person which is closest to him. In that manner he pays the standard price but can get the highest utility. "Diminishing marginal utility of talk" is a simple answer to this question. And for phone calls the rate of decline is generally very high. Most of the time seconds would be enough to accomplish your goal of calling. Therefore, it can be said that, people get higher utility from talking to a closer person on the social circle, but still they want to talk with different people as much as possible. To cover this fact we assume each people talks "one minute" with others. As in Laffont, Rey and Tirole (1998) paper, firms are placed on the two extremes of the curve, namely points 0 and 1. This placement is exogenous and not the main point of this paper.\textsuperscript{2} Nevertheless I can say that, these two firms appeal

\footnote{Note that firms and consumers are placed on a circle, not on a line. My model looks more like Salop model than Hotelling model in that sense.}
to different consumer types with their services and consumers want a match between their preferences and these services as perfect as possible. However it is quite clear that, this perfect match is highly unlikely. Therefore, by choosing either Firm 0 or Firm 1 a consumer wants to minimize the disutility he gets from this match. Utility function of a person $x$ (Each point on the circle, other than points "0" and "1" represents a consumer.) can be stated as:

$$U_x(\Phi, t) = \int_{y \in \Phi} \frac{1}{|y - x| + 1} dy - \ln(\tau + 1)$$
$$\tau \in \{(x), (1 - x)\}$$

That is, a person located at the point $x$ on the social circle and talk all the $y$'s on a set $\Phi$, get the total utility above from cell phone talking. Observe that; according to firm choice, part of the total utility function that is coming from firm match, $-\ln(\tau + 1)$, appears either as $-\ln(x+1)$ or $-\ln((1-x)+1)$. The term 1 in $\frac{1}{|y-x|+1}$ and in $\ln(\tau + 1)$ is added for mathematical purposes.$^3$

On the social circle, it is hypothesized that marginal consumers $x^*$'s exist and their places are normalized so that they are symmetrically located around the points 0 and 1. (See figure 2.)

$^3$With this addition, I make sure that, the ln terms in the utility function don’t get negative values. Note that $\int_{y \in \Phi} \frac{1}{|y - x| + 1} dy$ also becomes an "ln" expression after the integration.
By marginal consumer here, it is meant that the consumers who are indifferent between choosing either firm. The utility they can get from any firm would be equal considering prices and locations of both firms and their own locations on the social circle. In the model, I assume there are two firms in the market: Firm 0 and Firm 1. Since I am working on a (0,1) space, places of the marginal consumers tell us the shares of firms. (From 0 to $x^*$ Firm 0’s customers and from $x^*$ to 1 Firm 1 customers)

These are stated; the total utility of the person $x$ who is a customer of Firm 0 ($x_0$) can be written as:\footnote{For the total utility of person $x$, rather than writing the direct expression I get from this integration, another form of the expression which makes use of the "1 minute" assumption will be stated. That form makes the utility function easier to follow.}
\[ U_{X_0}(x_{00}, x_{01}) = \ln(x_{00} - x^* + x + 1) + \ln(x_{01} + x^* - x + 1) - \ln(x + 1) \]

where;

\( x_{00} \) is total in-line talk of \( x_0 \). (talks between \( x \) who is a Firm 0 customer and other people who are Firm 0 customers)

\( x_{01} \) is between-line talk of \( x_0 \). (talks between \( x \) who is a Firm 0 customer and people who are Firm 1 customers)\(^5\)

\(-\ln(x+1)\) is the utility, consumer located at \( x \) get, from choosing Firm 0.

and similarly we can state the utility of a person \( x \) who is a customer of Firm 1 (\( x_1 \)) as:

\[ U_{X_1}(x_{10}, x_{11}) = \ln(x_{10} - x^* + x + 1) + \ln(x_{11} + x^* - x + 1) - \ln(2 - x) \]

\( x_{11} \) is total in-line talk of \( x_1 \). (talks between \( x \) who is a Firm 1 customer and other people who are Firm 1 customers)

\(^5\)Note that the first part in the utility function is the utility of person "\( x \)" that he gets from the calls he made to the persons left of him on the social curve and the second expression is the utility of person "\( x \)" that he gets from the calls he made to the persons right of him on the social curve. This separation is obligatory due to the properties of "\( \ln \)" function. Readers that are interested might want to look at figure 6 for a better understanding. In that figure \( x^*-a=x_{00} \) and \( b-x^*=x_{01} \). With the subtraction of \( x^*-x \) from \( x_{00}+1 \), I get the first part in the utility function. One can add \( x^*-x \) to \( x_{01}+1 \) to get the second expression in the utility function.
$x_{10}$ is between-line talk of $x_1$. (talks between $x$ who is a Firm 1 customer and people who are Firm 0 customers)

$-\ln(2-x)$ is the utility, consumer located at $x$ get, from choosing Firm 1.

Observe that; as a result of the normalization done about the place of marginal consumer, we able to solve the model through solving only one semi-circle between points 0 and 1. Everything is completely symmetric.

For the budget constraints of the consumers I assume that everybody has m dollars to spend for wireless communication. This result comes up as a result of the form of the demand function I assumed, which is a Cobb-Douglas demand function. Therefore a Firm 0 customer, is trying to maximize its utility as:

$$
\max_{x_0, x_1} U_{x_0} = \ln(x_0 - x^* + x + 1) + \ln(x_1 + x^* - x + 1) - \ln(x + 1)
$$

subject to

$$
x_{00}p_{00} + x_{01}p_{01} = m
$$

where;

$p_{00}$ is in-line per unit price of Firm 0. (price charged by Firm 0 for the talks between Firm 0 customers)
\( p_{01} \) is between-line per unit price of Firm 0. (price charged by Firm 0 when its customers call Firm 1 customers)

When the maximization problem is solved, one can find the demands of consumer who is located at \( x \) as:

--- if a customer of Firm 0:

\[
x_{00} = \frac{m + p_{01}(x^* - x + 1) + p_{00}(x^* - x - 1)}{2p_{00}} \quad \text{(demand for in-line talks)}
\]

\[
x_{01} = \frac{m - p_{00}(x^* - x - 1) - p_{01}(x^* - x + 1)}{2p_{01}} \quad \text{(demand for between-line talks)}
\]

--- if a customer of Firm 1

\[
x_{10} = \frac{m - p_{11}(x^* - x - 1) - p_{10}(x^* - x + 1)}{2p_{10}} \quad \text{(demand for in-line talks)}
\]

\[
x_{11} = \frac{m + p_{10}(x^* - x + 1) + p_{11}(x^* - x - 1)}{2p_{11}} \quad \text{(demand for between-line talks)}
\]

where;

\( p_{11} \) is in-line per unit price of Firm 1. (price charged by Firm 1 for the talks between Firm 1 customers)

\( p_{10} \) is between-line per unit price of Firm 1. (price charged by Firm 1 when its customers call Firm 0 customers)

\textbf{Firms} As usual, firms are trying to maximize their profits. However before solving this maximization problem, we have to differentiate between consumers who talk only in-line and consumers who talk both in-line and between-line. That is, according to their place on the circle some consumers talk only in-line and some consumers talk both in-line and between-line.
Figure 1.3: Shares of Firms on the Simplified Semi-circle Form.

**Proposition 1** For both firms there exists consumers $r_i$ who act as a borderline between only in-line talking consumers and both in-line and between-line talking consumers.

In the following part, I show how to find consumer $r_i$ on the social circle.

First of all note that I am solving the model with a semi-circle since everything is symmetric. With the normalization of the place of the marginal consumer $x^*$, I hypothesize to get a social distribution of the market as shown in the Figure 3. One can observe that consumers until $x^*$ are customers of Firm 0 and consumers from $x^*$ to 1 are customers of Firm 1. (One can find the place of marginal consumer by using the fact that, he should get the same utility by choosing either firm, that is;

\[
U_{X_0}(x_{00}, x_{01}) = \ln(x_{00} + 1) + \ln(x_{01} + 1) - \ln(x + 1^*) = U_{X_1}(x_{10}, x_{11}) = \ln(x_{10} + 1) + \ln(x_{11} + 1) - \ln(2 - x^*)
\]
Figure 1.4: For Firm 0, consumers up to r0 speak only in-line.

By observing figure 4, which is designed to show how different utility a person gets from talking different people, one can easily see that; to maximize their utility, customers try to talk as much people as possible, given their budgets starting with the closest people on the right and left of themselves. It is also clear that consumers up to $x^*-y$ use network 0 only. (See figures 5 and 6 as well.) For consumer $r_0$ the marginal utility he gets from talking to the person at $y-z$ and the marginal utility he gets from talking to marginal consumer should be equal. Then;

$$\frac{p_{01}}{p_{00}} = \frac{f_x(x^*)}{f_x(x^*-y-z)}$$

$$\frac{p_{01}}{p_{00}} = \frac{1}{y+1}$$

and the budget constraint of the people $r_0$ (the person on the boundary who talks only in-line)
Figure 1.5: A Firm 0 customer who talks only in-line.

\[
\frac{m}{p_{00}} = z + y \quad (2)
\]

(Note that he spends all his wireless communication budget for in-line talks which is equal to \(z+y\) in this case.)

And from equations (1) and (2) one can get \(y\) as \(\frac{m+p_{01}-p_{00}}{p_{01}+p_{00}}\)

So we can state the place of the consumer \(r_0\) as \(x^* - \frac{m+p_{00}-p_{01}}{p_{01}+p_{00}}\) speak only in-line and people from \(x^* - \frac{m+p_{00}-p_{01}}{p_{01}+p_{00}}\) to \(x^*\) speak both in-line and between-line.

Similarly for Firm 1 customers; people from \(x^*\) to \(x^* + \frac{m+p_{11}-p_{10}}{p_{11}+p_{10}}\) speak both in-line and between-line and people from \(x^* + \frac{m+p_{11}-p_{10}}{p_{11}+p_{10}}\) to 1 speaks only in-line. These concepts are illustrated in Figures 5 and 6.
Figure 1.6: A Firm 0 customer who talks both in-line and between-line.

Relevant distinctions being noted, the total demand for Firm 0 can be stated according to types of consumers as:

\[
A = \int_{0}^{x^* - m + p_{00} - p_{01}/p_{00} + p_{01}} \frac{m + p_{01}(x^* - x + 1) + p_{00}(x^* - x - 1)}{2p_{00}} \, dx
\]

\[
B = \int_{x^* - m + p_{00} - p_{01}/p_{00} + p_{01}}^{x^*} \frac{m - p_{00}(x^* - x - 1) - p_{01}(x^* - x + 1)}{2p_{01}} \, dx
\]

\[
D = \int_{x^* - m + p_{00} - p_{01}/p_{00} + p_{01}}^{x^*} \frac{m + p_{01}(x^* - x + 1) + p_{00}(x^* - x - 1)}{2p_{00}} \, dx
\]

where \(A\) represents total demand of only in-line talking customers and \(B+D\) represents total demand of both in-line and between-line talking customers.

Similarly total demand for Firm 1 is:
\[ J = \int_{x^*}^{x^*+m+p_{11}-p_{10}/p_{11}+p_{10}} \frac{m + p_{10}(x^* - x + 1) + p_{11}(x^* - x - 1)}{2p_{11}} \, dx \]

\[ K = \int_{x^*}^{x^*+m+p_{11}-p_{10}/p_{11}+p_{10}} \frac{m - p_{11}(x^* - x - 1) - p_{10}(x^* - x + 1)}{2p_{10}} \, dx \]

\[ L = \int_{x^*}^{x^*+m+p_{11}-p_{10}/p_{11}+p_{10}} \frac{m + p_{10}(x^* - x + 1) + p_{11}(x^* - x - 1)}{2p_{11}} \, dx \]

where \( J \) represents total demand of only in-line talking customers and \( K+L \) represents total demand of both in-line and between-line talking customers.

### 1.3 Pricing Structures

**Per unit pricing** In this part I look for an equilibrium in the market with two firms, when they charge only for the time, their consumers use for talking. Firm 0 has a marginal cost of \( c_0 \) and Firm 1 has a marginal cost of \( c_1 \). I assume that there is a cost incurred only to the calling party’s firm. There is no access charge. First, firms announce their prices and then consumers make their wireless network provider choices. I look specifically for the existence of a two firm equilibrium in which the social distance curve separated into two pieces.

**Lemma** In the market constructed, there is only one marginal consumer on the semi social distance curve.
Existence of marginal consumers is quiet obvious. Remember that the utility function of a consumer has a strong firm relation part. (distance of a consumer to his firm.) By this strong relation we make sure a consumer who is next to a firm is better off by choosing his "neighbor" firm. That is, some consumers are better off by choosing Firm 0 and some consumers are better off by choosing Firm 1. Therefore on the social curve there has to be marginal consumers.\(^6\) However, how can we make sure there is only "one"?

Suppose there are more than one marginal consumer: \(x_1^*\) and \(x_2^*\). That is there are two consumers who are indifferent between choosing either firm. Then the equi-

\(^6\)One also can easily see by the symmetry of utility functions for Firm 0 and Firm 1 customers and by the strong firm-consumer relationship that the derivative of the difference between the utility of consumer \(x\) from buying from Firm 0 and utility of \(x\) from buying from Firm 1 is non-increasing.

Since I am not able to get open form solutions for some of the components like "\(x^*\)" in terms of "prices" and "\(m\)". I am not able to get open form solutions for the derivatives of differences of these utility functions. This inability due to mathematical restrictions is also the reason of numerical exercises for prices in this paper.
librium would appear as in figure 7 with three pieces. However if consumer \( x_1^* \) is indifferent between choosing either firm with given prices and its place according to firms, consumer \( x_2^* \) has to be better off by choosing Firm 1. (Same utility from talks but he can get more utility from firm choice, by choosing Firm 1, since he is closer to Firm 1 than consumer \( x_1^* \).) So, existence of the utility one can get from firm choice, rule out the possibility of equilibria with more than one marginal consumer for the semi-circle.\(^7\)

For my model, I also assume costs of firms are greater than zero and different from each other. In addition, as the meaningful cost range; I am interested in the cost interval of \((0,1)\). This restriction is necessary due to the size of the social distance curve. And it is also assumed a firm’s both type of prices are higher than its own marginal cost. Given the demands above, which are the results of consumers’ utility maximization processes, firms try to maximize their profits as the following:

Total profits of firms Firm 0 and Firm 1; \( \pi_0 \) and \( \pi_1 \) can be represented as:

\[
\pi_0 = A(p_{00} - c_0) + B(p_{00} - c_0) + D(p_{01} - c_0)
\]

and

\(^7\)This time, due to simplifications, we can use derivative of difference function to show that utility of consumer \( x^* \) from buying from Firm 0 minus utility of \( x \) from buying from Firm 1 is strictly decreasing at \( x^* \) so that there is only one marginal consumer.

\[
f'(\ln(x_{00} + 1) + \ln(x_{01} + 1) - \ln(x + 1) - \ln(x_{10} + 1) - \ln(x_{11} + 1) + \ln(2 - x))
\]

\[
= -\frac{1}{x_{01}+1} - \frac{3}{2-x^*}
\]

\[
= \frac{-3}{(x_{00}+1)(2-x^*)}
\]
given \( 0 < x < 1 \), this ratio is negative, hence \( f \) is strictly decreasing. Q.E.D.
\[
\pi_1 = J(p_{11} - c_1) + K(p_{11} - c_1) + L(p_{10} - c_1)
\]

marginal cost of Firm 0 is pre-determined as \(c_0\) so Firm 0 tries to maximize its profit with respect to \(p_{00}\) and \(p_{01}\).

So we have two first order conditions for Firm 0:

\[
u_0 = \frac{\partial \pi_0}{\partial p_{00}} \quad v_0 = \frac{\partial \pi_0}{\partial p_{01}}
\]

and the first order conditions for Firm 1:

\[
u_1 = \frac{\partial \pi_1}{\partial p_{11}} \quad v_1 = \frac{\partial \pi_1}{\partial p_{10}}
\]

We have four equations for our four unknowns. However, instead of providing open form solutions for each price, which takes pages as high dimension and unsuitable for interpretation equations; we provide the proof for Firm 0’s equilibrium prices’ uniqueness after the proposition. In the appendix part you can find the proof for Firm 1’s prices.

**Proposition 2** Under the assumption of per unit pricing, for marginal costs greater than zero and different for each firm, and each firm’s both type of prices higher than their own marginal costs, there exists a two firm equilibrium in which the lower cost firm gets a higher share with its lower prices.
Proof

For the existence of the single equilibrium, I need to show successively that no consumer is better off by switching between firms and no firm has a reason to change its pricing scheme in the range we are looking for: (0,1).

By construction consumers has no reason to change their cellular talk providers. One of the key points of the model is that marginal consumers dictate the shares and profits of firms. Marginal consumers get the same utility by choosing either firm and so all the consumers other than the marginals are better off by being a customer of a particular firm according to their place on the social curve.

It is proposed that in equilibrium, small cost firm has lower prices and higher share. Intuitively, small cost firm use its advantage in costs to ask prices low enough to attract more consumers and increase its share and high enough to have a profit margin to get higher profit from a customer. Big cost firm is still able to get share from the market mainly because it offers high utility from firm choice to the consumers who are close to it on the social circle. I need to show that these stated prices, which are found by maximizing firms’ profits are the only stable equilibrium prices in the market for the relevant cost range. That is I need to show both firms’ profit functions have only one local maximum for given costs and phone call budget. In other words I need to prove profit functions are concave. So I try to prove both firms’ profits functions are concave in the restricted cost range according to their two choice variables; in-line \((p_{00}, p_{11})\) and between-line \((p_{01}, p_{10})\) prices.
Lemma Let $f$ be a function of many variables with continuous partial derivatives of first and second order on the convex open set $S$ and denote the Hessian of $f$ at the point $x$ by $H(x)$. If $H(x)$ is negative definite for all $x \in S$ then $f$ is strictly concave.

Lemma Second partial derivative test: For a two variable function, if the determinant of the Hessian matrix is positive and sign of the leading principal minors are negative than $H(x)$ is negative definite.

That is I need to show both firms profit functions’ in the given pricing scheme is negative(semi) definite. Simplified form of the Hessian of Firm 0’s profit function can be shown as: (open form of the Hessian is very long, massy and difficult to follow, that form is available upon request.)

\[
\begin{bmatrix}
\frac{-a_0(-c_0+p_{00})(A_0^2)-b_0(B_0^2)}{C_0^2} & \pi_{p00,p01} \\
\pi_{p01,p00} & \frac{-w_0(-c_0+p_{01})(D_0^2)-z_0(E_0^2)}{F_0^2}
\end{bmatrix}
\]

As clearly seen in the simplified form both of the principal minors $(\pi_{p00,p00}, \pi_{p01,p01})$ are negative. ($a_0 > 0$, $b_0 > 0$, $w_0 > 0$, $z_0 > 0$ and note the assumption that $p_{00}$ and $p_{01}$ should be greater than marginal cost: $c_0$)
And the determinant of the Hessian can be shown in a simplified form as:

\[
\frac{(-c_0 + p_{00})G_0^2 \ast H_0^2 + J_0^2 \ast J_0^2 + K_0^2}{L_0^4}
\]

which is positive. (again note the assumption that \(p_{00} > c_0\)) This shows that Firm 0’s profit function matrix is negative definite and so it is concave. Proof for the other firm’s profit function’s concavity is given in the appendix part.

\[\blacksquare\]

Comparative Statistics and Numerical examples As the costs of firms increase, both in-line and between-line prices of firms rise as well.

\[\frac{\partial p_{00}}{c_0} > 0 \quad \frac{\partial p_{01}}{c_0} > 0 \quad \frac{\partial p_{11}}{c_1} > 0 \quad \frac{\partial p_{10}}{c_1} > 0\]

Increase in a cost of single firm causes all prices in the market to increase. That is when cost of a firm increase, it increases its own prices and in response other firm raise its prices as well, by increasing its profit margins.

When I compare different cost pairs for firms, it is seen that lower cost firm charges a bigger profit margin and prices of both firm are close to each other in the equilibrium. (As an example; for \(m=4, \ c_0=0.1, \ c_1=0.2 \rightarrow p_{00}=0.45, \ p_{01}=0.38, \ p_{11}=0.47, \ p_{10}=0.41\), share of Firm 0: 52%, share of Firm 1: 47%) For moderate changes in cost differences one can claim that, shares of firms do not change radically;
Figure 1.8: Per unit charging prices. (Firm 0’s cost: 0.1. Firm 1’s cost: X-axis)

instead profit margins change and again prices of firms can be considered as close to each other. (For m=4, c₀=0.1, c₁=0.5 → p₀₀=0.59, p₀₁=0.56, p₁₁=0.72, p₁₀=0.67, share of Firm 0: 69%, share of Firm 1: 30%) This causes price elasticities of small cost firm to be smaller than big cost firm.⁸ In other words although one might expect small cost firm’s elasticity to be greater, its elasticity is lower. Since small cost firm has high profit margins it is able to adjust its margin and keep its share rather than changing the price directly. Big cost firm has not much chance than reflecting the change in cost onto its prices, since its profit margins are already low. Trends for prices, profits and shares of the two firm are provided in figures 8-10, where the cost of Firm 0 is fixed at 0.1 and cost of Firm 1 is getting bigger (0.2 to 1)

For unrealistically big cost differences there might arise cases that in the equilibrium one of the firms goes out of the market. However these cases are out of

⁸Price elasticities with respect to costs.
Figure 1.9: Per unit charging profits. (Firm 0’s cost: 0.1. Firm 1’s cost: X-axis)

Figure 1.10: Per unit charging shares. (Firm 0’s cost: 0.1. Firm 1’s cost: X-axis)
the scope of our paper. Also when the budget for cell phone talk increases prices for in-line and between-line talks has a tendency to rise as well. \((\frac{\partial p_{01}}{\partial m} > 0 \quad \frac{\partial p_{02}}{\partial m} > 0 \quad \frac{\partial p_{10}}{\partial m} > 0)\)

Comparison with the results of the baseline model  
As we emphasized before, most important distinction of this paper is its use of "social circle/distance" concept. A person does not get the same utility from talking to every person. If a person talks with somebody who is closer to him in the social environment, he gets higher utility than the case he talks with somebody who is apart from him. So as the baseline model from the literature, we can think of a construction, where there is no difference in the utility from talking with different people. If one keeps the assumptions of this paper and try to solve the model without the social distance concept it is seen that there are not different prices for in-line and between-line talks. Intuitively, a customer does not insist to call a specific person if cost of talk is higher but the utility he can get is still same, so there is no opportunity for firms to price discriminate. In a paper by Laffont, Rey and Tirole (1998) different prices for in-line and between-line talks are justified with different cost structures for in-line and between-line talks. Different from that, this paper is able to explain price discrimination with customer necessities and without cost differences. Your eagerness to talk with different people is different and now it makes sense for firms to have different prices as in-line and between-line prices. (As a result of the construction of the model, firms charge higher prices for in-line talks in this paper; people around you are possibly in the same network company with you because of the utility a person gets from closeness to a specific firm on the
social curve. And since it is not easy for a customer to change its provider firms are tend to charge higher prices for in-line talks. (It is more difficult, due to high utility, for a consumer not to call his close friends, relatives etc.) This can be seen as an important strength because it explains how firms can price discriminate in a highly regulated network market structure with sophisticated technology, where the extra costs for between-line talks are negligible. (These market conditions become more realistic everyday)

However it should be noted that in today’s world, access costs are still not insignificant. That is one can still assume positive extra costs for reaching another network’s customer. For this extra cost assumption, the model I use, perfectly estimates the on-going different prices in the market in the sense that between-line talks are more expensive than in-line talks.(even that price difference between in-line talks and between-line talks is less in my model than Tirole’s model.) After the above figures with no access charge, in figures 11-13, I provided the corresponding graphs, in which I assume access cost of 0.2.

Two Part Tariffs In this pricing scheme firms charge a fixed fee to the consumers. Firm 0 charges a fixed fee of "h₀" and Firm 1 charges a fixed fee of "h₁". (assume h₀ and h₁ is less than m) Since it is originally assumed that each consumer has m dollars to spend at wireless phone talking, in this tariff structure there remains m-h₀ dollars to spend at phone talks for Firm 0 customers and m-h₁ dollar for Firm 1 customers. Consumers maximize their utilities according to those remaining amounts for phone
Figure 1.11: Per unit charging, with 0.2 access cost, prices. (Firm 0’s cost: 0.1. Firm 1’s cost: X-axis)

Figure 1.12: Per unit charging, with 0.2 access cost, prices. (Firm 0’s cost: 0.1. Firm 1’s cost: X-axis)
Figure 1.13: Per unit charging, with 0.2 access cost, shares. (Firm 0’s cost: 0.1. Firm 1’s cost: X-axis)

talks. (again (0,1) is the interval of firms’ cost range, marginal costs are greater than zero and a firm’s between-line price is higher than its own marginal cost.)

For firms, observing the real market, especially the US market, we assume that firms use marginal cost pricing for in-line talks. That is firms charge their marginal costs as their in-line talk prices. They can still make profits from between-line talks. With these new assumptions firms’ choice variables are fixed fee and between-line pricing this time. Everything else remains same as in the one part tariff case in utility and profit maximization processes. Demand for Firm 0 can be represented as:

---

In many markets, including the US market firms charge very low prices for in-line talks. Most of the time in-line price is as low as firms’ marginal costs and in some cases, it is equal to zero. For the zero in-line price case you can see the appendix. (A Discussion on American Wireless Market)
\[ A^* = \int_{0}^{x^*} \frac{m - h_0 + p_{01}(x^* - x + 1) + p_{00}(x^* - x - 1)}{2p_{00}} \, dx \]

\[ B^* = \int_{x^* - m - h_0 + p_{00}/p_{00} + p_{01}}^{x^*} \frac{m - h_0 - p_{00}(x^* - x - 1) - p_{01}(x^* - x + 1)}{2p_{01}} \, dx \]

\[ D^* = \int_{x^* - m - h_0 + p_{00}/p_{00} + p_{01}}^{x^*} \frac{m - h_0 + p_{01}(x^* - x + 1) + p_{00}(x^* - x - 1)}{2p_{00}} \, dx \]

where \( A^* \) represents total demand of only in-line talking customers and \( B^* + D^* \) represents total demand of both in-line and between-line talking customers.

and demand for Firm 1 can be represented as:

\[ J^* = \int_{x^*}^{x^* + m - h_1 + p_{10}/p_{11} + p_{10}} \frac{m - h_1 + p_{10}(x^* - x + 1) + p_{11}(x^* - x - 1)}{2p_{11}} \, dx \]

\[ K^* = \int_{x^*}^{x^* + m - h_1 + p_{11}/p_{10} + p_{10}} \frac{m - h_1 - p_{11}(x^* - x - 1) - p_{10}(x^* - x + 1)}{2p_{10}} \, dx \]

\[ L^* = \int_{x^*}^{x^* + m - h_1 + p_{10}/p_{11} + p_{10}} \frac{m - h_1 + p_{10}(x^* - x + 1) + p_{11}(x^* - x - 1)}{2p_{11}} \, dx \]
where J* represents total demand of only in-line talking customers and K*+L* represents total demand of both in-line and between-line talking customers.

Since firms do not make profits from in-line talks as a result of the marginal cost pricing assumption, all the profits come from between-line talks and fixed fees. Firm 0 get a revenue of

$$\varphi_0 = \int_0^{x^*} h_0 dx$$

from fixed fees. The revenue Firm 1 get from fixed fees is:

$$\varphi_1 = \int_{x^*}^1 h_1 dx$$

As a result, total profits of firms Firm 0 and Firm 1; \(\pi_0^*\) and \(\pi_1^*\) can be represented as the following:

$$\pi_0^* = \varphi_0 + D^*(p_{01} - c_0)$$

and

$$\pi_1^* = \varphi_1 + L^*(p_{10} - c_1)$$

Firms try to maximize their profits with respect to fixed fees and between-line prices.
So we have two first order conditions for Firm 0:

\[
\mu_0 = \frac{\partial \pi_0^*}{\partial p_{01}} \quad \lambda_0 = \frac{\partial \pi_0^*}{\partial h_0}
\]

and the first order conditions for Firm 1:

\[
\mu_1 = \frac{\partial \pi_1^*}{\partial p_{10}} \quad \lambda_1 \frac{\partial \pi_1^*}{\partial h_1}
\]

Again I provide the proof for existence of single equilibrium rather than stating the open forms of the solutions for prices and fees. Proof for Firm 0 is given below and proof for Firm 1 can be found in the appendix part.

**Proposition 3** Under the assumption of two part tariffs, for marginal costs greater than zero and different from each other, and each firms’ between-line prices higher than their own in-line prices, there exists a two firm equilibrium where higher cost firm charges higher prices and lower fixed fee whereas the lower cost firm charges lower prices and higher fixed fee.

**Proof**

As in the proof of per-minute pricing scheme consumers has no reason to change their cellular talk providers by construction. Remember that one of the key points of this paper’s model is that marginal consumers dictate the shares and profits of
firms. Marginal consumers get the same utility by choosing either firm and so all the consumers other than the marginals are better off by being a customer of a particular firm according to their place on the social curve in this pricing scheme as well.

In this pricing scheme low cost firm automatically offers lower in-line prices than the high cost firm. (Due to its cost advantage its between-line prices are lower as well.) Therefore, low cost firm is still able to get a high share from the market by asking higher fees than the high cost firm. Intuitively, it asks fixed fees high enough to get more profit from a customer and low enough to attract people and get higher share. By asking lower fixed fees and using the advantage of firm choice for getting closer consumers, high cost firm is able to maintain its place in the market with the stated prices and fees. Again using the same Lemmas I need to show the concavity of firms’ profit functions to prove that, equilibrium that is found by maximizing profits is the only stable equilibrium in the relevant cost range. (Again, uninterestingly long open forms are available upon request)

I prove both firms’ profits functions are concave in the restricted cost range according to their two choice variables; fixed fees \((h_0, h_1)\) and between-line \((p_{01}, p_{10})\) prices.

**Lemma** Let \(f\) be a function of many variables with continuous partial derivatives of first and second order on the convex open set \(S\) and denote the Hessian of \(f\) at the point \(x\) by \(H(x)\). If \(H(x)\) is negative definite for all \(x \in S\) then \(f\) is strictly concave.
Lemma Second partial derivative test: For a two variable function, if the determinant of the Hessian matrix is positive and sign of the leading principal minors are negative than $H(x)$ is negative definite.

That is I need to show both firms profit functions’ in the given pricing scheme is negative(semi) definite. Open form of the Hessian of Firm 0’s profit function can be shown as:

$$
\begin{bmatrix}
-\alpha_0(-\theta_0+p_{01})\Psi_0^2 - \beta_0\Psi_0^2 & \pi_{p_{01},p_{01}} \\
\pi_{p_{01},p_{01}} & -\frac{\psi_0^2}{\theta_0}
\end{bmatrix}
$$

As one can clearly see, with the condition $p_{01}>\theta_0$, principal minors of the Hessian is negative. And determinant of the Hessian is:

$$
\frac{\lambda_0^2 \cdot \Psi_0^2 + \gamma_0^2}{v_0^2}
$$

In the given cost range (0,1) this determinant is positive. This shows that Firm 0’s profit function matrix is negative definite and so it is concave. Proof for the other firm’s profit function’s concavity is given in the appendix part.
Comparative Statistics and Numerical examples As the cost of a firm increases between-line price of the firm tends to increase however its fixed fee tends to decrease. Intuitively it wants to keep its market share by a decrease in fixed fee in response to an increase in its prices. There is no significant relationship between the magnitudes of price elasticities this time. The direction of changes in prices with respect to changes in costs can be represented as:

\[
\frac{\partial p_{01}}{c_0} > 0 \quad \frac{\partial h_0}{c_0} < 0 \quad \frac{\partial p_{10}}{c_1} > 0 \quad \frac{\partial h_1}{c_1} < 0
\]

When different cost pairs for firms are compared, one can observe that again fees and prices of firms are close to each other. (As an example; for m=4, c_0=0.1, c_1=0.2 → p_{00}=0.1, p_{01}=0.32, p_{11}=0.2, p_{10}=0.37, h_0=3 h_1=2.5 share of firm 0: 57%, share of firm 1: 42%) With cost differences getting larger, the gap between firms’ fixed fees gets larger as well. (For m=4, c_0=0.1, c_1=0.5 → p_{00}=0.1, p_{01}=0.43, p_{11}=0.5, p_{10}=0.53, h_0=3.2, h_1=2.0, share of firm 0: 70%, share of firm 1: 29%) Again unrealistically high cost differences may lead a monopoly structure in the market which is out of the scope of this paper. In addition; when the budget for cell phone talk increases, prices for between-line talks and fixed fees tend to increase as well. 

\[
\left( \frac{\partial h_0}{m} > 0 \quad \frac{\partial p_{01}}{m} > 0 \quad \frac{\partial h_1}{m} > 0 \quad \frac{\partial p_{10}}{m} > 0 \right)
\]

Trends for prices, fixed fees, profits and shares of the two firm are provided in figures 14-16, where the cost of Firm 0 is fixed at 0.1 and cost of Firm 1 is getting bigger (0 to 1) \(^{11}\)

\(^{10}\)Price elasticities with respect to costs.  
\(^{11}\)Numbers provided in graphs are results of numerical exercises done with computer programs. All the lines in the figures keep their trends between the costs 0 and 1.
Figure 1.14: Two part tariff prices. (Firm 0’s cost: 0.1. Firm 1’s cost: X-axis)

Figure 1.15: Two part tariff profits. (Firm 0’s cost: 0.1. Firm 1’s cost: X-axis)
Figure 1.16: Two part tariff shares. (Firm 0’s cost: 0.1. Firm 1’s cost: X-axis)

Also, for the same cost pairs, I compared the above case that, in-line prices are equal to marginal costs and between-line prices and fixed fees vary, with the unrealistic case that between-line prices are equal to marginal costs and in-line prices and fixed fees vary. The model estimates; higher in-line prices and lower fixed fees for the unrealistic case (higher(lower) than the between-line prices(fixed fees) of the above examined case). A short discussion about American wireless markets can be found in the Appendix.

Comparison with the results of the baseline model  This time explanatory strength of the model is even more clear. Since in this pricing, it is assumed that prices of in-line talks are equal to firms’ marginal costs there would be no profit opportunity from any charge other than fixed fee. So in a baseline model, where people get same utility from talking every people, both in-line and between-line prices are equal to firms’ marginal costs. Firms able to make profits only from fixed fees. This is clearly
not the case for the real world. When we look at the market of fixed fee tariffs it can be seen that to talk with somebody from your own network is certainly cheaper than to talk with somebody from other networks. (with lower prices for in-line talks, or completely unlimited calling for in-line talks at high fixed fee tariffs.)

1.4 Concluding Remarks

The article has developed a social interaction model of wireless pricing to study the network competition. As a distinguishing feature of the model, this paper based the utilities consumers get from cell phone talking on a social structure. People get higher utilities from talking to people who are closer to them in the social environment. Assuming people are placed on a social circle, the paper is able to come up with different equilibria for the wireless market under different tariff types. As a result of the profit maximization process of firms and utility maximization process of consumers; firms get a portion of customers on the circle. The size of the portions determines the shares of firms. Now, let me recap the main results, starting with the case of one-part tariffs.

With per unit charging, that is under the pricing scheme in which firms charge only for the time used by the consumers for cell-phone talks, I come up with a two firm equilibrium. Assuming each firm has different costs which are larger than zero, smaller cost firm gets higher share with lower prices in the equilibrium. (higher in-line prices for zero access charge and higher between-line prices for positive access charge.)
Other tariff structure I investigated is the two part tariff structure in which customers pay a fixed fee for the period independent from their talks in that period. This pricing scheme is also commonly seen in the wireless markets around the world. Most of the times firms charge very low prices for in-line talks under this tariff structure. Considering all these I assume firms charge their marginal costs as their in-line prices. With the addition of costs higher than zero and different from each other assumptions, a two firm equilibrium is reached in which higher cost firm charges higher prices and lower fixed fee whereas the lower cost firm charges lower prices and higher fixed fee.

In both pricing schemes the model is able to explain price discrimination in the market for in-line talks and between-line talks without the use of any assumption of different costs for different types of talk. I believe this is an important addition to the literature in the sense that differences in these costs in today’s sophisticated communication technology is becoming negligible everyday and firms might need different justifications for different types of discrimination.

Although the model is mainly based on the cell-phone market it can apply to many other areas as well. Any network structure in which other people socially matters for you can be investigated under this mechanism. Networking websites that you pay a subscription fee to become a member are good examples to the phenomena we examine. People generally choose websites which they feel like to find more people socially closer to them. With modifications to price structure and other necessary changes, core of my model has a wide application area.
1.5 References


1.6 Appendix

Proof

Concavity of Firm 0’s profit function is given in the main text. Here, we prove Firm 1’s profit function’s concavity by following a similar argument.

We have to show firm 1’s profits function is concave in the restricted cost range according to its two choice variables; in-line \( p_{11} \) and between-line \( p_{10} \) prices.

Using the same Lemmas:

**Lemma** Let \( f \) be a function of many variables with continuous partial derivatives of first and second order on the convex open set \( S \) and denote the Hessian of \( f \) at the point \( x \) by \( H(x) \). If \( H(x) \) is negative definite for all \( x \in S \) then \( f \) is strictly concave.
Lemma Second partial derivative test: For a two variable function, if the determinant of the Hessian matrix is positive and sign of the leading principal minors are negative than \( H(x) \) is negative definite.

Simplified form of the Hessian of Firm 1’s profit function can be shown as: (open form of the Hessian is again uninterestingly long, that form is available upon request)

\[
\begin{pmatrix}
\frac{-a_1(-c_1+p_{11})(A_1^2)-b_1(B_1^2)}{C_1^2} & \pi_{p_{11},p_{10}} \\
\pi_{p_{10},p_{11}} & \frac{-w_1(-c_1+p_{10})(D_1^2)-z_1(E_1^2)}{F_1^2}
\end{pmatrix}
\]

As clearly seen in the simplified form both of the principal minors \( (\pi_{p_{11},p_{11}}, \pi_{p_{10},p_{10}}) \) are negative. \( (a_1 > 0, b_1 > 0, w_1 > 0, z_1 > 0 \) and note our conditions that \( p_{11} \) and \( p_{10} \) should be greater than marginal cost: \( c_1 \))

And the determinant of the Hessian can be shown in a simplified form as:

\[
\frac{(-c_1+p_{11})C_1^2 * H_1^2 + J_1^2 * J_1^2}{K_1^4} + \frac{L_1^2}{N_1^2}
\]

which is positive. (again note the assumption that \( p00 > c_0 \) ) This shows that Firm 1’s profit function matrix is negative definite and so it is concave as well.

Q.E.D.

Proof
Concavity of Firm 0’s profit function for the two part tariffs is shown in the main text. Following the same path proof of Firm 1’s profit function’s concavity is as the following. Again I have to show firm 1’s profits function is concave in the restricted price range according to its two choice variables in two part tariffs; fixed fees $(h_1)$ and between-line $(psc)$ prices. Again same Lemmas will be used to show the concavity of firms’ profit functions.

**Lemma**  Let $f$ be a function of many variables with continuous partial derivatives of first and second order on the convex open set $S$ and denote the Hessian of $f$ at the point $x$ by $H(x)$. If $H(x)$ is negative definite for all $x \in S$ then $f$ is strictly concave.

**Lemma** Second partial derivative test: For a two variable function, if the determinant of the Hessian matrix is positive and sign of the leading principal minors are negative than $H(x)$ is negative definite.

Simplified form of the Hessian of Firm 1’s profit function can be shown as:

$$
\begin{bmatrix}
-\alpha_1(-\alpha_1+\rho_{10})\gamma_1^2-\beta_1\Phi_t^2 & \pi_{h_1:p_{10}} \\
\pi_{p_{10},h_1} & -\Theta_{1}^2-\Xi_{1}^2
\end{bmatrix}
$$

With the extra condition of $h_1<\text{m}$ leading principal minors of the Hessian is negative. And determinant of the Hessian is:

$$
\frac{\lambda_1^2 \cdot \vartheta_1^2 + \gamma_1^2}{\varphi_1^2}
$$

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In the given cost range (0,1), with the condition \( p_{10} > c_1 \), this determinant is positive. This shows that Firm 1’s profit function matrix is negative definite and so it is concave as well.

Q.E.D.

A Discussion on American Wireless Market

When the American cell-phone networks’ common pricing schemes are considered one can claim that in this specific market, in-line talks are free and charges for between-line talks are as low as marginal costs. In this extreme case this paper’s model has an extreme estimation as well. That is fixed fees of both company should be equal to budget for cell phone talks i.e. "m" in the model. So prices for between-line talks become meaningless since consumers pay all their money to firms as fixed fees. Even in the case with a more moderate interpretation that there is no restriction on the between-line price and in-line prices are zero fixed fees approach to this budget limit "m" by the estimations of the model. Note also that between-line talks become very expensive. (for \( m=4, c_0=0.1, c_1=0.2 \rightarrow p_{00}=0 \ p_{01}=1.97, \ p_{11}=0, \ p_{10}=2.04, \ h_0=3.9, \ h_1=3.9 \) share of firm 0: 51%, share of firm 1: 48% and for \( m=4, c_0=0.1, c_1=0.3 \rightarrow p_{00}=0 \ p_{01}=2.02, \ p_{11}=0, \ p_{10}=2.49, \ h_0=3.9, \ h_1=3.9 \) share of firm 0: 56%, share of firm 1: 43%) However, I still believe even American wireless market is better represented by the two-part tariff model given in the main text, since effective rates on talks perceived by the consumers are almost never be equal to zero. (Still there are limits on any kind of talks in the American market’s popular pricing schemes.)
CHAPTER 2.

DEMAND ESTIMATION WITH
COMPLAINT CALLS TO PROXY
UNOBSERVED QUALITY: EVIDENCE
FROM TURKISH DISHWASHER
MARKET

2.1 Introduction

Estimation of demand for consumer durable goods has been an important topic for the economics literature for a long time. In this estimation endogeneity of price due to unobserved heterogeneity has been a major problem. We see a popular solution to this in the famous paper by Wright (1928). It is agreed that the suggested instrumental variables method by that paper can be used for the solution of unobserved heterogeneity problem as well. However recent econometrics literature shows that issues like finding the proper instruments, assumptions about linearity make the use of instrumental variables method questionable in some frameworks. In this paper, I’ll try to come up with an alternative solution to this problem for the demand estimation of durable goods.

To understand the validity of the alternative solution that is going to be offered in this paper, I’ll work with data from Turkish dishwasher market. This market is very interesting for a demand - supply estimation with its distinct structure. In Turkey, dishwashers are still not a popular good. Only around 30% of the households
have dishwashers. Since its mass marketing started around 1995, there is no resale consideration for this durable good yet. According to international standardization, 90% of the market has similar (A-) general quality standards in Turkey. There is no big price differences between firms for these similar quality machines. With the help of this special structure "dishwasher" in Turkey is modeled as a composite good.\footnote{More on this can be found in The Model part.}

The similarity of prices for this composite good between different brands and stability of the leader firm’s share make me to choose an Stackelberg type oligopolistic competition model. In this model considering competitors’ response, leader firm sets its quantity. Competitors supply the remaining part of the demand in the market. This model construction solves part of the endogeneity problem that may arise from simultaneity. In addition, the model has a strong testable implication that, the coefficients of shifters in leader firm’s supply function have to be half of the coefficients of shifters in the market demand function. Simple comparison of the estimated coefficients and formal tests that are employed, shows us that the constructed model is fairly successful in explaining the real market conditions.

These are being said about the market, it should be noted that the perceived quality of machines, after sale service quality, or other similar efforts that can effect demand for this kind of good in each marketing region of the country are again unobservable in this study as usual. This might be a cause of downward biased estimations for price in the demand equation. Actually Braeutigam and Pauly (1986) showed that assumption about the exogeneity of the service quality leads to biased
estimates. Since then, different techniques are employed to cope with the exclusion of "quality" variables in the data set. Use of instrumental variables partly solves the unobserved heterogeneity problem. However, weak instruments and non-linearity of the functions to be estimated create problems for the validity of this technique.\(^2\)

For the unobservables mentioned above, use of a proxy is offered for the first time in this paper. It is the ratio of complaint calls, which is defined as the number of complaints per new machines sold.\(^3\) Presumably unobservables mentioned above like perceived quality, after sale service quality in a region, will be inversely proportional to complaint calls received by a firm’s customer service. Use of this data as a control variable is possible under less restrictive assumptions and will provide an alternative to instrumental variables for the estimation of these kind of goods.

To understand the validity of this alternative method, I estimated the demand-supply equations with and without using complaint calls as a control variable. When complaint calls are not included; IV (3SLS) and OLS (SUR) techniques give significantly different estimates (especially for price). It can be assumed that, they are different because IV (3SLS) is solving the unobserved heterogeneity problem while OLS (SUR) is not.

However, when complaint calls is added as a control variable, the estimates by IV (3SLS) and OLS (SUR) are not significantly different. This shows that, inclusion

\(^2\)For a full discussion on the topic see the paper by Angrist and Krueger (2001)

\(^3\)Some studies like Trandel (1991), Crandall (1984), controlled for quality using consumer reports. However these reports have the problems of size and self-selection. Complaint call data is aggregate and presumably people are more likely to complain about the product to the producer not to the reports. Complaint calls can be assumed to better reflect the after-sale service quality, as well.
of complaint calls as a proxy for the unobservables mentioned before, might be an alternative to instrumenting to solve the omitted variable bias arising in these kind of estimations, when proper instruments are not available. The remaining small difference can be explained by the endogeneity of price. Note that, this proxy method can be applied to non-linear models as well.

The estimations in this paper are done keeping in mind the fact that "dishwashers" being a women’s labor saving appliance have many distinct properties that should be taken into consideration in the estimation process. Following the literature and observing the socioeconomic structure of Turkey I use; household income, education, women employment, price, retail electricity price as the demand variables. I follow the stream of using transitory income rather than permanent income for durable good demand estimation, which is led by Smith (1962). Keith (1996) showed that women employment levels in a region affects the quantity sold of labor saving appliances. Dishwasher, being a labor saving appliance, can be affected by women employment as well. I included regional women employment ratio as a demand variable.

As shown by Park and Capps (1997), education is a key factor for explaining demand for labor saving goods. With education, a stronger belief about gender equality is generally observed and the likelihood of having women’s labor saving goods increases. I have percentage of people who attended college in each region as an explanatory variable for demand as well. Dishwashers use electricity and water; so, I have the retail price of electricity in each region as a demand shifter. However,
due to lack of data, I don’t have price of water as an explanatory variable in my study. Interest rate is also a determinant that is considered for durable good demand estimation in the literature. Real interest rate is added as a control variable in this study too. Estimated price elasticities of demand are between -2.95 and -1 which shows that demand for dishwashers is elastic and are consistent with the literature.

For the supply side, as marginal cost variables, I included labor and capital variables. Goyal (1996) uses wages, material, and fuel costs in the cost calculations. Following a similar methodology, I have labor cost, material cost and energy cost which are provided by the producer as averages for each quarter. Here the material cost represents both the plastic and iron cost, and the energy cost represents both the industrial electricity and natural gas costs. More detailed information about the production is kept confidential by the firms in the industry.

For the elasticities calculated, it should be noted that education level is very significant factor for these kind of machines. Even firms cannot directly play role in the general education levels of a country, they may want to keep this in their minds when they are designing their marketing and advertisement campaigns. Exceptionally for Turkey, women employment seems to not have a significant role on the purchase decisions of these kind of goods. Possible reasons for this is discussed in The Results part.
2.2 The Model

As I mentioned in the introduction part, I am going to model the demand and supply of a labor saving appliance "dishwasher" for the Turkish market. For marketing purposes, by this industry, Turkey is divided into 10 different regions. I am going to follow the same pattern.\(^4\) The big firm of the market which is also the first entrant has a share more than 50%. Competitors have shares between 3% -13%. Big firm’s share can be considered as stable across regions and time. The big firm has a very strong brand name in the durable goods market in the country. The big firm’s domestic production approaches to 100%. Some followers produce domestically and others only import.

According to international standardization 90% of the market has similar (A-) standards. Not surprisingly, there are no big price differences between firms for these similar quality machines. These machines, all of which have similar standards, are grouped as high-end, middle-end and low-end by the firms in the industry. Some of these machines have different features, electronic equipment, more programs etc. But all of them are in the similar quality range. Furthermore, share of low-end models in the market is close to 80%, and high-end models have a share close to 3% in Turkey. This composition is fairly stable across regions and years. Using all these evidence I am going to approach the "dishwasher" in Turkey as a composite good.

What can be the key components that can affect dishwasher demand? When answering this question one has to remember that "dishwasher" is still not a popular

\(^4\)This also helps to increase variation for estimation purposes.
good in Turkey. Only around 30% of the households have dishwashers. Since its mass marketing started around 1995, there is no resale consideration for this durable good yet. After observing the socio-cultural aspects and regional differences in the country and following the literature mentioned in introduction, I come up with the demand determinants as household income, women employment, education level, interest rate and electricity cost.

Demand is expected to be affected also by unobservables like perceived machine and after sale service satisfaction. These unobservables will affect the price of the machines sold and create an endogeneity problem. Solutions to this problem are presented in the estimations part. After all these discussions, market demand for dishwashers can be written as:

\[ q = a_1 X - b_1 P + v_1 + \varepsilon_{01} \]  \hspace{0.5cm} (1)

Here let \( X \) be a vector of all the demand shifters I mentioned above, \( P \) represents the real prices for the composite good "dishwasher" and \( v_1 \) the quality unobservables, which are correlated with price, mentioned above. On the supply side, I have to mention the fact that the producer under investigation in this paper is fairly independent in its decisions. The firm is producing all kinds of home appliances in its production facilities that are located in different cities of the country. Marketing and pricing decisions for each type of good are independent. For the supply side one has to consider the marginal cost structure of the producers. After the interviews with the leader dishwasher firm’s production team in Turkey, for the relevant time period,
I safely assume constant marginal cost for the quantities I am interested in. For the given period average capacity utilization is around 60%. For the quantity range produced, energy and material costs are fixed. Turkey has a very high unemployment rate which is around 13%. This makes production of different quantities easier, in the sense that, the plant can hire and fire workers, change the quantity of labor easily. It does not have to face increasing average wages with extra hours of labor as much as its correspondents in many other countries.\textsuperscript{5} Given all these facts and examples from the literature I assume a constant marginal cost function for the producer.\textsuperscript{6} Due to limited available data, I write the marginal cost function of the firm as a function of input prices.

\[ MC = (\alpha \text{ laborcost} + \beta \text{ materialcost} + \lambda \text{ energycost} + \varepsilon_2) \quad (2) \]

The composite good dishwasher is supplied by a leader firm, which has more than 50\% market share, and followers which has shares between 13\% and 3\%. There are many evidences that the top market-share firm is also the leader of the market. First of all, as the first entrant it is always the brand that comes to a typical consumer’s mind when he thinks about a dishwasher.\textsuperscript{8} Many new technologies, like half-wash (2002), tech-touch (2008), fastest washing (2009) are all introduced by this company to Turkish market. Decrease in the energy consumption levels are also led

\textsuperscript{5}Financial leverage ratio for the firms in the industry is between 50\% and 70\%. In addition, considering the existence of importing firms and capacity utilization rates around 60\%, interest rates is safely assumed out of the MC functions for this 8 years model.


\textsuperscript{7}From now on the part in paranthesis will be shortened as "R".

\textsuperscript{8}Nielsen, consumer insight reports (1995-2009).
by the big firm. Since prices of same quality machines by different brands are very
close and share of the big firm is fairly stable around 50%, one can assume that the
big firm is able to determine the quantity of sales in the market by its pricing decisions
given market demand. Therefore, a Stackelberg type oligopolistic competition model
is assumed.

In this model, considering competitors’ response, leader firm sets its quantity.
Competitors supply the remaining part of the demand in the market. Therefore,
competitors’ supply curve intersects with the market demand and determines the
equilibrium price and quantity. Graphically, I can represent the market condition
as in Figure 1, where "q_1" represents the profit maximizing quantity of the leader
firm, "D" represents market demand, "S" represents supply of the competitors, "q^*"
represents equilibrium market quantity and "p^*" represents equilibrium market price
(q^*−q_1 = quantity supplied by other firms)

Leader firm is trying to maximize its profits given its cost function and market
demand. By this maximization, it decides a quantity to supply to the market knowing
that remaining demand will be supplied by the competitors. Assuming other firms
have a supply function in the form of:

\[ q_{-1} = mP + \varepsilon_1 \quad (3)^9 \]

and considering total market quantity is the sum of leader firm’s and other
firms’ quantities we can write price as a function of big firm’s quantity and other

---

9Due to competitors’s small shares and the model constructed accordingly, prices are indirectly
set by the leader firm. This low power of small firms on the equilibrium price, makes "price"
exogenous for them.
Figure 2.1: Stackelberg type oligopolistic competition.

demand shifters:

\[ P = aX - bQ + v_0 + \varepsilon_0 \quad (4)^{10} \]

\[ P = aX - b(mP + \varepsilon_1 + q_1) + v_0 + \varepsilon_0 \quad (5)^{11} \]

\[ P = \frac{aX - bq_1 + v_0 + \varepsilon_0 - b\varepsilon_1}{1 + bm} \]

Therefore the big firm is maximizing the following total profit function.

\[ \pi = \left( \frac{aX - bq_1 + v_0 - b\varepsilon_1}{1 + bm} \right) q_1 - C(q_1) \quad (5)^{12} \]

\[ \frac{\partial \pi}{\partial q_1} = \frac{aX + v_0 - 2bq_1 + v_0 - b\varepsilon_1}{1 + bm} - c'(q_1) = 0 \]

\(^{10}\)Note that \(a_1\) in (1) is equal to \(\frac{2}{b}\), \(b_1\) in (1) is equal to \(\frac{1}{b}\), \(v_1\) in (1) is equal to \(\frac{\varepsilon_0}{b}\) and \(\varepsilon_{01}\) in (1) is equal to \(\frac{\varepsilon_0}{b}\).

\(^{11}\)Total market quantity is written as the sum of the quantities of the big firm and the other firms.

\(^{12}\)\(C(q_1)\) representing the total cost function of the big firm.
After necessary adjustments and replacing $c'$ in the first order condition above with the marginal cost function assumed before:

$$aX + v_0 - (1 + bm)R + \varepsilon_0 - b\varepsilon_1 - (1 + bm)\varepsilon_2 = 2bq_1$$

$$q_1 = \frac{aX + v_0 - (1 + bm)R}{2b} + \varepsilon_3 \quad (6)$$

That is, I am able to write profit maximizing quantity of the big firm as a function of demand and supply variables and unobservables as in (6). So according to this paper’s construction, one should note (1) as the market demand function (3) as the total supply function of the competitors and (6) as the supply function of the leader firm. My model implies an identification restriction to test. Note that according to the model, parameters of shifters ($X$) in leader firm’s supply function have to be half of the parameters of shifters ($X$) in the market demand function.

2.3 Data

To estimate my model I have used two data sets. Data regarding the supply side is mainly provided by the leader firm of the dishwasher sector. This is a confidential data set. The leader firm in the dishwasher market divides the country into 10 different regions for marketing and service purposes. I have quarterly sales of the leader firm and total sales of its competitors in each region.

On the demand side I have complaint calls data about leader’s products in each region, quarterly. Complaint call data here is a ratio of the complaint calls per
new machines sold in each region for each quarter. Since some time is needed for the
complaints to diffuse to people, in the estimation, two period lags of this data will
be used. Firm's confidential data set has quarterly data on average real input prices:
labor cost (hourly wage), energy cost (an index used for electricity and natural gas
costs), material cost (an index used for plastic and iron costs). Note that the firm
has one plant at the capital of the country. So these input prices are not regional.
For possible regional differences, regional dummies are included.

For the variables on the demand side, I used data provided by TurkStat (Turk-
ish Statistical Institute) databank. This databank provides data for each city. I
constructed regional data by using this city data, and by using population weights
where necessary. For income, I constructed a measure for each region by multiplying
the number of households in each region by the purchasing power of an individual in
that particular region. With this construction, I am able to consider the fact that
dishwasher demand is expected to be controlled by number of households but not by
the actual population.

Number of households and real purchasing power (real GDP/population) are
both provided by TurkStat. I included woman employment, education level and
real interest rate figures from the same data bank. For education level, there are
many choices that can be included. I decided to include ratio of people who are
college attendants. The purchase decisions of these kind of labor saving appliances are
generally based on the consensus of household members. That is why I include general
education ratio but not only for men or women. In addition, I believe, this consensus
is more significantly affected with higher levels of education. Thus, I included the percentage of college attendants in each region.

Finally, on the demand side, I have real retail electricity cost in kw/h terms provided by OECD. Since electricity cost of previous periods will be considered in the purchase decision of today, average of the last three periods is going to be used in the estimation. I included this due to possible negative (positive) effect of increasing (decreasing) electricity costs on dishwasher demand. I attempted to get retail water cost too. However, water prices differ significantly from city to city and even from town to town. Hence, there is no reliable quarterly data set for this cost across regions. Nevertheless regional dummies are also included for the regional differences that are not directly considered in my data set. Name of variables and their descriptions are also provided in Table 1.\(^{13}\)

### 2.4 Estimation

In this part, I am going to estimate the demand and supply system for dishwashers. Following equations will be estimated;

\[ q_{i,t} = \alpha X_{i,t} + \beta P_{i,t} + \varphi D_i + \upsilon_{i,t} + \epsilon_{1i,t} \quad (I) \]

\[ q_{-1i,t} = \mu P_{i,t} + \dot{\upsilon} D_i + \epsilon_{2i,t} \quad (II) \]

\[ q_{3i,t} = \delta X_{i,t} + \lambda R_t + \Upsilon D_i + \epsilon_{3i,t} \quad (III) \]

\(^{13}\)Summary statistics about the non-confidential data, used in this study, are provided in the appendix.
<table>
<thead>
<tr>
<th>Variables</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>pppop</td>
<td>number of households*purchasing power of an individual. (regional)</td>
</tr>
<tr>
<td>emp</td>
<td>women employment ratio. (regional)</td>
</tr>
<tr>
<td>ed</td>
<td>ratio of college attendants. (regional)</td>
</tr>
<tr>
<td>call</td>
<td>complaint calls per number of new machines sold. (regional)</td>
</tr>
<tr>
<td>p</td>
<td>price. (regional)</td>
</tr>
<tr>
<td>laborc</td>
<td>hourly wage.</td>
</tr>
<tr>
<td>materialc</td>
<td>an index used for plastic and iron costs.</td>
</tr>
<tr>
<td>energyc</td>
<td>an index used for industrial electricity and natural gas cost.</td>
</tr>
<tr>
<td>electric</td>
<td>retail price of electricity.</td>
</tr>
<tr>
<td>q</td>
<td>total number of machines sold. (regional)</td>
</tr>
<tr>
<td>q1</td>
<td>number of machines sold by the leader firm. (regional)</td>
</tr>
<tr>
<td>q_1</td>
<td>number of machines sold by other firms. (regional)</td>
</tr>
<tr>
<td>D</td>
<td>regional dummies.</td>
</tr>
<tr>
<td>int</td>
<td>real interest rate</td>
</tr>
</tbody>
</table>

Table 2.1: Summary of the variables.
Here with (I) I’ll estimate the market demand. Since I have a Stackelberg kind of oligopolistic model and firms have different places in the market; the market supply is going to be estimated separately, (II) as other firms’ supply and (III) as the leader firm’s supply.

The existence of unobservables like after-sale service or perceived machine quality might be creating a problem of endogeneity in the system that will be estimated. With the Stackelberg kind of oligopolistic model used, price does not directly appear in the supply function of big firm. In addition, since small firms have not much market power, price works more as an exogenous variable in the supply equation of small firms. According to the model construction and the conditions of the market, endogeneity of price due to reasons other than unobserved heterogeneity should not create a big problem. However, existence of omitted variables about quality is still expected to create bias for the estimated coefficient of price in the demand equation. 

(Cov(P, v) \neq 0)

To cope with this omitted variable bias, I use complaint calls rate which is represented with "call" in the estimation as a proxy for the unobservables that are represented with "v" in the demand function. I assume that unobservables that are mentioned above, like perceived quality of machines, and after-sale service quality in a region, will be inversely proportional to complaint calls received by a firm’s customer service hence will make a good proxy for these demand unobservables. That is call can now be included in the vector of control variables for demand (X’) and the new
market demand function to be estimated can be written as:\textsuperscript{14}

\[ q_{i,t} = \alpha X'_{i,t} + \beta P_{i,t} + \varphi D_i + \epsilon'_{1i,t} \quad (I') \]

To get the best estimates and understand the endogeneity problem with its offered solutions better, different techniques are employed. First, I start with IVREG (I) - OLS (II) - OLS (III) triple.\textsuperscript{15} To get rid of the endogeneity, in that "price" is instrumented with energy cost and labor cost. Apparently those costs affect price but not quantity demanded, directly. The demand equation is estimated with and without using complaint calls as a control variable. The unobservable "\( v_{i,t} \)" is included in the error term when complaint calls is not used as a control variable.

Then same equations are also estimated without instrumenting, using OLS. Estimations are made with and without the use of complaint calls as a control variable again. Comparison of the estimates (especially the estimates of price) and use of the Hausman test will allow us to have a better idea about the endogeneity problem due to unobservables and its possible solutions.

First of all I compare the estimates by IV and by OLS to see that if the estimates differ much when complaint calls are not used in the estimation. (by simple comparison and Hausman test) Then I’ll make the same comparison when complaint calls are included as a control variable. If only at this time estimates don’t differ much, we can safely conclude that IV is not the only possible solution method be-

\textsuperscript{14} And note that eq. III will be estimated as:
\[ q_{i,t} = \delta X'_{i,t} + \lambda R_t + \Upsilon D_i + \epsilon'_{3i,t} \quad (III') \]

\textsuperscript{15} Here, I assume \( v_{i,t} \), \( \epsilon_{i,t} \) and \( \nu_{i,t} \) are independent.
cause complaint calls are able to solve the endogeneity problem due to unobserved heterogeneity in the estimation.

Then I provide the results of two different system estimators to increase efficiency, in case the errors in different equations are correlated. I estimate my model with 3 Stage - Least - Squares (3SLS) and Seemingly Unrelated Regression (SUR) techniques. Similar comparisons that are done for IV and OLS are repeated for 3SLS and SUR, as well. The model’s testable implication that parameters of shifters (X) in leader firm’s supply function have to be half of the parameters of shifters (X) in the market demand function is also going to be tested with the use of system estimators.

In my data set, I have call rates only for the leader firm. However, considering the leader firm’s extremely powerful brand name, its fairly stable shares, similarity of rates across firms for the single observable year and observing how people generalize this brand’s products to all the products in the market; call rate in my data is taken as a shifter for market demand when it is used as a control variable. I have to note at this point again that after thorough investigation of the data, I decided that average of the last three periods for electricity cost and two period lags for complaint calls are the relevant terms for estimation of the demand in period "t".

\[\text{\textsuperscript{16}}\text{According to mathematical model constructed, error terms are actually correlated.}\]
2.5 Results

When the model is estimated without call rates by IVREG, and OLS we get the estimates, provided in Table 2. With the rejection of the hypothesis that coefficients are not significantly different by Hausman test and simply observing the estimates (demand) that are not close to each other, it can be said that using instruments helps to deal with the endogeneity problem due to unobserved heterogeneity.

In Table 3, same estimations are done with including complaint calls as a control variable. This time Hausman Test cannot reject the hypothesis and estimates are much more close. This shows us that complaint calls as a control variable helps to cope with the endogeneity problem arising from unobserved heterogeneity in the estimation and can be offered as an alternative to IV method to get rid of the omitted variable bias in the estimation.\(^\text{17}\) This finding is important given the fact that weak instruments and non-linearity of the functions to be estimated create problems for the validity of IV technique.

In Table 4, average elasticities that are calculated with IV method is presented. Two points are noticeable in this estimation. First, even it is not significant, women employment has an unexpected sign for demand. I believe when a woman became employed the household make their purchase decision in the same period. Nevertheless, I suspect that women employment may have a lagged effect on dishwasher sales, so I tried the estimation with many different time periods. Not surprisingly, I get

\(^{17}\)The remaining difference is possibly due to simultaneity.
<table>
<thead>
<tr>
<th></th>
<th>$q$(IV)</th>
<th>$q_{-1}$(OLS)</th>
<th>$q_1$(OLS)</th>
<th>$q$ (OLS)</th>
<th>$q_{-1}$(OLS)</th>
<th>$q_1$(OLS)</th>
</tr>
</thead>
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<tr>
<td>pppop</td>
<td>20.57**</td>
<td>12.31**</td>
<td>21.79**</td>
<td>12.31**</td>
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<tr>
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<td>(1.44)</td>
<td>(.96)</td>
<td>(1.41)</td>
<td>(.92)</td>
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<tr>
<td>ed</td>
<td>6634.6**</td>
<td>4552.5**</td>
<td>6081.96**</td>
<td>4552.5**</td>
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<td></td>
<td>(2054.8)</td>
<td>(1156)</td>
<td>(1875.0)</td>
<td>(1104)</td>
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Standard errors in parentheses.
*Significance at 0.05 level.
**Significance at 0.01 level.
$q =$ market demand, $q_{-1} =$ others’ supply, $q_1 =$ big firm’s supply.

Table 2.2: Estimation Results with IV and OLS (Complaint calls are not included).
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<td>(244.14)</td>
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<td>-129.66**</td>
<td>16.72*</td>
<td>-121.37**</td>
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<td>(8.27)</td>
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<td>-1303.80**</td>
<td>(466.29)</td>
<td>(449.35)</td>
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<tr>
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<td>(466.29)</td>
<td>(466.29)</td>
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<td>(466.29)</td>
<td>(466.29)</td>
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</tr>
<tr>
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<td>360</td>
<td>318</td>
<td>360</td>
<td>318</td>
<td>360</td>
</tr>
<tr>
<td>R²</td>
<td>0.91</td>
<td>0.84</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
<td>0.91</td>
</tr>
</tbody>
</table>

Standard errors in parentheses.

*Significance at 0.05 level.

**Significance at 0.01 level.

$q = \text{market demand, } q_{-1} = \text{others’ supply, } q_1 = \text{big firm’s supply.}$

Table 2.3: Estimation Results with IV and OLS (Complaint calls are included).
the best estimates without any lag or average usage. Even its confidence interval has
a large positive portion, point estimate for women employment still seems to have a
negative effect on quantity demanded of dishwashers. I’ll come to this issue after
the model’s estimation using systems estimators.

Second point to note is the price elasticity of demand. Claiming dishwasher is
not a popular good with its high price in Turkey, a price elasticity of demand of -3 is
an acceptable estimate even it is a little high when we look at the literature. I’ll come
to this issue after system estimations as well. Price elasticity of supply is 1.20 and
not in contrast with the literature. Note that, the new control variable "complaint
calls" is also a significant demand determinant with an elasticity around -.11.

On the supply side we observe insignificance for material cost. I want to
note again at this point that, this cost item in the data is provided by the firm and
can be thought as an index for plastic and iron prices for the relevant year. In the
unit price of iron, like many other metals, for the period under investigation, major
fluctuations happened. For example in the year 2008 it hit to a record high level.
And firms might respond to these by new production technologies. However, these

---

18 In this, I also suspected about the possible correlation between employment and education, and
employment and household income. Correlations are 0.09 and 0.19 respectively. It is not as high as
to take into account.

19 Electric’s insignificance for demand estimation might be a point of concern too. But considering
"retail electricity prices" instability as a voting instrument by the government for the period under
investigation, this doesn’t come as a surprise. Based on election times electricity prices was artificially
kept low for a time than sudden peaks are observed as a result of the policies of the governments
between 2002 and 2009.

20 At this point, one might doubt whether there is a correlation between education and complaint
calls. Correlation is -0.21, not too high to consider.
<table>
<thead>
<tr>
<th></th>
<th>(q) (IV)</th>
<th>(q_{-1}) (OLS)</th>
<th>(q_1) (OLS)</th>
</tr>
</thead>
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<td><strong>pppop</strong></td>
<td>1.02** (.071)</td>
<td></td>
<td>.993** (.083)</td>
</tr>
<tr>
<td><strong>ed</strong></td>
<td>1.46** (1.12)</td>
<td></td>
<td>3.90** (1.03)</td>
</tr>
<tr>
<td><strong>emp</strong></td>
<td>-.103 (.158)</td>
<td></td>
<td>-.252 (.173)</td>
</tr>
<tr>
<td><strong>interest</strong></td>
<td>-.144 (.078)</td>
<td></td>
<td>-.164 (.105)</td>
</tr>
<tr>
<td><strong>call</strong></td>
<td>-.110** (.036)</td>
<td></td>
<td>-.118** (.036)</td>
</tr>
<tr>
<td><strong>electric</strong></td>
<td>-.087 (.199)</td>
<td></td>
<td>-.084 (.266)</td>
</tr>
<tr>
<td><strong>P</strong></td>
<td>-3.18** (.477)</td>
<td>1.20* (.582)</td>
<td></td>
</tr>
<tr>
<td><strong>laborc</strong></td>
<td></td>
<td>-1.24* (.554)</td>
<td></td>
</tr>
<tr>
<td><strong>materialc</strong></td>
<td></td>
<td>-.207 (.436)</td>
<td></td>
</tr>
<tr>
<td><strong>energyc</strong></td>
<td></td>
<td>-.575** (.205)</td>
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</tr>
<tr>
<td><strong>N</strong></td>
<td>318</td>
<td>360</td>
<td>320</td>
</tr>
<tr>
<td><strong>R^2</strong></td>
<td>0.89</td>
<td>0.83</td>
<td>0.89</td>
</tr>
</tbody>
</table>

Standard errors in parenthesis.

*Significance at 0.05 level

**Significance at 0.01 level

\(q\) = market demand, \(q_{-1}\) = others’ supply, \(q_1\) = big firm’s supply.

Table 2.4: 3SLS elasticities (constrained).
new techniques which may allow firms to alter their material usage structure are kept secret by the industry.\textsuperscript{21}

To increase efficiency, I estimated my model with system estimators, 3SLS and SUR. Taking into account the endogeneity problem I instrumented "price" in 3SLS. The estimates that I got without complaint calls are presented in Table 5 and with complaint calls are presented in Table 6. Even it is not as perfect as in IV vs. OLS case, again, the comparison of the results shows us that use of complaint calls to correct endogeneity due to omitted variables works properly and give safe results as an alternative to IV method.\textsuperscript{22}

I test my model’s implied restriction that the coefficients of shifters (X) in leader firm’s supply function have to be half of the coefficients of shifters (X) in the market demand function one by one and jointly. Constraints for ppop, call, interest and emp pass the test. Even I couldn’t jointly accept the hypothesis implied by model, I believe parameters of X in the demand function is close to the two times of the coefficients of X in the leader firms supplied function, especially when the confidence intervals are considered. (Note that, ppop estimate in the demand function is 10.88 and in the leader firm’s supply function is 5.51, call estimate in the demand function is -235 and in the leader firm’s supply function is -131, interest estimate in the demand function is -312 and in the leader firm’s supply function is

\textsuperscript{21}Change in input stocks might be another response by the firms, which is not observable.

\textsuperscript{22}Also note that in SUR method without calls, sign of electricity variable at the demand equation is positive and labor cost loose significance in supply estimation.
<table>
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<tr>
<th></th>
<th>$q$ (3SLS)</th>
<th>$q_{-1}$ (3SLS)</th>
<th>$q_1$ (3SLS)</th>
<th>$q$ (SUR)</th>
<th>$q_{-1}$ (SUR)</th>
<th>$q_1$ (SUR)</th>
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<td>ppop</td>
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<td>6.88** (.57)</td>
<td>11.97** (.94)</td>
<td>6.95** (.57)</td>
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<td></td>
</tr>
<tr>
<td>ed</td>
<td>6956.67** (1182.0)</td>
<td>5167.9** (708.35)</td>
<td>8590.0** (1816.2)</td>
<td>3423.8** (701.00)</td>
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<td>emp</td>
<td>130.90 (103.19)</td>
<td>67.92 (83.85)</td>
<td>149.1 (104.12)</td>
<td>81.61 (63.50)</td>
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</tr>
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<td>-177.28** (41.15)</td>
<td>-325.75** (63.84)</td>
<td>-190.96** (40.58)</td>
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<tr>
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<td>-68.86 (161.03)</td>
<td>10.26 (256.25)</td>
<td>-28.00 (159.96)</td>
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</tr>
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<td>-27.54** (8.08)</td>
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<td>-43.22 (665.35)</td>
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<td>-381.05** (159.96)</td>
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</table>

| N       | 318 | 360 | 320 | 318 | 360 | 320 |
| R$^2$   | 0.89 | 0.83 | 0.89 | 0.88 | 0.82 | 0.89 |

Standard errors in parenthesis.

*Significance at 0.05 level.

**Significance at 0.01 level.

$q$ = market demand, $q_{-1}$ = others’ supply, $q_1$ = big firm’s supply.

Table 2.5: Estimation Results with 3SLS and SUR (Complaint calls are not included).
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<th>$q_1$ (3SLS)</th>
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<th>$q_{-1}$ (SUR)</th>
<th>$q_1$ (SUR)</th>
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<td><strong>pppop</strong></td>
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<td>10.88** (.95)</td>
<td>5.51** (.55)</td>
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<td><strong>ed</strong></td>
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<td>5251.9** (912.71)</td>
<td>3128.6** (485.91)</td>
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<td>129.95 (103.19)</td>
<td>67.82 (62.92)</td>
<td>120.56 (102.35)</td>
<td>14.88 (59.81)</td>
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<td><strong>call</strong></td>
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<td>-235.91 (60.99)</td>
<td>-131.53** (36.89)</td>
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<td>320</td>
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<td><strong>R²</strong></td>
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<td>0.88</td>
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Standard errors in parentheses.

*Significance at 0.05 level.

**Significance at 0.01 level.

$q =$ market demand, $q_{-1} =$ others’ supply, $q_1 =$ big firm’s supply.

Table 2.6: Estimation Results with 3SLS and SUR (Complaint calls are included).
-170.  

All these strengthen the validity of the model.

To test the validity of implied constraints, I also estimate the system with the relevant constraints, results of which are given in the appendix part. Most of the coefficients are very similar in the constrained and unconstrained models. (for example, for the demand function $ppp_{pop_u} = 10.88$, $ppp_{pop_c} = 10.8$, $call_{u} = -208$, $call_{c} = -205$, $interest_{u} = -325$, $interest_{c} = -323$) By all these and the similarity of the estimates I assume my model is satisfactory for explaining the dishwasher market in Turkey.

In Table 7 and 8 elasticities that are calculated by constrained 3SLS and SUR methods are presented.  

It is seen that in those techniques the point estimate for employment becomes positive as expected, even it is still insignificant. For this insignificance I have to note the cultural norm in Turkey which is a product of traditions and religious beliefs and says that “women should do the housework.” This norm still seems to be the main rule for these kinds of purchase decisions in Turkey. For example women employment is relatively high in northeast Turkey when compared with similar income-education region (mid-east) but there is no relatively high demand for dishwashers in that northeast region.

---

23 Estimates with SUR method.
24 Estimates with SUR method.
25 Estimates with 3SLS method.
26 Estimates with SUR method.
27 Unconstrained elasticity estimates which are close to constrained ones are presented in the appendix.
However education is a significant determinant for demand. (and for supply) It is significant and have a very high elasticity which is close to 3%. It is not surprising in the sense that it brings "gender equality" into place in the purchasing decisions of households. Therefore, households with higher education are more likely to buy dishwasher which is mainly seen as a labor saving machine for women’s housework.

The variable for number of households and income "pppop" also has an expected sign and significant. It has demand and supply elasticity around .5.\(^\text{28}\) It should be noted that price elasticity of demand estimates by system estimators which are around -1. can be considered as closer to the numbers in the literature.

Complaint calls are again significant and has an elasticity close to -1 which makes it one of the most important determinants of demand. It plays a similar role for the supply of goods as well. Price elasticity of supply for other firms is around 1.6 which is again consistent with the literature. Also, I want to note that, in system estimators interest rate becomes significant with an elasticity around -.2.

2.6 Concluding Remarks

In this study, for the first time in the literature, complaint calls rate is used as a proxy for the omitted variables like perceived and after sale service quality. It is found that the method offers safe estimates and can be used as an alternative to

\(^{28}\)When high and low income regions are estimated seperately, low income region’s has an "income elasticity" around 0.7, which is still less than "1". 

Note the definition of pppop in this paper as; "number of households * purchasing power of an individual."
<table>
<thead>
<tr>
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<th>$q_{-1}$ (3SLS)</th>
<th>$q_1$ (3SLS)</th>
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<td>.577**</td>
<td>.481**</td>
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</tr>
<tr>
<td></td>
<td>(.050)</td>
<td>(.042)</td>
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</tr>
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<td>3.55**</td>
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<td>(.557)</td>
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<td></td>
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<td>(.139)</td>
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<td>-.223**</td>
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</tr>
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<td>(.043)</td>
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<td>(.020)</td>
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<td>(.141)</td>
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<td>(.707)</td>
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<td></td>
<td></td>
<td>(.064)</td>
<td></td>
</tr>
<tr>
<td>energyc</td>
<td></td>
<td>-.223**</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.051)</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>318</td>
<td>360</td>
<td>320</td>
</tr>
<tr>
<td>$R^2$</td>
<td>.89</td>
<td>.82</td>
<td>.88</td>
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</table>

Standard errors in parenthesis.
*Significance at 0.05 level
Significance at 0.01 level
$q =$ market demand, $q_{-1} =$ others’ supply, $q_1 =$ big firm’s supply.

Table 2.7: 3SLS elasticities (constrained).
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<th>$q_{-1}$ (SUR)</th>
<th>$q_1$ (SUR)</th>
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<tr>
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<td>.552** (.048)</td>
<td></td>
<td>.464** (.040)</td>
</tr>
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<td>ed</td>
<td>3.16** (.488)</td>
<td></td>
<td>2.66** (.410)</td>
</tr>
<tr>
<td>emp</td>
<td>.144 (.158)</td>
<td></td>
<td>.120 (.132)</td>
</tr>
<tr>
<td>interest</td>
<td>-.257** (.049)</td>
<td>-.216** (.041)</td>
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</tr>
<tr>
<td>call</td>
<td>-.079 (.024)</td>
<td></td>
<td>-.066** (.020)</td>
</tr>
<tr>
<td>electric</td>
<td>-.054 (.163)</td>
<td></td>
<td>-.045 (.137)</td>
</tr>
<tr>
<td>P</td>
<td>-1.03* (.247)</td>
<td>1.77* (.667)</td>
<td></td>
</tr>
<tr>
<td>laborc</td>
<td></td>
<td></td>
<td>-.240* (.150)</td>
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<td>materialc</td>
<td></td>
<td></td>
<td>-.211 (.086)</td>
</tr>
<tr>
<td>energyc</td>
<td></td>
<td></td>
<td>-.322** (.063)</td>
</tr>
</tbody>
</table>

| N    | 318 | 360 | 320 |
| R²   | 0.88 | 0.82 | 0.88 |

Standard errors in parenthesis.
*Significance at 0.05 level
Significance at 0.01 level
$q =$ market demand, $q_{-1} =$ others’ supply, $q_1 =$ big firm’s supply.

Table 2.8: SUR elasticities (constrained).
instrumental variable method to cope with unobserved heterogeneity, when finding proper instruments is not possible.

The constructed model’s validity is tested by its implication that coefficients of shifters (X) in leader firm’s supply function have to be half of the coefficients of shifters (X) in the market demand function and evidence was found in favor of the model.

The paper offers elasticity estimates for this important durable good in an emerging county; Turkey. Education level is very significant factor for the demand of these kind of labor saving appliances with demand elasticities estimated between 3.6 and 5.7. Firms might want to design their marketing and advertisement policies considering the education levels of the regions they are targeting.

Exceptionally for Turkey, women employment seems to not have a significant role on the purchase decisions of these kind of goods. It is probably the result of strong traditional beliefs regarding the role of women in the society. Many people think women should do the housework regardless of their excuses like being employed. Employment has an estimated elasticity around .1 even it is not significant.

Price elasticity of demand is estimated in the range of -3 and -1. We can conclude from this that consumers are highly price sensitive for dishwashers in Turkey. Income is also an important demand variable with estimated demand elasticities between .5 and 1.
On the supply side all the cost variables have expected negative signs at the supply estimation with differing supply elasticities that are calculated by different estimators. Labor cost’s elasticity is in the range of -.3 and -.4, material cost’s elasticity is in the range of -.02 and -.2 and energy cost’s elasticity is in the range of -.2 and -.3.

It is concluded that, the alternative method to cope with unobserved heterogeneity problem, offered in this paper can be used safely. The constructed model is shown to work properly in stable leader firm-follower firms markets. Also the estimated elasticities can be used as a guide by durable goods firms for emerging countries for an efficient use of resources, in the investment and marketing efforts.

2.7 References


2.8 Appendix

Summary statistics about the non-confidential variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev</th>
<th>Min</th>
<th>Max</th>
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<td>523</td>
<td>207</td>
<td>2248</td>
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<td>27</td>
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<td>16</td>
<td>47</td>
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<td>price</td>
<td>460</td>
<td>25</td>
<td>393</td>
<td>510</td>
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<td>ed</td>
<td>9.62</td>
<td>2.32</td>
<td>5.5</td>
<td>12</td>
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<td>elecaver</td>
<td>10.54</td>
<td>1.00</td>
<td>8.06</td>
<td>12</td>
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</table>

Residuals

Time/Residuals
When the residuals from SUR demand estimation are plotted with time on the x-axis the graph above is observed. Heteroskedasticity doesn’t seem to be a major concern.

Tables
<table>
<thead>
<tr>
<th></th>
<th>(q) (3SLS)</th>
<th>(q_{-1}) (3SLS)</th>
<th>(q_{1}) (3SLS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pppop</td>
<td>11.28** (.98)</td>
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</tr>
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<td>ed</td>
<td>7724.953*** (1207.9)</td>
<td>3862.4** (603.99)</td>
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<td>emp</td>
<td>147.01 (105.05)</td>
<td>73.50. (52.52)</td>
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<td>interest</td>
<td>-333.14** (64.50)</td>
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<tr>
<td>call</td>
<td>-205.85 (63.43)</td>
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<tr>
<td>electric</td>
<td>-129.87 (257.82)</td>
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<td>P</td>
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<td>materialc</td>
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<td>-1208.16 (501.40)</td>
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</tr>
<tr>
<td>energyc</td>
<td></td>
<td>-504.76** (115.90)</td>
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</tr>
<tr>
<td>N</td>
<td>318</td>
<td>360</td>
<td>320</td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.89</td>
<td>0.82</td>
<td>0.88</td>
</tr>
</tbody>
</table>

Standard errors in parenthesis.

*Significance at 0.05 level

Significance at 0.01 level

\(q\) = market demand, \(q_{-1}\) = others’ supply, \(q_{1}\) = big firm’s supply.

Table 2.9: Estimation results with 3SLS (constrained).
<table>
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<th>$q_1$ (3SLS)</th>
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<td>(.051)</td>
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<td>(.645)</td>
<td>(.60)</td>
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<td>.182</td>
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<tr>
<td></td>
<td>(.162)</td>
<td>(.166)</td>
<td></td>
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<tr>
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<td>-.226**</td>
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<td></td>
<td>(.051)</td>
<td>(.054)</td>
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<td>(.025)</td>
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<td>R²</td>
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Standard errors in parenthesis.
*Significance at 0.05 level
**Significance at 0.01 level

$q$ = market demand, $q_{-1}$ = others’ supply, $q_1$ = big firm’s supply.

Table 2.10: 3SLS elasticities.
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<td>( R^2 )</td>
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Standard errors in parenthesis.
*Significance at 0.05 level
Significance at 0.01 level

\( q = \) market demand, \( q_{-1} = \) others’ supply, \( q_1 = \) big firm’s supply.

Table 2.11: Estimation results with SUR (constrained).
<table>
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<th>( q_1 ) (SUR)</th>
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<td>( .474^{**} )</td>
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<td></td>
<td>(.049)</td>
<td>(.048)</td>
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<td>ed</td>
<td>( 2.88^{**} )</td>
<td>( 2.89^{**} )</td>
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<td>(.448)</td>
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<td>( .80 )</td>
<td>( .039 )</td>
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</tr>
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<td></td>
<td>(.161)</td>
<td>(.158)</td>
<td></td>
</tr>
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<td>interest</td>
<td>( -.249^{**} )</td>
<td>( -.228^{**} )</td>
<td></td>
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<td></td>
<td>(.051)</td>
<td>(.054)</td>
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<td>( -.086^{**} )</td>
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<td>(.170)</td>
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<td>P</td>
<td>( -1.19^{*} )</td>
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<tr>
<td>R²</td>
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<td>0.83</td>
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Standard errors in parenthesis.
*Significance at 0.05 level
**Significance at 0.01 level
\( q \) = market demand, \( q_{-1} \) = others’ supply, \( q_1 \) = big firm’s supply.

Table 2.12: SUR elasticities.
CHAPTER 3.
MARKET SHARE RESTRICTIONS
AND EFFICIENCY

3.1 Introduction

In the industrial organization literature, market shares have been a major topic for years. It is important because it can be regarded as the evidence of market power. In some cases, it is seen that market shares even as low as 30% are even enough for antitrust authorities to act to regulate the market.¹

Market share restrictions are basically designed to protect smaller firms in the industry. By this protection, the regulators’ objective is usually to keep the market competitive, by preventing the dominant firm’s monopolization of the market. The regulators have divided monopolists into a few firms; and sometimes they implicitly threaten the dominant firm so that, too high market share would lead to a serious consequence. However, as in every policy, trade-offs are important to consider. Market share restrictions prevent the monopolization of the market; however can lead to higher costs, lower efforts for product development etc. In this paper, we’ll try to examine a particular one: The effects of market share restrictions on the research and development efforts of big and small firms of a market.

In the literature, we see many studies on the total quantity implications of market share restrictions. For example in a study by Donald W. Kloth and Leo V.

¹Ivo Van Bael, Van Bael & Bellis Competition law of the European Community , p. 225
Blakley (1971), it is found that total quantity in milk industry can be increased by market share restrictions. On the other hand, in some other industries market share restrictions can reduce the market output. A recent case is shown by Foros, Kind, and Shaffer (2007), in which they consider a model of resale price maintenance.

In addition, there is a big literature on the determinants of research and development efforts and their results. As shown by Spence (1984) in many cases R&D has the same ultimate effect as direct cost reduction. So in this paper, we are going to approach R&D efforts as cost-reduction efforts. In another paper by Creane and Konishi (2008) effects of cost reductions via technology transfers are studied. They study the effects of joint production between rival firms using a basic Cournot model with possible exits by firms in the industry. A similar Cournot model is also used in this paper to investigate the question of this paper. In this paper, however, we only investigate the effects of market share restrictions on the optimal levels of research and development investments of big and small firms of a market.

In some industries such as the washing machine and dishwasher industries, especially in Europe, certain producers like Siemens, Bosch and Miele introduce many of the innovations to the market. Most of these innovations are patented for limited times and competitors especially in smaller economy countries generally apply those to their production without significant R&D effort. So these high share firms are nearly sure that their efforts are not going to matched by the smaller competitors in a very short period.

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We start with covering this possibility. However, these high share firms may be under the pressure of market share regulations. We’ll try to see how these regulations will affect the optimal levels of R&D investments, obviously for the big firm of the market.

We proceed with a more natural case in which each firm has equal access to R&D efforts and can reduce their production costs. The case we consider will be a market with a small number of firms, similar cost structures, and small possible gains from R&D in terms of cost reduction. We’ll see how the market share restrictions affect both the cost efficient/high market share firms and higher cost/lower share firms of the market.

Generally, we found that market share restrictions lower the level of competition and possible rewards from R&D efforts. Therefore this causes smaller levels of R&D efforts for both big and small firms in the market.

3.2 The Model

We are assuming a highly homogenous good. Therefore, the basic Cournot model will be our reference point. The demand curve is described by a twice continuously differentiable monotonically decreasing function for $Q \leq \bar{Q}$:

$$ p = p(Q) $$

where $p(0) = 1$, $p(Q) \geq 0$ if $Q \leq \bar{Q}$, and $p(Q) = 0$ otherwise. Thus, $p'(Q) < 0$ for all $Q \in (0, \bar{Q})$. 
For the market we assume $N \geq 2$ firms where $N$ shows the number of firms in the market. Firms are indexed as $n \in \{1, 2, \ldots, N\}$. Here, the firm which is indexed with one is the most cost efficient firm and so the one which is most likely to face market share restrictions. We will represent the set of $\{1, 2, \ldots, N\}$ with the letter $N$. We assume each firm has a marginal cost of $c_n$ and they all face the same operational fixed cost $F$. Each firm’s production level is denoted by $q_n$. Throughout the chapter we assume that firms do not exit from the industry. We also assume interior solutions.

We assume each firm can reduce their costs by $\Delta$ by their research and development efforts. However it is known that cost reduction efforts are not always successful. Considering this fact, we assume that as the firms increase their R&D efforts they are more likely to decrease their cost levels by $\Delta$. Hence we assume each firm is able to choose their success probability level for cost reduction "$r^n"$. Of course higher levels of the probability of success is more costly, so we assume the cost of R&D effort which brings probability of success of $r$ is $\frac{\theta(r)^2}{2}$.

In this Cournot model each firm is producing the quantity level $q_n$ based on their marginal costs.

**Lemma 4** For marginal cost profile $C = (c_1, c_2, \ldots, c_N)$ there exists a unique equilibrium, which is characterized by $p^e = p(Q^e) = \frac{1+\sum c_i}{n+1}$, $q_n^e = q_n(Q^e) = -c_n + \frac{1+\sum c_i}{n+1}$, $\pi_n^e = \pi_n(Q^e) = (-c_n - \frac{1+\sum c_i}{n+1})^2$.
\[ q_n = \frac{1 + C_{-n} - n(c_n)}{n+1}. \]

where \( C_{-i} \) represents the sum of all marginal costs except the Firm \( n \).

Assuming no share restriction is applied, if a firm is able to decrease its costs by \( \Delta \) then it will produce the quantity level \( \frac{1 + C_{-n} - n(c_n - \Delta)}{n+1} \).

3.3 R&D Done Only by the Dominant Firm

In industries where the new technologies are protected at least in the short term by patent laws, the dominant firms are nearly sure that their efforts are not going to be matched by competitors in the short run. As an example to this we can cite the durable good industries in Europe.

When the number of firms is small, cost structures are not very different and possible gains from R&D in terms of cost reduction are not very high, the exit threat is not very big for the existing firms. In the following case a market under such conditions will be examined.

We consider a market with 2 firms. Firm 1 will know that Firm 2 will not try to reduce costs in the short run. Hence it will try to maximize its profit level by choosing the optimal probability of success "\( r_1 \)."

\[
 r_1 \left[ \left( \frac{1 + C_{-1} - n(c_1 - \Delta)}{n+1} \right)^2 - F - \frac{\theta(r_1)^2}{2} \right] + (1 - r_1) \left[ \left( \frac{1 + C_{-1} - n(c_1)}{n+1} \right)^2 - F - \frac{\theta(r_1)^2}{2} \right]^2
\]

\(^2\)Here, \( n \) can be replaced with 2. We keep \( n \) in this form just to give an idea about the effect of the number of firms.
For simplicity from now on $\frac{\Delta}{n+1}$ will be shortened as $m$, and $\frac{1+C_{-1}-n(e)}{n+1}$ will be shortened as $A$ in this paper.

When Firm 1 is not under any market share restriction threat, the optimal success probability level for cost reduction that is chosen by the leader firm can be written as:

$$r_1 = \frac{2mA+n^2m^2}{\theta}$$

If market share restriction is effective then Firm 1 cannot increase its production levels, even it is successful in its cost reduction efforts. So it will be still producing the same quantity $A$. However, due to decreasing marginal costs it will get an extra profit equal to the quantity it produces times the reduction in its marginal cost, $A\Delta^3$. In this case the profit function to be maximized will be

$$r_1[(A)^2 + Am(n + 1) - F - \frac{\theta(r_1)^2}{2}] + (1 - r_1)[(A)^2 - F - \frac{\theta(r_1)^2}{2}]$$

and the optimal level of success probability can be written as:

$$r_1 = \frac{Am(n+1)}{\theta}$$

Since $2n > n + 1$ and the second term is positive when share restrictions are in effect, we can conclude that under these patent laws and leader-follower assumptions, market share restrictions cause the big firm to lower its R&D efforts.

---

3Since $\frac{\Delta}{n+1}$ is shortened as $m$ before, not to add extra notation $m(n + 1)$ will be used instead of $\Delta$.
**Proposition 5** Suppose that only the dominant firm engages in R&D, and assume that there exist short term patent laws in a leader-follower firms structure; market share restrictions lower the rewards from innovation and so lower the incentives for R&D efforts for the cost efficient firm of the market.

3.4 R&D Done by the Dominant and Small Firms

After this restricted case we’ll examine a more natural case in which both the dominant and small firms can do cost reduction by their R&D efforts. We will assume again that exit is not a big threat for the firms of the market as we did in the above part.

When we consider a market with 2 firms, Firm 1 will know that Firm 2 is going to be successful in its cost reduction efforts with the probability $r_2$. Hence it will try to maximize its profit level by choosing the optimal probability of success "$r_1$".

$$r_1[r_2[\left(\frac{1+C_{c_1}-\Delta-n(c_1-\Delta)}{n+1}\right)^2 - F - \frac{\theta(r_1)^2}{2}] + (1-r_2)[\left(\frac{1+C_{c_1}-n(c_1-\Delta)}{n+1}\right)^2 - F - \frac{\theta(r_1)^2}{2}] + (1-r_1)r_2[\left(\frac{1+C_{c_2}-\Delta-n(c_2)}{n+1}\right)^2 - F - \frac{\theta(r_2)^2}{2}] + (1-r_2)[\left(\frac{1+C_{c_2}-n(c_2)}{n+1}\right)^2 - F - \frac{\theta(r_2)^2}{2}] ]^4$$

The profit function to be maximized will be symmetric for the Firm 2. and $\frac{1+C_{c_2}-n(c_2)}{n+1}$ will be shortened as $B$ from now on in this paper.

The first order conditions for $r_1$ and $r_2$ can be written as:

\[4\text{Here, } n \text{ can be replaced with } 2. \text{ We keep } n \text{ in this form just to give an idea about the effect of the number of firms.}\]
\[
 r_1 = \frac{2nmA + n^2m^2 - 2nr_2m^2}{\theta} \quad \text{and} \quad r_2 = \frac{2nmB + n^2m^2 - 2nr_1m^2}{\theta}
\]

and the equilibrium levels of \( r_1 \) and \( r_2 \) can be written as:

\[
 r_1 = \frac{2nmA + n^2m^2 - \frac{2nm^2}{\theta}(2nmB + n^2m^2)}{\theta - \frac{4n^2m^2}{\theta}} \quad \text{and} \quad r_2 = \frac{2nmB + n^2m^2 - \frac{2nm^2}{\theta}(2nmA + n^2m^2)}{\theta - \frac{4n^2m^2}{\theta}}
\]

Now let’s consider the case where the market share restrictions are applied and they are effective for Firm 1. Using the simplified notations we assumed before; Firm 1 is trying to maximize the following profit function.

\[
 r_1[r_2[(A + (n - 1)m)^2 - F - \frac{\theta(r_1)^2}{2}] + (1 - r_2)[(A)^2 + Am(n + 1) - F - \frac{\theta(r_1)^2}{2}]] + (1 - r_1)[r_2[(A - m)^2 - F - \frac{\theta(r_1)^2}{2}] + (1 - r_2)[(A)^2 - F - \frac{\theta(r_1)^2}{2}]]
\]

In this function, note that, Firm 1 cannot freely increase its production levels even if it is successful in its cost reduction efforts. If Firm 1 is successful and Firm 2 is not successful in their R&D efforts, then Firm 1 won’t be able to increase its production level at all due to market share restrictions. The only gain will be the increase in its profits due to smaller marginal cost. So it will resume producing the same quantity A, but will get an extra profit equal to the quantity it produces times the reduction in its marginal cost, \( A\Delta^5 \).

And Firm 2 will be maximizing the function;

\[
 r_2[r_1[(B + (n - 1)m)^2 - F - \frac{\theta(r_2)^2}{2}] + (1 - r_1)[(B + nm)^2 - F - \frac{\theta(r_2)^2}{2}]] + (1 - r_2)[r_1[(B)^2 - F - \frac{\theta(r_2)^2}{2}] + (1 - r_1)[(B)^2 - F - \frac{\theta(r_2)^2}{2}]]
\]

\(^5\text{Since } \frac{\Delta}{n+1} \text{ is shortened as } m \text{ before, not to add extra notation } m(n + 1) \text{ will be used instead of } \Delta.\)
Here, note the third term which shows the fact that even if the small firm is not successful and bigger firm is successful in its cost reduction efforts, the small firm is still able to keep its pre-cost reduction profit level. This is due the fact that big firm is not able to increase its quantity as a result of the market share restrictions.

The first order conditions for \( r_1 \) and \( r_2 \) when there are effective market share restrictions can be written as:

\[
r_1 = \frac{m(n+1)A+r_2(n-1)mA+r_2(n^2-2n)m^2}{\theta} \quad \text{and} \quad r_2 = \frac{(-2n+1)m^2r_1-2r_1mB+2nmB+n^2m^2}{\theta}
\]

and the equilibrium levels of \( r_1 \) and \( r_2 \) can be written as:

\[
r_1 = \frac{m(n+1)A+D}{\theta-D\left(\frac{2Bnm+n^2m^2}{\theta-2Bm}\right)} \quad \text{and} \quad r_2 = \frac{2nmB+n^2m^2+E\left(\frac{(n+1)mA}{\theta}\right)}{\theta-E\left(\frac{(n-1)mA+(n^2-2n)m^2}{\theta}\right)}
\]

After careful comparisons and with the proofs that can be found in appendix, we can show the following results:

**Proposition 6** Suppose that both dominant and small firms engage in R\&D, then, market share restrictions lower the level of competition and cause small firm(s) to choose smaller levels of R\&D investment to reduce their marginal costs.

**Proposition 7** Suppose that both dominant and small firms engage in R\&D, unless \( n \) is extremely big and \( \Delta \) is extremely small, then, market share restrictions make it more difficult to get the rewards of its cost decreasing efforts and cause the cost efficient firm to choose smaller levels of R\&D investment to reduce its marginal costs.

\(^{6}D = (n-1)^2m^2 + (n^2 - 2n)m^2\)

\(^{7}E = (-2n + 1)m^2 - 2Bnm\)
3.5 Concluding Remarks

In this paper we show that, under certain assumptions as no exit, market share restrictions lower the level of competition and possible rewards from R&D efforts, therefore causing smaller levels of R&D efforts both for big and small firms of the market. However there are many cases in real world which need an opposite explanation in the sense that, restrictions can cause higher levels of R&D efforts obviously there are many industries in which exit is a real threat. This possibility may be a feasible topic for future research.

3.6 References


3.7 Appendix

The steps that take us from the profit functions for the dominant and small firms to equilibrium levels of R&D probabilities when there is not a big exit consideration are shown in this part of the appendix.

When we get the first derivative of the profit function to be maximized by the dominant firm when there is no market share restriction

\[
\frac{r_2 A^2 + r_2 (n-1) m A + r_2 (n-1)^2 m^2 + A^2 + 2 n m A + n^2 m^2 - r_2 A^2 - 2 r_2 n m A - r_2 A^2 - 2 r_2 m A - r_2 m^2 - A^2}{\theta} = r_1
\]

\[
\frac{2 n m A + n^2 m^2 - 2 r_2 m^2}{\theta} = r_1 \text{ and it will be symmetric for } r_2
\]

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When we solve for the equilibrium value of \( r_1 \):

\[
2nmA + n^2m^2 - 2nm^2 \left( \frac{2nmB + n^2m^2 - 2nr_2m^2}{\theta} \right) = r_1 \theta
\]

\[
r_1 \theta - \frac{4n^2m^4 r_1}{\theta} = 2nmA + n^2m^2 - \frac{2nm^2(2nmB + n^2m^2)}{\theta}
\]

so we get:

\[
\frac{2nmA + n^2m^2 - \frac{2nm^2}{\theta}}{\left( \theta - \frac{4n^2m^4}{\theta} \right)} = r_1 \text{ and symmetrically for } r_2 \text{ as equilibrium values.}
\]

When we get the first derivative of the profit function to be maximized by the dominant firm, when there is effective market share restriction:

\[
r_2A^2 + 2r_2(n-1)mA + r_2(n-1)^2m^2 + A^2 + Am(n+1) - r_2A^2 - r_2(n-1)mA - r_2A^2 - r_2mA - r_2m^2 - A^2 + r_2A^2 = \frac{m(n+1)A + r_2(n-1)mA + r_2(n^2-2n)m^2}{\theta} = r_1
\]

and for the smaller firm it will be

\[
r_1B^2 + 2r_1(n-1)MB + r_1(n-1)^2m^2 + B^2 + 2nmB + n^2m^2 - r_1B^2 - r_12nmB - r_1n^2m^2 - rB^2 - B^2 + r_1B^2 = \frac{(-2n+1)m^2r_1 - 2r_1mA + 2nmB + n^2m^2}{\theta} = r_2
\]

If we try to solve for the equilibrium value of \( r_1 \):

\[
m(n + 1)A = r_1 \theta - r_2(n - 1)^2m^2 - r_2(n^2 - m^2)
\]

\[
m(n + 1)A = r_1 \theta - r_2((n - 1)^2m^2 + (n^2 - m^2))
\]

\[\text{\small\textsuperscript{8}}\text{Call the part in parenthesis as "D".}\]
\[ m(n+1)A + D\left(-\frac{2Bm_{r_1} + 2Bm + n^2m^2}{\theta}\right) = r_1(\theta - D\left(-\frac{2(n+1)m^2 - 2Bm}{\theta}\right)) \]
\[ r_1 = \frac{Am(n+1) + D\left(\frac{2Bm + n^2m^2}{\theta}\right)}{\theta - D\left(-\frac{2(n+1)m^2 - 2Bm}{\theta}\right)} \]

and when we solve for the equilibrium value of \( r_2 \):

\[ 2nmB + n^2m^2 = r_2\theta - (-2n+1)m^2r_1 + 2mBr_1 \]
\[ 2nmB + n^2m^2 = r_2\theta - r_1(-2n+1)m^2 - 2mB \]
\[ 2nmB + n^2m^2 = r_2\theta - r_1((-2n+1)m^2 - 2mB) \]
\[ 2nmB + n^2m^2 = r_2\theta - E\left(\frac{(m(n+1)A + r_2(n-1)mA + r(n^2-2n)m^2)}{\theta}\right) \]
\[ 2nmB + n^2m^2 = E\left(\frac{(m(n+1)A)}{\theta}\right) = r_2(\theta - E\left(\frac{(n-1)mA + (n^2-2n)m^2}{\theta}\right)) \]
\[ r_2 = \frac{2nmB + n^2m^2 + E\left(\frac{(n+1)mA}{\theta}\right)}{\theta - E\left(\frac{(n-1)mA + (n^2-2n)m^2}{\theta}\right)} \]

We’ll compare the \( r_1' \)'s and \( r_2' \)'s of without restriction case and with restriction cases. In the denominators one can realize a negative expression is subtracted from \( \theta \) in the restriction cases which makes the denominators bigger and so causes the equilibrium levels of investment to be lower in the restriction cases. For the numerators, the numerator of small firm in the restriction case is clearly smaller, but the comparison is not that easy for the big firm. However it is still clear that as long as number of firms is not unrealistically large and the cost reduction, is not extremely small the numerator is smaller in the restriction case. Observing all these as evidence, we proved the lemma 3 and 4 stated in the text.

\[ \text{Call the part in paranthesis as } "E". \]