Flexible or Uniform? Optimal Pricing Strategies of Pharmacy Chains

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Abstract

Networks of chain stores cover various markets of different local demands. Despite the benefits of geographical price discrimination that standard theoretical models predict, some chains commit to setting the same price across all markets. We develop a stylized yet novel model of spatial competition that explains the co-existence of flexible and uniform pricing strategies. In particular, we focus on two chains with stores located in both peripheral markets and a central market. Our insight on heterogeneous pricing strategies lies in (1) limited access to some of the peripheral markets one of the chains may have *(competition channel)* and (2) consumers who move between the peripheral markets and the central market and do not observe prices in the latter location *(information channel)*. The uniform pricing scheme allows chains to enlarge their markets by making their price in one market informative about prices in other chains' locations. Our model is rich enough to confront empirical evidence on diverse relative price patterns and heterogeneous pricing strategies of pharmacy chains.

Keywords: pricing strategy, uniform pricing, chain stores, pharmacies

JEL Codes: D22, L11, L2, L81

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1. Introduction

In the retail sector, large players form chains of stores located in markets featured with heterogeneous demographics and demand. The traditional theoretical models predict profitability improvements for firms applying third-degree price discrimination, i.e., adjusting prices to local demand. Moreover, the return from the price discrimination policy should be larger in markets where a chain faces less competition. Therefore, the more uncontested markets a chain is present in, the larger should be the benefits of exploiting local monopoly power. Nonetheless, numerous empirical studies document that some chains opt out of the opportunity to price discriminate against their consumers and commit to the unified chain-level price.[1] Whereas recent empirical literature mainly focuses on the overall price stickiness and the uniform pricing puzzle, the present examines the determinants of heterogeneous pricing policies across retail chains.

We construct a stylized yet novel model of spatial competition that explains the co-existence of flexible and uniform pricing strategies. In our parsimonious setup, we consider two chains with stores located in both peripheral markets and a central market. Demand in the periphery and the center are interconnected by the presence of commuting consumers. Coming to a market with unknown prices, a consumer forms respective beliefs. When a certain chain applies a uniform pricing scheme, it informs consumers in all markets about its price which, in turn, allows this chain to enlarge its demand. Therefore, our insight on heterogeneous pricing strategies lies in (1) limited access to some of the peripheral markets one of the chains may have *(competition channel)* and (2) consumers who move between the peripheral markets and the central market and do not observe prices in the latter location *(information channel)*. Depending on the composition of these two effects, the model can rationalize various patterns of the chain-level pricing policies and the relative local prices of uniform and flexible pricing chains. Novel to the existing literature, with our framework we can show that even if a chain has many 'monopoly' locations that are fruitful for price discrimination, it can still commit to a uniform price. Moreover, we can confront the empirical evidence on the existence of flexible pricing chains present only in high-competitive markets,

[1]The uniform pricing puzzle is discussed and confirmed by numerous studies among others analyzing pricing patterns in movie-theater industry (Orbach and Einav, 2007), car rental market (Cho and Rust, 2010), iTunes Music store songs (Shiller and Waldfogel, 2011), retail markets in the US (Nakamura, 2008; Hitsch, Hortaçsu, and Lin, 2019; DellaVigna and Gentzkow, 2019) and France (Allain, Chambolle, Turolla, and Villas-Boas, 2017).

ex ante expected to be more prone to use uniform pricing as a competition softening means.

To justify that our theoretical findings are consistent with empirical evidence, we collect data on pharmacy chains operating in Moscow, Russia. We start with the list of stylized facts captured in our theoretical setting. Then, we test predicted regularities relying on detailed information on spatial chain structure, market characteristics, and location-specific levels of competition. In the reduced form analysis, we confirm the inverse U-shape relation between the share of 'monopoly' markets a chain is present in and the propensity to opt for the uniform pricing strategy, i.e., only with the intermediate number of 'monopoly' markets a chain finds it optimal to commit to a unified chain-level price. Moreover, our empirical findings support the non-trivial relative prices across markets and chains depending on the strength of the competition and information channels.

In what follows, we discuss related literature in Section 2, and summarize the empirical firm-level findings in Section 3 that are further met by our theoretical framework presented in Section 4. Then we present our data in Section 5 and test main theoretical predictions in Section 6. Section 7 concludes.

2. Related Literature

The studies on uniform pricing provide various explanation to this phenomena and, overall, low price dispersion. The prevailing explanation comes from the managerial inertia (Levy, Bergen, Dutta, and Venable, 1997). Moreover, uniform pricing can serve as a signal for loyal consumers and result from perception of a fair price (Kahneman, Knetsch, and Thaler, 1986b,a; Chen and Cui, 2013). Another explanation relates to the presence of pricing zones, where prices are uniform within a certain geographic area (Hoch, Kim, Montgomery, and Rossi, 1995; Adams and Williams, 2019). Since we look at the online pricing strategies, it is important to note that the spread of online retailing has also raised the degree of uniform pricing (Brynjolfsson and Smith, 1999; Brown and Goolsbee, 2002; Cavallo, 2018; Clay, Krishnan, and Wolff, 2001). Ater and Rigbi (2018) explain this pattern by an increased transparency that limits third-degree price discrimination online. Finally, our story of inter-market commutes relates to the explanation of uniform pricing by low consumer search costs (Chandra and Tappata, 2011).

Primarily, we contribute to the literature by analyzing the choice between uniform pricing and third-degree price discrimination. In his seminal paper, Holmes (1989) shows that under a certain relation of industry- and cross-elasticities of demand across markets, oligopolistic firms can prefer uniform pricing to third-degree discrimination.[2] Moreover, uniform pricing can be observed under ensured commitment and known consumer's location or brand loyalty (Thisse and Vives, 1988), or under sufficiently asymmetric best response functions of competing firms (Corts, 1998). Relating the choice of uniform pricing to the degree of competition, Armstrong and Vickers (2001) conclude that firms can commit to uniform prices only if markets are sufficiently uncompetitive. Extending the idea, Dobson and Waterson (2005) show that uniform pricing can be profitable even with the presence of competitive markets if uncompetitive ones are large enough. In their framework, uniform pricing relaxes competition in contested markets. Therefore, a chain finds it profitable to commit to uniform price if the share of uncontested markets is not too large and competition in the contested markets is not too high. These findings are confirmed by Li, Gordon, and Netzer (2018) who analyze optimal geographical pricing for three major retailers of digital cameras in the US. With the use of a structural model, the authors find that for the two leader firms is it more profitable to apply uniform pricing as they face higher competition, whereas the third discount chain should optimally price differentiate accounting for the local demand. Whereas previous papers assume away demand connection between markets and look at isolated markets, in our model due to the presence of commuters local markets become interconnected. The ability of consumers to travel across markets makes the relation between competition and pricing policy richer – our model can rationalize why a chain with no uncontested markets opts for a flexible pricing scheme, whereas a chain with a large share of 'monopoly' markets sets uniform prices.

As regard of uniform pricing puzzle, there are certain peculiarities found for the pharmaceutical sector. With a consumer search model, Sorensen (2000) finds that prices for repeatedly purchased drugs, such as prescription drugs, are less dispersed and markups are lower. The opposite result is documented by Gellad, Choudhry, Friedberg, Brookhart, Haas, and Shrank (2008), who find that poorer neighborhoods in Florida face higher prices for prescribed drugs.

Results on the effect of uniform pricing on welfare diverge. Miravete, Seim, and Thurk (2020) look at the liquor market in Pennsylvania where markups for spirits are fixed by law. With the pro-

[2] In particular, if smaller markets are characterized by lower industry elasticity of demand, but higher cross-elasticity of demand, then price discrimination leads to lower than optimal prices in smaller markets.

hibited price discrimination, the winners are low-income households and small specialized firms. An inverse U-shape relation of welfare on uniform pricing was found by Fabra and Reguant (2020), who shows that medium-size buyers benefit the most from a common market price. Analyzing the consequences of a ban on price discrimination in broadband carriers in Colombia, Vélez-Velásquez (2024) shows that this policy results in large welfare transfers from low-income households towards high-income households accompanied by the price increase for Internet provision.

3. Evidence on Uniform Pricing Pharmacies

In this section, we present a list of stylized facts of pharmacy chains that apply uniform pricing. We rely on firm-level data on chain pharmacies that operate in Moscow, Russia.[3] Overall, we have 26 uniform pricing chains and 42 flexible pricing chains having, in total, of 1,895 and 1,317 affiliates, respectively.

In the following discussion, we provide two alternative market definitions. First, we define a market by pharmacies' geographical closeness. In doing so, we find clusters of pharmacies such that the diameter of each cluster does not exceed one kilometer. Second, we create a one-kilometer grid that covers the map of Moscow.[4]

Since pharmacy chains widely use franchising, it is arguable whether location decisions are centralized. Therefore, when presenting stylized facts we take locations of a chain fixed and assume that it is harder to adjust relative to the chain pricing policy.

Stylized fact 1: Uniform pricing chains are bigger and more spread in the city On average, pharmacy chains that apply uniform pricing have more affiliates and are present in more locations (see Table 1). On top, we compute the Herfindal-Hirshman index that reflects the spread of a chain across markets. We find that affiliates of uniform pricing chains are more evenly distributed in the city, and this observation is mainly driven by 'periphery' locations, i.e. drug stores located outside Moscow center rings. Whereas, in absolute terms, uniform pricing chains are more present in the center, the proportion of affiliates in the center is the same for uniform and flexible pricing chains.

[3] We limit our attention to 'old' Moscow borders that mostly coincide with the Moscow Automobile Ring Road (MKAD). In Appendix A, we depict the area of Moscow that is taken into consideration in our analysis.

[4] We get 806 with clustering and 731 markets with grid.

TABLE 1: CHAIN SIZE

	Pricing			Pricing		
	Flexible	Uniform	$p-$value	Flexible	Uniform	$p-$value
Number of affiliates	31.357	72.885	0.103			
inside 1^{st} ring	2.688	7.417	0.042			
inside 2^{st} ring	5.710	13.227	0.064			
inside 1^{st} ring (share)	0.050	0.047	0.859			
inside 2^{st} ring (share)	0.183	0.192	0.858			
	Market defined by clustering			**Market defined by grid**		
Number of markets	27.929	57.731	0.091	28.095	58.077	0.092
Average number of affiliates in a market	1.040	1.094	0.094	1.034	1.088	0.070
HHI						
Total	0.111	0.065	0.016	0.109	0.064	0.016
Periphery – outside 1^{st} ring	0.120	0.067	0.012	0.119	0.066	0.011
Periphery – outside 2^{nd} ring	0.140	0.085	0.048	0.138	0.086	0.055
Center – inside 1^{st} ring	0.546	0.390	0.274	0.562	0.391	0.227
Center – inside 2^{nd} ring	0.468	0.308	0.095	0.463	0.309	0.107

Note: 26 uniform pricing pharmacies and 46 flexible pricing pharmacies. 1^{st} ring is the Garden Ring; 2^{nd} ring is the Third Transport Ring.

To make our comparison more vivid, we selected two medium-sized pharmacies that have an identical number of affiliates – "Zdravcity" (uniform) and "Dezhurnaya apteka" (flexible). In Figure 1, we marked on the city map the respective locations of these two chains. As one can see, for a uniform pricing chain, drug stores are located in relatively distant areas one from another, whereas for a flexible one, there are zones of high concentration (e.g., in the southwest region).

Stylized fact 2: Uniform pricing chains have more 'monopoly' markets Affiliates of uniform pricing chains are more likely to be the only ones in their respective markets (see Table 2). *Ex ante* one could expect that such a monopolist position in a larger number of markets should increase benefits from adjusting prices to local demand (Varian, 1980). However, the empirical evidence suggests the opposite result – even though uniform pricing chains can exploit their monopoly power in more locations they opt for the same online price independent of whether their affiliate is located in the periphery or the center. We also notice that uniform pricing chains face less competition from 'big players' – top-5 and top-10 competitors in terms of the number of affiliates.

Stylized fact 3: Uniform pricing chains tend to locate in markets with more commuters On average, markets of uniform pricing chains attract more commuters. In the absence of detailed

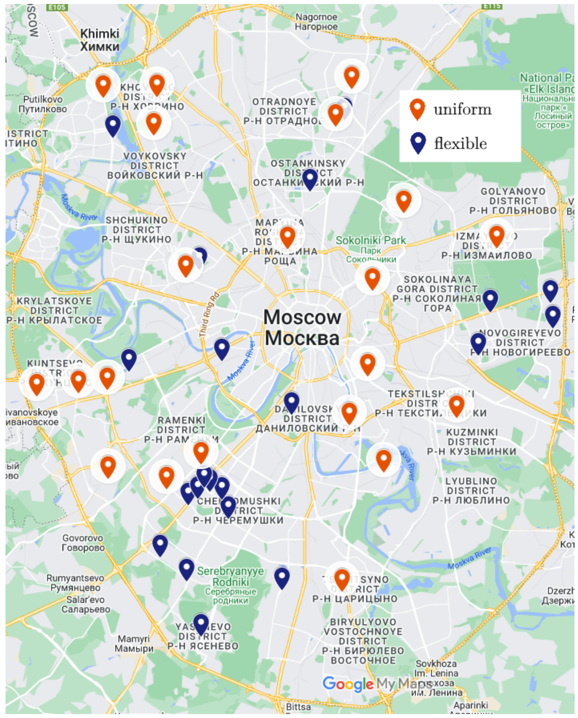


FIGURE 1: COMPARISON OF TWO EQUAL SIZE CHAINS – UNIFORM VS. FLEXIBLE

TABLE 2: MONOPOLY MARKETS

	Pricing			Pricing		
	Flexible	Uniform	$p-$value	Flexible	Uniform	$p-$value
	Market defined by clustering			**Market defined by grid**		
Number of monopoly markets	1.865	5.000	0.082	1.189	3.077	0.087
Share of monopoly markets	0.056	0.074	0.363	0.036	0.045	0.467
Number of 'big 5' competitors	3.054	2.038	0.057	3.081	1.885	0.022
Number of 'big 10' competitors	4.000	2.731	0.088	4.243	2.962	0.059
No 'big 5' competitors	0.135	0.346	0.064	0.189	0.154	0.718
No 'big 10' competitors	0.135	0.308	0.119	0.081	0.115	0.664
Share of markets with no 'big 5' competitors	0.131	0.166	0.295	0.125	0.152	0.254
Share of markets with no 'big 10' competitors	0.101	0.138	0.235	0.070	0.100	0.130

Note: 26 uniform pricing pharmacies and 37 flexible pricing pharmacies that allow online orders. 1^{st} ring is the Garden Ring; 2^{nd} ring is the Third Transport Ring.

data on internal migration in Moscow, we rely on information about the inflow and outflow of passengers for each metro station.[5] Net passenger outflow serves as a good proxy for the locations attracting the most commuters. In general, stations located next to business areas, e.g. Moscow City – the business skyscrapers, are characterized by a large positive net passenger outflow, i.e. the number of travelers to these stations largely exceeds the number of inflow travelers.

As it is shown in Table 3, markets covered by uniform pricing chains are more populated by metro stations and crosswalks. Presumably due to the extensive presence in the periphery markets, for an average market the passenger inflow exceeds passenger outflow. Still, we observe that the ratio is significantly larger for markets of uniform pricing affiliates. Following our intuition on the proxy for attractive to commuters markets, we look only at metro stations characterized by the positive net passenger outflow. For each market, we compute the total number of such stations and their total net passenger outflow. In both measures, the markets of uniform pricing affiliates prevail. In line with this, markets of uniform pricing chains are more populated with business centers.[6] Moreover, in markets of uniform pricing affiliates, there are less free parking zones which is typical for business areas.

TABLE 3: MARKETS AND COMMUTERS

	Pricing			Pricing		
	Flexible	Uniform	$p-$value	Flexible	Uniform	$p-$value
	Market defined by clustering			**Market defined by grid**		
N metro stations	0.686	0.793	0.001	0.312	0.419	0.000
Passenger outflow/inflow	0.693	0.805	0.001	0.573	0.692	0.000
Positive net passenger outflow						
Absolute sum	29,443.490	38,555.210	0.002	22,608.800	33,905.100	0.000
N of stations	0.405	0.504	0.001	0.405	0.504	0.001
N business centers	2.169	2.775	0.000	1.583	2.248	0.000
N crosswalks	2.768	3.486	0.000	2.093	2.524	0.001
N free parking zones	9.762	8.944	0.024	6.988	6.231	0.000

Note: 1,895 affiliates of uniform pricing chains and 1,317 affiliates of flexible pricing chains. Net passenger outflow is the difference between passenger outflow and inflow.

Stylized fact 4: Uniform pricing chains tend to be located in richer markets Uniform pricing affiliates are facing higher demand from high-willingness to pay consumers. In Russia, private

[5] Moscow is fully covered by the metro network, and the metro is the most popular public transportation mean (65% of all travels are done via metro).

[6] Unfortunately, we cannot access the number of workers and size of a business center.

medicine is more expensive and typically is used by individuals with higher incomes. In Table 4, one can see that a uniform pricing chain covers markets with more private medical centers. In line with this observation, markets of uniform pricing chains are more populated with relatively more expensive grocery stores, such as ‘Azbuka vkusa’, and less popular cheaper chains, such as ‘5ka’.

4. The Model

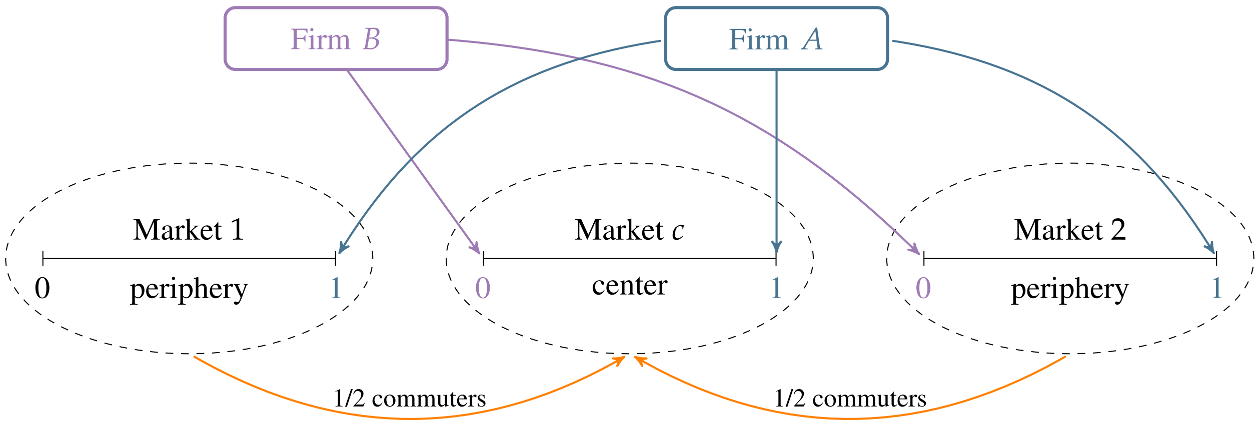
4.1 Setup

Firms and markets We consider an economy that consists of three markets: two periphery markets (denoted by 1 and 2) and one central market (denoted by c); and two firms labeled with A and B. Each market can be viewed as a Hotelling linear city on the $[0, 1]$ interval. We assume that firm A operates in all three markets, while firm B is active only in the central market c and market 2. That is, firm A is the only seller in market 1 and, therefore, acts there as a monopolist. In the other markets, firm A competes with firm B. Notice that the above assumption implies heterogeneity across two firms in terms of their presence in a certain market, which is the only source of firm heterogeneity in the model. It is also worth noting that we do not consider in the present paper the mechanism of how firms choose which market to serve, the distribution of firms across the markets is exogenously given in the model.[7]

We also assume that each firm has exactly one store in market 2 and in market c and firm A has one store in market 1. In other words, one can think about these firms as chains that operate in different markets (see Figure 2). We denote their respective stores by A_j, where $j \in \{1, 2, c\}$, and B_k with $k \in \{2, c\}$. Without the loss of generality, we assume that the stores of firm B (respectively A) are located at 0 (respectively 1) in each market. The firms sell homogeneous good produced according to a constant returns to scale technology with zero marginal and fixed costs of production. The assumption about zero marginal cost of production simplifies the analysis of the equilibrium in the model and at the same time does not affect the qualitative implications of the model and the intuition behind them. The firms do not face any capacity constraints and, hence, can serve any demand.

[7] As noted in section 3, this assumption is less strict for chains that use franchising.

Figure 2: Baseline model: Markets and firms



Consumers In each market $i \in \{1, 2, c\}$, there is a mass of consumers that are uniformly distributed over the $[0, 1]$ interval with density $n_i > 0$: that is, the total number of consumers in market i is n_i. We assume that consumers leave for two periods, $t = 1, 2$. Each consumer needs one unit of a good per period, and this unit gives her the value of $v > 0$. In the first period (that can be viewed as a weekend, for instance), consumers from the peripheral markets can shop only in their "home" markets. In the second period (working days), the half of consumers *from each periphery market* travels to the central market and makes purchases there. This assumption can be interpreted as that in each peripheral market there is a share of consumers who need to commute to the center during working days and cannot postpone their purchases until returning to the home market. In the model, we normalize this share to $1/2$. On the one hand, this allows us avoiding unnecessary complications in the model. On the other hand, this assumption does not seem too restrictive, as the effects of a change in this share on the equilibrium outcome can be at least partly (if not completely) represented by the effects of corresponding changes in the market densities n_i. For instance, a rise in the share of "commuters" makes the presence of "peripheral" consumers in the central market more pronounced, which in turn can be achieved by reducing the relative size of the central market. Consumers from the central market always make their purchases in their home market and, thereby, never travel.

In each market, each consumer is characterized by location $x \in [0, 1]$. As in a standard Hotelling model, to reach a certain store in her home market located at $l \in \{0, 1\}$, she needs to pay the cost of $\tau\,|x - l|$, where $\tau > 0$ holds. In the central market, each commuter arrives at location

$y \in [0, 1]$, which is uncorrelated with her home location x, and all commuters are uniformly distributed over the $[0, 1]$ interval. Similarly, to reach a certain store in the central market, a commuter at y needs to pay the cost of $\tau \left|y - l\right|$.

Information and pricing We define by p_{Aj} and p_{Bk} prices set by firms A and B in the markets with $j \in \{1, 2, c\}$ and $k \in \{2, c\}$. We assume that consumers *know prices only in their home market*. Namely, they observe (1) p_{A1} in market 1, (2) p_{A2} and p_{B2} in market 2, and (3) p_{Ac} and p_{Bc} in market c. When commuters arrive to market c, they generally do not have information about p_{Ac} and p_{Bc}, but form expectations about them. We denote these expected prices by $\tilde{p}_{Ac}$ and $\tilde{p}_{Bc}$, respectively, and assume that they do not depend on consumers' identities.

Firms set prices to maximize their profits over two periods. We consider two pricing strategies. First, a firm can set different prices in different markets. We denote this strategy as ***flexible pricing***. In this case, the prices set by the firm in peripheral markets are not informative about the prices it sets in the central market. Alternatively, a firm can choose to set identical prices in all the markets (for instance, $p_{A1} = p_{A2} = p_{Ac} \equiv p_A$). We refer to this strategy as ***uniform pricing***.[8] Under such a strategy, the price in the peripheral markets set by the firm, using this strategy, is perfectly informative about the price set by that firm in the central market. We assume that both firm's pricing strategy and prices are set for two time periods, i.e., the firms commit to their choices.

The game proceeds in two stages.

STAGE 1:

Firm A and firm B simultaneously choose their pricing strategy (flexible or uniform) and commit to it.

STAGE 2:

1. The firms set prices in all markets simultaneously and non-cooperatively.

2. Consumers observe prices set by the firms in their home markets:

    - $t = 1$: Given these prices, consumers decide which store to visit in their home market.

[8] In the paper, we assume away firm strategies, when uniform pricing is "partial" – identical prices are set on the subset of the markets.

- $t = 2$: The half of consumers, or commuters, travel from the periphery to the central market. Given her beliefs, each commuter chooses which store to visit in market c. Consumers who stay at their home locations, shop exactly like at $t = 1$.

We solve the game by backward induction. At *Stage 2*, we consider a sequential equilibrium that can be defined as follows.

Definition. *The equilibrium at Stage 2 is a collection of prices* $\mathrm{p} = \{p_i\}_{i\in\{A1,A2,Ac,B2,Bc\}}$ *and beliefs* $\tilde{\mathrm{p}} = \{\tilde{p}_i\}_{i\in\{Ac,Bc\}}$ *such that:*

- *each consumer maximizes her utility given* p *and* $\tilde{\mathrm{p}}$*,*
- p *maximizes firms' profits given* $\tilde{\mathrm{p}}$*, and*
- *beliefs are consistent, i.e.,* $\mathrm{p} = \tilde{\mathrm{p}}$.

At *Stage 1*, we consider a Nash equilibrium. In the next subsection, we characterize the aggregate consumer demand in the model.

4.2 Demand Characterization

As the first step in deriving the equilibrium at *Stage 2*, we represent the aggregate demand for the product sold by each store in each market as a function of observed firms' prices and consumers' beliefs about the unobserved prices.

4.2.1 The Peripheral Markets

We start with the peripheral markets. In market 1, there is only one store of firm A located at 1. Thus, a consumer located at x buys from it if and only if (we normalize the utility in the case of zero consumption of the good to zero):

$$v - p_{A1} - \tau(1 - x) \geq 0 \Longleftrightarrow$$
$$\frac{p_{A1} - v}{\tau} + 1 \leq x.$$

As a result, the aggregate demand in market 1 (here, we take into account consumer demand in both periods) is given by

$$D^1(p_{A1}) = \begin{cases} 0 & , p_{A1} > v, \\ \frac{3n_1}{2}\left(\frac{v - p_{A1}}{\tau}\right) & , p_{A1} \in [v - \tau, v], \\ \frac{3n_1}{2} & , p_{A1} < v - \tau, \end{cases} \tag{1}$$

where the coefficient $3/2$ captures the fact that at $t = 2$ one-half of the consumers leave market 1 and travel to market c. Later in the paper, we determine the condition on the parameters such that $v \geq p_{A1} + \tau$ in the equilibrium, implying that all consumers in market 1 purchase the good.

In market 2, the firms compete with each other. A consumer located at x chooses to purchase the product in the store of firm B if and only if:

$$v - p_{B2} - \tau x \geq v - p_{A2} - \tau(1 - x) \Longleftrightarrow x \leq \frac{p_{A2} - p_{B2} + \tau}{2\tau}$$

and

$$v - p_{B2} - \tau x \geq 0.$$

The latter inequality holds if

$$v - p_{B2} \geq \frac{p_{A2} - p_{B2} + \tau}{2} \Longleftrightarrow v \geq \frac{p_{A2} + p_{B2} + \tau}{2}. \tag{2}$$

If the inequality in (2) takes place, then, given the prices, all consumers purchase the good either from firm A or firm B. In the paper, we consider the equilibrium where this is the case and formulate later the corresponding constraint on the parameters. Checking for corner solutions, we obtain that the aggregate demand for the good sold by firm i in market 2 is given by:

$$D^{i,2}(p_{i2}, p_{j2}) = \begin{cases} 0 & , p_{i2} > p_{j2} + \tau, \\ \frac{3n_2}{2}\left(\frac{p_{j2} - p_{i2} + \tau}{2\tau}\right) & , p_{i2} \in \left[p_{j2} - \tau, p_{j2} + \tau\right], \\ \frac{3n_2}{2} & , p_{i2} < p_{j2} - \tau, \end{cases} \tag{3}$$

where $i, j \in \{A, B\}$ and $i \neq j$.

4.2.2 *The Central Market*

The aggregate demand functions for the good sold in the central market have two ingredients. First, there are local consumers who are aware of the prices set by the firms in this market. As for market 2, the aggregate demand over two time periods of these consumers can be written as follows (recall that these consumers shop only in their home market):

$$D^{i,c}\left(p_{ic}, p_{jc}\right) = \begin{cases} 0 & , p_{ic} > p_{jc} + \tau, \\ 2n_c \left(\frac{p_{jc} - p_{ic} + \tau}{2\tau}\right) & , p_{ic} \in \left[p_{jc} - \tau, p_{jc} + \tau\right], \\ 2n_c & , p_{ic} < p_{jc} - \tau, \end{cases}$$

where $i, j \in \{A, B\}$ and $i \neq j$. Similarly to the assumption about the prices set by the firms at market 2, we assume that

$$v \geq \frac{p_{Ac} + p_{Bc} + \tau}{2}. \tag{4}$$

Second, there are commuters form the peripheral markets. At the moment, we express their demand for the good sold by the firms in terms of their beliefs about the prices. In particular, we have that the aggregate demand of commuters is

$$D^{i,c}_{com}\left(\tilde{p}_{ic}, \tilde{p}_{jc}\right) = \begin{cases} 0 & , \tilde{p}_{ic} > \tilde{p}_{jc} + \tau, \\ \frac{n_1 + n_2}{2} \left(\frac{\tilde{p}_{jc} - \tilde{p}_{iC} + \tau}{2\tau}\right) & , \tilde{p}_{ic} \in \left[\tilde{p}_{jc} - \tau, \tilde{p}_{jc} + \tau\right], \\ \frac{n_1 + n_2}{2} & , \tilde{p}_{ic} < \tilde{p}_{jc} - \tau, \end{cases}$$

where $i, j \in \{A, B\}$ and $i \neq j$. As before, we assume that

$$v \geq \frac{\tilde{p}_{Ac} + \tilde{p}_{Bc} + \tau}{2}. \tag{5}$$

In the next section, we derive the equilibrium at *Stage 2*. Specifically, we find firms' optimal pricing and profits given the pricing strategies they choose at *Stage 1*.

4.3 The Aggregate Demand of Commuters

Next, we focus on consumers who arrive to market c from the periphery markets at $t = 2$. To characterize their demand, it is important to know the pricing strategies of both firms because they affect consumers' shopping decisions. Let us look at each of the four possible cases separately.

Both firms use flexible pricing In this case the price in a consumer's home market is not informative about the price in market c. A commuter located at y in market c chooses firm B if and only if

$$\begin{gathered} v - \tilde{p}_{Bc} - \tau y \geq v - \tilde{p}_{Ac} - \tau\left(1 - y\right) \Leftrightarrow \\ y \leq \frac{\tilde{p}_{Ac} - \tilde{p}_{Bc} + \tau}{2\tau}, \end{gathered}$$

where $\tilde{p}_{Ac}$ and $\tilde{p}_{Bc}$ indicate consumers' expectations about prices in market c set by firm A and firm B , respectively. Then, the aggregate demand of commuters can be characterized as follows:

$$D_c^{i,c}\left(\tilde{p}_{ic}, \tilde{p}_{jc}\right) = \begin{cases} 0 & , \tilde{p}_{ic} > \tilde{p}_{jc} + \tau \\ \frac{n_1+n_2}{2}\left(\frac{\tilde{p}_{jc}-\tilde{p}_{ic}+\tau}{2\tau}\right) & , \tilde{p}_{ic} \in \left[\tilde{p}_{jc} - \tau, \tilde{p}_{jc} + \tau\right] \\ \frac{n_1+n_2}{2} & , \tilde{p}_{ic} < \tilde{p}_{jc} - \tau, \end{cases}$$

where $i, j \in \{A, B\}$ and $i \neq j$.

Only one firm uses flexible pricing Now, assume firm A sticks to uniform pricing but firm B still uses flexible pricing. This means that p_{A1} and p_{A2}, which are equal to each other, are perfectly informative about p_{Ac}, that is, $p_{Ak} = p_A$ for $k \in \{1, 2, c\}$. At the same time, $\tilde{p}_{Bc}$ remains unknown for commuters. A commuter located at y chooses firm B if and only if

$$\begin{gathered} v - \tilde{p}_{Bc} - \tau y \geq v - p_A - \tau\left(1 - y\right) \Leftrightarrow \\ y \leq \frac{p_A - \tilde{p}_{Bc} + \tau}{2\tau} \end{gathered}$$

and we can characterize the aggregate demand:

$$D_c^{B,c}\left(p_A, \tilde{p}_{Bc}\right) = \begin{cases} 0 & , \tilde{p}_{\mathrm{BC}} > p_A + \tau \\ \frac{n_1+n_2}{2}\left(\frac{p_A-\tilde{p}_{Bc}+\tau}{2\tau}\right) & , \tilde{p}_{Bc} \in \left[p_A - \tau, p_A + \tau\right] \\ \frac{n_1+n_2}{2} & , \tilde{p}_{\mathrm{BC}} < p_A - \tau \end{cases}$$

$$D_c^{A,c}\left(p_A, \tilde{p}_{Bc}\right) = \begin{cases} 0 & , p_A > \tilde{p}_{Bc} + \tau \\ \frac{n_1+n_2}{2}\left(\frac{\tilde{p}_{Bc}-p_A+\tau}{2\tau}\right) & , p_A \in \left[\tilde{p}_{Bc} - \tau, \tilde{p}_{Bc} + \tau\right] \\ \frac{n_1+n_2}{2} & , p_A < \tilde{p}_{Bc} - \tau. \end{cases}$$

When firm B adopts uniform pricing but firm A sets market-specific prices, the aggregate demand looks differently. Now, commuters arriving from market 2 perfectly observe p_B because firm B posts the same price in their home location. They choose firm B in market c if and only if

$$\begin{gathered} v - p_B - \tau y \geq v - \tilde{p}_{Ac} - \tau\left(1-y\right) \Leftrightarrow \\ y \leq \frac{\tilde{p}_{Ac} - p_B + \tau}{2\tau} \end{gathered}$$

which results in:

$$D_{c,2}^{B,c}\left(\tilde{p}_{Ac}, p_B\right) = \begin{cases} 0 & , p_B > \tilde{p}_{Ac} + \tau \\ \frac{n_2}{2}\left(\frac{\tilde{p}_{Ac}-p_B+\tau}{2\tau}\right) & , p_B \in \left[\tilde{p}_{Ac} - \tau, \tilde{p}_{Ac} + \tau\right] \\ \frac{n_2}{2} & , p_B < \tilde{p}_{Ac} - \tau \end{cases}$$

$$D_{c,2}^{A,c}\left(\tilde{p}_{Ac}, p_B\right) = \begin{cases} 0 & , \tilde{p}_{Ac} > p_B + \tau \\ \frac{n_2}{2}\left(\frac{p_B-\tilde{p}_{Ac}+\tau}{2\tau}\right) & , \tilde{p}_{Ac} \in \left[p_B - \tau, p_B + \tau\right] \\ \frac{n_2}{2} & , \tilde{p}_{Ac} < p_B - \tau \end{cases}$$

At the same time, commuters who arrive from market 1 where firm B is not present, remain uninformed about p_B and must rely on their expectations when choosing what shop to visit:

$$D_{c,1}^{B,c}\left(\tilde{p}_{Ac}, \tilde{p}_B\right) = \begin{cases} 0 & , \tilde{p}_B > \tilde{p}_{Ac} + \tau \\ \frac{n_1}{2}\left(\frac{\tilde{p}_{Ac} - \tilde{p}_B + \tau}{2\tau}\right) & , \tilde{p}_B \in \left[\tilde{p}_{Ac} - \tau, \tilde{p}_{Ac} + \tau\right] \\ \frac{n_1}{2} & , \tilde{p}_B < \tilde{p}_{Ac} - \tau \end{cases}$$

$$D_{c,1}^{A,c}\left(\tilde{p}_{Ac}, \tilde{p}_B\right) = \begin{cases} 0 & , \tilde{p}_{Ac} > \tilde{p}_B + \tau \\ \frac{n_1}{2}\left(\frac{\tilde{p}_B - \tilde{p}_{Ac} + \tau}{2\tau}\right) & , \tilde{p}_{Ac} \in \left[\tilde{p}_B - \tau, \tilde{p}_B + \tau\right] \\ \frac{n_1}{2} & , \tilde{p}_{Ac} < \tilde{p}_B - \tau. \end{cases}$$

Both firms use uniform pricing When both firms adopt uniform pricing, consumers who arrive from market 2 can immediately infer prices in market c, i.e., there is no uncertainty about p_{Ac} and p_{Bc}. Such commuters behave exactly like consumers residing in market c, and their aggregate demand looks as follows:

$$D_{c,2}^{i,c}\left(p_A, p_B\right) = \begin{cases} 0 & , p_i > p_j + \tau \\ \frac{n_2}{2}\left(\frac{p_j - p_i + \tau}{2\tau}\right) & , p_i \in \left[p_j - \tau, p_j + \tau\right] \\ \frac{n_2}{2} & , p_i < p_j - \tau \end{cases}$$

where $i, j \in \{A, B\}$ and $i \neq j$. Commuters arriving from market 1 know only p_A and must form expectations about p_B, which is similar to some of the cases we have studied above. The aggregate demand of such consumers is given by:

$$D_{c,1}^{B,c}\left(p_A, \tilde{p}_B\right) = \begin{cases} 0 & , \tilde{p}_B > p_A + \tau \\ \frac{n_1}{2}\left(\frac{p_A - \tilde{p}_B + \tau}{2\tau}\right) & , \tilde{p}_B \in \left[p_A - \tau, p_A + \tau\right] \\ \frac{n_1}{2} & , \tilde{p}_B < p_A - \tau \end{cases}$$

$$D_{c,1}^{A,c}\left(p_A, \tilde{p}_B\right) = \begin{cases} 0 & , p_A > \tilde{p}_B + \tau \\ \frac{n_1}{2}\left(\frac{\tilde{p}_B - p_A + \tau}{2\tau}\right) & , p_A \in \left[\tilde{p}_B - \tau, \tilde{p}_B + \tau\right] \\ \frac{n_1}{2} & , p_A < \tilde{p}_B - \tau. \end{cases}$$

4.4 Optimal Pricing Strategies

To characterize the optimal pricing strategies of the firms, we apply backward induction. First, we solve for an equilibrium of Stage 2 (profit maximization) for each of the four possible combinations of pricing strategies. Second, we focus on *Stage 1* and find a Nash equilibrium of the game where the firms choose their pricing strategies independently and simultaneously.

4.4.1 The Equilibrium of Stage 2

To illustrate how we find the equilibrium of *Stage 2*, let us focus on the case when both firms use flexible pricing. We impose the following constraints on prices in order to make the problem non-trivial:

$$\begin{cases} p_{A1} \leq v & \\ p_{i2} \in \left[p_{j2} - \tau,\ p_{j2} + \tau\right] & ,\ \forall\ i \neq j \text{ where } i,\ j \in \{A,\ B\} \\ p_{ic} \in \left[p_{jc} - \tau,\ p_{jc} + \tau\right] & ,\ \forall\ i \neq j \text{ where } i,\ j \in \{A,\ B\} \\ v - \max\left\{p_{A2},\ p_{B2}\right\} - \tau \geq 0 & \\ v - \max\left\{p_{Ac},\ p_{Bc}\right\} - \tau - z \geq 0 & \end{cases} \tag{6}$$

The first inequality indicates that for given p_{A1}, firm A does not face zero demand in market 1. The next two inequalities ensure that *in equilibrium* no firm faces zero demand in market 2 and market c, respectively. The last two inequalities guarantee that *all* consumers want to buy the good in market 2 and market c, respectively. Then, under flexible pricing firm A solves (condition (6) is verified later):

$$\max_{p_{A1},\, p_{A2},\, p_{Ac} \geq 0} \left\{ \pi_A^{FF} = \frac{3n_1}{2}\left(\frac{v - p_{A1}}{\tau}\right)p_{A1} + \frac{3n_2}{2}\left(\frac{p_{B2} - p_{A2} + \tau}{2\tau}\right)p_{A2} \right.$$
$$\left. \left(2n_c\left(\frac{p_{Bc} - p_{Ac} + \tau}{2\tau}\right) + \frac{n_1 + n_2}{2}\left(\frac{\tilde{p}_{Bc} - \tilde{p}_{Ac} + \tau}{2\tau}\right)\right)p_{Ac} \right\},$$

where the first (resp. second) entry refers to consumers who shop in market 1 (resp. 2) in both periods and the third entry corresponds to consumers who shop in market c where commuters arrive at $t = 2$. Firm B, which operates only in market 2 and market c, solves:

$$\max_{p_{B1}, p_{B2}, p_{Bc} \geq 0} \left\{ \pi_B^{FF} = \frac{3n_2}{2} \left(\frac{p_{A2} - p_{B2} + \tau}{2\tau} \right) p_{B2} + \right.$$

$$\left. \left(2n_c \left(\frac{p_{Ac} - p_{Bc} + \tau}{2\tau} \right) + \frac{n_1 + n_2}{2} \left(\frac{\tilde{p}_{Ac} - \tilde{p}_{Bc} + \tau}{2\tau} \right) \right) p_{Bc} \right\}.$$

Since under flexible pricing the price set in market 1, where only firm A operates, does not affect the other markets, solving for p_{A1} is the easiest. Take the derivative of π_A^{FF} with respect to p_{A1}

$$\frac{\partial \pi_A^{FF}}{\partial p_{A1}} = \frac{3n_1}{2\tau} \left(v - 2p_{A1} \right).$$

Setting $\frac{\partial \pi_A^{FF}}{\partial p_{A1}} = 0$ and solving this for p_{A1}, we obtain:[9]

$$p_{A1} = \frac{v}{2} > 0.$$

This solution is always compatible with condition (6), and we can compute the aggregate demand of local consumers in market 1 for such p_{A1}:

$$D_l^1 \left(p_{A1} = \frac{v}{2} \right) = \begin{cases} \frac{3n_1}{2} \left(\frac{v}{2\tau} \right) & , v < 2\tau \\ \frac{3n_1}{2} & , v \geq 2\tau. \end{cases}$$

For $v < 2\tau$, this aggregate demand is strictly positive but smaller than $\frac{3n_1}{2}$, so the solution of firm A's profit maximization program with respect to p_{A1} is interior. When $v \geq 2\tau$ holds, setting $p_{A1} = v - \tau$ is optimal – at this price, all consumers in market 1 make purchases, and the profit of firm A achieves its maximum with respect to p_{A1} (in this case, $p_{A1} = \frac{v}{2}$ is not feasible). To make the analysis tractable, let us assume that v is sufficiently large, and all consumers buy from firm A in market 1:

$$v \geq 2\tau \tag{7}$$

that leads to $p_{A1} = v - \tau$ in case when firm A sticks to flexible pricing. The following proposition characterizes the equilibrium of *Stage 2* when both firms use flexible pricing.

[9] Since π_A^{FF} is strictly concave in p_{A1}, this corresponds to interior optimum.

Proposition 1. *Suppose conditions (6) and (7) hold and both firms use flexible pricing. Then, the equilibrium price vector is:*

$$\begin{aligned} p_{A1}^{FF} &= v - \tau \\ p_{A2}^{FF} &= p_{B2}^{FF} = \tau \\ p_{Ac}^{FF} &= p_{Bc}^{FF} = \tau + \frac{\tau\left(n_1 + n_2\right)}{4} \end{aligned}$$

and the firms earn

$$\begin{aligned} \left(\pi_A^{FF}\right)^* &= \frac{3n_1}{2}\left(v - \tau - c\right) + \frac{3n_2\tau}{4} + \frac{\tau\left(n_1 + n_2 + 4\tau n_c\right)^2}{16n_c} \\ \left(\pi_B^{FF}\right)^* &= \frac{3n_2\tau}{4} + \frac{\tau\left(n_1 + n_2 + 4\tau n_c\right)^2}{16n_c}. \end{aligned}$$

Proof. See Appendix. □

When both firms use flexible pricing, the only source of heterogeneity between them is market 1 that is unavailable to firm B. This explains why the firms' equilibrium profits differ. As we showed above, for v large enough all consumers who stay in market 1 buy the good from firm A. In this case, setting $p_{A1}^{FF} = v - \tau$ supports the largest possible aggregate demand (namely, $D_l^1\left(p_{A1}^{FF}\right) = \frac{3n_1}{2}$) and results in the highest profit firm A can extract from market 1 under flexible pricing. If we focus on market 2, then one can notice that the equilibrium prices there look exactly like in a standard Hotelling model with two firms and exogenous locations. In market c, commuters' expectations about p_{Ac} and p_{Bc} turn out to be important, and this increases the equilibrium price set by each firm by $\frac{\tau(n_1+n_2)}{4}$ compared to the price observed in market 2. Interestingly, p_{Ac}^{FF} and p_{Bc}^{FF} increase in n_1 and n_2, that is, more commuters lead to higher prices in market c, which is in line with empirical evidence.

Next, let us assume that both firms stick to uniform pricing. As before, we look for a *Stage 2* equilibrium where both firms face non-zero aggregate demand in all the markets where they operate. Formally, this requires:

$$
\begin{cases}
p_i \in \left[p_j - \tau,\, p_j + \tau\right] & ,\, \forall\, i \neq j \,\text{where}\, i,\, j \in \{A,\, B\} \\
v - p_A - \tau \geq 0 \\
v - p_B - \tau \geq 0,
\end{cases} \tag{8}
$$

where the second inequality implies that all consumers from market 1 buy from firm A. Then, the program of firm A looks as follows:

$$
\max_{p_A \geq 0} \left\{ \pi_A^{UU} = p_A \left(\frac{3n_1}{2} + \left(\frac{p_B - p_A + \tau}{2\tau} \right) 2\left(n_2 + n_c\right) + \frac{n_1}{2} \left(\frac{\tilde{p}_B - p_A + \tau}{2\tau} \right) \right) \right\}
$$

and firm B solves:

$$
\max_{p_B \geq 0} \left\{ \pi_B^{UU} = p_B \left(\left(\frac{p_A - p_B + \tau}{2\tau} \right) 2\left(n_2 + n_c\right) + \frac{n_1}{2} \left(\frac{p_A - \tilde{p}_B + \tau}{2\tau} \right) \right) \right\}.
$$

The following proposition characterizes a *Stage 2* equilibrium when both firms choose uniform pricing.

Proposition 2. *Suppose condition (8) holds and both firms use uniform pricing. Then, the equilibrium price vector is:*

$$
\begin{aligned}
p_A^{UU} &= \frac{4\tau\left(2n_1^2 + 17n_1\left(n_2 + n_c\right) + 12\left(n_2 + n_c\right)^2\right)}{\left(n_1 + 4n_2 + 4n_c\right)\left(n_1 + 12n_2 + 12n_c\right)}, \\
p_B^{UU} &= \frac{3\tau\left(3n_1 + 4n_2 + 4n_c\right)}{n_1 + 12n_2 + 12n_c}.
\end{aligned}
$$

and the firms earn:

$$
\begin{aligned}
\left(\pi_A^{UU}\right)^* &= 4\tau\left(\frac{2n_1 + 17n_1\left(n_2 + n_c\right) + 12\left(n_2 + n_c\right)^2}{\left(n_1 + 4n_2 + 4n_c\right)\left(n_1 + 12n_2 + 12n_c\right)}\right)^2, \\
\left(\pi_B^{UU}\right)^* &= \frac{9\tau\left(n_2 + n_c\right)\left(3n_1 + 4n_2 + 4n_c\right)^2}{\left(n_1 + 12n_2 + 12n_c\right)^2}.
\end{aligned}
$$

Proof. See Appendix. □

As one can see, this equilibrium looks much more complicated than what we get in Proposition 1 when both firms stick to flexible pricing. To illustrate that the set of parameters that support condition (8) is non-empty, let us focus on the following example. Take the case of $n_1 = n_2 = n_c \equiv n$ when all the markets have the same density of local consumers at each point of the unit interval. Then, the equilibrium price vector and the profits reduce to:

$$p_A^{UU} = \frac{112\tau}{75},\ p_B^{UU} = \frac{33\tau}{25},\ \left(\pi_A^{UU}\right)^* = \frac{2178n\tau}{625},\ \left(\pi_B^{UU}\right)^* = \frac{3136n\tau}{625}$$

and condition (8) holds if and only if

$$v \geq \max\left\{\frac{187\tau}{75}, \frac{58\tau}{25}\right\} = \frac{187\tau}{75},$$

which is definitely non-empty. Since both equilibrium prices and profits are continuous in n_1, n_2, and n_c, condition (8) must define a non-empty set in the neighborhood of $n_1 = n_2 = n_c \equiv n$.

When the firms use different pricing strategies, the equilibrium of *Stage 2* turns out to be even more complex. All technical details can be found in Appendix. To illustrate how such equilibria look like, let us again focus on the case of $n_1 = n_2 = n_c \equiv n$ when all the markets have the same density of local consumers at each point of the unit interval. Suppose only firm A adopts uniform pricing. As before, we assume that all consumers from market 1 buy from firm A, that is, $p_A \leq v - \tau$ holds. Then, the equilibrium looks as follows:

$$p_A^{UF} = \frac{67\tau}{43},\ p_{B2}^{UF} = \frac{55\tau}{43},\ p_{Bc}^{UF} = \frac{66\tau}{43}$$
$$\left(\pi_A^{UF}\right)^* = \frac{40401n\tau}{7396},\ \left(\pi_B^{UF}\right)^* = \frac{26499n\tau}{7396}$$

and it is well-defined (namely, both firms face non-zero demand from all consumers' types in all the markets where they are present) if and only if

$$v \geq \frac{110\tau}{43} > 2\tau.$$

When only firm B chooses uniform pricing, the equilibrium of Stage 2 is:

$$p_{A1}^{FU} = v - \tau,\ p_{A2}^{FU} = \frac{130\tau}{119},\ p_{Ac}^{FU} = \frac{156\tau}{119},\ p_B^{FU} = \frac{141\tau}{119}$$
$$\left(\pi_A^{FU}\right)^* = \frac{3n\left(10513\tau + 14161v\right)}{28322},\ \left(\pi_B^{FU}\right)^* = \frac{39762n\tau}{14161}$$

and this equilibrium is well-defined if and only if

$$v \geq \frac{275\tau}{119} > 2\tau.$$

4.5 The Equilibrium of Stage 1

To characterize the equilibrium of *Stage 1*, we start with two simple cases. First, we focus on a setting where $n_1 = n_2 = n_c \equiv n$ holds, that is, all the markets have the same density of local consumers at each point of the unit interval. Second, we let n_1 change but impose $n_2 = n_c = 1$ – this allows us to investigate how the size of the market where firm A acts a monopolist affects its choice of pricing strategy.

The case of $n_1 = n_2 = n_C \equiv n$. Suppose all the markets have the same density of local consumers at each point of the unit interval. The *Stage 1* game between firm A and firm B in normal form looks as follows

		Firm B F	Firm B U
Firm A	F	$\left(\pi_A^{FF}\right)^*, \left(\pi_B^{FF}\right)^*$	$\left(\pi_A^{FU}\right)^*, \left(\pi_B^{FU}\right)^*$
	U	$\left(\pi_A^{UF}\right)^*, \left(\pi_B^{UF}\right)^*$	$\left(\pi_A^{UU}\right)^*, \left(\pi_B^{UU}\right)^*$

where F and U correspond to flexible pricing and uniform pricing, respectively, and

$$\left(\pi_A^{FF}\right)^* = \frac{3n\left(\tau + v\right)}{2}, \left(\pi_B^{FF}\right)^* = 3n\tau, \left(\pi_A^{UU}\right)^* = \frac{3136n\tau}{625}, \left(\pi_B^{UU}\right)^* = \frac{2178n\tau}{625}$$

$$\left(\pi_A^{FU}\right)^* = \frac{3n\left(10513\tau + 14161v\right)}{28322}, \left(\pi_B^{UF}\right)^* = \frac{39762n\tau}{14161}$$

$$\left(\pi_A^{UF}\right)^* = \frac{40401n\tau}{7396}, \left(\pi_B^{FU}\right)^* = \frac{26499n\tau}{7396}$$

To ensure that both firms face non-zero demand in all the markets where they are present and all consumers' types buy the good *under all pricing schemes*, it must be:

$$v \geq \frac{110\tau}{43} = \tilde{v} \tag{9}$$

In the game between the two firms, we focus on a symmetric Nash equilibrium. First, we check when F turns out to be a dominant strategy for firm A, which requires:

$$\begin{cases} \left(\pi_A^{FF}\right)^* \geq \left(\pi_A^{UF}\right)^* \\ \left(\pi_A^{FU}\right)^* \geq \left(\pi_A^{UU}\right)^* \end{cases} \iff \begin{cases} v \geq \frac{9769\tau}{3698} = \hat{v}_1 \\ v \geq \frac{69105917\tau}{26551875} = \hat{v}_2 \end{cases}$$

where $\hat{v}_1 \geq \hat{v}_2$ and $\hat{v}_2 \geq \tilde{v}$ for any $\tau \geq 0$. If $v < \hat{v}_2$ holds, U is a dominant strategy for firm A. For $v \in [v_2, v_1)$, firm A chooses action U (resp. F) when firm B plays action F (resp. U). With $v \geq v_1$, F is a dominant strategy for firm A.

Second, we look at firm B for which F is a dominant strategy if and only if:

$$\begin{cases} \left(\pi_B^{FF}\right)^* \geq \left(\pi_B^{FU}\right)^* \\ \left(\pi_B^{UF}\right)^* \geq \left(\pi_B^{UU}\right)^* \end{cases} \iff \begin{cases} \frac{2721n\tau}{14161} \geq 0 \\ \frac{453387n\tau}{4622500} \geq 0 \end{cases}$$

and these inequalities hold for any $n, \tau \geq 0$. Then, we can summarize our findings in the following proposition.

Proposition 3. *Suppose condition (9) holds. Then, F is a dominant strategy for firm B, and the Nash equilibrium of Stage 1 depends on v:*

- *For $v \in [\tilde{v}, v_1)$, the Nash equilibrium of Stage 1 is (U, F), and*
- *For $v \geq v_1$, the Nash equilibrium of Stage 1 is (F, F).*

Given Proposition 3, we can take a closer look at the *Stage 2* prices that are going to be set by the firms in equilibrium (U, F) and equilibrium (F, F), respectively:

$$(\text{F}, \text{F}): \; p_{A1}^{FF} = v - \tau, \; p_{A2}^{FF} = p_{B2}^{FF} = \tau, \; p_{Ac}^{FF} = p_{Bc}^{FF} = \frac{3\tau}{2}$$

$$(\text{U}, \text{F}): \; p_A^{UF} = \frac{67\tau}{43}, \; p_{B2}^{UF} = \frac{55\tau}{43}, \; p_{Bc}^{UF} = \frac{66\tau}{43}$$

As one can see, the price firm A charges in market 2 and market C under uniform pricing is higher than both p_{A2}^{FF} and p_{Ac}^{FF} that correspond to equilibrium (F, F). Moreover, p_A^{UF} exceeds the prices firm B sets in the markets where competition is at place.

The case of $n_2 = n_c = 1$. Consider a setting where the size of market 1 can change. To ensure that both firms face non-zero demand in all the markets where they are present and all consumers' types buy the good *under all pricing schemes*, we must impose:

$$\begin{cases} v \geq \tilde{v} \\ n_1 \leq 5.0917 = \hat{n} \end{cases} \tag{10}$$

where

$$\tilde{v} = \max\left\{\frac{\tau(9+n_1)}{4}, \tau + \frac{\tau\left(18n_1^2 + 138n_1 + 240\right)}{2n_1^2 + 45n_1 + 211}, \tau + \frac{4\tau\left(2n_1^2 + 34n_1 + 48\right)}{(n_1+8)(n_1+24)}\right\}.$$

The following proposition characterizes the equilibrium of Stage 1 for all feasible parameters.

Proposition 4. *Suppose condition (10) holds. Then, there exist $\underline{n}_1 > 0$, $\bar{n}_1 \in \left(\underline{n}_1, \hat{n}\right)$ and $\underline{v} > 0$, $\bar{v} > \underline{v}$ such that:*

- *For $n_1 \in \left[0, \underline{n}_1\right)$, the Nash equilibrium of Stage 1 is (F, F) for any feasible v,*
- *For $n_1 \in \left[\underline{n}_1, \bar{n}_1\right)$, the Nash equilibrium of Stage 1 depends on v:*
  - *for $v \in [\tilde{v}, \bar{v})$, the Nash equilibrium of Stage 1 is (U, F), and*
  - *for $v \geq \bar{v}$, the Nash equilibrium of Stage 1 is (F, F),*
- *For $n_1 \in [\bar{n}_1, \hat{n}]$, the Nash equilibrium of Stage 1 can be in both pure and mixed strategies, which also depends on v:*
  - *for $v \in \left[\tilde{v}, \max\{\underline{v}, \tilde{v}\}\right)$, the Nash equilibrium of Stage 1 is (U, U),*
  - *for $v \in \left[\max\{\underline{v}, \tilde{v}\}, \bar{v}\right)$, the Nash equilibrium of Stage 1 is in mixed strategies, that is, each pure strategy profile is played with a non-zero probability,*
  - *for $v \geq \bar{v}$, the Nash equilibrium of Stage 1 is (F, F).*

Proof. See Appendix. □

As Proposition 4 indicates, uniform pricing is an equilibrium outcome if and only if (1) n_1 is not too small and not too large, and (2) v is rather low. Moreover, it is mainly firm A that chooses U in a pure strategy Nash equilibrium. Intuitively, the size of market 1 where firm A acts as a monopolist, as well as the surplus it can extract from local consumers there under flexible pricing, should be relatively low in order to make uniform pricing more attractive.

Since any action profile may be an equilibrium, thanks to mixed strategies, let us focus on prices that can be observed in the markets under different scenarios:

$$(\mathrm{F}, \mathrm{F}): \ p_{A1}^{FF} = v - \tau, \ p_{A2}^{FF} = p_{B2}^{FF} = \tau, \ p_{Ac}^{FF} = p_{Bc}^{FF} = \frac{\tau(n_1 + 5)}{4}$$

$$(\mathrm{U}, \mathrm{F}): \ p_A^{UF} = \frac{\tau\left(16n_1^2 + 165n_1 + 221\right)}{2n_1^2 + 45n_1 + 211}, \ p_{B2}^{UF} = \frac{3\tau\left(3n_1^2 + 35n_1 + 72\right)}{2n_1^2 + 45n_1 + 211}, \ p_{Bc}^{UF} = \frac{6\tau\left(3n_1^2 + 23n_1 + 40\right)}{2n_1^2 + 45n_1 + 211}$$

$$(\mathrm{F}, \mathrm{U}): \ p_{A1}^{FU} = v - \tau, \ p_{A2}^{FU} = \frac{2\tau\left(n_1^2 + 21n_1 + 108\right)}{27n_1 + 211},$$

$$p_{Ac}^{FU} = \frac{4\tau\left(n_1^2 + 17n_1 + 60\right)}{27n_1 + 211}, \ p_B^{FU} = \frac{\tau\left(4n_1^2 + 57n_1 + 221\right)}{27n_1 + 211}$$

$$(\mathrm{U}, \mathrm{U}): \ p_A^{UU} = \frac{4\tau\left(2n_1^2 + 34n_1 + 48\right)}{(n_1 + 8)(n_1 + 24)}, \ p_B^{UU} = \frac{3\tau(3n_1 + 8)}{n_1 + 24}.$$

We do not specifically look at action profile (F, U) because it only emerges as a result of mixing in equilibrium. All other action profiles, however, correspond to a Nash equilibrium in pure strategies for some parameters of the model. Let us first consider equilibrium (U, F) where firm A sticks to uniform pricing. Here, we always observe $p_A^{UF} > p_{B2}^{UF}$, but the relationship between p_A^{UF} and p_{Bc}^{UF} is ambiguous and depends on n_1 – actually, $p_A^{UF} < p_{Bc}^{UF}$ holds for n_1 small enough. At the same time, prices in market 2 always turn out to be higher than they would be in equilibrium (F, F), but in market c consumers enjoy lower prices under (U, F) if n_1 is sufficiently small.

Next, we focus on equilibrium (U, U) where both firms choose uniform pricing. One can easily show that $p_A^{UU} > p_B^{UU}$ holds for any feasible n_1:

$$p_A^{UU} > p_B^{UU} \Leftrightarrow \frac{\tau n_1 (40 - n_1)}{n_1^2 + 32n_1 + 129}.$$

In words, a bigger chain that has access to a market where it can act as a monopolist, prices higher than a smaller firm. If we compare equilibrium (U, U) to equilibrium (F, F), then one can notice that under (U, U) market 2 faces higher prices from both firms. In market c, however, $p_B^{UU} < p_{\mathrm{Bc}}^{FF}$ holds for any feasible n_1, and $p_A^{UU} < p_{\mathrm{Ac}}^{FF}$ requires n_1 to be small enough.

5. Data

Our data combine information on pharmacies' locations, assortment, and prices in Moscow, Russia.

First, we take information about locations of pharmacies from 2gis maps. Together with data on pharmacies, we collect other relevant market information from 2gis and the open data portal of Moscow government.

The information on assortment and prices is collected from a popular online platform, aptekamos.ru, that allows consumers to find drugs' availability and their prices in different pharmacy stores. Since the platform simplifies the search, the majority of chain pharmacies share information on their assortment and prices via this platform. In particular, 58% of drug stores under analysis are listed in aptekamos.ru website. Still, the information provision is voluntary which limits our sample to those affiliates that decide to be present.[10] We acknowledge that online prices can be different from offline ones (Cavallo, 2017), and therefore consider only a market of online pre-orders and, therefore, online search via platform aggregators,such as aptekamos.ru, or directly through a pharmacy's website.

When comparing uniform and flexible pricing chains, we limit our sample to those pharmacy chains that have at least four affiliates and provide their prices online.[11]

Potential differences in pricing may come from the quality of locations where pharmacy affiliates are placed. The comparison is presented in Table 4.

First, we look at the distribution of medical organizations across markets. When getting a prescription for a drug, a patient can decide not to search for cheaper prices and get her drug in the nearby drug store. Thus, we can expect that if the search is not relevant then a flexible pricing scheme is more likely to be observed.

Without considering the type of medical organization, we do not see any significant difference across markets covered by flexible or uniform pricing chains. However, when we look at the particular categories, we can notice that flexible pricing affiliates are better located in terms of their proximity to all medical organizations of non-stationary type but private medical centers. At

[10] Notably, two large pharmacy chains – "36,6" and "Apteki Stolichki" – were only recently listed on the platform so that we do not have full information on some of their affiliates.

[11] Among the smaller chains, only a few of them can be clearly identified as uniform-pricing ones, whereas for the rest we cannot find reliable information on prices.

TABLE 4: LOCATION QUALITY

	Pricing			Pricing		
	Flexible	Uniform	$p-$value	Flexible	Uniform	$p-$value
	Market defined by clustering			**Market defined by grid**		
Medical organizations						
Total	21.099	21.220	0.845	16.326	16.776	0.210
Public medical center	10.588	9.947	0.051	7.992	7.623	0.024
Private medical center	9.856	10.825	0.007	7.812	8.843	0.000
Adult polyclinic	0.484	0.439	0.058	0.383	0.328	0.002
Children polyclinic	0.327	0.281	0.017	0.260	0.231	0.077
Emergency room	0.144	0.115	0.029	0.114	0.087	0.014
Women clinic	0.257	0.209	0.010	0.193	0.149	0.002
Day hospital	0.289	0.244	0.040	0.241	0.197	0.009
Adult hospital	0.061	0.055	0.496	0.034	0.040	0.390
Children hospital	0.023	0.014	0.084	0.011	0.014	0.427
Oncology hospital	0.058	0.050	0.391	0.051	0.044	0.430
Health center	0.124	0.115	0.492	0.110	0.093	0.134
Specialized hospital	0.062	0.074	0.184	0.043	0.050	0.363
Military hospital	0.004	0.003	0.767	0.003	0.001	0.241
Dispensary	0.108	0.106	0.876	0.092	0.089	0.763
Shops						
Merchandise stores	126.017	131.655	0.286	104.413	107.705	0.450
Merchandise stores with aggregates molls	156.426	173.120	0.087	122.364	121.091	0.818
Big chain stores	34.797	37.180	0.083	28.450	30.210	0.080
Molls	107.270	106.894	0.924	77.507	78.653	0.425
Popular cheap grocery – ‘5ka’	2.065	1.900	0.052	1.682	1.475	0.000
Popular expensive grocery – ‘Azbuka vkusa’	0.150	0.197	0.004	0.144	0.201	0.000

Note: 26 uniform pricing pharmacies and 46 flexible pricing pharmacies.

the same time, for places with more serious treatments, such as adult or oncology hospitals, the difference is not significant.

Except for already mentioned in Section 3 differences in exposure to areas with cheap and expensive grocery stores, for other potential attraction points, as big chain stores or molls, there is no difference in markets of different types of pricing chains.

Uniform and flexible pricing competition Next we look at how uniform and flexible pricing affiliates are located with respect to each other (see Table 5). Affiliates of uniform pricing chains share market with other uniform pricing competitors less frequently and have a larger share of markets where all competitors apply flexible pricing.

Assortment We also try to uncover assortment differences across uniform and flexible pricing chains.

TABLE 5: JOINT LOCATIONS DISTRIBUTION OF UNIFORM AND FLEXIBLE PRICING CHAINS

	Pricing			Pricing		
	Flexible	Uniform	$p-$value	Flexible	Uniform	$p-$value
	Market defined by clustering			**Market defined by grid**		
N uniform pricing pharmacies	3.976	3.366	0.000	3.508	2.995	0.000
No uniform pricing pharmacies	0.108	0.154	0.000	0.097	0.113	0.137

Note: 1,895 affiliates of uniform pricing chains and 1,317 affiliates of flexible pricing chains. Net passenger outflow is the difference between passenger outflow and inflow.

TABLE 6: PRICE INDEX OF ASSORTMENT, AFFILIATE LEVEL

	Pricing			
	Flexible	Uniform	$p-$value	N
Price index, total	6.054	6.088	0.001	45294
By category				
Drugs	6.064	6.074	0.316	17041
Medical cosmetics	5.973	6.169	0.000	8469
Medical devices	6.167	6.094	0.000	5397
BAD	6.169	6.308	0.000	4754
Homeopathy	5.831	6.005	0.000	3602
Care products	5.547	5.556	0.667	2143
Hygiene products	5.797	5.881	0.000	1130
Food products	5.076	5.351	0.000	837
Therapeutic nutrition	6.680	6.388	0.000	140
Disinfectants	5.115	5.459	0.000	84
Other	5.951	5.752	0.000	1697

Note: A drug is defined at the level of its trade name, dosage, producer, and country.

Similarly to DellaVigna and Gentzkow (2019), we compute the average city-level price index for each pharmacy. In doing so, we first compute the average log price for each drug, and then compute the average price index at the chain affiliate level. Overall, products sold by uniform pricing chains are more expensive (see Table 6). Nonetheless, this difference is driven not by the main product category of pharmacies – drugs, rather by medical cosmetics, BADs, homeopathy and a number of other categories. At the same time, certain categories, as non-drug medical products as medical devices, we observe more expensive assortment for flexible pricing stores.

6. Reduced Form Analysis

In this section, we test some of our theoretical predictions on data.

Density of market 1 and uniform pricing As Proposition 4 suggests, one can observe uniform pricing only for intermediate values of density n_1 of the 'monopoly' market 1. Therefore, we predict the inverse U-shape relation between the share of 'monopoly' markets a chain is present in. Table 7 confirms this prediction. Thus, contrary to Dobson and Waterson (2005) we get a non-monotone relation of uniform pricing policy on the number of uncontested markets. This is crucial for explaining flexible pricing for chains that are present only in contested markets (with zero share of 'monopoly' markets).

Table 7: Share of 'monopoly' markets, probit

	Uniform
Constant	-0.5646^{**}
	(0.2489)
Share of 'monopoly' markets	12.70^{**}
	(6.384)
Share of 'monopoly' markets squared	-50.62^{*}
	(27.70)
Observations	64

Note: Significance levels: ***: 0.01, **: 0.05, *: 0.1.

Next, we turn to the relative prices of pharmacies across markets and chains.

Comparison of p_A^{UF} and p_{B2}^{UF} Results presented in Table 8 are in line with our prediction for contested markets, that is, that in periphery markets of type 2 uniform pricing chains set higher prices than their flexible pricing competitors – 2.1% higher for all products available at pharmacies and 2% higher for drugs specifically.

TABLE 8: RELATIVE PRICES OF UNIFORM AND FLEXIBLE PRICING CHAINS IN A CONTESTED MARKET

	log(*price*)	
	All products	Drugs only
Uniform pricing chain	0.0214***	0.0197***
	(0.0026)	(0.0028)
R^2	0.93159	0.93219
Observations	5,120,116	3,422,744
Product FE	✓	✓
Market FE	✓	✓
Product producer FE	✓	✓
Product origin FE	✓	✓

Note: We test if $p_A^{UF} > p_{B2}^{UF}$ for markets where uniform pricing chains compete with flexible pricing chains. The periphery is defined as outside the Third Ring – circle automobile road in the center of Moscow.

Comparison of p_A^{UF} and p_{BC}^{UF} For markets in the center of Moscow, we observe that a uniform price is not always higher than a flexible one – for a sufficiently low share of the 'monopoly' market uniform pricing chain sets lower prices in the center market than its competitors. In particular, the share of markets of type 1 should not exceed 7.4% (7.2%) when looking at all products (drugs) sold by pharmacies.

Comparison of prices in (U,F) and (F,F) equilibria in periphery Another prediction coming from Proposition 4 is that consumers face lower prices in markets of type 2 in (F,F) equilibrium. Whereas we do not observe the counterfactual prices for uniform pricing chains if they would set flexible prices, we compare the level of prices in markets with all chains setting flexible prices to markets of type 2 (see Table 10). The obtained results go in line with previous findings suggesting that uniform pricing softens competition in contested markets.

TABLE 9: RELATIVE PRICES OF UNIFORM AND FLEXIBLE PRICING CHAINS IN A CENTRAL MARKET

	log(*price*)	
	All products	Drugs only
Uniform pricing chain	-0.0711^{***}	-0.0483^{***}
	(0.0037)	(0.0039)
Share of 'monopoly' markets	0.9580^{***}	0.6671^{***}
	(0.0302)	(0.0328)
R^2	0.93234	0.93091
Observations	1,243,336	808,972
Product FE	✓	✓
Market FE	✓	✓
Product producer FE	✓	✓
Product origin FE	✓	✓

Note: We look the relation of p_A^{UF} and p_{Bc}^{UF} for central markets where uniform pricing chains compete with flexible pricing chains. The center is defined as inside the Third Ring – circle automobile road in the center of Moscow.

TABLE 10: RELATIVE PRICES OF UNIFORM AND FLEXIBLE PRICING CHAINS IN (U,F) AND (F,F) EQUILIBRIA, PERIPHERY

	log(*price*)	
	All products	Drugs only
(U,F) market	0.0099^{***}	0.0029^{*}
	(0.0014)	(0.0017)
R^2	0.93027	0.93112
Observations	5,537,958	3,716,332
Product FE	✓	✓
Product producer FE	✓	✓
Product origin FE	✓	✓

Note: We look the relation of p_{B2}^{UF} and p_{B2}^{FF}. The center is defined as inside the Third Ring – circle automobile road in the center of Moscow.

Comparison of prices in (U,F) and (F,F) equilibria in central markets Finally, in Table 11, we show that flexible pricing chains set 0.7% lower prices for drugs in the center, and as the average 'monopoly' power of present uniform pricing chains increases, prices in the center become larger than in central markets with flexible pricing only.

TABLE 11: RELATIVE PRICES OF UNIFORM AND FLEXIBLE PRICING CHAINS IN (U,F) AND (F,F) EQUILIBRIA, CENTER

	log(price)	
	(1)	(2)
(U,F) market	-0.0001	-0.0074^{***}
	(0.0017)	(0.0022)
Average share of 'monopoly' markets for U-firms	0.1937^{***}	0.2275^{***}
	(0.0104)	(0.0139)
R^2	0.94459	0.93608
Observations	422,639	276,208
id_drug fixed effects	✓	✓
cntrys fixed effects	✓	✓
firms fixed effects	✓	✓

Note: We look the relation of p_{Bc}^{UF} and p_{Bc}^{FF}. The center is defined as inside the Third Ring – circle automobile road in the center of Moscow.

7. CONCLUSION

This study analyzes the determinants of choice between uniform and flexible pricing strategies. The key difference to the previous studies is that we enlarge the support for the uniform pricing puzzle by treating the chain's local markets not like isolated islands but rather potentially interdependent in demand via the presence of commuters. Indeed, in the context of retail chains for many geographical markets it is hard to determine exact geographical borders, and assuming away commuting opportunities sharply limits the set of equilibria when uniform pricing can be preferred to price discrimination.

Depending on the trade-off between enlarging the chain's demand with the help of commuters and exploiting monopoly power in uncontested markets, our theoretical framework can rationalize rich patterns of relative local prices across pharmacies and markets observed in the data.

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A. Map of Moscow

By the end of the 1960s, Moscow was limited by the Moscow Automobile Ring Road (MKAD). In 1969, the city Zelenograd became officially the first 'enclave' part of Moscow outside the Moscow Automobile Ring Road (MKAD). Finally, substantial changes happened in 2011–2012 with the inclusion of Moscow's borders of a large area, so-called 'New Moscow', to the South-West of the city.

To make sure that our sample is rather homogenous in geographical and population characteristics, we limit our attention to 'old' Moscow borders that mostly coincide with the MKAD. Therefore, we exclude two big cities – Zelenograd and Troitsk – that are officially located in Moscow but are geographically remote and potentially different in demand. The same concerns hold for the 'New Moscow', which is still poorly connected to the city center via public transportation and is distinct not just geographically but also in population characteristics and urban organization.

Figure 3: The Moscow Automobile Ring Road (MKAD) and Moscow borders