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Characteristics of the Residential LPG Market in Israel: Theory and Data

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Abstract

Gas companies in Israel can be categorized into large companies with a significant market share and small companies with a smaller market share. Residential consumers who are supplied gas in storage tanks, where gas is streamed to a storage tank buried underground, face heterogeneous switching costs when changing from one company to another. The data suggest that households face a price gap within a locality, where a large company charges a household a higher price than a small company does.

Sociodemographic data at the locality level (communalism and household size) are correlated with the average prices and the price gaps. In *Haredi* (ultra-Orthodox) localities, where there is a tendency toward greater communalism that is expressed as cooperation in consumer-related issues, the average price is low, and the price gap between large and small companies is also somewhat low. Localities with large households have relatively low price gaps and more companies. In localities where there are no small companies, prices are particularly high. To explain these empirical phenomena, a formal model with heterogeneous switching costs for households was developed. The model relates the characteristics of the distribution of households' switching costs (expected value and standard deviation) to their sociodemographic characteristics (communalism and household size). The formal model's findings supported the results of estimating gas prices by company (large or small) and by sociodemographic data at the locality level.

מאפייני ענף הגז הביתי בצובר בישראל: תיאוריה ונתונים

רן שהרבני

תקציר

חברות הגז נחלקות לחברות גדולות (בעלות נתח שוק גדול) ולחברות קטנות (בעלות נתח שוק קטן). לצרכנים הביתיים בצובר גז (מכל בעל קיבולת של 0.5-5 טון גז שמוטמן בקרקע) יש עלויות מעבר הטרוגניות (Heterogeneous Switching Costs) בין חברות. הנתונים מראים שביישובים מתקיים הפרש במחירים - חברה גדולה גובה מחיר גבוה יותר מחברה קטנה - וכן שנתונים סוציו־דמוגרפים ברמת היישוב (קהילתיות וגודל משק בית), מתואמים עם ממוצע המחירים ועם ההפרש במחירים ביישוב. ביישובים החרדים, שבהם יש נטייה לקהילתיות שמתפרשת כשיתוף פעולה בענייני צרכנות, ממוצע המחירים נמוך, ובמידת מה גם ההפרש במחירים שקיים בין חברות גדולות לקטנות הוא נמוך. ביישובים שבהם משקי הבית הם גדולים, ההפרש במחירים הוא נמוך והם מאופיינים בריבוי של חברות. ביישובים שבהם אין נוכחות של חברות קטנות, המחירים בצובר גבוהים במיוחד. כדי להסביר את התופעות האמפיריות הללו פותח מודל פורמלי עם עלויות מעבר הטרוגניות של הצרכנים. מאפייני התפלגות עלויות המעבר של הצרכנים (סטיית תקן ותוחלת) קושרו למאפיינים סוציו־דמוגרפים של הצרכנים (קהילתיות וגודל משק הבית). נמצא שהתוצאות מהמודל הפורמלי תומכות בתוצאות מאמידה של מחירי הגז לפי חברה ויישוב.

ממצאי המחקר אודות השפעתם של עלויות מעבר גבוהות על רמות המחירים רלוונטית גם לענפי משק אחרים שבהם יש לצרכנים עלויות מעבר. הממצאים מלמדים שניתן להביא להפחתת מחירים על ידי המשך הפחתת עלויות המעבר של הצרכנים באמצעות הנגשת המידע לצרכנים ולנותני שירותים בענף ויצירת תנאי אסדרה למתחרים חדשים.

1. Introduction

Israeli households' total annual expenditure on residential gas is approximately NIS 1.8 billion, which accounts for 0.35% of their total expenditures.[1] There are two primary methods of connecting residential gas in Israel: supplying gas to consumers in cylinders, which are mainly used for private homes, and storing gas in tanks for apartment buildings. In the cylinder connection method, gas companies exchange an empty cylinder for a full one. In the storage tank method, the company's tanker streams gas through a pipe to the storage tank, a fixed repository embedded in the ground next to the building[2], containing 0.5 to 5 tons of gas. The market includes four established companies with a significant market share and several emerging companies with a smaller market share. In Israel, the price of residential gas is not regulated, indicating a free market. However, consumers supplied by storage tanks who wish to switch from one company to another face high barriers, since such a switch requires a joint decision of the building's tenants. In contrast, switching costs for consumers supplied through gas cylinder connections are generally lower.

Switching costs (SC) are defined for households per unit of consumption. They include costs such as time, money, and effort in changing from one supplier to another. Switching costs for gas consumers depend not only on the connection method—storage tank or cylinder—but also on the sociodemographic characteristics of consumers in a particular locality. For example, the number of people in a household can indicate the size of the gas consumer. A larger household generally means lower switching costs, because they use more gas than smaller ones. They may switch to a cheaper gas company even if the price difference per cubic meter is small, since they will cover the switching costs in a shorter time frame than a smaller household. Large households may thus facilitate the entry of emerging companies into a specific local market, while also reducing the price that established companies may charge. In some localities, consumers can organize more easily in matters of consumption, which may help to reduce prices.

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1 The calculation is based on a household's total monthly consumption expenditure of NIS 16,267 (Household Expenditure and Income Survey, 2017), the rate of expenditure on household gas in the Consumer Price Index 0.00355, and the number of households, about 2.587 million (Consumer Price Index update, 2019). By multiplying this monthly data by 12, residential consumers' annual expenditure on liquefied petroleum gas amounts to NIS 1.79 billion per year.

2 An alternative connection method for apartment buildings involves a set of storage cylinders with similar features to those used in the storage tank connection method.

The aim of this study is to establish a link between the sociodemographic characteristics of households and the prices of liquefied petroleum gas (LPG) in storage tanks. This will be achieved by employing a formal switching costs model and conducting an empirical analysis. First, the study connects the sociodemographic traits of households, such as the communalism of the locality and household size, to the standard deviation and expected value of the probability distribution of the households' switching costs. Second, a formal static model is developed for LPG consumers with heterogeneous switching costs. The model finds that the characteristics of the probability distribution affect the average price charged, and the price gaps between large and small companies. Therefore, the research established a link between the sociodemographic characteristics of households and the average price and price gaps in the locality. The research shows that the formal results are consistent with the data on the average price of LPG, given the locality's average sociodemographic characteristics and company characteristics (large or small company).

Further, the formal model's correspondence with the data was tested by estimating regressions of the gas price on the factors that affect the price. Although the research focuses on the storage tank connection method, it also refers to the cylinder connection method compared to the storage tank connection method as an example of the effect of the connection method on the characteristics of the probability distribution of the households' switching costs, and thus on the prices. Price data were obtained from a unique database maintained by the Israeli Ministry of Energy and Infrastructure.

For the sake of simplicity, the modeling of the competitive situation in the locality includes only two companies. At the initial position, the market share of the large company is $x>0.5$, while the smaller one has $1-x$. The model does not explain the dynamics of the process in which the market is divided among the companies. However, it is possible that one company enters the locality before the other. Now, the exogenous market shares of the companies are x and $(1-x)$, respectively, and the analysis is conducted in the framework of a static model. The companies simultaneously announce the price of a homogeneous product, while at the same time, households may switch between companies to maximize their financial benefit through the Bertrand equilibrium.[3]

[3] The assumption is that the companies cannot discriminate their prices among consumers. This assumption stems from empirical considerations—the existing database does not include data that make it possible to check whether there is price discrimination by a company in a locality because the data on the prices are only averages at the company and locality levels. Allowing a large company to discriminate prices will further worsen the situation of the smaller company. Refer to Appendix D.1 for further details.

This particular scenario is suitable for the residential LPG market since all the market shares are already occupied by the companies in the locality. This market took shape over time in response to the characteristics of the population in the locality.[4] The market's predetermined data include sociodemographic characteristics, which usually change slowly at the local level, and the market share of the large and small companies at the outset. The historical classification of market share is relevant, as the assumption is that the process of market share adjustment to prices is slow, as detailed below.

An equilibrium solution of the model shows that a small company will be forced to lower its price to attract households from a company with a large initial market share and thereby compensate the households for the switching cost. This is how the price gap between large and small companies in the market is created. The equilibrium solution finds a relationship between the price characteristics and the switching cost probability distribution.

In order to link the equilibrium results of the model with the sociodemographic characteristics of the localities, it is assumed that the switching cost probability distribution (expected value and standard deviation) is affected by certain sociodemographic characteristics that vary between the localities. Specifically, we consider two such characteristics: the average household size in the locality, and the degree of communalism, which we define as being higher in *Haredi* (ultra-Orthodox) localities.

Due to the heterogeneity in households' switching cost distribution *within* the locality, it is possible that only some households will switch to the small company. This heterogeneity can be due to sociodemographic characteristics as well as other characteristics hidden from the eyes of the researcher and the gas companies. This heterogeneity is a necessary condition for an equilibrium in which households are transitioned. For the sake of simplicity, it is assumed that the probability distribution of the switching costs of the storage tank consumers in the locality is uniform.[5]

A notable observation in the data is the significant price gap between emerging small companies and established large companies (Table 1). In this table, we have presented the

[4] This is in contrast to the situation where a new product is created, for example, an Internet connection, and the companies are all emerging and competing for the entire market.

[5] The following is a simplified version of reality. Additionally, a symmetric triangular probability distribution was also considered, yielding similar results. See Chapter C and Appendix B for further details.

average prices of a large company and a small company in all localities, without distinguishing between large and small households or *Haredi* households.

Table 1: Average Price (NIS) per Cubic Meter[1] of Liquefied Petroleum Gas in the Storage Tank Connection Method

Established / large companies	Emerging / small companies	The price gap
36.2	**26.1**	**10.09**

1 The average price is the simple arithmetic mean of localities with at least one small and one large company, based on 2018:Q4 data. See Table 5a for more information.

To demonstrate the effect of the sociodemographic characteristics on the average price and the price gap, let us assume that in the initial situation, two localities have identical sociodemographic characteristics so that the uniform SC probability distribution in these localities is identical.[6] In this situation, these two localities' average price and the price gap are the same.

The first sociodemographic change examined is that households in the second locality are larger than those in the first. For simplicity, we assume that all households in the second locality grew by a constant factor. This is equivalent to households having a lower switching cost, which means that the switching cost of each household decreases by the same fixed amount (a lump sum decrease). As a result, the expected value of the SC probability distribution will be lower, while the standard deviation remains unchanged. The low expected switching cost makes it easier for the small company to increase its market share by offering a smaller reduction in price. It also makes it difficult for the large company to charge its high price. In equilibrium, the price gap between the companies in the large household locality will be lower than in the first locality.

The second sociodemographic change examined is that households in the second locality become more cooperative with each other than in the first locality. For instance, in a *Haredi* locality, people are likely to engage in joint activities related to consumerism. This community cooperation may lead to both lower expected value and lower standard deviation of the SC probability distribution as compared to the first locality. In other words, the probability distribution of switching costs for households in the second locality will be lower than that of the first locality, and this difference will be proportional to their size. The

6 The underlying assumption is that the probability distribution of the household size and the level of communalism in both localities are identical.

lower standard deviation will impact both large and small companies, forcing them to lower their prices. Additionally, the lower expected value of the switching cost will reduce the price gap. In equilibrium, both the gap in price and the average price will be lower in the second, "*Haredi*", locality than in the first locality.[7]

The model assumes that equilibrium prices were determined based on the initial market shares and the sociodemographic characteristics of the locality. A static model is more advantageous than a dynamic one because the adjustment market shares to prices is slow. If the adjustment were fast, the small company would quickly become large, and the classification of the companies from the outset as small or large would no longer reflect the competitive situation.[8]

In addition to the previously described interior solution equilibrium, where households switch between companies and there is a price gap between large and small companies, there is another equilibrium with a reservation price. In this equilibrium, both companies set a uniform and maximum price that households are willing to pay. Companies cannot raise prices above this reservation price due to household's ability to switch to other means of energy, such as electricity. This equilibrium occurs when households do not switch between the companies because both companies have set the same price. In this scenario, the small company will not charge a lower price than the large company because it is always worthwhile for it to match the price of the large company.

The primary condition for equilibrium with a reservation price is that the initial (exogenous) market shares in the locality are similar. This means that no company has a significantly smaller market share than the other. As the assumption is that companies cannot discriminate in their pricing, lowering the price will force them to lower it for *all* customers, which reduces the incentive to increase their market share. Since the model is static, it cannot answer the question of how the situation of similar initial market shares was obtained in the first place. However, this can be the case if the two companies entered the locality long ago and have since accumulated customers there.

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[7] It is important to note that the example assumes that only the communalism attribute was changed compare to the first locality. However, *Haredi* households are not only characterized by their communalism attribute, but also by having large family sizes. Therefore, the prices in *Haredi* localities will depend on both characteristics.

[8] The model is not suitable for describing dynamic processes such as new neighborhoods or those undergoing rapid sociodemographic change. The data support the proposition that the market share of emerging gas companies is growing slowly.

Another condition that encourages equilibrium with a reservation price is high switching cost, even for households from the low end of the SC probability distribution.[9] In this scenario, if a company wants to attract a marginal household, it will have to reduce the price steeply, lessening its incentive to increase its market share. Since the switching cost in the storage tank connection method is higher than that of the cylinder connection method, an equilibrium with a reservation price is expected to be created in the former more than in the latter. Moreover, in the storage tank connection method, this equilibrium is expected when the switching cost is high, that is, when the households are small. Thus, it will be too expensive for the small company to attract households from the lower end of the heterogeneous SC probability distribution in the locality.

The empirical tests conducted on the raw data as well as the estimation were made possible due to the distinctions between the localities in terms of household size, and the unique distinctions between the localities in Israel with respect to the level of cooperation in matters of consumerism. In Israel, there is a distinct segment of the population, the *Haredi* community, which is concentrated in separate localities and which cooperates when it comes to matters of consumption. Even though the researchers do not know the value of the switching cost for each household, as well as the expected value and standard deviation of the probability distribution, it is still possible to infer the effect of the characteristics of the probability distribution on the equilibrium prices.[10]

As expected, the price gap was found to be low in localities with large households. In these localities, there were, in the spirit of the model, a high number of companies (relative to the population[11]) since, according to the equilibrium result, the small company gains a relatively large market share[12], and its profitability is high. In *Haredi* localities, both the

[9] Consumers from the lower end of the SC probability distribution are sensitive to price and tend to switch to the company offering the lowest prices. In the professional context, these customers are referred to as "front book customers"—new customers who are offered an introductory price.

[10] The companies are assumed to know the expected value and standard deviation of the switching cost probability distribution in the locality, as detailed in Chapter C of the formal model.

[11] When analyzing the number of companies in a locality, it is better to consider the population size rather than the number of households. Assuming that gas consumption per person is fixed, this can neutralize the effect of market size on the number of companies in a locality. However, it is worth noting that larger households may consume more gas per person than smaller households, which should also be considered.

[12] This outcome cannot be attributed directly to the formal model since the model assumes that only two companies exist in the locality exogenously. It does not account for the entry and exit of companies from the locality.

average price and, to some extent, the price gap were found to be low.[13] Typically, localities with only large companies present had high and similar prices. This finding could correspond to an equilibrium with a maximal and uniform price, known as the reservation price.[14]

It is important to note that this research does not claim that the price averages and gaps are solely due to the phenomena discussed in the formal model. The reality is much more complex. The SC probability distribution is not uniform in practice, and there are usually more than two companies in a locality. Large companies may engage in price discrimination, but the existing price data only provide average values by company and locality, making it impossible to examine this. Companies and households have to consider several periods, whereas the model presented here is only for one period. It is possible that gas services in the storage tank connection method are not homogeneous. That is, households may believe that there are quality differences between large and small companies. Large and small companies may have cost differences per cubic meter of gas. A small company may attract price-sensitive households with introductory prices (front book customers). These may also be large households, resulting in a different cost structure for large and small companies. [15]

2. Literature Review and the Study's Place in the Literature

The literature on switching costs is extensive, with Klemperer's (1987) study being one of the earliest to introduce a two-period model. Subsequent studies have focused on the pricing strategies employed by companies in dynamic environments.[16] However, these studies often make assumptions about consumers' switching costs that are limited to uniform switching costs or probability distributions with one high and one low value.

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[13] This finding in the raw data regarding *Haredi* localities must be scrutinized because such localities are characterized by cooperation in consumer affairs for which the model anticipates both low price gaps and a low average price, and are also characterized by large households, for which the model predicts low price gaps. Therefore, we will check below through the estimation whether the price gaps in *Haredi* localities are lower than expected given the large households.

[14] A problem of endogeneity may arise in the analysis. To address this issue, we introduced localities that have similar characteristics, except for the mix of companies in the locality (Section 5.2 in the explanations below Table 6). We also carried out an estimation that includes an auxiliary variable (Section 6.1.) to further deal with the endogeneity.

[15] There are no available data on costs.

[16] Among the studies that deal with the dynamic pricing strategy of companies are Fabra and Garcia (2015), Somaini and Einav (2013), Rhodes (2014), Pearcy (2015), Cabral (2016), and Biglaiser et al. (2013).

In contrast, our model includes households with heterogeneous SC probability distribution, which allows for analysis of the effect of household characteristics on prices. There are few studies, including this one, that have focused on heterogeneous switching costs. The studies of Beckert and Siciliani (2017), Chen (1997), Bouckaert et al. (2012), Biglaiser et al. (2016), and Shaffer and Zhang (2000) are most similar to the present research since they assume a model with heterogeneous and continuous switching cost. Similiar this research, these studies include at most two periods to avoid the complication usually involved in solving a model with many periods.

Our theoretical model shares similarities with the model proposed by Bouckaert et al. (2012), as both use a uniform probability distribution of consumers' switching costs. However, there are several differences between their model and ours. First, they assume two periods, with the possibility of price discrimination in the second period, while our research focuses on one period only. Second, their approach assumes that a regulatory body enforces a change in the SC probability distribution. In contrast, in our research, the sociodemographic characteristics of consumers affect the SC probability distribution. In addition, our research characterizes the conditions for equilibrium with a reservation price, which is not addressed in their work. Lastly, our research emphasizes examining empirical data in conjunction with the model, while their work is purely theoretical.

Most of the empirical studies conducted so far have focused on estimating the amount of the switching cost.[17] However, as in our study, some studies have also explored the impact of consumers' sociodemographic features on the SC probability. Brunetti et al. (2016) conducted a study on the effect of household characteristics on their switching rate between banks, while Brunetti et al. (2020) investigated the impact of household characteristics on their switching rate between mortgage banks. This research contributes to the existing empirical literature on the effect of households' sociodemographic characteristics on the

[17] The empirical literature on SC has primarily focused on estimating their monetary value using data on prices and market shares. For instance, Honka (2013) examined car insurance premiums and Shcherbakov (2016) investigated SC in the satellite and cable industries. Sánchez et al. (2012) analyzed the impact of a systemic change, specifically mobile number portability, on the SC probability distribution and the churn rate—the proportion of the market that shifts to competing companies. Additionally, evidence for the existence of SC has been found across various industries. For example, Shy (2002) studied cell phones and bank accounts and Giulietti et al. (2005) focused on residential gas using data from consumer surveys. A study conducted by Barone et al. (2011) explored how customer characteristics influence the price of loans, revealing that banks often offer discounts to new customers as a way to offset their switching costs.

switching cost. Furthermore, it incorporates a formal analysis to establish empirical hypotheses for the first time.

Another sequence of studies to which this research can contribute is the literature on distinctions in the level of cooperation in distinct cultures. Gächter et al. (2010) found that a distinct cultural background affects the level of cooperation within the group. Kasir et al. (2019) found that in the Jewish society in Israel, the higher the level of religiosity, the higher the level of mutual assistance. Therefore, it is also possible that the level of cooperation in consumer affairs within the *Haredi* localities will be relatively high compared to the level of cooperation within the general population localities.

The main contribution of this study is in articulating the characteristics of the households, which, through their effect on the SC probability distribution, affect the distribution of prices. The effect of the SC probability distribution on the prices was evaluated using a formal model from which the equilibrium prices were derived. Thus, it was possible to formulate hypotheses about the influence of the sociodemographic characteristics on the equilibrium characteristics through the formal model.

Chapter 3 presents the characteristics of the LPG sector. Chapter 4 presents the formal model for switching costs. Chapter 5 examines whether the raw data are consistent with the results derived from the model. Chapter 6 presents an empirical assessment based on the formal model. Chapter 7 concludes.

3. The Characteristics of the LPG Sector

There are several companies involved in the residential LPG market, which can be categorized into four **large** or **established** companies and about 22 **small** or **emerging** companies (Millard, 2014).[18] The four largest companies held an 85 percent share of the private market in 2016.[19] According to the Household Expenditure Survey, households

[18] The companies supplying gas to home consumers in storage tanks and/or in 12 kg cylinders, according to data from the first quarter of 2019.

[19] The Competition Authority (formerly the Antitrust Authority), Final Report - LPG Supply to Households Through a Central Gas System, Jerusalem, January 23, 2017 (in Hebrew). In addition, the four largest companies withdrew 88 percent of LPG from refineries and imports for residential and institutional use in 2014, according to Millard (2014). This figure was about 80 percent in 2020, as stated in a conversation with Mr. Nahum Yehoshua, the Chief Economist of the Fuel Administration at the Ministry of Energy and Infrastructure on September 29, 2020. This does not include withdrawals by the companies to the Palestinian Authority.

spent approximately NIS 1.8 billion per year on LPG, which accounted for 0.35 percent of total household expenditure on private consumption.[20]

Government policy: Currently, prices in the industry are not regulated, and there are no significant barriers to entry. The Gas Economy (Promotion of Competition in LPG for Home Consumption) Law, 2008 (through the Economic Arrangements Law for 2008) governs the activity and relationships between large and small companies.[21]

Table 2 indicates that households face significant switching costs when switching between gas companies, particularly in the storage tank connection method, i.e., in high-rise condominium buildings. The Ministry of Energy and Infrastructure also identified signs of limited competition in the industry, a lack of customer switching between companies, wide price variations despite uniform products, a consistently high market share concentration, and high company profitability.[22,23]

Table 2: Key Characteristics of Residential Gas in the Storage Tank Connection Method Compared to the Cylinder Method[1]

A	Storage tank	Cylinder of 12 kg
Type of consumer	Usually a condominium building.	Usually a detached or semi-detached house.
The gas bill	Includes a fixed fee and payment for the gas.	Payment for gas only.
Switching from one gas company to another	Complicated: written consent from at least half of the apartment owners or a majority decision at a residents' assembly. The established gas company (the one that supplies gas to the building) can discriminate the pricing between the residents and thus hamper the move. However, if there is a committed resident, he or she can act on behalf of all residents. The gas company owns the storage tank, so switching requires the smaller company to purchase or replace the tank and gas meters.	Simple: The cylinder is on loan (a deposit is collected) from a gas company. When switching, the consumer returns the cylinder to the old supplier and receives the deposit, or hands over the cylinder to the new/smaller company. The companies then settle between themselves, including the deposit.
Price discrimination	The current company is allowed to discriminate in prices even between residents of the same building.	Price discrimination is allowed.
Information	The price database enables consumers to identify the companies operating in their area and view the average prices charged by each company for the storage tank connection method and the cylinder connection method. (Section 5.1.)	

[1] For details on the rules governing decisions about changing the gas supplier in a condominium building, please refer to: https://www.nevo.co.il/law_html/Law01/286_075.htm (in Hebrew).

[20] For the details of the calculation, please see Footnote 1.

[21] The Gas (Safety & Licensing) Law, 1989 regulates the safety of the use of LPG. The regulatory body supervises the suppliers and investigates safety incidents in the industry.

[22] The smaller (emerging) companies also encounter capacity barriers, although this issue will not be addressed in the present study.

[23] The Ministry of Infrastructure and Energy, Fuel and Gas Administration, "The LPG Industry, Background, Competitive Failures, Proposed Tools," 2014 (in Hebrew).

4. The Formal Model

This chapter outlines the theoretical framework utilized in Chapters 5 and 6 to analyze the empirical data in relation to the formal forecasts.

Model and Market Share Distribution in the Initial Situation: There exists a single market (comprised of a unit mass of consumers) for a homogeneous product, where each consumer purchases one unit from either Company 1 or Company 2. In the initial situation, Company 1 (the larger company) holds a market share of x, while Company 2 holds a market share of 1-x, with the assumption that $x > 0.5$.[24] These initial market shares (x, 1-x) are predetermined before the commencement of the game. In the static model, pricing occurs simultaneously, determining new prices and market shares.[25]

Consumers and Information: Each consumer purchases one unit of the product. Consumers have heterogeneous switching costs, which are incurred when they switch gas companies.[26] The switching costs (denoted as SC) are distributed according to a uniform probability distribution, i.e. $SC_i \sim U(\underline{sc}, \overline{sc})$. Each consumer's specific switching cost (SCi) is private information known only to them, while gas companies are aware of the characteristics of the probability distribution, including its expected value and standard deviation.

Gas Companies: The marginal cost per unit of gas, denoted as C, is constant and equal across all companies, and can be normalized to 0. Initially, consumers are randomly distributed among the companies, meaning that both companies experience the same uniform probability distribution (U) of consumers.[27] Companies 1 and 2 sell units of identical products and set their prices simultaneously in a Bertrand equilibrium, represented as P_1 and P_2, leading to the conclusion of the game.

[24] In this chapter, there is also a reference to the situation where the market shares are symmetrical x=0.5.
[25] The prices are set immediately, while adjusting the new market shares takes time.
[26] The model can also be applied to a cylinder connection method. The SC probability distribution varies for each connection method. Additionally, it is assumed that the markets for the storage tank and cylinder methods operate independently, with consumers not switching between the two connection methods.
[27] This assumption is strong because it is possible to argue that consumers of small or emerging companies are more price-sensitive (front book customers). This assumption becomes irrelevant if the entire market is dominated by the larger company (x=1).

4.1. Interior and Reservation Price Equilibrium Characteristics

A Bertrand equilibrium may result in an equilibrium featuring either an interior solution or a reservation price solution.

Equilibrium with an interior solution: In an interior equilibrium, the marginal consumer, for whom $SC_i = \widetilde{sc}$, is indifferent between remaining with Company 1 and incurring a gas bill of amount P_1, or switching to the cheaper Company 2[28], which entails a one-time cost of $\widetilde{sc}$ and a gas bill of P_2.

$$(1) \quad \widetilde{sc} = (P_1 - P_2)$$

The companies' profits are as follows:

The profit of the largest company (Company 1) is represented by

$$(2) \qquad \pi_1 = (P_1 - C)\left(x - \overbrace{x\frac{(P_1 - P_2 - \underline{sc})}{\overline{sc} - \underline{sc}}}^{A}\right)$$

The market share that transitions to Company 2 is denoted by A.

For the smaller company (Company 2), the profit is represented by

$$(3) \qquad \pi_2 = (P_2 - C)\left(1 - x + \overbrace{x\frac{(P_1 - P_2 - \underline{sc})}{\overline{sc} - \underline{sc}}}^{A}\right)$$

The model does not require an assumption about the duration until the market prices stabilize, meaning the market shares can be updated without a specified timeframe.[29]

Solving the first-order conditions leads to:

$$(4a) \qquad P_1 = c + \frac{(\overline{sc} - \underline{sc})}{3 \cdot x} + \frac{\overline{sc}}{3}$$

$$(4b) \qquad P_2 = c + \frac{2(\overline{sc} - \underline{sc})}{3 \cdot x} - \frac{\overline{sc}}{3}$$

[28] It is important to note that the model does not assume that Company 2, the smaller company, charges a lower price than Company 1. As we will discuss further, an interior equilibrium involving consumer transition will typically see Company 2 charging a lower price than Company 1.

[29] In the empirical section, however, it is assumed that this duration is long. For more details, please see the discussion at the beginning of Section 4.4.

It is easy to show that in an interior solution, always $P_1 > P_2$. That is, the company with an initial large market share will sell at a higher price.

Equilibrium with a reservation price: In this equilibrium, the prices of the two companies are equal and higher than the prices in an interior equilibrium.

$$(5) \qquad P_1 = P_2 = reservation\ price$$

From now on, the assumption is that C = 0, unless explicitly stated otherwise.

4.2. Conditions for Interior and Reservation Price Equilibrium

An interior solution occurs when consumers transition from Company 1 to Company 2. If there is no shift of consumers toward Company 2, then Company 2 can set a higher price—such as matching Company 1's price—without affecting its market share, which allows it to increase profits. The initial market shares of the two companies, represented as Company 1's share (x) and Company 2's share (1-x), along with the characteristics of the SC probability distribution , will determine whether the equilibrium is an interior solution or with a reservation price.

For consumers to switch from one company to another, the expression denoted as A in Equation (3) must be positive. By substituting the interior equilibrium prices (as defined in Equations (4a) and (4b) under the condition that A>0, we can conclude that this condition is equivalent to:

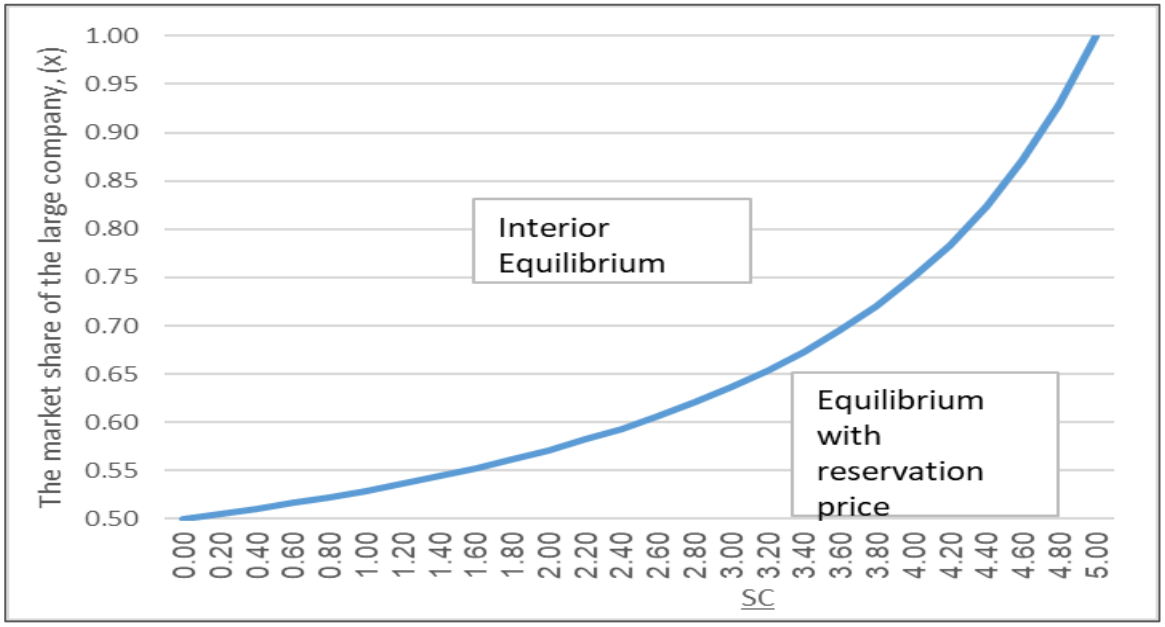
$$(6) \qquad x > 0.5 + \frac{1}{2}\left(\frac{\underline{sc}}{2\,\overline{sc} - 3\,\underline{sc}}\right) \; where \; 2\,\overline{sc} - 3\,\underline{sc} > 0$$

For details on the calculation of Condition (6), please see Appendix A.1.

There is an additional condition for achieving interior equilibrium: The price P_2 must be positive. This condition is always met when consumers transition, as indicated in Equation (6). For further details, please see Appendix A.2.

Figure 1 illustrates Equation (6), that is, the conditions for interior (continuous) equilibrium or equilibrium with a reservation price, where the varying factors are the initial market share of the large company (x) , and $\underline{sc}$, while $\overline{sc}$ is held constant at 10.

Figure 1: Conditions for Interior Equilibrium and Equilibrium with a Reservation Price[1]



[1] $\overline{sc} = 10$

Using Figure 1, we will analyze the two factors influencing the type of equilibrium (interior or reservation price). These factors are the initial market share of the larger company (x) and $\underline{sc}$, with $\overline{sc}$ held constant.

1. The effect of the initial market share of the larger company (x), given ($\underline{sc}$) and a constant ($\overline{sc}$) is illustrated in Figure 1. As the market shares of both companies become more equal—meaning (x) approaches 0.5—the smaller company has less incentive to adopt a pricing strategy that encourages customers to switch to it. This is because the potential additional market share for the smaller company diminishes as the shares equalize. Moreover, this situation can adversely affect profits, as all consumers of the smaller company benefit from its price offering.[30]

2. The effect of ($\underline{sc}$), given an initial market share (x) of the large company and a constant ($\overline{sc}$): The lower the ($\underline{sc}$), the greater the incentive for a smaller company to achieve an interior equilibrium, where it attracts more consumers. This happens because a low ($\underline{sc}$) means that the smaller company needs to lower its prices by a smaller amount to gain additional market share. In Figure 1, it is evident that for a specific initial market share of the larger company (x), an interior (or reservation price) equilibrium will exist when

[30] No price discrimination is assumed. For an extension of the model where price discrimination is possible, please see Appendix D.1.

the ($\underline{sc}$) is sufficiently low (or sufficiently high). Since a situation where ($\underline{sc}$) is high is more compatible with a storage tank connection method rather than a cylinder connection method—due to the higher customer switching costs (SC) in the storage tank method—there is a greater likelihood of achieving reservation price equilibrium with the storage tank connection method than with the cylinder connection method.

It is important to note that in an equilibrium with a reservation price, prices tend to be high and closely aligned across these companies. In contrast, in an interior equilibrium, there are price gaps between the companies, and the average price is lower.

4.3. The Relationship Between Uniform Probability and SocioDemographic Characteristics, and Their Impact on Prices and Profits in Interior Equilibrium

The variables[31] of the uniform probability distribution (SC) include the expected value ($E(SC_i)$) and the standard deviation ($\sigma(SC_i)$). The sociodemographic traits of the local population influence these variables. In this section, we will explore the relationship between the uniform probability distribution variables, $E(SC_i), \sigma(SC_i)$, and the sociodemographic characteristics, as well as their effects on prices and profits in interior equilibrium, based on results from the formal model.

In the following section (4.4), we will formulate hypotheses from the formal model that can be tested empirically. The reservation price solution will also be discussed.

The shift from formulating the model's results in terms of the edges of the probability distribution, $\left(\underline{sc}, \overline{sc}\right)$ (see price equations 4a and 4b) to expressing them using the characteristics of the probability distribution arises from the intuitive connection between sociodemographic characteristics and the features of the probability distribution.

It is assumed that there is a uniform probability distribution $SC_i \sim U\left(\underline{sc}, \overline{sc}\right)$, which serves as the benchmark probability distribution (see Figure 2, Scenario A). Scenario B is attributed to a locality where households are large consumers, meaning they use liquefied petroleum gas in significant quantities.[32] However, similar to Scenario A, these households

[31] We treat the standard deviation and expected value as variables rather than parameters, as they differ from one locality to another.

[32] The same price discount per gas unit is more significant for large consumers than for average-sized consumers.

do not cooperate in consumer affairs. Given their larger size, the current expenditures on liquefied petroleum gas are greater, leading them to invest more effort in securing a lower price. In this scenario, the SC_i for each consumer decreases by the same fixed amount compared to Scenario A (referred to as a lump-sum decrease[33]). Consequently, the expected value of the probability distribution decreases ($E(SC_i) \downarrow$), while the standard deviation remains unchanged, just as it was in Scenario A, ($\overline{\sigma(SC_i)}$).

Scenario C is attributed to a locality in which households actively cooperate in consumer matters.[34] The underlying assumption is that the flow of information among consumers influences the SC_i in relation to its size. This means that for consumers with a high SC_i, the impact is substantial, resulting in a significant decrease in their switching costs. Conversely, for consumers with a low SCi, the decrease is minimal. That is

$sc_{i_{emerging}} = \alpha \cdot sc_i \; where \; \alpha \in (0,1)$.[35,36]

Scenario C may also clarify the differences between the storage tank connection method and the cylinder connection method. Beyond sociodemographic factors, the characteristics of the uniform probability distribution are influenced by the connection method. The cylinder connection method makes it easier for consumers to switch providers than the storage tank connection method (see Table 2). This seamless transition between companies is expected to result in a relative decrease in SCi, i.e. a lower expected value and standard deviation of the probability distribution.[37]

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[33] The assumption is that all consumers have become large. Therefore, each consumer is willing to invest another $\varepsilon>0$ effort to switch to a gas company. Therefore, the SC_i of each consumer decreases by the same value, and therefore, the probability distribution shifts to the left.

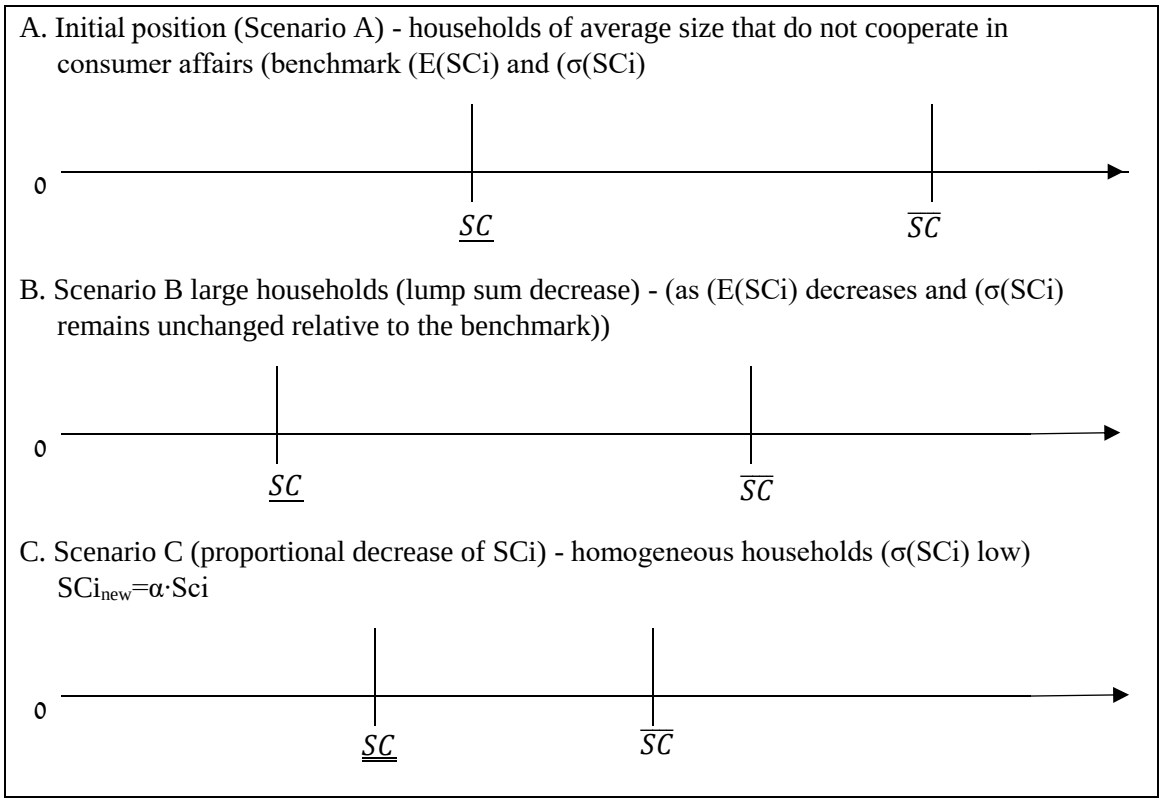
[34] Refer to the literature review discussing the levels of assistance provided by the ultra-Orthodox population compared to other population groups.

[35] Alternatively, it could be assumed that the flow of information mainly affects those with a high SC_i and does not affect those with the lowest SC_i, that is, $sc_{i_{emerging}} = \alpha \cdot (sc_i - \underline{sc}) \; where \; \alpha \in (0,1)$ where $\alpha \in (0,1)$. This scenario is expressed in the decrease of the $\overline{sc}$ relative to the probability distribution at the initial position, while the $\underline{sc}$ is constant. The effects of both scenarios are similar. For details, see Appendix C.

[36] *Haredi* (Ultra-Orthodox) households tend to be large. In the empirical part, we will examine whether the two characteristics, cooperation in consumer affairs and household size, are reflected in prices in *Haredi* population localities.

[37] The expected distribution is lower in the cylinder connection method than in the storage tank connection method, for obvious reasons. The standard deviation is also lower: If we were to conduct a hypothetical test on the switching costs (SC) of consumers using the storage tank connection, those with high switching costs would likely experience a significant decrease if they were connected by cylinder. In contrast, consumers with low switching costs in the storage tank method would see a much smaller decrease.

Figure 2: Scenarios for Different Probability Distributions of the SC



It is important to note that in Figure 2, two sociodemographic characteristics are identified: (1) in Scenario B, households are larger than the average household size, which is reflected in a lower expected value of the probability distribution; and (2) in Scenario C, households that cooperate in consumer affairs show both a lower standard deviation and a lower expected value of the probability distribution.

Next, we will analyze how the characteristics of the uniform probability distribution, $E(SC_i) = \frac{\overline{sc}+\underline{sc}}{2}, \sigma(SC_i) = \frac{\overline{sc}-\underline{sc}}{\sqrt{12}}$, affect the interior equilibrium.

The subsequent analysis in this section will focus on the storage tank method, and will assume that the larger company's initial market share is represented by x = 1. This scenario indicates that Company 1 holds the entire market share while Company 2 is attempting to enter the market. This situation leads to an interior equilibrium across a broad range of parameters. (See Equation (6) and Figure 1).[38]

[38] For x=1, the condition for interior equilibrium in Equation 6 is $\overline{sc} - 2\,\underline{sc} > 0$.

The results of this equilibrium will be expressed in terms of the characteristics of the probability distribution (as shown in Equations (7), (8), and (9)). Additionally, in Corollary 1, we will describe how the characteristics of the probability distribution impact the results of the equilibrium.

$$(7) \quad P_1 = \frac{(2\,\overline{sc} - \underline{sc})}{3} = \frac{E(SC_i)}{3} + \sqrt{3}\sigma(SC_i),\ P_2 = \frac{(\overline{sc} - 2\,\underline{sc})}{3} = -\frac{E(SC_i)}{3} + \sqrt{3}\sigma(SC_i)$$

$$(8) \quad |P_1 - P_2| = \left(\frac{\overline{sc} + \underline{sc}}{3}\right) = \frac{2\,E(SC_i)}{3}, Average(P_1, P_2) = \left(\frac{(\overline{sc} - \underline{sc})}{2}\right) = \sqrt{3}\,\sigma(SC_i)$$

$$(9) \quad \pi_2 = \frac{1}{9}\frac{(\overline{sc} - 2\underline{sc})^2}{\overline{sc} - \underline{sc}} = \frac{1}{9}\frac{\left(-E(SC_i) + 3\sqrt{3}\,\sigma(SC_i)\right)^2}{2\sqrt{3}\,\sigma(SC_i)}, \pi_1 = \frac{1}{9}\frac{(2\,\overline{sc} - \underline{sc})^2}{\overline{sc} - \underline{sc}} = \frac{1}{9}\frac{\left(E(SC_i) + 3\sqrt{3}\,\sigma(SC_i)\right)^2}{2\sqrt{3}\,\sigma(SC_i)}$$

For the details of the calculation, please see Appendix A.3.

Equations (7) and (8) show that the higher the expected value of the distribution, given a fixed standard deviation, the more difficult it will be for Company 2 to enter, allowing Company 1 to charge a higher price while Company 2 will be forced to charge a lower price. A higher standard deviation, given a fixed expected value, enables both Company 1 and Company 2 to charge higher prices.

Corollary 1 will characterize the effect of the characteristics of the SC probability distribution (expected value and standard deviation) on the prices, on the gap between the prices and the average price, and on the profits of the companies in interior equilibrium.

Corollary 1

The effect of the characteristics of the probability distribution on the average price and the price gaps, as well as on the companies' profits in interior equilibrium, assuming that the initial market share of the large company is x = 1:

$$\frac{\partial P_1}{\partial E(SC_i)} > 0, \frac{\partial P_2}{\partial E(SC_i)} < 0, \frac{\partial Avg(P_1, P_2)}{\partial E(SC_i)} = 0, \frac{\partial |P_1 - P_2|}{\partial E(SC_i)} > 0, \frac{\partial \pi_1}{\partial E(SC_i)} > 0, \frac{\partial \pi_2}{\partial E(SC_i)} < 0$$

$$\frac{\partial P_1}{\partial \sigma(SC_i)} > 0, \frac{\partial P_2}{\partial \sigma(SC_i)} > 0, \frac{\partial Avg(P_1, P_2)}{\partial \sigma(SC_i)} > 0, \frac{\partial |P_1 - P_2|}{\partial \sigma(SC_i)} = 0, \frac{\partial \pi_1}{\partial \sigma(SC_i)} > 0, \frac{\partial \pi_2}{\partial \sigma(SC_i)} > 0$$

Proof: The proof stems immediately from Equations (7), (8) and (9).

From Corollary 1, we can conclude that in large households ($\underline{E(SC_i)}$), the price gap is lower, the average price remains unchanged, and the smaller company's profit increases. This makes it more attractive for the smaller company to enter the market. In households that cooperate in consumer affairs ($\underline{E(SC_i)}$, $\underline{\sigma(SC_i)}$), both the price gap and the average price are lower.

Table 3 presents the results of Corollary 1, which were calculated using numerical examples for each scenario in the SC probability distributions depicted in Figure 2. This table examines how the characteristics of the SC probability distribution, specifically the expected value and standard deviation, affect the price gap, average price, and company profit. Table 3 focuses on a uniform probability distribution. Subsequently, Table 4 will compare the uniform probability distribution with a symmetric triangular probability distribution.

Table 3: Comparison of Average Prices, Price Gaps, and Profits across Different Probability Distribution Scenarios $SC_i \sim U(\underline{sc}, \overline{sc})$ (initial market share x=1)

	Initial position (Scenario A) - households of average size $\overline{E(SC_i)}$ and not homogeneous $\overline{\sigma(SC_i)}$	**Scenario B[2] (lump sum decrease) - large households ↓ $E(SC_i)$ and not Homogeneous $\overline{\sigma(SC_i)}$**	**Scenario C (proportional decrease of SCi) – households that cooperate in consumer affairs ↓ $E(SC_i)$,↓ $\sigma(SC_i)$**
SC probability distribution			
$SC_i \sim U(\underline{sc}, \overline{sc})$	$SC_i \sim U(6,24)$	$SC_i \sim U(1,19)$	$SC_i \sim U(4,16)$
$E(SC_i) = \frac{\overline{sc} + \underline{sc}}{2}$	15	10	10
$\sigma(SC_i) = \frac{\overline{sc} - \underline{sc}}{\sqrt{12}}$	$\frac{18}{\sqrt{12}}$	$\frac{18}{\sqrt{12}}$	$\frac{12}{\sqrt{12}}$
Results[1]			
P_1	14	12.33	9.33
P_2	4	5.67	2.67
$Average(P_1, P_2)$	9	9	6
$\lvert P_1 - P_2 \rvert$	10	6.67	6.67
π_1	10.89	8.45	7.26
π_2	0.89	1.78	0.59

[1] For additional results on the prices and market shares after the prices have cleared the market, please see Appendix C. As we will discuss later, the available empirical data do not allow us to analyze the model's results regarding the new market shares, so the formal analysis has been moved to Appendix C.

[2] For more information on how consumer size affects equilibrium prices, please see Appendix D.1.

For an analysis of the model that assumes a symmetric triangular probability distribution, please see Appendix B. Table 4 qualitatively summarizes the impact of large households and households cooperating in consumer affairs on the equilibrium results for both probability distributions. The key difference observed is that, under a uniform probability distribution, large households do not affect the average price relative to the initial position (average size households). In contrast, in a triangular probability distribution, large households tend to lower the average price. Additionally, there is no qualitative difference between the two probability distributions regarding the effect of households cooperating in consumer affairs on the equilibrium results.

Table 4: The Effect[1] of Large Households and Cooperative Households[2] on Average Prices, Price Gaps, and Profits in Equilibrium, Analyzed within both a Uniform Probability Distribution and a Symmetric Triangular Probability Distribution

	Probability distribution	P_1	P_2	$Average(P_1, P_2)$	$\lvert P_1 - P_2 \rvert$	π_1	π_2
Large households	Uniform	↓	↑	-	↓	↓	↑
	Symmetric triangular	↓↓	↑	↓	↓	↓	↑
Households that cooperate in consumer affairs	Uniform	↓↓	↓	↓	↓	↓	↓
	Symmetric triangular	↓↓	↓	↓	↓	↓	↓

[1] The effect is relative to the initial position (Scenario A), considering households of average size that are not homogeneous.

[2] For households that cooperate in consumer affairs, the assumption is similar to Scenario C in Table 3, which involves a proportional decrease in SCi. Appendix B proves that the same impacts on the equilibrium characteristics also apply when a different assumption is made: proportional decrease of SCi - SC.

Hypotheses will be formulated based on the summaries of the scenarios presented in Table 3 and Table 4, along with the conditions for interior equilibrium and reservation price equilibrium. These hypotheses can be tested empirically, as mentioned. The testing will utilize raw data discussed in Chapter 5 and the regression analysis presented in Chapter 6.

4.4. Testable Hypotheses from the Formal Model

First, let's provide an overview of the available data for this research and its limitations, as well as how these relate to the model from which the hypotheses are derived. The price database includes information on average gas prices for storage tanks and cylinders specific to a company and locality, covering nearly all localities in Israel. However, there is a lack

of detailed data on market shares at the locality level for the companies involved. Instead, there are approximate data characterizing the market shares, distinguishing between "large" and "small" companies based on their identities. There are four large companies at the national level, while the rest are classified as small.

This classification refers to the period before the market dynamics began, indicating the initial exogenous market share. Based on this market share, equilibrium prices were established, and an adjustment to the endogenous market shares occurred. This adjustment is assumed to take a significant amount of time and is still ongoing. In this context, the classification into large and small companies serves as an exogenous variable that can help explain the price characteristics in equilibrium. If the adjustment of market shares had occurred immediately, the initial classification of companies as large or small would no longer be relevant.[39]

The data allow for the calculation of average prices and the price differences between large and small companies at the local level. It also enables us to analyze the ratio of companies to consumers, which indicates potential barriers to entry. Additionally, there are average sociodemographic statistics available for each locality, such as the average number of individuals per household and the characteristics of *Haredi* communities.

It is essential to approach the extrapolation from formal predictions to empirical data with caution. The formal analysis is based on a limited model involving only two companies[40], whereas the empirical data cover localities that typically contain more than two companies.

In Hypotheses 1 to 5, we assume an interior equilibrium. Hypothesis 6 will outline the conditions under which a reservation price equilibrium can be expected and the outcomes that would arise from it.

[39] With an immediate adjustment in market share, the game would conclude, followed by the start of a new game characterized by smaller price gaps and another round of market share adjustments. After several adjustments, it would be impossible to use the initial classification of companies as large or small, as the price difference between a historically large company and a historically small company would no longer exist. In reality, the adjustment of market share takes a prolonged period.

[40] For example, price discrimination is not allowed, and the model assumes only one period.

Hypothesis 1: In an interior equilibrium, there is always a price gap between a large company and a small company. As mentioned, the condition for achieving interior equilibrium is that there is a difference in the initial market shares, meaning that both a large company and a small company are present in the local market.

Hypothesis 2: In households that are large relative to the initial position (Scenario B, which involves a lump sum decrease), the price gap is small, the average price remains unchanged or decreases slightly, and barriers to entry are lower. As a result, there will be many companies relative to the number of consumers. The intuition behind this is that if households become larger without a change in the level of cooperation in consumer affairs[41], the expected value of the probability distribution decreases. This shift, illustrated by the transition from Scenario A to Scenario B in Figure 2, results in lower SC for all consumers. Consequently, this change decreases P_1 and increases P_2.[42]

Hypothesis 3: In households that cooperate in consumer affairs relative to the initial position (Scenario C), the average price is low and price gaps are small, while barriers to entry for small companies are high—resulting in fewer companies per consumer. The lower profitability of smaller companies, relative to the initial position, is reflected in these high barriers to entry.

Hypothesis 4: In large and homogeneous households relative to the initial position (a combination of Scenarios B and C, which applies to *Haredi* households that are both communally cooperative and large), both characteristics work together to lower the average price and the price gap, but they exert opposite effects on barriers to entry. The communal aspect reduces smaller companies' profitability, while large households increase it.

Hypothesis 5: In the cylinder connection method, the average price and price gap are lower than those in the storage tank connection method. The intuition here is that, compared to a hypothetical probability distribution using the storage tank connection method, the SC probability distribution of in the cylinder connection method has a lower expected value and standard deviation. This means that consumers in the cylinder

[41] For accuracy, we assume that the switching cost (SCi) for each household decreases by a constant factor, denoted as Ɛ.

[42] Due to a lack of data on profitability, the hypotheses are formulated in terms of barriers to entry that are correlated with profitability in a way that can be tested empirically.

connection method experience a proportional decrease in their SC. For consumers with high SC, this decrease is substantial, while for those with low SC, it is minimal. Therefore, similar to Scenario C, both the average price and the price gap in the cylinder connection method will be lower than in the storage tank connection method.
Now, the conditions for reservation price equilibrium and interior equilibrium in the storage tank connection method will be characterized.

Hypothesis 6: In the storage tank connection method, the presence of large companies without small companies leads to an equilibrium characterized by high and similar prices. Conversely, the presence of both large and small companies results in an interior equilibrium with different prices and a lower average price. The intuition for this is illustrated in Figure 1. When the initial market shares of companies in a locality are similar (i.e., only large companies[43] are present), the incentive to lower prices and gain market share is minimal. However, the presence of companies with different initial market shares (both large and small) promotes an interior equilibrium. Furthermore, reservation price equilibrium is more likely to occur in a storage tank connection method than in a cylinder connection method because one of the prerequisites for reservation price equilibrium is a high SC.

This model does not include extensions for consumers of variable sizes, different qualities of large and small companies, the ability to discriminate prices, or the entry of a third company. These extensions can be found in Appendix D. It is worth noting that the presence of a third company typically drives prices down in the locality.

5. The Database of Prices and Additional Data

5.1. The Database of Prices

The Ministry of Energy and Infrastructure maintains a database that includes average prices of liquefied petroleum gas (LPG) based on locality, gas company, and connection method (either storage tank connection or 12 kg cylinder). This database is designed to promote competition by ensuring price transparency for consumers. It operates similarly to the retail

[43] When considering a storage tank connection, a small company's decision to enter a locality is endogenous because it depends on pricing and potential profits. As we will see later, I took this into account in presenting the empirical data—by comparing similar localities with and without small companies—and in the econometric model—using an auxiliary variable such as the size of the population in multi-unit (apartment) buildings and the locality's potential for storage tank users.

price database in Israel and other price databases worldwide, such as those for gasoline in certain European countries. The LPG price database in Israel allows consumers to compare prices and identify which companies operate in their locality.

The price reporting is done monthly, with a three-month moving average calculated each month. This analysis is based on data from the fourth quarter of 2018. The storage tank connection service is available in 113 localities.[44]

During the analysis period, the average cost of LPG at the refinery gate[45], including excise tax and VAT, was approximately NIS 6.3 per cubic meter of gas (equivalent to 2.352 kg), while the average cost to residential consumers using the storage tank connection method ranged between NIS 26.1 and NIS 36.2, depending on whether they were serviced by smaller or larger companies (as shown in Table 1).[46]

5.2. The Additional Data

This section will present the relationship between the characteristics of the SC probability distribution ($E(SC_i)$, $\sigma(SC_i)$) that result partly from the sociodemographic and pricing data (including price gaps and average prices). To calculate the price gaps in the locality, we classified four companies (Pazgas, Supergas, Amisragas, and Dorgas) as large and the rest as small. The assumption is that the initial market share of a company classified as large is large at the locality level, and the initial market share of a company classified as small is small. However, it is important to note that the initial partition of the market shares at the locality level is only sometimes consistent with this assumption. [47,48]

Table 5a shows the average prices and price gaps in the locality between companies classified as large and those classified as small using the storage tank connection method. This table examines the data's compatibility with a model of competition between a large and a small company; that is, for an interior solution only, only localities where there are both large and small companies were taken into account.[49]

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44 Cities and local councils.

45 According to the import price at the refinery gate.

46 For calculation details, please refer to the notes for Table 1.

47 The four largest companies accounted for approximately 80 percent of the market in 2020. For further details, please see Note 19.

48 The classification of companies may need to be adjusted at the local level because even a large company can be considered a small company in a particular locality.

49 It is important to note that a solution with a reservation price is expected only when companies in the locality are classified as large. In Table 6 of this chapter, we will test Hypothesis 6 concerning the conditions for interior equilibrium and equilibrium with a reservation price.

The data presented in the table regarding the general population and the *Haredi* population support **Hypothesis 1, which asserts that there is always a price gap between large and small companies in interior equilibrium.** This price gap is found to be significant across both groups: the total population and the general and *Haredi* population segments.

The table also investigates **Hypothesis 2, which addresses price differences in relatively large households compared to the initial position (lump sum decrease).**[50,51] It suggests that the price gap is small, and the average price may remain unchanged or decrease slightly. To analyze this hypothesis, we will focus solely on general population localities, and exclude *Haredi* localities.[52] These localities are divided into those with large and small (nonhomogeneous) households based on the median. As shown in Table 5a, the findings align with Hypothesis 2, In localities with large households, the price gap is NIS 10.08, which is lower than the NIS 11.20 gap found in localities with small households. However, the difference in the price gaps (NIS 11.20 – NIS 10.08 = NIS 1.12) is not statistically significant. Additionally, the average price in large households is lower. This last result is supported only by the triangular probability distribution and not by the uniform distribution. Nonetheless, the reduced average price in large households may also arise from external factors, such as size discounts or lower supply costs.

Hypothesis 4: In large and homogeneous households, relative to the initial position (proportional decrease), both characteristics work together to reduce price gaps and the average price. As indicated in Table 5a, localities with a *Haredi* population (characterized by large and homogeneous households) show particularly low price gaps and average prices when compared to general population localities. The differences in price gaps and average prices between *Haredi* and general population localities are statistically significant, supporting Hypothesis 4. It's important to note that while there are no explicit data on the *Haredi* population that confirm a greater tendency for collaborative consumer activity, research indicates that a higher level of religiosity is associated with increased mutual assistance (Kasir et al., 2019).

[50] The conclusion regarding the average price relies on the selected probability distribution in the formal model, which can be either uniform or symmetric triangular.

[51] Hypotheses 2 to 4 also discuss barriers to entry. Further details are found in Table 7.

[52] Arab localities are also excluded from this analysis, as only a few have storage tank gas supplies and possess distinct sociodemographic characteristics compared to the general Jewish localities.

In this analysis of raw data, Hypothesis 3 cannot be discussed separately, especially regarding average-sized and homogeneous households, as no empirical examples were found. *Haredi* households exhibit both large and homogeneous characteristics.

The socioeconomic cluster of the locality had no significant effect on the average price or price gaps. The socioeconomic cluster correlates significantly with the level of education. A higher socioeconomic cluster may enhance a consumer's ability to organize, potentially leading to a decrease in $(E(SC_i))$. Conversely, a higher socioeconomic cluster could also increase the consumer's time costs, thus resulting in an increase in $E(SC_i)$. Therefore, the overall effect of this variable on prices cannot be predicted with certainty.

Table 5: Weighted Average Price (NIS) per Cubic Meter of LPG in Storage Tanks[1] and 12 kg Cylinders[2], Categorized by Company Size and Locality Characteristics, Fourth Quarter of 2018[3]

Table 5a: Storage tank

Characteristics of switching costs	The weighted price of 1 cubic meter of LPG in storage tanks				Number of localities[6]
	Small companies	Large companies	Gap[4;5] (NIS)	Median[5]	
All localities:	26.1	36.2	10.09***	31.19	87
General population localities[7]	27.1	37.8	10.7***	32.47	75
Haredi population localities[8]	20.1	26.4	6.24**	23.23	12
Details of the general population localities (without *Haredi* population localities)[9]					
The number of persons per household **above** the median	25.9	36.0	10.08***	30.96	37
The number of persons per household **below** the median	28.3	39.5	11.20***	33.91	37
Low socioeconomic cluster 1–3 without *Haredi* population localities	28.04	38.83	10.56***	33.37	23
Medium socioeconomic cluster 4–7 without *Haredi* localities	29.93	38.59	11.66***	32.76	27
High socioeconomic cluster 8–10 without *Haredi* population localities	26.4	35.95	9.57***	31.17	24

+p<0.10 * p<0.05 ** p<0.01 *** p<0.001

[1] The weighted price also includes fixed expenses related to the gas bill, calculated per cubic meter of gas. The allocation of these fixed expenses in the storage tank connection method is based on an average consumption of 3.824 cubic meters of gas over a two-month period, as well as the number of people in each household. This is because it is assumed that gas consumption is proportional to the number of individuals living in a household.

[2] The cylinder connection method does not incur fixed expenses. The calculation for 12 kg of liquefied petroleum gas is converted to one cubic meter of gas, which contains 2.352 kg of this gas.

[3] For each locality, the average prices of both small and large companies are calculated. The price gaps and average prices within the locality are derived from this data and then averaged across all localities. Each locality is given equal weight in this calculation, and a weighted calculation based on the size of the population in each locality yielded similar results.

[4] The significance of the price gaps was tested using a one-tailed t-test, comparing the average prices of small companies in the specified localities to those of large companies within the same sample.

[5] Additional significance tests showed a significant difference in average prices and price gaps between general population localities and *Haredi* population localities. In contrast, the significance tests for the differences in price gaps between localities with large households and those with small households were not significant.

[6] The analysis included localities that had at least one large and one small company.

[7] Similar average prices and price gaps were observed when dividing the general population localities into categories of cities and local councils.

[8] The localities included in the study are Elad, Efrat, Beit El, Beitar Illit, Bnei Brak, Givat Ze'ev, Modi'in Illit, Immanuel, Safed, Kedumim, Kiryat Arba, Kiryat Ye'arim, and Rekhasim.

[9] Nazareth was not included in the analysis.

Table 5b: Cylinder

	The weighted price of 1 cubic meter of LPG in cylinder				**Number of localities[1]**
Characteristics of switching costs	**Small companies**	**Large companies**	**Gap (NIS)**	**Median**	
All Jewish localities	26.1	30.0	3.9***	28.1	81

[1] Only Jewish localities that include at least one small company and one large company.

Hypothesis 5: The cylinder connection method results in lower average prices and smaller price gaps than the storage tank connection method. A comparison of the average prices and price gaps for each method is shown in Table 5a for the storage tank connection method and Table 5b for the cylinder connection method. It's important to note that the storage tank connection method is only available in Jewish localities. Therefore, to maintain consistency, only Jewish localities were included in the cylinder connection method analysis.[53] The findings indicate that the average price and price gaps for the cylinder connection method were significantly lower than those for the storage tank connection method, supporting Hypothesis 5.[54]

[53] To clarify, only one Arab locality, Nazareth, employs the storage tank connection method where both a small and a large company are present.

[54] Furthermore, in 97 percent of localities utilizing the storage tank connection method and 91 percent of those using the cylinder connection method, the prices charged by large companies exceed those of small companies.

It is assumed that consumers using the cylinder connection method experience a proportional decrease in their switching cost (SC) compared to those using the storage tank connection method (see Figure 2, Scenario C). Specifically, consumers with a high SC observe a substantial decrease in SC, while those with a low SC observe only a minor reduction. Additionally, the results supporting Hypothesis 5 gain further validity when considering that economies of scale may result in higher costs for the cylinder connection method than for the storage tank method, potentially counteracting the expected decrease of Hypothesis 5 in average prices.

However, the results presented in Table 5 should be interpreted with caution. We do not claim that the average prices and price gaps are solely influenced by the phenomena outlined in the formal model. The reality is much more complex: the SC probability distribution is not uniform or triangular; typically, there are more than two companies in a locality; price discrimination can occur, especially by large companies; companies and consumers may factor in multiperiod considerations, while the model we presented is limited to a single period; and there may also be quality and cost differences between large and small companies. Cost disparities may arise from varying SC probability distributions among the companies. Consumers with lower SCs, who are usually larger households, tend to favor smaller companies, leading in turn to cost differences.

Hypothesis 6: The presence of only large companies in the storage tank connection method will lead to an equilibrium characterized by high and similar prices (reservation price). Conversely, when both large and small companies are present, the equilibrium will be interior, resulting in different prices and a lower average price. According to Hypothesis 6 (see Figure 1), an equilibrium with a reservation price occurs only when companies in the locality are classified as large. It is essential to investigate whether localities meeting this condition exhibit an equilibrium with a reservation price. Table 6 compares the average prices of large companies using the storage tank connection method in localities that do not have small companies with those in localities that include both large and small companies. The analysis reveals that prices among large companies are significantly higher in localities without small companies.

Conversely, as anticipated, in the cylinder connection method, in Jewish localities where small companies do not exist, prices set by large companies were not found to be higher than in localities where both large and small companies operate.

Table 6: Average Price and Standard Deviation (NIS) for the Storage Tank Connection Method in Localities with Exclusively Large Companies Versus Localities with Both Large and Small Companies[1]

	Connection method	Large Companies (NIS) standard deviation in (%)	The price gap between the two types of localities (NIS)	Number of companies in the locality[1]	Number of large companies in the locality	Number of small companies in the locality	Consumer population in the locality[2,3] (thousand)	Socioeconomic cluster	Number of persons per household	Number of localities[4,5]
Localities with large companies only	Storage tank	44.0 (6.2)	*3.4	2.8	2.8	-	15.8	4.9	3.1	11
Localities with large and small companies	Storage tank	40.6 (6.8)		4.2	3.1	1.1	21.5	6.5	3.4	22

1 Localities that include a maximum of five companies are considered, as those with only large companies tend to have fewer companies. The addition of companies can lower prices. For further details, please see Appendix D.2.

2 In each locality, the population was divided into consumers using the storage tank connection method based on statistics regarding the number of housing units in high-density construction.

3 In some cases, private homeowners may also receive storage tank connection services, which can be more expensive but may offer better quality since there is no need to order a new cylinder. To ensure this phenomenon does not skew the results, only localities where the ratio of residents in high-density construction exceeds 56 percent were included.

4 *Haredi* population localities were excluded to prevent price reductions being influenced by factors unrelated to Hypothesis 6.

5 Only localities with a minimum of 2,000 residents using the storage tank connection method were included

It is important to note that, according to Hypothesis 6, the standard deviation of prices in the locality using the storage tank connection method is expected to be significantly lower than in the interior equilibrium. However, the data presented in Table 6 show no noticeable difference in the standard deviation of prices between the two types of equilibrium. Nonetheless, the findings align with theoretical expectations. In localities with only large companies, the standard deviation accounts for 14 percent of the price, while in localities with both large and small companies, it makes up 17 percent of the price.

The results should be emphasized as endogenous. To address the endogeneity problem, a comparison was made between localities with similar characteristics, differing only in the composition of companies—either large companies alone or a mix of large and small companies. The analysis included: a) localities with a similar consumer population size; and b) localities with up to five companies including both large and small companies, as localities with a larger number of companies are not suitable for comparison with those that have fewer companies, which is typical of localities with only large companies (see Table 6).[55] The endogeneity problem can also be addressed in empirical estimation using an auxiliary variable. Another implication of these results is the existence of barriers to entry. Otherwise, small companies would likely enter these localities, leading to a reduction in prices.

Barriers to entry and the number of companies in the locality - Hypotheses 2–4 in the context of barriers to entry

To analyze barriers to entry, we use an index that measures the number of companies per 10,000 residents in localities with high-density construction. In each locality, this index—representing a potential consumer base using the storage tanks connection method.

[55] This is because the average price in the locality decreases as the number of companies incrases. For further details, please see Appendix D.2 and the coefficient of 'n'—the number of companies in the locality—found in Table 9.

Table 7: The number of companies per 10,000 users in a locality[1;2]

	Average number of companies[3,4] per 10,000 residents	Average number of companies[3,4] per 10,000 households	Socioeconommic cluster	Population in a locality with high-density construction	Number of localities
General population, small households - the number of persons per household **below** the median	1.52	4.22	6.35	87.9	34
General population, large population households - the number of persons per household **above** the median	2.53	9.04	6	68.5	32
Haredi households	1.81	8.75	2.17	64.4	6

1 Each locality contains at least one small company and one large company.
2 Localities include at least 10,000 residents living in high-density construction.
3 Each locality has information on the number of companies using the storage tank connection method. The average is calculated for all localities. A calculation according to the median number of companies per 10,000 residents yields similar results.
4 The reference pertains to the total number of companies in the locality rather than solely the number of small companies, as the presence of small companies is influenced by the number of large companies.

Table 7 examines Hypothesis 2, which posits that small households reduce the profits of smaller companies. The findings indicate that there are fewer companies in localities with small households than in those with larger households. Hypothesis 4 highlights two opposing forces at play within *Haredi* households. On one hand, these households tend to be large, which encourages the establishment of more companies. On the other hand, the sense of community in these localities may deter new entries. Therefore, the observation in Table 7—that the number of companies per resident in *Haredi* localities is lower than in general population localities with larger households—does not contradict Hypothesis 4.

6. The Empirical Variables, the Econometric Model, and the Results

6.1. The Empirical Variables and the Econometric Model

The hypotheses derived from the formal model can be empirically tested through regressions of gas prices. The explanatory variables are categorized into three types: variables that influence the SC probability distribution in the locality, specifically focusing on the expected value and standard deviation of that distribution; variables that characterize the oligopolistic

structure within the locality—which are endogenous and will therefore be treated as auxiliary variables; and control variables.

The data analyzed are from the last quarter of 2018 and consist of 572 observations.

$$(10) \quad P_{i,l} = f(SC\ distribution\ charectures, market\ structure, controls)$$

$$where \quad i \in \{company\ name\}, \quad l \in \{localities\}$$

The dependent variable, $P_{i,l}$, represents the weighted price per cubic meter of gas for company i in locality j. This price also accounts for the fixed expenses on the gas bill calculated per cubic meter, and the weighting takes into account the number of people per household.[56]

Regarding the factors that affect the SC probability distribution, a decrease in the expected value, $E(SC_i)$, was estimated using the "Household size" Variable. Hypothesis 2 predicts that larger households in the locality will reduce the price gap between larger and smaller companies. This means that the estimated coefficient for the "Large company x Household size" interaction variable will be negative. Additionally, Hypothesis 2 suggests that larger households may also lead to lower average prices, indicating that the coefficient for "Household size" will also be negative.[57]

A decrease in the standard deviation of the probability distribution $\sigma(SC_i)$ and the expected value of the probability distribution $E(SC_i)$ was assessed using the commonality variable dummy for *Haredi* localities. Hypothesis 3 posits that the influence of the commonality variable, specifically the *Haredi* community, on the average prices within the locality is negative. Additionally, Hypothesis 3 suggests that communal households contribute to narrowing the price gap. Thus, the coefficient of the interaction variable between a large company and a *Haredi* locality—designated as Large company x Haredi—is anticipated to be negative.

[56] The assumption is that as the average number of people in a household increases within the locality, the fixed expenses included in the price of the gas unit for the storage tank connection method will decrease.

[57] When households are larger, the average prices are expected to decrease, according to the triangular probability distribution, or remain unchanged, according to the symmetrical probability distribution. Please see Table 4 for more details.

Furthermore, other variables, such as the socioeconomic cluster of a locality, may also impact the SC probability distribution. While the effect of this variable is expected to influence the expected value of the probability distribution, its direction remains inconclusive.[58,59]

The oligopolistic structure of the locality is incorporated into the estimation through several key variables. The dummy variable for large companies, labeled "*Large*," is expected to yield a positive coefficient in interior equilibrium, reflecting differences in initial market shares, which are assumed to remain relatively stable. Consequently, this dummy variable can be considered exogenous. It is important to clarify that the "*Large*" variable is not solely indicative of the oligopolistic structure, but also captures factors such as quality differences between large and small companies, cost variations, the large company's pricing power, and other distinguishing characteristics.

Equilibrium with a reservation price is modeled through the "*No small companies*" dummy variable, which applies to localities where only large companies operate. In such cases, higher prices are anticipated in the storage tank connection method, as outlined in Hypothesis 6 and Figure 1. Additionally, the number of companies in locality *n* is hypothesized to lower the price level under certain conditions, as discussed in Appendix D.2. The estimation of oligopolistic structure variables (e.g., "*No small companies*," *n*) was carried out using auxiliary variables, which will be described in more detail later.

Table 8 lists the main estimation variables.

[58] Since this variable is expected to affect the expected value of the probability distribution, it is likely to influence the price differentials between a large company and a small company, rather than the overall average price. Therefore, it should be included as an interaction term — *large company* × *socioeconomic-cluster*. For further elaboration, please see the discussion preceding Table 5.

[59] Additional factors that may influence the SC probability distribution include the proportion of consumers living in rental housing within the locality and the Gini index of income inequality. A high proportion of rental housing is expected to increase the expected value of the SC probability distribution, as landlords may impose obstacles related to switching gas providers, and the housing unit life cycle for renters tends to be shorter. According to the Gini index, a more income-egalitarian locality is expected to reduce the standard deviation of the SC probability distribution.

Table 8: Key Variables of Switching Costs, Oligopolistic Market Structure, and Quality–Cost Differentials Between Large and Small Firms

Empirical variable[1]	Description	The effect on the price according to the model	Category
Household size x Large company	Interaction variable: number of persons per household x large company.	According to Hypothesis 2 it is expected to be negative.	SC probability distribution
Household size	The number of persons per household.	According to Hypothesis 2 it is possible to be negative.	SC probability distribution
Haredi	Dummy for a *Haredi* locality.	According to Hypothesis 3 it is expected to be negative.	SC probability distribution
Haredi size x Large company	Interaction variable: *Haredi* locality x large company.	According to Hypothesis 3 it is expected to be negative.	SC probability distribution
Socioeconmic cluster x Large company	Socioeconomic cluster in the locality - value between 1 and 10.	Inconclusive.	SC probability distribution
Rent percent x Large company *(in percent)*	The proportion of people living in the locality that are renting.	According to Hypothesis 2 is expected to be positive.	SC probability distribution
Gini index	Gini index for income - for a value index between 0 and 1.	According to Hypothesis 3 is expected to be positive.	SC probability distribution
n	The number of companies in the locality.	According to Appendix D.2 it is expected to be negative.	*Market structure*
No small companies	A dummy variable for localities where there are no small companies.	According to Hypothesis 6 it is expected to be positive.	*Market structure*
Large company	Dummy for a large company.	According to Hypothesis 1 it is expected to be positive.	*Quality, Market structure, Cost*

[1] The variables in this table are presented in their specified form based on their predicted effects as outlined in the model. As such, some variables include interaction terms.

The auxiliary variables for the endogenous variables: The variables related to oligopolistic structure, specifically the number of companies (*n*) and the "*No small companies*" variable, are considered endogenous. This is because the number of companies in a locality and the decision of small companies not to enter the locality depend on various factors, including local pricing. To address the issue of endogeneity, the estimation was performed using auxiliary variables. These auxiliary variables include the population of the

locality and the population living in areas with high-density construction, in the locality — a potential pool of consumers who utilize the storage tank connection method.[60]

Another useful auxiliary variable leverages spatial characteristics from a cost perspective. It is the number of localities within a half-hour drive from the main locality in which a company is present.[61] Companies in a specific locality are more likely to enter nearby markets, as costs in these regions are generally lower than in more distant markets. However, the presence of companies in surrounding localities is not independent of pricing, as it can also influence marginal costs.[62]

Control variables: The dummy variable for a district, referred to as "*District*," serves as a control variable because costs can vary significantly based on the district. Another control variable is a dummy variable for localities characterized by low average winter temperatures, which are defined by National Insurance Institute standards (cold locality). In these cold localities, gas is often used for heating, leading to greater usage and potential size discounts. Additional control variables include the population growth rate in the locality from 2009 to 2017, labeled "*pop growth*." A higher growth rate tends to increase companies' willingness to lower prices to attract new consumers.[63] Lastly, the locality's peripherality index, known as the "*Peripherality index*," reflects its geographic location in relation to population centers.[64]

[60] Another auxiliary variable was examined: "the company's presence in previous quarter periods." This analysis utilized data regarding the company's activities in the locality prior to the fourth quarter of 2018. However, due to the minimal variation observed from quarter to quarter, this approach closely resembles the use of the endogenous variable as an auxiliary variable for itself.

[61] According to Google Maps, on a typical day, at noon time.

[62] While the distance to the supply center could have served as a natural instrumental variable, the exact location of the supply center is confidential and could not be disclosed. We were noted that operating costs are lower than the profits generated.

[63] In this way, the empirical model deals with the effect of new neighborhoods in the locality.

[64] The locality's peripherality index characterizes and ranks local authorities in Israel based on their geographical proximity to major population centers. This index may serve as a control variable if it is correlated with the location of the supply center, thereby accounting for associated expenses. Additionally, it could function as an auxiliary variable if correlated with the endogenous number of companies in the locality. However, econometric tests have shown that it does not contribute significantly to the model. For more information, see Appendix E.

6.2. Results

Table 9 includes the results of the estimations. Regressions (1) to (4) include all 93 localities (general population and *Haredi*) that each have at least three companies, of which 82 general population localities were estimated separately in Regressions (5) and (6) and 11 *Haredi* localities were estimated separately in Regression (7). Generally, the results are consistent with the formal model and the raw data.

In Estimations (1) to (4), it is possible to identify the effect of communalism since the estimate includes both types of localities—general population and *Haredi*. The comprehensive model (Estimation (1)) includes all the variables according to the formal model. As expected according to Hypothesis 3, the dummy for *Haredi* localities, where communalism is high, is negative and significant. It therefore lowers the average prices in the locality, that is, both the price charged by a large company and that charged by a small company. As expected according to Hypothesis 3, the *Haredi x Large company* interaction variable is also negative and thus decreases the price gap between the large and small companies in the *Haredi* households in the locality. However, it is only at the significance limit (please see additional estimations in Appendix E).

As expected, according to Hypothesis 2, the interaction variable (*Household size x Large company*) is negative and significant. It thus decreases the price gap between the large and small companies in large households in the locality. As expected according to Hypothesis 2, the variable ("*Household size*"), which examines the effect of the number of persons per household on the average prices, is negative. However, it is significant only at the 10% level.[65]

[65] However, it is possible to think of a situation that needs to be included in the formal model, where all the gas companies give a discount to a large consumer when they price in the low marginal cost for a large consumer. In this case, the average price in the locality decreases.

Table 9: Estimation Results for the Storage Tank Connection Method[1]

The dependent variable is pi, j the price of 1 cubic meter of LPG by company and locality	All localities (general & *Haredi* populations				General population localities		*Haredi* localities
	Total model				Inclusive model		Inclusive model
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
n	-0.634***	-0.622***	-0.535**	-0.565***	-0.339+	-0.297+	-2.204*
	(-3.76)	(-3.69)	(-3.26)	(-3.43)	(-1.88)	(-1.76)	(-2.08)
No small companies	6.175*	6.298*	5.983*	5.777*	8.479***	8.670***	No localities with only large companies
	(2.49)	(2.54)	(2.42)	(2.38)	(3.64)	(3.74)	
Large company	14.49***	16.13***	16.17***	16.88***	13.93***	14.51***	13.09**
	(7.97)	(11.76)	(10.38)	(13.62)	(6.27)	(7.48)	(2.71)
Household size	-0.964+	-0.617			-0.344		-3.224*
	(-1.86)	(-1.25)			(-0.51)		(-2.14)
Household size x Large company	-1.469**	-2.033***	-1.982***	-2.238***	-1.301+	-1.484*	-1.672+
	(-2.61)	(-5.44)	(-4.09)	(-6.61)	(-1.87)	(-2.43)	(-1.88)
Haredi population	-3.787**	-5.209***	-5.470***	-6.368***			
	(-3.08)	(-4.10)	(-6.84)	(-7.39)			
Haredi x Large company	-2.389		-1.762				
	(-1.56)		(-1.19)				
Pop growth	-5.607*	-5.741*	-5.926*	-5.850*	-6.426*	-6.528*	18.95+
	(-1.96)	(-2.02)	(-2.07)	(-2.05)	(-1.98)	(-2.04)	(1.71)
Cold locality	-3.292**	-3.346**	-2.513*	-2.530*	-3.783*	-3.792*	-3.342*
	(-2.67)	(-2.77)	(-2.16)	(-2.49)	(-2.46)	(-2.54)	(-2.03)
District	V	V	V	V	V	V	V
Constant	30.05***	28.93***	24.94***	25.40***	25.10***	23.45***	36.74***
	(9.61)	(9.22)	(14.78)	(16.93)	(6.57)	(12.39)	(4.26)
N	572	572	572	572	514	514	58
adj. R-sq	0.681	0.680	0.682	0.682	0.624	0.624	0.676

t - statistics in parentheses

+p<0.10 * p<0.05 ** p<0.01 *** p<0.001

Notes:

[1] For additional estimations that include the variables: socioeconomic cluster, the proportion of people renting homes, the Gini index, and the peripherality index, which were found to be nonsignificant please see Appendix E.

As for the variables that characterize the market structure, the number of companies in the locality (n) was found to be negative and significant, as expected. (For additional information see Appendix D.2.) The dummy variable for localities without small companies (No small companies) where an equilibrium with a reservation price is possible, according to

Hypothesis 6, was found to be positive and significant, as expected. The dummy for a large company is positive, as expected according to Hypothesis 1.

As for the control variables, control for the district ("*District"*), cold locality, and pop growth — these were found to be significant.

Although the estimates for the coefficients are consistent with the hypotheses from the formal model, the findings should be treated with caution. For example, part of the estimated coefficient value for the *Haredi* variable can be attributed to effects other than communalism. Supply costs are lower in *Haredi* localities because many households may use liquefied petroleum gas for cooking (heating). Part of the value of the Large company coefficient can also be attributed to the difference between large and small companies in the quality of service and costs.[66]

Robustness tests - to test the correctness of the formal model, apart from the inclusive model, missing models (2) to (4) were also estimated, in which no significant differences were found compared to Estimation (1). For additional estimations that include the socioeconmmic cluster, the proportion of people renting homes, and the Gini index variables, which were found to be insignificant, please see Appendix E.

Estimations (5) to (6) include the general population localities only, and Estimations (7) to (8) include the *Haredi* localities only. In all models, the estimates were consistent with the theory. It is important to note that there are few observations for *Haredi* localities.

7. Summary

The research examines the characteristics of the residential gas sector by utilizing the storage tank connection method. It includes a formal model that accommodates consumers facing switching costs when changing companies. An empirical analysis was conducted based on price data at the locality level and the type of company (large or small) for the fourth quarter of 2018. This research benefited from a unique database that captures residential gas prices in Israel at the company, locality, and connection method levels.

[66] Although economies of scale may lower the cost for large companies.

The formal model involves two gas companies: a large company with a significant initial market share and a small company. Consumers using the storage tank connection method have heterogeneous switching costs. In a state of interior equilibrium, the large company typically charges a higher price than the small company, leading to a transition of consumers toward the smaller company. A reservation price equilibrium can develop when both companies have similar initial market shares within a locality. In this scenario, the overall prices are higher than in the interior equilibrium, and there is no consumer switching between companies.

The primary contribution of this research to the literature lies in establishing the formal and empirical relationship between consumers' sociodemographic characteristics (such as household size and community ties) and the equilibrium characteristics (including prices, the gap in prices, average prices, and barriers to entry). While these sociodemographic factors impact the switching cost probability distribution (including the expected value and standard deviation), the formal model connects the switching cost probability distribution to equilibrium characteristics. Thus, this research formulates hypotheses about how sociodemographic characteristics influence equilibrium outcomes.

As the number of individuals per household in a locality increases, the consumers' switching costs decrease by a fixed amount (a lump sum decrease). Consequently, the expected value of the probability distribution for consumers' switching costs becomes lower. The formal model reveals that a lower expected value reduces the price gap between the large and small companies. As a result, the price charged by the large company decreases, while the price charged by the small company increases. Additionally, the profits of the small company tend to rise, which suggests that more companies are likely to enter these localities.

Households in communal localities are assumed to cooperate in consumer affairs. This cooperation leads to a proportional decrease in consumers' switching costs. Those with high switching costs will see a substantial decrease, while those with low switching costs will experience a smaller reduction. This results in a low standard deviation and expected values in the switching cost probability distribution. The model suggests that these reduced switching costs significantly lower the prices set by both large and, to some extent, small

companies. Therefore, in *Haredi* households—known for their cooperative consumer behavior—both average prices and price gaps are expected to decline.[67]

The model enables a comparison between two connection methods: the storage tank connection method and the cylinder connection method. Switching consumers from one company to another is considerably simpler with the cylinder connection method than with the storage tank method. As a result, it is anticipated that switching costs will decrease proportionately. Those with high switching costs will see a significant reduction, while those with low switching costs will experience a smaller decrease. Accordingly, the model predicts, as in localities with *Haredi* populations, that the average prices and the price gap using the cylinder connection method will be lower than those using the storage tank method.

Empirical tests were conducted using equilibrium results from the model. Identification was possible due to the distinct sociodemographic characteristics of consumers at the locality level. For instance, household sizes vary between localities, and there are *Haredi* localities that collaborate on consumer affairs. Although there is no data on the initial market shares of the companies—only a historical classification of companies as either large or small—market share adjustments to prices occur slowly. This allows for the identification of companies as small or large. If market share adjustments were rapid, small companies would quickly grow into large companies. Thus, classifying companies as small or large from the outset might not accurately reflect the competitive situation.

The raw data and estimation of gas prices associated with the storage tank connection method support the switching cost model. As expected, a price gap exists within localities between large and small companies. According to the model, this gap is attributed to the oligopolistic market structure. The large company, which has established its market share, holds an advantage over the small company trying to enter or expand within the locality. However, the price gap may also be due to factors not analyzed in the model, such as quality or cost differences between large and small companies.

In *Haredi* localities, the model found, as expected, that average prices, as well as the price gap, are low. In localities with a larger number of people per household, the model found, as anticipated, that the price gap is small, and there is a higher number of companies relative to

[67] This goes beyond the anticipated reduction in price gaps influenced by household size.

the consumer population, likely due to the high profitability of small companies.[68] In localities where only large companies were initially classified, evidence supporting an equilibrium with a reservation price and higher prices was found, consistent with the formal model. As indicated by the model, the price gap and average price in the storage tank connection method were higher than those in the cylinder connection method.

Another significant aspect of the research pertains to policy implications. The findings reveal a notable disparity between the gas prices charged by large companies and those charged by smaller ones, particularly regarding the gas supply method using storage tanks. This method involves high switching costs due to the need for coordinated action from most tenants in a building. In contrast, the cylinder connection method allows each consumer to act independently, making it easier to switch between different suppliers. Therefore, implementing policies aimed at reducing switching costs could help lower the excessive expenses faced by gas consumers using the storage tank connection method.

A crucial component of such a policy is improving consumers' access to information about prices and the available companies in their locality. This was achieved through the establishment of a price database by the Ministry of Energy and Infrastructure[69], which required companies to report their local prices periodically. Such transparency enables consumers to make more informed choices among various gas suppliers. Moreover, reducing switching costs can involve simplifying the requirements for consumers transitioning between companies in condominium buildings. For instance, the rules for obtaining a majority consent among residents for switching could be eased, or the ability of companies to charge different prices to similar consumers could be limited. Additionally, improving the accounting mechanisms for the equipment involved in the storage tank connection method between outgoing and incoming suppliers could be beneficial. Similar strategies can be implemented in other sectors of the economy, particularly banking and insurance, where consumers also face switching costs. By making information more accessible to consumers and service providers and creating regulatory conditions that favor emerging competitors, it is possible to further reduce prices in these industries.

[68] However, it is possible, that the number of companies in localities with large households is due to other reasons, such as lower costs due to the optimization of the supply process.

[69] This trend is prevalent globally, and in Israel, it is reflected in a retail price database that enhances transparency.

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Appendix A: The Formal Model in a Uniform Probability Distribution

A.1. The Details of the Calculation of Condition (6) – the Transition of Consumers

To find the condition for consumer transition (Equation 6 in Section 4.2), we will ensure that the expression marked as A in Company 2 profit (Equation 3 in Section 4.1) is positive.

$$(1) \quad \pi_2 = (P_2 - C)\left(1 - x + \overbrace{x\frac{(P_1 - P_2 - \underline{sc})}{\overline{sc} - \underline{sc}}}^{A}\right)$$

We will substitute the internal equilibrium prices (Equations 4a and 4b in Section 4.1)

$$(2) \quad P_1 = c + \frac{(\overline{sc} - \underline{sc})}{3 \cdot x} + \frac{\overline{sc}}{3}$$

$$(3) \quad P_2 = c + \frac{2(\overline{sc} - \underline{sc})}{3 \cdot x} - \frac{\overline{sc}}{3}$$

under the condition 0 < A in Equation (1) and we get:

$$(4) \quad P_1 - P_2 - \underline{sc} > 0$$

$$(5) \quad \left(\frac{(\overline{sc} - \underline{sc})}{3 \cdot x} + \frac{\overline{sc}}{3}\right) - \left(\frac{2(\overline{sc} - \underline{sc})}{3 \cdot x} - \frac{\overline{sc}}{3}\right) - \underline{sc} > 0$$

It is easy to show that (5) is equivalent to

$$(6) \quad x > 0.5 + \frac{1}{2}\left(\frac{\underline{sc}}{2\,\overline{sc} - 3\,\underline{sc}}\right) \; where \; 2\,\overline{sc} - 3\,\underline{sc} > 0$$

Condition (6) is called the consumer transition condition.

A.2. Proof of the Conditions for an Interior Solution and a Reservation Price Solution

An internal solution will occur when: (1) There is a consumer transition, meaning Condition (6) from Section 4.2 is met and (2) the price charged by Company 2 is positive (recall that the assumption is that the cost C is 0). Therefore, we impose ($P_2 > 0$) on the price in Equation 2.

$$(7) \quad P_2 = \frac{2\left(\overline{sc} - \underline{sc}\right)}{3 \cdot x} - \frac{\overline{sc}}{3} > 0$$

We get that this condition is equivalent to

$$(8) \quad x < 2 - \frac{2\,\underline{sc}}{\overline{sc}}$$

Condition (8) is referred to as the condition for $P_2 > 0$.

Proposition 1

When the initial market share of the large company is $1 \geq x > 0.5$, a necessary and sufficient condition for an interior solution is that there is a transition of consumers from Company 1 to Company 2 in equilibrium, that is, $x > 0.5 + \frac{\underline{sc}}{4\,\overline{sc} - 6\,\underline{sc}}$ $where\ 4\,\overline{sc} - 6\,\underline{sc} > 0$

Proof:

The transition condition is more likely to exist as the market shares of Companies 1 and 2 diverge, that is, as (x→1). The larger the initial market share of Company 1 and the smaller the market share of Company 2, the greater the incentive for Company 2 to resort to aggressive pricing to acquire market share.

Conversely, the positive price condition for Company 2 (8) is more likely to exist as the market shares of the companies become more similar, that is, as (x→0).

Therefore, if it appears that for (x = 1), the two conditions on the probability distribution function (6) and (8) are equal, it is evident that for a smaller (x), the incentive to switch customers decreases, making condition (6) the binding condition. In contrast, condition (8) regarding the price will hold, meaning (P_2) will be positive.

It seems that for (x = 1), the two conditions on the probability distribution function (6) and (8) are equal. It is straightforward to show that substituting (x = 1) in the transition condition (6) results in the same condition as substituting (x = 1) in the positive price condition (8).

Conclusion: The transition condition (6) is the binding condition. Therefore, an interior equilibrium will exist if condition (6) is fulfilled. Another conclusion is that when the transition condition (6) is not met, there will be an equilibrium with the reservation price.

A.3. Formulation of Equilibrium Results in Terms of the Properties of the Probability Distribution

It is known that:

$$(9) \quad E(SC_i) = \frac{\overline{sc} + \underline{sc}}{2}, \sigma(SC_i) = \frac{\overline{sc} - \underline{sc}}{\sqrt{12}}$$

First, we solve for $\overline{sc}$, $\underline{sc}$, that is,

$$(10) \quad \overline{sc} = E(SC_i) + \sqrt{3}\sigma(SC_i), \underline{sc} = E(SC_i) - \sqrt{3}\sigma(SC_i)$$

Now we will substitute P_1 and P_2 for the simple case c=0, x=0, and we will get

$$(11) \quad P_1 = \frac{(2\,\overline{sc} - \underline{sc})}{3} = \frac{E(SC_i)}{3} + \sqrt{3}\sigma(SC_i), \; P_2 = \frac{(\overline{sc} - 2\,\underline{sc})}{3} = -\frac{E(SC_i)}{3} + \sqrt{3}\sigma(SC_i)$$

Appendix B: The Formal Model in a Symmetric Triangular Probability Distribution

The analysis in this section assumes that the initial market share of the large company is (x = 1). By doing so, the focus is on examining a scenario where the entire market is initially dominated by Company 1, and Company 2 seeks to enter and compete in this market.

B.1. The Profits of the Companies in a Symmetrical Triangular Probability Distribution

It appears that the profit of the large company (c=0, x=1)

$$(1) \quad \pi_1 = (P_1)\left(1 - \frac{\overbrace{\left(P_1 - P_2 - \underline{sc}\right)^2}^{A}}{0.5\left(\overline{sc} - \underline{sc}\right)^2}\right)$$

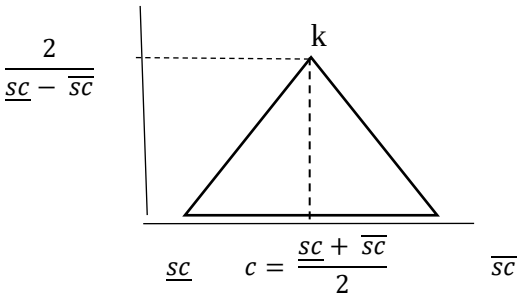
and of the small company

$$(2) \quad \pi_2 = (P_2)\left(\frac{\overbrace{\left(P_1 - P_2 - \underline{sc}\right)^2}^{A}}{0.5\left(\overline{sc} - \underline{sc}\right)^2}\right)$$

The expression marked as A represents the market share transitioning from Company 1 to Company 2 in a symmetric triangular probability distribution with the parameters $\underline{sc}, \overline{sc}$.

Appendix Figure B.1 shows the probability density function of a symmetric triangular probability distribution. When the probability density function is an isosceles triangle the area of which is 1, the height from *k* intersects the side $\underline{sc}, \overline{sc}$ at point c.

Appendix Figure B.1: The probability density function of a symmetric triangular probability distribution



The generalized cumulative probability function (CDF) for the triangular probability distribution is

$$(3)\qquad \text{CDF}=\begin{cases} 0\ for & x_1 \le \underline{sc} \\ \frac{(x_1-\underline{sc})^2}{(\overline{sc}-\underline{sc})(c-\underline{sc})}\ for & \underline{sc} < x_1 < c \\ 1-\frac{(\overline{sc}-x_1)^2}{(\overline{sc}-\underline{sc})(\overline{sc}-c)}\ for & c < x_1 < \overline{sc} \end{cases}$$

where x_1[70] is a random variable that expresses the price gap, that is, $x_1 = P_1 - P_2$, in a symmetrical triangular probability distribution, where $c = \frac{\underline{sc}+\overline{sc}}{2}$ (on the x axis);

From the substitution of c and x_1, it is easy to show that

$$(4)\qquad CDF = \frac{(x_1-\underline{sc})^2}{(\overline{sc}-\underline{sc})(c-\underline{sc})} = \frac{(P_1-P_2-\underline{sc})^2}{0.5\,(\overline{sc}-\underline{sc})^2}$$

Thus, we proved the equations of the firms' profit (1) and (2).

B.2. Equilibrium Properties in the Presentation According to $\overline{\mathbf{sc}}$, $\underline{\mathbf{sc}}$ and According to $\boldsymbol{\sigma}(\mathbf{SC_i}), \mathbf{E}(\mathbf{SC_i})$

B.2.A The Prices, the Average Price, and the Price Gaps

From first-order conditions that are not shown and the formulas for $\sigma(\mathrm{SC_i}), \mathrm{E}(\mathrm{SC_i})$ in a symmetric triangular probability distribution

$\sigma(SC_i) = \frac{\overline{sc}-\underline{sc}}{\sqrt{24}}, E(SC_i) = \frac{\underline{sc}+\overline{sc}}{2}$ so that $\overline{sc} = E + \sqrt{6}\ \sigma$, $\underline{sc} = E - \sqrt{6}$, we obtain that, (5)

$$(5)\qquad P_1 = \frac{1}{8}\left(3\sqrt{\left(3\,\underline{sc}^2 - 4\,\overline{sc}\,\underline{sc} + 2\,\overline{sc}^2\right)} + 5\underline{sc}\right)$$
$$= \frac{1}{8}\left(3\sqrt{\left(E^2 - 2\sqrt{6}\,E\,\sigma\ + 54\,\sigma^2\right)} + \ 5E - 5\sqrt{6}\ \sigma\right)$$

[70] x_1 is used instead of the usual notation x because x already denotes the initial market share of company 1.

$$(6)\quad P_2 = \frac{1}{8}\left(\sqrt{\left(3\,\underline{sc}^2 - 4\,\overline{sc}\,\underline{sc} + 2\,\overline{sc}^2\right)} - \underline{sc}\right)$$

$$= \frac{1}{8}\left(\sqrt{\left(E^2 - 2\sqrt{6}\,E\,\sigma + 54\,\sigma^2\right)} - E + \sqrt{6}\,\sigma\right)$$

$$(7)\quad Avg(P_1, P_2) = \frac{1}{4}\left(\sqrt{\left(3\,\underline{sc}^2 - 4\,\overline{sc}\,\underline{sc} + 2\,\overline{sc}^2\right)} + \underline{sc}\right)$$

$$= \frac{1}{4}\left(\sqrt{\left(E^2 - 2\sqrt{6}\,E\,\sigma + 54\,\sigma^2\right)} + E - \sqrt{6}\,\sigma\right)$$

$$(8)\quad P_1 - P_2 = \frac{1}{4}\left(\sqrt{\left(3\,\underline{sc}^2 - 4\,\overline{sc}\,\underline{sc} + 2\,\overline{sc}^2\right)} + 3\underline{sc}\right)$$

$$= \frac{1}{4}\left(\sqrt{\left(E^2 - 2\sqrt{6}\,E\,\sigma + 54\,\sigma^2\right)} + 3\,E - 3\sqrt{6}\,\sigma\right)$$

The assumption is that $\underline{sc} > 0$ since there is no meaning for the consumer with a negative SC.

B.2.B Conditions for Interior Equilibrium and the Proportion of Consumers Switching to the Smaller Company for (x = 1)

This section examines the conditions under which an interior equilibrium exists and the proportion of consumers who switch to Company 2. In this equilibrium, Company 1 initially controls the entire market (x = 1), and Company 2 is attempting to enter that market.

Proposition 1: Conditions and Characteristics of Equilibrium in a Symmetric Triangular Probability Distribution

For x=1, there is only an interior equilibrium in any set of variables:

A. The price charged by Company 2 is positive and lower than that of Company 1.

B. The proportion of consumers who switch companies is positive and less than 0.5.

Proof:

A. Under the conditions mentioned above, an interior equilibrium will exist, meaning $P_2 > 0$

From (6), it must be shown that, $P_2 = \frac{1}{8}\left(\sqrt{\left(E^2 - 2\sqrt{6}\,E\,\sigma + 54\,\sigma^2\right)} - E + \sqrt{6}\,\sigma\right) > 0$

The proof that the price charged by Company 2 is lower than that of Company 1 follows directly from the proof of Section B of the proposition.

B. According to Equation (3), it must be shown that for $x_1 = P_1 - P_2$, $\underline{sc} < x_1 < \frac{\underline{sc} + \overline{sc}}{2}$, the proportion of consumers who switch companies is positive and less than 0.5. Remember that in a symmetric probability distribution, the condition $\underline{sc} < x_1$ results in a positive transition rate, and the condition $x_1 < \frac{\underline{sc} + \overline{sc}}{2}$ results in a transition rate smaller than 0.5. When $x_1 = \frac{\underline{sc} + \overline{sc}}{2}$, exactly half of the consumers switch to Company 2. To sum up, it should be shown that:

$$(9) \qquad \underline{sc} < P_1 - P_2 < \frac{\underline{sc} + \overline{sc}}{2}$$

Now, we will substitute the price gap from equilibrium Equation (8) into Equation (9). Therefore, it should be:

$$(10a) \qquad P_1 - P_2 = \frac{1}{4}\left(\sqrt{\left(E^2 - 2\sqrt{6}\,E\,\sigma + 54\,\sigma^2\right)} + 3\,E - 3\sqrt{6}\,\sigma\right) < E$$

$$(10b) \qquad \underline{sc} < P_1 - P_2 = \frac{1}{4}\left(\sqrt{\left(3\,\underline{sc}^2 - 4\,\overline{sc}\,\underline{sc} + 2\,\overline{sc}^2\right)} + 3\underline{sc}\right)$$

Proof: by transposition.

B.2.C Equilibrium Characteristics: the Effects of $\overline{sc}$ and $\underline{sc}$ on Prices

Proposition 2: In a triangular symmetrical probability distribution, the derivatives of the prices, according to the SC

$$\frac{\partial P_1}{\partial \underline{sc}} > 0, \qquad \frac{\partial P_1}{\partial \overline{sc}} > 0, \qquad \frac{\partial P_2}{\partial \underline{sc}} < 0, \qquad \frac{\partial P_2}{\partial \overline{sc}} > 0$$

Whereas in a uniform probability distribution

$$\frac{\partial P_1}{\partial \underline{sc}} < 0, \qquad \frac{\partial P_1}{\partial \overline{sc}} > 0, \qquad \frac{\partial P_2}{\partial \underline{sc}} < 0, \qquad \frac{\partial P_2}{\partial \overline{sc}} > 0$$

Proof: immediate from the definitions.

Now we will examine the differences between the triangular and uniform distributions in the effects of large households and households that cooperate in consumption matters. Although the derivative $\frac{\partial P_1}{\partial \underline{sc}}$ has an opposite sign between the two distributions, it appears that this difference does not lead to significant differences in the effects of large households and households that cooperate in consumption matters on the average and price gap.

B.2.D Equilibrium Characteristics: The Impact of Large Households and of Homogeneous Households on the Average Price and Price Gap.

We will prove the effects taken from Table 4 for a symmetric triangular distribution.

Appendix table B.2: Scenarios for different SC probability distributions

	Probability distribution	P_1	P_2	$Average(P_1, P_2)$	$\lvert P_1 - P_2 \rvert$
Large households	Uniform	↓	↑	-	↓
	Symmetric triangular	↓↓	↑	↓	↓
Households that cooperate in consumer affairs	Uniform	↓↓	↓	↓	↓
	Symmetric triangular	↓↓	↓	↓	↓

Section D.1 will examine the impact of large households on equilibrium characteristics, while Section D.2 will explore the influence of households that cooperate in consumer affairs on equilibrium characteristics.

B.2.D.1. The Impact of Large Households on Prices, the Average Price, and Price Gaps

Proposition 3:

$$(11) \qquad \frac{\partial P_1}{\partial E(SC_i)} > 0, \ \frac{\partial P_2}{\partial E(SC_i)} < 0$$

Proof: immediate from the definitions.

Now we will prove that the impact of the mean of the distribution on the price gap is positive and greater than its impact on the average price. The economic implication is that in large

households, where the price gap decreases, the average price also decreases to some extent. Formally,

Proposition 4:

$$(12) \qquad \frac{\partial|P_1-P_2|}{\partial E(SC_i)} > \frac{\partial Avg(P_1,P_2)}{\partial E(SC_i)} > 0$$

Proof:

We will divide the proof into two parts: 1. $\frac{\partial|P_1-P_2|}{\partial E(SC_i)} > \frac{\partial Avg(P_1,P_2)}{\partial E(SC_i)}$ and 2. $\frac{\partial Avg(P_1,P_2)}{\partial E(SC_i)} > 0$.

1. By substituting the explicit expression of Equation (7) for the derivative in Equation (12) and performing an algebraic manipulation, we arrive at:

$$(13) \qquad \frac{\partial Avg(P_1,P_2)}{\partial E(SC_i)} = \frac{d}{dE}\frac{1}{4}\left(\sqrt{\left(E^2 - 2\sqrt{6}\,E\,\sigma\ + 54\,\sigma^2\right)} + E - \sqrt{6}\ \sigma\right)$$

$$= \frac{1}{4}\left(\frac{\left(E - \sqrt{6}\ \sigma\right)}{\sqrt{\left(E^2 - 2\sqrt{6}\,E\,\sigma\ + 54\,\sigma^2\right)}} + 1\right)$$

To show that this expression is always positive, we analyze the numerator and denominator separately:

- The numerator, $\underline{sc} = \left(E - \sqrt{6}\ \sigma\right) > 0$, is positive by assumption (see Section B.2.A).
- The denominator is given by $\sqrt{\left(E^2 - 2\sqrt{6}\,E\,\sigma\ + 54\,\sigma^2\right)} = \sqrt{\left(\left(E - \sqrt{6}\ \sigma\right)^2\ + 48\,\sigma^2\right)} > 0$

Since it consists of squared terms, the denominator is always positive.

Since both the numerator and denominator are positive, it follows that $\frac{\partial Avg(P_1,P_2)}{\partial E(SC_i)} > 0$.

2. $\frac{\partial|P_1-P_2|}{\partial E(SC_i)} > \frac{\partial Avg(P_1,P_2)}{\partial E(SC_i)}$

follows immediately from $\frac{\partial Avg(P_1,P_2)}{\partial E(SC_i)} > 0$, $\frac{\partial P_1}{\partial E(SC_i)} > 0$ and $\frac{\partial P_2}{\partial E(SC_i)} < 0$.

B.2.D.2. The Impact of Homogeneous Households on the Average Price and Price Gaps

The analysis of households that cooperate in consumer decisions considers two cases:

1. **Proportional Decrease in** SCi-SC: In this scenario, the standard deviation and the expected value of the probability distribution decrease due to a reduction in $\overline{sc}$ alone, while $\underline{sc}$ remains unchanged. This represents an extreme assumption about household behavior, as it is more likely that $\underline{SC}$ would also decrease, albeit to a lesser extent.

2. **Proportional Decrease Across the Distribution**: In this case, the tails of the symmetric probability distribution shrink at a rate of $\alpha \in (0,1)$.

Proposition 5:

A. Under a proportional decrease in SCi-SC, both the price gap and the average price decline.[71] A numerical example illustrating this effect is provided in Appendix C.

$$(14) \qquad \frac{\partial Avg(P_1, P_2)}{\partial\, \overline{sc}} > 0$$

$$(15) \qquad \frac{\partial |P_1 - P_2|}{\partial\, \overline{sc}} > 0$$

B. Under a proportional decrease, both the price gap and the average price decline.

$$(16) \qquad \alpha\left(\frac{\partial Avg(P_1, P_2)}{\partial\, \overline{sc}} + \frac{\partial Avg(P_1, P_2)}{\partial\, \underline{sc}}\right) > 0$$

$$(17) \qquad \alpha\left(\frac{\partial |P_1 - P_2|}{\partial\, \overline{sc}} + \frac{\partial |P_1 - P_2|}{\partial\, \underline{sc}}\right) > 0$$

Proofs:

A.

Proof of (14): We will substitute (7) for (14) and differentiate

$$(18) \qquad \frac{\partial Avg(P_1, P_2)}{\partial\, \overline{sc}} = \left[\frac{-2\underline{sc} + 2\overline{sc}}{\sqrt{\left(3\,\underline{sc}^2 - 4\,\overline{sc}\,\underline{sc} + 2\,\overline{sc}^2\right)}}\right]$$

The expression in (18) is always positive.

[71] It should be noted that despite the decrease in $\overline{sc}$, the symmetry of the triangular probability distribution is preserved because first-order conditions assume a symmetric probability distribution.

Proof of (15): We will substitute (8) for (15) and differentiate:

$$(19) \qquad \frac{\partial |P_1 - P_2|}{\partial\, \overline{sc}} = \left(\frac{2\overline{sc} - 2\underline{sc}}{\sqrt{\left(3\ \underline{sc}^2 - 4\ \overline{sc}\ \underline{sc} + 2\ \overline{sc}^2\right)}} \right)$$

The expression in (19) is always positive.

B.

Proportional decrease of SCi

Proof of (16): We will substitute (7) for (16) and differentiate:

$$(20) \qquad \frac{\partial Avg(P_1,P_2)}{\partial\, \overline{sc}} + \frac{\partial Avg(P_1,P_2)}{\partial\, \underline{sc}} = \left[\frac{2\underline{sc}}{\sqrt{\left(3\ \underline{sc}^2 - 4\ \overline{sc}\ \underline{sc} + 2\ \overline{sc}^2\right)}} + 1 \right]$$

The expression in (20) is always positive.

Proof of (17):

We will substitute (8) for (17) and differentiate

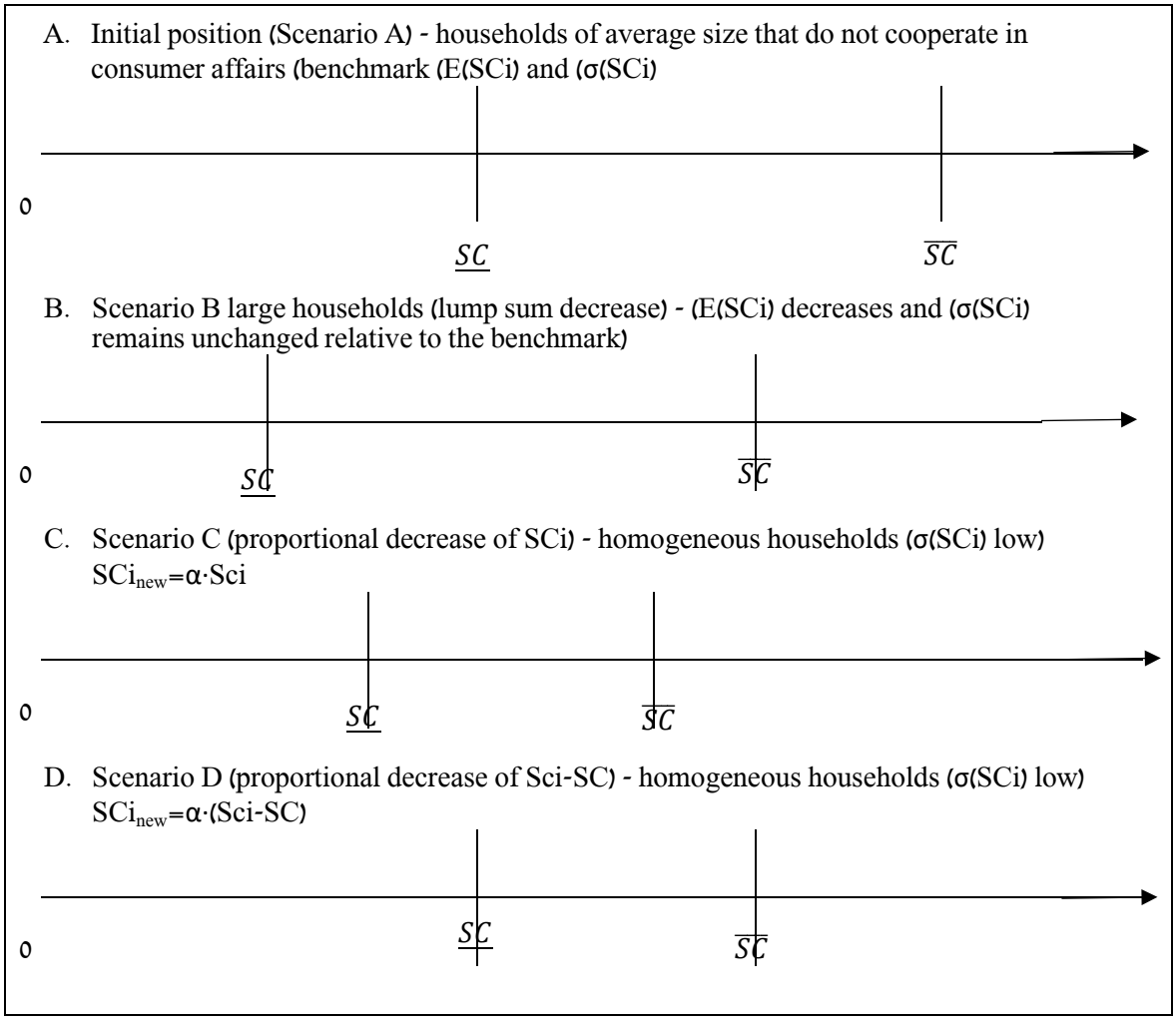
$$(21) \qquad \frac{\partial |P_1 - P_2|}{\partial\, \overline{sc}} + \frac{\partial |P_1 - P_2|}{\partial\, \underline{sc}} > 0$$

The expression in (21) is always positive.

Appendix C: An Alternative Scenario for Homogeneous Households (Proportional Decrease in SCi-SC) and an Extended Analysis of Market Shares After Price Adjustment

The figure in Appendix C introduces Scenario D as an extension of Figure 2 in the main text, providing an additional case alongside Scenario C for homogeneous households. For Scenario D, which examines the proportional decrease of SCi-SC, further details can be found in Section D.2. As outlined in Appendix B.2, this adjustment primarily impacts households with high SCi values, while those with the lowest SCi remain unaffected. This scenario results in a relative decrease in $\overline{sc}$ from its initial position within the probability distribution. In both Scenarios C and D, the mean and standard deviation decline relative to their initial values within the probability distribution.

Appendix C Figure: Scenarios for different SC probability distributions



The small company's market share after clearing the market:

$$market\ share_2 = \left(\frac{1}{3} - \frac{\underline{sc}}{3\left(\overline{sc}-\underline{sc}\right)}\right) = \left(\frac{1}{3} - \frac{E(SC_i)-\sqrt{3}\sigma(SC_i)}{6\sqrt{3}\sigma(SC_i)}\right) = \left(\frac{1}{2} - \frac{E(SC_i)}{6\sqrt{3}\sigma(SC_i)}\right),\ \text{when:}$$

$$(1) \qquad \frac{\partial market\ share_2}{\partial E(SC_i)} < 0, \frac{\partial market\ share_2}{\partial \sigma(SC_i)} > 0$$

Appendix Table C provides numerical examples for scenarios. In this appendix table, a more detailed breakdown is provided for the numerical example presented in Table C.

Appendix Table C: Comparison of Average Prices, Price Gaps, Profits, and Market Shares across Different Probability Distribution Scenarios $SC_i \sim U\left(\underline{sc}, \overline{sc}\right)$ (initial market share x=1)

	Initial posion (Scenario A) – households of average size $E(SC_i)$ and not homogeneous $\sigma(SC_i)$	**Scenario B (lump sum decrease) - large households ↓ $E(SC_i)$ and not homogeneous $\overline{\sigma(SC_i)}$**	**Scenario C (proportional decrease of SCi) - households that cooperate in consumer affairs ↓ $E(SC_i)$ ↓ $\sigma(SC_i)$**	**Scenario D (proportional decrease of SCi-SC) ($\overline{sc}$ ↓) – households that cooperate in consumer affairs ↓ $E(SC_i)$ ↓ $\sigma(SC_i)$**
The SC probability distribution				
$SC_i \sim U\left(\underline{sc}, \overline{sc}\right)$	$SC_i \sim U(6,24)$	$SC_i \sim U(1,19)$	$SC_i \sim U(4,16)$	$SC_i \sim U(6,18)$
$E(SC_i) = \frac{\overline{sc} + \underline{sc}}{2}$	15	10	10	12
$\sigma(SC_i) = \frac{\overline{sc} - \underline{sc}}{\sqrt{12}}$	$\frac{18}{\sqrt{12}}$	$\frac{18}{\sqrt{12}}$	$\frac{12}{\sqrt{12}}$	$\frac{12}{\sqrt{12}}$
Results[1]				
P_1	14	12.33	9.33	10
P_2	4	5.67	2.67	2
$Average(P_1, P_2)$	9	9	6	6
$\lvert P_1 - P_2 \rvert$	10	6.67	6.67	8
$market\ share_2$	0.222	0.315	0.222	0.167
π_1	10.89	8.45	7.26	8.33
π_2	0.89	1.78	0.59	0.33

Appendix D:

D.1. Extensions to Bertrand Competition for Consumers with Heterogeneous Switching Costs under a Uniform Probability Distribution

Appendix Table D.1: Bertrand Competition with Switching Costs. For simplicity, it is assumed that (c = 0) and (x = 1)

Market description	Large company	Small company	Market partition and notes
1. Consumers of Variable Size[1]: A large consumer is reflected by a decrease in (**Ɛ**), that is, in the uniform distribution, we get that $\overline{sc} - \varepsilon, \underline{sc} - \varepsilon$ (see the extension below the table)	$P_1 = \frac{(2\overline{sc} - \underline{sc}) - \varepsilon}{3}$	$P_2 = \frac{(\overline{sc} - 2\underline{sc}) + \varepsilon}{3}$	Market distribution as in the benchmark model. The average price remains unchanged compared to the benchmark model $Average(P_1, P_2) = \left(\frac{(\overline{sc} - \underline{sc})}{2}\right)$ while the price gap decreases $\lvert P_1 - P_2 \rvert = \left(\frac{\overline{sc} + \underline{sc} - 2\varepsilon}{3}\right)$.
2. Quality difference between the companies: If the consumer pays P_1 for the product of company 1, she will pay $P_1 - Q$ for the product of company 2. For simplicity, the assumption is that $\underline{sc} = 0$.	$P_1 = \frac{2}{3}\overline{sc} + \frac{Q}{3}$	$P_2 = \frac{1}{3}\overline{sc} - \frac{Q}{3}$	The quality difference, Q, is not affected by the $\overline{sc}$. The Q affects the division of the market relative to the benchmark model. The market share of company 1 (the higher quality company) increases by Q after clearing the market.
3. Price discrimination by the large company: The large company can quote nonuniform prices P_{1H}, P_{1L}. For simplicity, the assumption is that $\underline{sc} = 0$.	$P_{1H} = \frac{4}{5}\overline{sc}$; $P_{1L} = \frac{2}{5}\overline{sc}$	$P_2 = \frac{1}{5}\overline{sc}$	The market distribution consists of 40% of consumers purchasing from the large company at a high price, 40% from the large company at a low price, and 20% from the small company. It can be demonstrated that consumer surplus remains nearly unchanged compared to the benchmark model. However, the profits of the small company decline by almost 67% relative to the benchmark model. Consequently, nonuniform pricing serves as a significant barrier to entry for small or emerging companies.

[1] See the detailed explanation in Section D.1.1.

D.1.1 Extension to Consumers with Variable Size:

We will represent a large consumer by a decrease in (SC_i) by (Ɛ). Specifically, within the uniform probability distribution, this results in $\overline{sc} - \varepsilon, \underline{sc} - \varepsilon, \varepsilon > 0$.

$$(1) \qquad \pi_1 = P_1\left(1 - \frac{(P_1 - P_2)}{(\overline{sc} - Ɛ) - (\underline{sc} - Ɛ)}\right)$$

$$(2) \qquad \pi_2 = P_2\left(\frac{(P_1 - P_2)}{(\overline{sc} - Ɛ) - (\underline{sc} - Ɛ)}\right)$$

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First order conditions show that the price gaps for large consumers decrease and the average price remains unchanged:

$$(3) \qquad P_1 = \frac{\left(2\overline{sc} - \underline{sc}\right) - \varepsilon}{3}, \qquad P_2 = \frac{\left(\overline{sc} - 2\underline{sc}\right) + \varepsilon}{3}$$

$$(4) \quad |P_1 - P_2| = \left(\frac{\overline{sc} + \underline{sc} - 2\varepsilon}{3}\right), Average(P_1, P_2) = \left(\frac{\left(\overline{sc} - \underline{sc}\right)}{2}\right), market\ share_2 =$$

$$\left(\frac{1}{3} - \frac{\underline{sc}}{3\left(\overline{sc} - \underline{sc}\right)}\right), \ \pi_2 = \frac{1}{9}\frac{\left(\overline{sc} - 2\underline{sc}\right)^2}{\overline{sc} - \underline{sc}}, \pi_1 = \frac{1}{9}\frac{\left(2\,\overline{sc} - \underline{sc}\right)^2}{\overline{sc} - \underline{sc}}$$

D.2 Three Companies in the Locality

In the local market, there are initially two companies: Company 1, which is the most established and holds the largest initial market share, and Company 2, which is smaller. An emerging company, Company 3, now enters the market. This model aims to demonstrate the impact of the third company on pricing dynamics. There are two alternative assumptions regarding consumer behavior when switching from Company 1: (a) Consumers are continuously distributed between Companies 2 and 3, with a greater proportion switching to Company 3 as its price becomes lower relative to Company 2; or (b) Consumers will switch to the company offering the lowest prices.

A. Equilibrium Assuming Consumers Departing from Company 1 Are Distributed Between Companies 2 and 3 Based on Price Ratios

The situation is ($P_1 > P_2 > P_3$). Therefore, both Company 2 and the emerging Company 3 can increase their market share at the expense of Company 1, and Company 3 can even increase its market share at the expense of Company 2.[72]

Consumers departing from Company 1 are distributed between Companies 2 and 3 according to the price ratio between the companies. In other words, consumers are more likely to switch to the company offering the lowest prices.

The probability that a consumer departing from Company 1 will switch to Company 2 is ($\frac{P_3}{(P_2 + P_3)}$), and the probability that he/she will switch to Company 3 is the complementary probability ($\frac{P_2}{(P_2 + P_3)}$). Some consumers who depart from Company 1 have a high switching cost (SC_i), making them more likely to switch to Company 3, which charges the lowest price.

For simplicity, we will limit the discussion to ($\underline{sc} = 0$). It is assumed that the SC probability distribution for consumers of Companies 1 and 2 is uniform and identical, i.e., ($SC_i \sim U(0, \overline{sc})$U). However, it is denser in Company 1 because it has a larger consumer base.[73]

The formulation of the equations:

The initial market share of Company 1 is (x1) and that of Company 2 is (1 - x1). The profit of Company 1 is equal to the price multiplied by the final market share (x1_new). Both Company 2 and Company 3 gain market share from Company 1.

The market share that shifts to Company 2 is (k1), and the market shares that shift to Company 3 are (k2) and (k3). The higher (P_2) is compared to (P_3), the smaller the market share that goes to Company 2 ($(\downarrow k1)$) and the larger the market share that goes to Company 3 ($\uparrow k2$). Some consumers who depart from Company 1 have a high switching cost (SC), so

[72] The number of competitors of Company 1 does not directly affect the number of consumers departing from Company 1. The number of consumers depends solely on the price gaps between Company 1 and the company charging the lowest price.

[73] In a previous period, Company 2 entered the market or increased its market share. As Company 3 enters the market, the consumer probability distributions of the two companies become identical, except for their market share. Now, each company chooses its equilibrium strategy.

they can only switch to Company 3 (represented by (k3) in the profit equation of Company 1).

$$(5) \qquad \pi 1 = p_1 \overbrace{\left(x1 - \frac{\overbrace{x1\,(p_1 - p_2)\cdot p_3}^{k1}}{\overline{sc}\,(p_2 + p_3)} - \frac{\overbrace{x1\,(p_1 - p_2)\cdot p_2}^{k2}}{\overline{sc}\,(p_2 + p_3)} - \frac{\overbrace{x1\,(p_2 - p_3)}^{k3}}{\overline{sc}} \right)}^{x1\_new}$$

The profit of Company 2 is calculated as the product of its price and market share. Initially, Company 2 holds a market share of (1 – x1). Company 2 acquires additional market share from Company 1, denoted as (k1), while simultaneously losing a portion of its market share to Company 3, denoted as (k4).

$$(6) \qquad \pi 2 = p_2 \overbrace{\left(1 - x1 + \frac{\overbrace{x1\,(p_1 - p_2)\cdot p_3}^{k1}}{\overline{sc}\,(p_2 + p_3)} - \frac{\overbrace{(1 - x1)(p_2 - p_3)}^{k4}}{\overline{sc}} \right)}^{x2new}$$

The profit of Company 3 is calculated as the product of its price and market share. Initially, Company 3 had a market share of zero. The market share gained from Company 1 is (k2+k3), while the market share acquired from Company 2 is (k4).

$$(7) \qquad \pi 3 = p_3 \overbrace{\left(\frac{\overbrace{x1\,(p_1 - p_2)\cdot p_2}^{k2}}{\overline{sc}\,(p_2 + p_3)} + \frac{\overbrace{x1\,(p_2 - p_3)}^{k3}}{\overline{sc}} + \frac{\overbrace{(1 - x1)\,(p_2 - p_3)}^{k4}}{\overline{sc}} \right)}^{x3new}$$

Due to the computational complexity, the solution is numerical. The third company, which has the smallest market share, was found to reduce the price in the local market compared to the scenario where there are only two companies. See Table D.2 for the simulation results. The initial market shares are 0.75 for Company 1 and 0.25 for Company 2.

Appendix Table D.2: The Prices, Profits, and Market Shares in a Local Market with Three Companies

	P_1	P_2	P_3	π_1	π_2	π_3	Market Share 1	Market Share 2	Market Share 3
Initial situation 2 companies	0.889	0.444	-	0.67	0.11	-	0.75	0.25	-
Consumers who depart Company 1 are split between Companies 2 and 3 according to the price ratio between the companies	0.622	0.427	0.243	0.29	0.127	0.0576	0.4662	0.297	0.237

1. for $\underline{sc} = 0$ and $\overline{sc} = 1$

B. Equilibrium Assuming Consumers Departing from Company 1 Switch Only to the Company Offering the Lowest Prices

When consumers switch to the company offering the lowest prices, equilibrium will only be achievable if Company 2 matches the price of Company 1, resulting in ($P_1 = P_2 = \frac{2 \cdot \overline{sc}}{3}$, $P_3 = \frac{\overline{sc}}{3}$). In this scenario, consumers will switch from Companies 1 and 2 to Company 3.

This situation, where consumers switch from Company 1 exclusively to the company with the lowest price, creates intense competition between Companies 2 and 3 and necessarily results in zero profit for Company 2. Consequently, Company 2 will prefer to match the price of Company 1 to maintain some profitability, despite a decrease in its market share. Assuming that the $\underline{sc} = 0$, the market share of the emerging Company 3 will always be one-third. Under these conditions, the prices in the market do not decline.

Appendix E:

Appendix Table E: Additional Estimations

The explained variable is pi, j the price of 1 cubic meter of LPG by company and locality.	All localities (general & ultra-Orthodox populations)						
	Inclusive model	A model that includes a socioeconomic cluster	A model that includes a socioeconomic cluster in interaction	A model that includes the rate of those renting their homes	A model that includes the rate of those renting their homes in interaction	A model that includes the Gini index	A model that includes a peripherality index[1]
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
L	-0.634***	-0.664***	-0.628***	-0.642***	-0.635***	-0.652***	-0.677***
	(-3.76)	(-3.73)	(-3.67)	(-3.76)	(-3.75)	(-3.76)	(-3.55)
No small companies	6.175*	5.852*	6.029*	5.450*	6.158*	5.730*	6.514**
	(2.49)	(2.28)	(2.36)	(2.01)	(2.22)	(2.15)	(3.04)
Large company	14.49***	14.54***	14.38***	14.60***	14.76***	14.50***	14.46***
	(7.97)	(7.96)	(5.56)	(8.07)	(5.30)	(7.93)	(7.90)
Household size	-0.964+	-1.058+	-0.990+	-0.683	-0.971+	-1.011+	-0.972+
	(-1.86)	(-1.93)	(-1.91)	(-1.22)	(-1.87)	(-1.91)	(-1.88)
Household size x Large Company	-1.469**	-1.484**	-1.451*	-1.486**	-1.507*	-1.469**	-1.465*
	(-2.61)	(-2.62)	(-2.43)	(-2.65)	(-2.48)	(-2.59)	(-2.57)
Haredi	-3.787**	-4.043**	-3.720**	-4.539**	-3.770**	-3.765**	-3.733**
	(-3.08)	(-3.03)	(-3.02)	(-3.19)	(-2.95)	(-3.06)	(-3.02)
Haredi x Large Company	-2.389	-2.346	-2.385	-2.403	-2.331	-2.429	-2.293
	(-1.56)	(-1.53)	(-1.54)	(-1.58)	(-1.41)	(-1.59)	(-1.52)
Pop growth	-5.607*	-5.540+	-5.671*	-4.960+	-5.662*	-5.836*	-5.539+
	(-1.96)	(-1.94)	(-1.98)	(-1.73)	(-1.99)	(-2.01)	(-1.96)
Cold locality	-3.292**	-3.174*	-3.286**	-2.875*	-3.306*	-3.170*	-3.395**
	(-2.67)	(-2.53)	(-2.63)	(-2.16)	(-2.47)	(-2.51)	(-2.93)
Socioeconomic cluster		-0.0799					
		(-0.53)					
Socioeconomic cluster x Large Company			0.0128				
			(0.07)				
Rent percentage				0.0463			
				(1.03)			
Rent percentage x Large Company					-0.00574		
					(-0.10)		
Gini index						-2.758	
						(-0.46)	
Peripheral index							0.137
							(0.54)
District	V	V	V	V	V	V	V
Constant	30.05***	30.87***	30.14***	27.01***	30.14***	31.56***	29.43***
	(9.61)	(8.94)	(9.62)	(6.82)	(9.34)	(7.00)	(9.07)
N	572	572	572	572	572	572	572
adj. R-sq	0.681	0.680	0.681	0.684	0.680	0.681	0.678

t statistics in parentheses

+p<0.10 * p<0.05 ** p<0.01 *** p<0.001

Notes:

[1] A model where the peripherality index was only used as an auxiliary variable.