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Estimating the Potential Effect of Multi-Market Contact on the Intensity of Competition

by

Alon Eizenberg, Dalia Shilian and Daniel D. Blanga

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בנין פרץ נפתלי, קמפוס האוניברסיטה העברית, הר הצופים, ירושלים 9190501
The Hebrew University Campus, MT. Scopus, 9190501 Jerusalem, Israel
www.falk.huji.ac.il

Estimating the Potential Effect of Multi-Market Contact on the Intensity of Competition*

Alon Eizenberg†
The Hebrew University of Jerusalem and CEPR

Dalia Shilian‡
Consumer Protection and Fair Trade Authority

Daniel D. Blanga§
The Hebrew University of Jerusalem

Abstract

Economic theory suggests that cross-market interactions affect the intensity of competition by aggregating Incentive Compatibility Constraints over markets. Building on this insight, we develop a structural econometric model of multimarket contact. We obtain empirical estimates of these constraints, and examine the effect of their aggregation on the range of prices that are sustainable in equilibrium. This approach identifies the potential effect of multimarket contact independently of whether this potential is actually realized, giving rise to meaningful counterfactual exercises despite the presence of multiple equilibria. We derive analytical results that associate the potential impact of multimarket contact with a "symmetric positioning" property. We further establish the connection between this property and the structure of demand in the relevant industries, motivating demand estimation as a key step in the analysis of multimarket contact. We apply our model to an observed case of multimarket contact in the Israeli food sector. Our estimates indicate that, in the studied case, the potential effect of this contact on prices and profits is small.

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†email: alon.eizenberg@mail.huji.ac.il ‡ email: Dalias@fta.gov.il § email: daniel.blanga@mail.huji.ac.il

1 Introduction

Multimarket contact occurs when the same set of competitors are present across multiple markets. Economists have long been concerned with a potential adverse effect of such contact on the intensity of competition. The economic theory underlying this effect was articulated in the seminal article of Bernheim and Whinston (1990, hereafter BW90). Sustaining prices above their competitive levels requires that Incentive Compatibility Constraints (ICC) hold, and multimarket contact results in the aggregation of each firms' constraints over markets. The question of interest is whether this aggregation allows higher prices to be sustained in equilibrium.

The answer to this question depends in intricate fashions on market-specific cost and demand parameters. We propose an empirical methodology that builds directly on this insight. We show that the components of firms' ICCs can be estimated given standard estimates of demand and an assumed (or estimated) conduct that characterizes the Data Generating Process. We then aggregate the estimated ICCs over the markets across which firms interact, and compare the set of supra-competitive prices that can be sustained with multimarket contact to the set of prices that can be sustained without it.

Importantly, this approach identifies the *potential*, rather than the *actual*, effect of multimarket contact. This is a natural consequence of the use of Supergames of competitive interaction. Supergame models typically have infinitely-many equilibria and so they do not uniquely predict which price equilibrium will be played. Satisfying ICCs that are associated with a particular price equilibrium is a necessary, but not a sufficient condition for this equilibrium to be played.[1] If multimarket contact relaxes the ICCs, it therefore has *the potential of supporting higher prices* — whether or not this potential is actually realized.

The extant empirical literature identifies the actual effect of observed changes in multimarket contact on observed (or estimated) margins. Our approach complements this familiar paradigm by providing a means of assessing the potential impact of multimarket contact even in cases where in-sample variation in multimarket contact is not available.

In particular, our approach allows one to assess the potential effect of multimarket contact that remains stable throughout the sample period. Another use for our method is to study the effect of hypothetical multimarket contact. Suppose that firms a and b operate in industry 1 while firms b and c operate in industry 2, and that firm a proposes to acquire firm c. This will create multimarket contact as firms a and b would then compete in both industries. The hypothetical merger can therefore affect prices despite having no impact on concentration in either industry. Our approach can quantify the magnitude of this potential price effect.[2]

[1]For example, firms may engage in a competitive Nash-in-prices equilibrium even if their ICCs hold with respect to less competitive outcomes.

[2]The issue of "conglomerate mergers" has a long history in the economics and antitrust literatures. See Ashenfelter, Hosken and Weinberg (2014) for an historical perspective.

Data and Identification requirements. The data that are necessary to implement our approach are those used to estimate the demand for differentiated products following Berry, Levinsohn and Pakes (1995, BLP). Namely, prices, quantities and product characteristics must be observed in the markets where firms overlap. The conditions for identifying the potential effect of multimarket contact match exactly those provided in Berry and Haile (2014) as sufficient for identifying demand systems and the competitive conduct that characterizes the Data Generating Process (DGP).

While we do not provide a formal identification argument, the intuition is that computing the ICC requires the firm's variable profit payoffs in three scenarios: on the equilibrium path, in an optimal one-shot deviation from this path, and when firms revert to competitive pricing following a deviation. Given demand estimates and a specific assumption (or identification) of the competitive conduct in the observed data, one can back out the marginal costs and compute variable profits under a wide range of scenarios — including these three.

Empirical strategy. Our method begins with demand estimation in the relevant industries. The next logical step is to also estimate the industry's conduct, allowing the computation of marginal costs and of the ICCs. In our empirical implementation to the Israeli food sector, we pursue a somewhat different approach: rather than estimating the competitive conduct characterizing the DGP, we instead assume that the data were generated by the competitive benchmark, i.e., Nash in prices. We then proceed to estimate the ICCs and explore whether multimarket contact expands the range of less competitive equilibria that could be sustained in equilibrium.

This approach bypasses the thorny challenge of identifying the industry conduct that prevails in the observed data, and leverages the fact that we study the potential, rather than the actual, effect of multimarket contact on the intensity of competition.[3] But in general, our approach is compatible with either estimating the conduct characterizing the DGP, or with using different assumptions regarding it, as may be suited for the application at hand.

Our model considers two markets (or industries) featuring the same two main competitors. Each market also features a fringe of smaller competitors, assumed to act competitively.[4] Our goal is to estimate the extent to which the leading firms' multimarket contact allows higher prices to be sustained in equilibrium.

Adapting the stylized models of BW90 to an empirical context requires several modeling choices. We use the Random Coefficient Logit model (BLP95) to describe the demand side of the market. On the supply side, we model a Supergame where past actions are perfectly observable before the next period play, and deviations from the behavior prescribed by the equilibrium strategies result in grim-trigger reversions to the most competitive behavior: Nash

[3]For a recent application estimating conduct parameters in the differentiated goods context, see Michel and Weiergraeber (2018).

[4]This assumption can also be easily modified to allow firms that are only present in one of the industries to engage in less competitive behavior.

in prices. We also assume that firms are characterized by bounded rationality: in computing the benefits and costs of deviation, they assume that current cost and demand conditions shall persist indefinitely. This simplification leads to transparent conditions that mimic those familiar from BW90, and does not appear to drive our empirical findings.

Unlike the setup in BW90, our empirical context features multi-product firms and so the definition of "higher prices" requires some care. To succinctly capture this notion, we assume that in the stage game, leading firms' pricing is governed by a "conduct parameter" denoted $\kappa \in [0, 1]$. As κ varies from zero to one, prices vary from their most competitive to their least competitive values. The conduct parameter is used here merely as a mechanical device that summarizes the distance of the market outcome from a competitive benchmark. In contrast to familiar applications of conduct parameters, our framework models the supply side using a repeated game rather than a static game, and is not subject to the Corts critique (Corts 1999).

We fix the firms' discount factor at a nontrivial value — i.e., a value under which the least-competitive behavior cannot be supported in a Subgame Perfect Nash Equilibrium (SPNE) of the Supergame absent multimarket contact. We then estimate the sets of (κ_1, κ_2) vectors — capturing the degree of departure from the competitive benchmark in both industries — that can be sustained in equilibrium with, and without multimarket contact. We use these sets to derive an estimate of the potential impact of multimarket contact on the intensity of competition.

Analytical results. While our method employs demand estimates to learn about the consequences of multimarket contact, the map from demand primitives to the role played by multimarket contact is far from obvious. This is particularly true in the presence of product differentiation, since it is then "...diffcult to say anything general about the welfare effect of the movement from the single-market outcomes to the multimarket solution" (BW90). We therefore provide not only an estimation routine and empirical results in a particular application, but also a sequence of analytical and simulation results that shed light on the relationship between demand primitives and the competitive impact of multimarket contact.

We begin by establishing a property to which we refer as "symmetric positioning" as an important driver of the competitive effect of multimarket contact. In the absence of this property, the largest departure from competition absent multimarket contact is located on the frontier of feasible departures with multimarket contact. When the symmetric positioning does not hold, therefore, the scope of impact from multimarket contact is severely limited right at the gate. Denoting the leading firms by a and b, "symmetric positioning" means that in one market, firm a can satisfy its ICC at a higher conduct parameter value than firm b, while in the other market, those roles are reversed. Intuitively, this property implies that slackness in ICCs can be allocated across markets via aggregation, allowing multimarket contact to affect prices.[5]

[5] This property is related to the "symmetric advantage" property in BW90. The property defined in our paper is different as it

The role played by the symmetric positioning property is established given shape restrictions on firms' flow profit functions. These shape restrictions are both consistent with the literature (e.g., BW90) and are also testable. Simulation analysis shows that profit functions implied by the Random Coefficient Logit (RCL) model of demand tend to satisfy these shape restrictions, but do not always do so. It is therefore important to verify in empirical applications whether the shape restrictions hold, as we do in our own application to the Israeli food sector.

The simulations also show that symmetric positioning is more likely to hold when each firm enjoys a *demand advantage* in a different market — where by "demand advantage" we refer to the situation where consumers value the firm's brand more than its rival brand. This combination of analytical and simulation results sharpens the intuition for the role played by demand primitives in determining the competitive effect of multimarket contact. It therefore also helps motivate how demand estimation informs the study of this competitive effect.

Empirical application. We take our approach to data from the Israeli food sector. We study two categories — Packaged hummus Salad and Instant Coffee — where the same two firms are the market leaders. Our estimates suggest that the potential effect of this multimarket contact on the intensity of competition is small. We interpret this finding as stemming, among other possible reasons, from the lack of a symmetric "demand advantage" across the two industries.

Following a brief literature review, section 2 presents the model. Section 3 presents the empirical application, while section 4 concludes.

Relationship to the literature. The strategic role of multimarket contact has received considerable attention. As reviewed in Evans and Kessides (1994, EK), some early analyses include Edwards (1955, in Scherer, 1980) and Kahn (1961). Empirical work has generally found multimarket contact to have a positive and significant impact on prices. EK94 exploit panel data to document the effect of changes over time in airlines' route overlaps, using fixed effects to control for time-invariant route characteristics. They contrast their approach with earlier work that focused on cross-sectional variation.[6] Ciliberto and Williams (2014) study multimarket contact in airline markets by estimating conduct parameters and explicitly relating them to variation in the extent of cross-market relationships.[7] Shim and Khwaga (2017) and Pus (2018) relate conduct parameters to observed variation in multimarket contact in the retail lumber and the freight industries, respectively.

In contrast to this literature, we do not exploit in-sample variation in the intensity of multimarket contact, and instead take the theory of BW90 directly to data. To the best of our knowledge, this is the first empirical study of multimarket contact to take this approach.

pertains directly to the ability to satisfy the ICCs rather than to a cost advantage.

[6]For example, Haggestad and Rhoades (1978), Whitehead (1978), Strickland (1984), Mester (1987), Feinberg and Sherman (1985), and Gelfand and Spiller (1987).

[7]See also Ciliberto, Watkins and Williams (2018).

The theory literature on Supergames of competitive interaction is vast and a complete survey of it is outside our scope. In these models, firms' strategies prescribe adhering to supra-competitive prices on the equilibrium path, and reverting to fierce price competition if deviations are detected. A seminal contribution was made by Friedman (1971) who assumed that past actions are perfectly observed and that deviations result in grim-trigger punishments of competitive (e.g., Cournot) pricing. Porter (1983) and Porter and Green (1984) allow for past actions that are not directly observed by rivals, so that a realized low price does not necessarily indicate a deviation. Rotemberg and Saloner (1986) introduce iid demand shocks and show that those are negatively correlated with the sustainable price level. Abreu (1986, 1988) derives optimal punishments that allow firms to sustain higher prices relative to simple grim-trigger mechanisms.

The idea of empirically estimating the components of firms' ICCs within such Supergames has been recently pursued by several authors. Goto and Iizuka (2016) estimate such quantities in the medical services industry. Igami and Sugaya (2017) assess the stability of the 1990s Vitamin cartels. Miller, Sheu and Weinberg (2018) estimate a price leadership model in the beer industry, and refer to ongoing work by Fan and Sullivan (2018). Our paper, which has developed independently of these contributions, shares some elements with those papers while focusing on a different question: the strategic role of multimarket contact.

2 Model

The model is presented in three steps. Section 2.1 outlines the supergame framework. Section 2.2 adds shape restrictions on firms' profit functions and establishes the role played by the *symmetric positioning* property in determining the potential competitive impact of multimarket contact. Section 2.3 embeds the Random coefficient Logit model of demand into the framework, and reports simulations results that establish a bridge between the *symmetric positioning* property and underlying demand primitives.

Taken together, these steps result in a theoretical framework that sheds light on the relationship between underlying demand properties and the impact of multimarket contact, and can be taken to data in the presence of differentiated products and multi-product firms, as we do below in the case of the Israeli food sector.

2.1 The Supergame framework

Consider a Supergame involving two industries (or markets) denoted by $m = 1, 2$. The markets feature product differentiation and multi-product firms. Two firms, denoted a and b, are present in each of the markets $m = 1, 2$. In each market there are also additional (different) competitors that are assumed to form a competitive fringe, noting that product differentiation keeps prices above marginal costs even for those firms. The set of competitors in each of the two industries is depicted in Figure 1.

Consistent with much of the theory literature surveyed above, we assume that past actions are perfectly observed before the next period play.[8] Deviations from equilibrium-path pricing result in reversion to competitive pricing — i.e., Nash-Bertrand pricing — forever, ruling out more sophisticated schemes such as the optimal punishments in Abreu (1986, 1988).Furthermore, and again consistent with much of the literature, we maintain that marginal costs are constant in output, and consider fixed costs, entry and exit decisions to be exogenous.[9]

The stage game. In stylized Supergame models, the stage game is often assumed to be identical over time — i.e., the same cost and demand conditions prevail in every period. This assumption considerably facilitates the exposition, but is inconsistent with our empirically-motivated framework that admits seasonality effects and other shocks that affect cost and demand.

To remedy this inconsistency, we refrain from assuming that the stage game is identical, but instead assume that firms are characterized by bounded rationality: at every period, when computing the discounted payoff streams from adhering to the equilibrium path, and from deviating, they simplify the computation by assuming that current cost and demand conditions shall prevail indefinitely.

The bounded rationality assumption has several benefits. First, it results in Incentive Compatibility Constraints that look exactly like those in the relevant theory literature, and, in particular, those in BW90. This results in an intuitive and transparent analysis of multimarket contact, whereas allowing firms to compute predictions regarding future shocks would complicate the math considerably. Second, the bounded rationality assumption is reasonable: firms are likely to make simplified, approximate calculations in determining real-world actions.

In practice, the bounded rationality assumption results in different calculations of the frontier of sustainable prices in every month. If this assumption was grossly misspecified, we might have expected our calculations regarding the effect of multimarket contact to be sensitive to the month in which they are performed. Our empirical analysis, however, yields the same qualitative (and very similar quantitative) conclusions in all 43 sample months, suggesting that little is lost by assuming away very complicated calculations on part of firms.

Another challenging aspect of real-world markets is the presence of multiproduct firms and product differentiation. BW90 allow each firm to sell a single product in each market and focus on homogeneous goods settings. When they do allow for product differentiation, they consider symmetric differentiation and hence symmetric price equilibria in each market. Consequently,

[8] In our empirical application (price setting in packaged-goods industries, observed in monthly data) this appears reasonable: while firms do not observe rivals' pricing directly, they are likely to become aware, fairly quickly, that a rival has cut prices substantially.

[9] Our assumptions are ubiquitous not only in stylized theory models but also in the empirical implementations of Supergames surveyed in the introduction.

the objects of interest — the highest sustainable prices with and without multimarket contact — are easy to define in their setup. In our empirical context, each firm sells a vector of non-symmetrically differentiated products in each market. It is then not immediately clear how to rank sustainable prices.

One could examine *any* vector of supra-competitive prices and compute the Incentive Compatibility Constraints (ICCs) associated with it. Given the unlimited number of such possibilities, we define a simple, one-dimensional statistic that captures, in each market, the distance between the prices that can be sustained in an SPNE, and the competitive benchmark of Nash Bertrand pricing. We denote this statistic as $\kappa_m \in [0,1]$ where $m = 1,2$ correspond to the two markets. We then compute the "frontiers" of vectors (κ_1, κ_2) that can be supported with and without multimarket contact, and work out a practical method for comparing these frontiers.

In practice, we restrict firms' strategies as follows. On the equilibrium path, pricing in each market $m = 1,2$ are determined "as if" firms were playing a static pricing game where each firm maximizes its own flow payoff function given its rivals' prices — but where firm a's payoff function places a weight of κ_m on the profits of firm b, and vice versa. Off the equilibrium path, these firms revert to the most competitive pricing by setting $\kappa_m = 0$. Importantly, firms' *actual* payoff functions place no weight on rivals' profits. The weight κ is merely a mechanical device that helps us define increasing levels of supra-competitive prices in a simple fashion.

The conventional use of conduct parameters in the empirical literature treats them as an "as-if" static model approximation to the true pricing behavior that may stem from a much more complicated dynamic model (Bresnahan 1989). Our use of conduct parameters is quite different: we study a Supergame, and use these parameters merely as a device that succinctly quantifies deviations from competitive pricing. This avoids the typical challenges associated with the use of conduct parameters. In particular, we do not estimate a conduct parameter model, and hence the Corts critique (Corts 1999) does not apply. Nonetheless, restricting attention to price vectors that are generated by this device does limit the scope of pricing possibilities that we can consider, and we continue to investigate this issue in ongoing work.[10]

Formally, we denote by p^{κ_m} the price vector set on the equilibrium path in each market $m = 1,2$ and define it as follows.

Definition 1. *On the equilibrium path, stage-game prices* p^{κ_m} *are determined as follows. Firm a's price vector is given by:*

$$p_a^{\kappa_m} = argmax_{p_a} \sum_{j \in \mathcal{J}_{a,m}} v_j(p_a, p_{-a}^{\kappa_m}) + \kappa_m \sum_{j \in \mathcal{J}_{b,m}} v_j(p_a, p_{-a}^{\kappa_m}),$$

[10] In recent work, Sullivan (2017) and Fan and Sullivan (2018) revisit the task of formally connecting static conduct parameters with a Supergame framework. Their work suggests that static conduct parameter equilibria do not necessarily capture all Pareto-optimal equilibria of the Supergame.

where $\mathcal{J}_{f,m}$ denotes the set of products sold by firm f in market m, $v_j(\cdot)$ denotes the variable profit generated by product j given a vector of market prices, and $p_{-a}^{\kappa_m}$ denotes the portion of market m's price vector that describes prices by firm a's rivals. Similarly, firm b's prices are given by

$$p_b^{\kappa_m} = argmax_{p_b} \sum_{j \in \mathcal{J}_{b,m}} v_j(p_b, p_{-b}^{\kappa_m}) + \kappa_m \sum_{j \in \mathcal{J}_{a,m}} v_j(p_b, p_{-b}^{\kappa_m}),$$

whereas the prices of any other firm $f \notin \{a, b\}$ are given by: $p_f^{\kappa_m} = argmax_{p_f} \sum_{j \in \mathcal{J}_{f,m}} v_j(p_f, p_{-f}^{\kappa_m})$.

Off the equilibrium path, i.e., following a deviation from the behavior prescribed above, all firms act like Nash-Bertrand competitors, and the resulting price vector in market m is denoted $p^{NB,m}$. Each firm f's price vector $p_f^{NB,m}$ then maximizes the expression $\sum_{j \in \mathcal{J}_{f,m}} v_j(p_f, p_{-f}^{NB,m})$.

The Incentive Compatibility Constraints. Consider a set of strategies for all firms such that market m's prices are given by p^{κ_m}, so long as a deviation did not occur in a previous period, and by $p^{NB,m}$ otherwise. Those strategies constitute an SPNE of the supergame if an Incentive Compatibility Constraint (ICC) holds for each of the firms a and b. Since all other firms are simply Nash players given any history, ICCs are only defined for the two leading firms.[11]

Consider first the ICCs that obtain when firms *do not internalize the multimarket contact*. Sustaining the price vector p^{κ_m} in market m requires that, for each firm a and b, the discounted stream of benefits from staying on the equilibrium path exceeds the benefits from a one-time deviation, followed by a competitive reversion. Formally, for each market $m = 1, 2$, and each firm $f \in \{a, b\}$, we define the following ICC, associated with a particular level of κ_m:

$$\Pi_{f,m}(\hat{p}_f^{\kappa_m}, p_{-f}^{\kappa_m}) + \frac{\delta_f}{1-\delta_f} \Pi_{f,m}(p^{NB,m}) \leq \frac{1}{1-\delta_f} \Pi_{f,m}(p^{\kappa_m}), \tag{1}$$

where $\Pi_{f,m}(p) = \sum_{j \in \mathcal{J}_{f,m}} v_j(p)$ is firm f's flow variable profit given some price vector p. This is the actual payoff of the firm, and it does not place any weight on the profit of a rival, stressing the point that our framework uses the "profit weight" κ_m only as a mechanical device that ranks supra-competitive profits in a well-defined fashion. Firm f's discount factor is denoted by δ_f. For simplicity, we do not let it vary across the two markets in which it operates, though this is not essential.[12] The price vector $\hat{p}_f^{\kappa_m} = argmax_{p_f} \Pi_{f,m}(p_f, p_{-f}^{\kappa_m})$ maximizes firm f's flow payoff if it deviates from the behavior prescribed by the equilibrium strategy given that all other firms adhere to the equilibrium strategies. Following such a deviation, the firm garners the Nash-Bertrand payoffs indefinitely.

[11] As long as prices are strategic complements, given $\kappa_m > 0$, the prices of those other firms would also be higher than those that would be set in a Nash-Bertrand equilibrium.

[12] See BW90 for a discussion of the possibility that a firm would apply different discount factors in different markets.

The ICC can be manipulated to obtain the threshold discount factor $\underline{\delta}_{f,m}(\kappa_m)$, defined as the lowest value of the discount factor that satisfies the firm's constraint:

$$\delta_f \geq \frac{\hat{\Pi}_{f,m} - \Pi_{f,m}}{\hat{\Pi}_{f,m} - \Pi_{f,m}^{NB}} \equiv \underline{\delta}_{f,m}(\kappa_m), \tag{2}$$

where we use the shorthand expressions $\hat{\Pi}_{f,m} \equiv \Pi_{f,m}(\hat{p}_f^{\kappa_m}, p_{-f}^{\kappa_m})$, $\Pi_{f,m} \equiv \Pi_{f,m}(p^{\kappa_m})$, and $\Pi_{f,m}^{NB} \equiv \Pi_{f,m}(p^{NB,m})$. In Section 2.2 we show, given additional structure, that the threshold $\underline{\delta}_{f,m}(\kappa_m)$ is increasing in κ_m: sustaining increasingly less competitive equilibria becomes more difficult in the sense that it requires higher discount factors..

Note also that $\hat{\Pi}_{f,m}, \Pi_{f,m}$ and $\Pi_{f,m}^{NB}$ correspond to profits evaluated given the prevailing cost and demand conditions in the relevant period. Firms' bounded rationality implies that these are the relevant quantities in the firm's ICC, since firms do not form expectations over future shocks to cost and demand when determining whether to remain on the equilibrium path, or deviate, in the current period, and instead set such expectations to zero.

Absent multimarket contact, sustaining specific levels (κ_1, κ_2) of supra-competitive prices in the two markets $m = 1, 2$, respectively, requires that condition (1) holds at each of the two markets $m = 1, 2$, and for each of the two firms $f = a, b$. So, in total, four ICCs need to hold.

We next allow firms a and b to *internalize their multimarket contact*, which, following BW90, considerably changes the strategic interaction. Firm a may now expect a Nash-Bertrand reversion in *both markets* $m = 1, 2$ if it were to deviate from the equilibrium in just one of them. Anticipating this, firm a should deviate in both markets. Consequently, both the benefits and the costs of deviation are aggregated over markets.

Formally, each firm $f \in \{a, b\}$ now has a single ICC with respect to a (κ_1, κ_2) outcome:

$$\sum_{m=1,2} \left[\Pi_{f,m}(\hat{p}_f^{\kappa_m}, p_{-f}^{\kappa_m}) + \frac{\delta_f}{1-\delta_f} \Pi_{f,m}(p^{NB,m}) \right] \leq \sum_{m=1,2} \frac{1}{1-\delta_f} \Pi_{f,m}(p^{\kappa_m}). \tag{3}$$

The impact of multimarket contact on the equilibrium conditions is summarized below.

Definition 2. *If firms do not internalize their multimarket contact, the (κ_1, κ_2) outcome is said to be supported in an SPNE of the Supergame if condition (1) holds for each market $m = 1, 2$, and for each firm $f \in \{a, b\}$. If firms do internalize their multimarket contact, the (κ_1, κ_2) outcome is supported if condition (3) holds for each firm $f \in \{a, b\}$.*

Our analysis of multimarket contact shall compare the set of (κ_1, κ_2) vectors that can be supported in equilibrium with multimarket contact, to the set of vectors that can be supported without it. In the following section we impose shape restrictions on firms' profit functions that sharpen the characterization of these (κ_1, κ_2) sets.

2.2 Additional structure and analytical results

We next place shape restrictions on firms' profit functions and derive a sequence of analytical results. These results not only help us to characterize the sets of supportable (κ_1, κ_2) vectors, but also establish the role of a property to which we refer as "symmetric positioning" in determining the potential impact of multimarket contact.

We place restrictions on the functions that describe firms' flow variable profits on the equilibrium path, and given an optimal one-shot deviation from that equilibrium, respectively. The restrictions focus on the relationship between those profits and the equilibrium level of κ_m, the divergence from competitive behavior on the equilibrium path. We therefore redefine firm f's profit functions (with a slight abuse of notation) to explicitly depend on this parameter: $\Pi_{f,m}(\kappa) \equiv \Pi_{f,m}(p^\kappa)$, $\hat{\Pi}_{f,m}(\kappa) \equiv \Pi_{f,m}(\hat{p}^\kappa_f, p^\kappa_{-f})$.[13]

Assumption 1. *(i)* $\Pi(\kappa), \hat{\Pi}(\kappa)$ *are twice continuously differentiable.*

(ii) $\Pi'(0) > 0$.

(iii) $\Pi''(\kappa) < (1-\delta)\hat{\Pi}''(\kappa)$ *for all* $\kappa \in [0,1]$.

(iv) The sum of profits for firms a and b in each market $m = 1, 2$, $\Pi_{a,m}(\kappa) + \Pi_{b,m}(\kappa)$, *is strictly increasing and concave in* κ.

Importantly, parts (*iii*) and (*iv*) are testable and we indeed verify that they hold in our empirical application to the Israeli food sector. In fact, stronger requirements — the concavity of $\Pi(\cdot)$ and the convexity of $\hat{\Pi}(\cdot)$ — are satisfied in this application, and these stronger conditions also hold in the analysis of BW90. The shape restrictions embodied in Assumption 1 are therefore both testable, and in line with the theory literature.

Below we shall introduce the assumption that demand follows the Random Coefficient Logit (RCL) model (Berry 1994, BLP 1995). Internal consistency of our analysis would therefore require that the profit functions implied by RCL demand satisfy the shape restrictions of Assumption 1. While we verify that this is the case in our specific application, and in many simulations, we also found simulation results where the RCL model generated profit functions that violate these shape restrictions.

It is therefore important to test these restrictions when taking our model to data. When the shape restrictions are violated, it is still possible to obtain empirical estimates of the potential impact of multimarket contact using the methods developed below — but it would not be possible to use the analytical results developed in the current section to understand what economic primitives drive those estimates. Importantly, it is quite easy to verify whether the restrictions hold in a specific empirical context, as we show in our empirical implementation below.

[13] This causes no difficulty as long as there is a one-to-one relationship between the price vector and κ. The uniqueness of the price vector given a value of κ is only guaranteed under particular demand structures (see Caplin and Nalebuff (1991), Nocke and Schutz (2018)). We follow a long tradition in the empirical IO literature and assume the uniqueness of p^κ.

We next use the shape restrictions of Assumption 1 to derive a sequence of analytical results. We first define normalized profit functions that subtract the Nash-Bertrand profits: let $\pi_{f,m}(\kappa) = \Pi_{f,m}(\kappa) - \Pi_{f,m}(0)$ and $\hat{\pi}_{f,m}(\kappa) = \hat{\Pi}_{f,m}(\kappa) - \Pi_{f,m}(0)$ for any value of κ, each firm $f \in \{a, b\}$ and each market $m = 1, 2$. Note that all of the restrictions on $\Pi(\cdot)$ and $\hat{\Pi}(\cdot)$ in Assumption 1 hold for the normalized functions $\pi(\cdot)$ and $\hat{\pi}(\cdot)$ as well. Note also that, by definition, when $\kappa = 0$ we have $p^{NB} = p^0 = \hat{p}^0$, hence: $\pi(0) = \hat{\pi}(0) = 0$. Furthermore, we have that $\pi'(0) = \hat{\pi}'(0)$.

We further define the following function:

$$\phi_{f,m}(\kappa) = \pi_{f,m}(\kappa) - (1-\delta)\hat{\pi}_{f,m}(\kappa),$$

allowing us to rewrite firm f's ICC in market m, absent multimarket contact (equation (1)) by:

$$\phi_{f,m}(\kappa_m) \geq 0. \tag{4}$$

The firm's ICC when multimarket contact is accounted for (equation (3)) can also be re-written:

$$\phi_{f,1}(\kappa_1) + \phi_{f,2}(\kappa_2) \geq 0. \tag{5}$$

Lemma 1. *Given the Supergame model of section 2.1, and the additional structure in Assumption 1, the following results hold (omitting firm and market indices):*
(i) $\lim_{\kappa \to 0} \underline{\delta}(\kappa) = 0$
(ii) $\underline{\delta}'(\kappa) > 0$ *for all* $\kappa > 0$ *s.t.* $\phi(\kappa) \geq 0$
(iii) $\phi(\kappa)$ *single crosses zero.*

Proof. (i) Using l'hoptial rule we get:

$$\lim_{\kappa \to 0} \underline{\delta}(\kappa) = \lim_{\kappa \to 0} \frac{\hat{\pi}(\kappa) - \pi(\kappa)}{\hat{\pi}(\kappa)} = \lim_{\kappa \to 0} 1 - \frac{\pi(\kappa)}{\hat{\pi}(\kappa)} \stackrel{L}{=} \lim_{\kappa \to 0} 1 - \frac{\pi'(\kappa)}{\hat{\pi}'(\kappa)} = 1 - 1 = 0 \tag{6}$$

(ii) By Assumption 1(*iii*) ϕ is concave in κ. Also: $\underline{\delta}'(\kappa) = \frac{\hat{\pi}'(\kappa)\pi(\kappa) - \hat{\pi}(\kappa)\pi'(\kappa)}{\hat{\pi}(\kappa)^2}$, hence $\underline{\delta}'(\kappa) > 0 \iff \hat{\pi}'(\kappa)\pi(\kappa) - \hat{\pi}(\kappa)\pi'(\kappa) > 0$. Since $\pi(0) = \hat{\pi}(0)$ and $\pi'(0) = \hat{\pi}'(0)$, we get: $\hat{\pi}'(0)\pi(0) - \hat{\pi}(0)\pi'(0) = 0$. Differentiating the numerator yields:

$$\begin{aligned} &\hat{\pi}''(\kappa)\pi(\kappa) + \hat{\pi}'(\kappa)\pi'(\kappa) - \hat{\pi}'(\kappa)\pi'(\kappa) - \hat{\pi}(\kappa)\pi''(\kappa) = \hat{\pi}''(\kappa)\pi(\kappa) - \hat{\pi}(\kappa)\pi''(\kappa) \geq \\ &\hat{\pi}''(\kappa)\hat{\pi}(\kappa)(1-\delta) - \hat{\pi}(\kappa)\pi''(\kappa) = (\hat{\pi}''(\kappa)(1-\delta) - \pi''(\kappa))\hat{\pi}(\kappa) = -\phi''(\kappa)\hat{\pi}(\kappa) > 0, \end{aligned} \tag{7}$$

where the first (weak) inequality is due to the focus on κ values that satisfy the firm's ICC, and the last inequality is due to concavity of ϕ.

(iii) It is easy to verify that $\phi(0) = 0$ and $\phi'(0) > 0$. The concavity of ϕ thus implies that if there exists $\tilde{\kappa}$ s.t. $\phi(\tilde{\kappa}) = 0$, then $\phi'(\kappa) < 0$ for every $\kappa \geq \tilde{\kappa}$, hence ϕ single crosses zero.

□

Lemma 1 carries several important takeaways. First, part (ii) implies that sustaining increasing levels of departure from the competitive benchmark becomes increasingly difficult, in the concrete sense of requiring higher levels of the discount factor. This feature motivates measuring the potential impact of multimarket contact via its impact on the κ levels that can be sustained in equilibrium given a fixed discount factor. Second, as long as $\delta > 0$, some departure from the competitive benchmark, however small, is always sustainable in equilibrium.

Third, part (iii) implies that if a firm's ICC is sustained at a given level of κ, it will also be sustained at any $\tilde{\kappa} < \kappa$. This motivates the following definition of the supportable conduct levels when firms do not internalize their multimarket contact.

Definition 3. *Fix the discount factor at some level δ.*

(i) denote by $\kappa_f(\delta) = (\kappa_{f,1}(\delta), \kappa_{f,2}(\delta))$ the largest vector of conduct levels $(\kappa_1, \kappa_2) \in [0,1]^2$ in each of the two markets that satisfies firm f's ICCs when it does not internalize the multimarket contact (i.e., the largest κ_m values satisfying (1) for $m = 1, 2$). The single-crossing property from Lemma 1 implies the uniqueness of $\kappa_f(\delta)$.

(ii) Let $\kappa_m(\delta) = \min_{f \in \{a,b\}} \kappa_{f,m}(\delta)$. Denote by $\kappa(\delta)$ the largest vector $(\kappa_1, \kappa_2) \in [0,1]^2$ that satisfies the ICCs of both firms $f = a, b$ when they do not internalize the multimarket contact:

$$\kappa(\delta) = \Big(\kappa_1(\delta), \kappa_2(\delta)\Big)$$

Simply put, when firms do not internalize multimarket contact, $\kappa_f(\delta)$ captures the biggest departure from competitive pricing that satisfies firm f's constraints, while $\kappa(\delta)$ is the largest departure that satisfies both firms' constraints — and is therefore sustainable in equilibrium. This departure takes the minimum over the departures allowed at the individual firm level. Taking the minimum is justified by the single crossing property established above — satisfying a firm's constraint at a given value of κ guarantees that it will be satisfied at any smaller value.

The conduct levels that are supportable absent multimarket contact are illustrated in Figure 2, displaying conduct levels for market 1, κ_1, on the horizontal axis, and conduct levels for market 2, κ_2, on the horizontal axis. The origin $(0, 0)$ corresponds to the Nash-Bertrand competitive benchmark. The vector $\kappa_a(\delta)$ shows the largest κ values that satisfy firm a's ICCs in both markets, while $\kappa_a(\delta)$ shows the same for firm b.

In the figure, firm a is able to support a larger departure from the competitive benchmark than firm b in market 2, while the reverse is true for market 1. We shall later define this property — each firm being able to support a larger κ than its rival in a different market — as "symmetric positioning." Finally, the vector $\kappa(\delta)$ shows the largest departure from the competitive benchmark that is feasible in equilibrium, since it satisfies the ICCs of both firms. This is the vector defined in part (ii) of definition 3.

We next define sets of κ vectors that satisfy the ICCs when multimarket contact is internalized.

Definition 4. *With multimarket contact, and for a fixed level of the discount factor δ:*

(i) For each firm $f \in \{a,b\}$, define the set of κ vectors that satisfy its individual ICC (3):

$$S_f(\delta) = \big\{(\kappa_1,\kappa_2) \in [0,1]^2 : \phi_{f,1}(\kappa_1) + \phi_{f,2}(\kappa_2) \geq 0\big\},$$

(ii) Define the "frontier" for the set $S_f(\delta)$:

$$F_f(\delta) = \big\{(\kappa_1,\kappa_2) \in [0,1]^2 : \phi_{f,1}(\kappa_1) + \phi_{f,2}(\kappa_2) = 0 \text{ or } \kappa_1 = 1 \text{ or } \kappa_2 = 1\big\}$$

(iii) Define the set of κ vectors that satisfies both firm's constraints:

$$S(\delta) = \bigcap_{f\in\{a,b\}} \big\{S_f(\delta)\big\}$$

(iv) Define the "frontier" of $S(\delta)$, $F(\delta)$, as the set of all $(\kappa_1,\kappa_2) \in S(\delta)$ that satisfy one of the following conditions:

1. $\phi_{a,1}(\kappa_1) + \phi_{a,2}(\kappa_2) = 0$ *or* $\phi_{b,1}(\kappa_1) + \phi_{b,2}(\kappa_2) = 0$
2. $\kappa_1 = 1$ *or* $\kappa_2 = 1$

Lemma 2. *(i) $\kappa_f(\delta) \in F_f(\delta)$*

(ii) $S_f(\delta)$ is a compact and convex set.

(iii) Recalling the definition of $(\kappa_{f,1},\kappa_{f,2})$ (Definition 3):

1. $(\kappa_1,\kappa_2) \in S_f(\delta)$ *for every* (κ_1,κ_2) *that satisfies* $\kappa_1 \leq \kappa_{f,1}$ *and* $\kappa_2 \leq \kappa_{f,2}$.
2. $(\kappa_1,\kappa_2) \notin S_f(\delta)$ *for every* (κ_1,κ_2) *that satisfies* $\kappa_1 > \kappa_{f,1}$ *and* $\kappa_2 > \kappa_{f,2}$.

Proof. (i) When either $\kappa_{f,1} = 1$ or $\kappa_{f,2} = 1$ this is true by definition. When $\kappa_{f,1} < 1$ and $\kappa_{f,2} < 1$ we have:

$$\phi_{f,1}(\kappa_{f,1}) = 0 \text{ and } \phi_{f,2}(\kappa_{f,2}) = 0 \Rightarrow \phi_{f,1}(\kappa_{f,1}) + \phi_{f,2}(\kappa_{f,2}) = 0 \Rightarrow \kappa_f(\delta) \in F_f(\delta) \tag{8}$$

(ii) Since $S_f(\delta) \subset [0,1]^2$, by continuity of $\phi(\cdot)$ we get that $S_f(\delta)$ is compact. By Assumption 1 $\phi(\cdot)$ is concave in κ, hence the sum of $\phi_{f,1}$ and $\phi_{f,2}$ is concave in (κ_1,κ_2) (and thus quasi-concave), hence $S_f(\delta)$ is a convex set.

(iii) Part (1). By Lemma 1 we know that $\phi_{f,m}$ single crosses zero. Hence $\phi_{f,1}(\kappa_1) \geq 0$ and $\phi_{f,2}(\kappa_2) \geq 0$, which implies $\phi_{f,1}(\kappa_1) + \phi_{f,2}(\kappa_2) \geq 0$ and so $(\kappa_1,\kappa_2) \in S_f(\delta)$.

Part (2). When either $\kappa_{f,1} = 1$ or $\kappa_{f,2} = 1$ this is true by definition (we restrict the analysis to $\kappa \in [0, 1]$). When $\kappa_{f,1} < 1$ and $\kappa_{f,2} < 1$, then $\phi_{f,m}(\kappa_{f,m}) = 0$ for $m = 1, 2$. The single-crossing property thus implies that $\phi_{f,m}(\kappa_m) < 0$, hence: $\phi_{f,1}(\kappa_1) + \phi_{f,2}(\kappa_2) < 0 \Rightarrow (\kappa_1, \kappa_2) \notin S_f(\delta)$.

□

The implications of Lemma 2 are illustrated in Figure 3. On the left, the figure displays $S_a(\delta)$, the set of κ vectors that satisfies firm a's constraint — an ICC that aggregates over both markets, along with its frontier $F_a(\delta)$. The figure shows that $\kappa_a(\delta)$, the largest vector that satisfies firm a's ICCs absent multimarket contact, lies on the $F_a(\delta)$ frontier as guaranteed by part (i) of the Lemma. The figure also shows that the set $S_a(\delta)$ is compact and convex, per part (ii) of the Lemma. The figure also shows the same information for firm b.

On the right, the figure displays the set $S(\delta)$ — the intersection of $S_a(\delta)$ and $S_b(\delta)$ — that contains all vectors that satisfy both firms' ICCs and are hence supportable when the two firms internalize their multimarket contact. Also displayed is the frontier of this set, denoted $F(\delta)$ per Definition 4.

The figure also displays the vector $\kappa(\delta)$, the largest supportable conduct vector *absent multimarket contact* (see Definition 3). By virtue of Lemma 1, any vector lying below $\kappa(\delta)$ is also supportable in that case. Note that $\kappa(\delta)$ appears in this figure to be located strictly inside the frontier $F(\delta)$. In general, this need not be true. We shall later see that this happens if and only if a *symmetric positioning* property holds.

Quantifying the potential impact of multimarket contact. Our analysis contrasts the set of supportable departures from competitive pricing when firms do not internalize their multimarket contact — all vectors smaller than $\kappa(\delta)$ in Figure 3 — with the set of supportable departures available with multimarket contact, $S(\delta)$. Section 2.3 below will show how to compute those sets given an estimated demand system.

The comparison of these sets emphasizes that we explore the *potential* impact of multimarket contact on competition. With multimarket contact, *any* vector within the set $S(\delta)$ can be supported in an SPNE. Without it, *any* vector $\tilde{\kappa}$ such that $\tilde{\kappa} \leq \kappa(\delta)$ can be supported. In both cases we have infinitely-many equilibria. Absent an equilibrium selection mechanism, we cannot determine the precise effect of multimarket contact. As a simple example, it is always possible that firms end up at the competitive benchmark origin, $\kappa = (0, 0)$, with or without multimarket contact, in which case there is clearly no actual multimarket contact effect on competition.

Our approach is therefore only informative about the potential effect of multimarket contact. As discussed above, this is a fundamental aspect of the Supergame framework, and an unavoidable aspect of taking such a framework to data. In this sense, our approach is complementary to the extant empirical literature on multimarket contact. While that literature uses observed variation in multimarket contact to estimate its actual effect, we can explore its potential effect in cases where such variation is not available, or perform counterfactual analysis of multimarket contact that does not actually exist in the data.

A practical challenge is to concisely summarize the potential impact of multimarket contact on competition. To this end, we need a simple way of comparing the sets of κ values that can be supported with and without this contact. Furthermore, the κ parameters are merely technical devices. An appreciation of the economic impact of multimarket contact requires its expression via economic quantities such as prices and profits.

We deal with both issues as follows. First, rather than comparing two sets of κ vectors, we focus, in each set, on the vector that maximizes the joint profits for firms a and b — and compare these two vectors. To this end, we first compute the conduct vector that maximizes this joint profit with multimarket contact. Define this vector by:

$$\begin{gathered}\hat{\kappa}(\delta) = argmax_{\kappa_1,\kappa_2} \sum_{f\in\{a,b\}} \pi_{f,1}(\kappa_1) + \pi_{f,2}(\kappa_2) \\ \text{s.t.}(\kappa_1,\kappa_2) \in S(\delta).\end{gathered} \tag{9}$$

We then compute prices and profits at $\hat{\kappa}(\delta)$, and compare them to prices and profits at $\kappa(\delta)$, the vector that maximizes joint profits absent multimarket contact. While other strategies could be considered for the purpose of quantifying the gains from multimarket contact, we find this one most intuitive.

The next Lemma establishes that $\hat{\kappa}(\delta)$ is unique, and, as illustrated in Figure 3, lies on the frontier of supportable conduct vectors given multimarket contact.

Lemma 3. $(\hat{\kappa}_1, \hat{\kappa}_2) \in F(\delta)$ *and is unique.*

Proof. Since by Assumption 1 total profits increase with κ in each market, by continuity of $\phi_{f,m}$ we get $(\hat{\kappa}_1, \hat{\kappa}_2) \in F(\delta)$. We also have that $S(\delta) = S_a(\delta) \cap S_b(\delta)$. Recalling from Lemma 2(ii) that these sets are convex, and since the intersection of two convex sets in also convex, we get that $S(\delta)$ is convex. By Assumption 1(iv), we get a maximization problem of a strictly concave objective function over a compact and convex set, hence there exists a unique solution.

□

A practical implication of Lemma 3 is that we can restrict attention to the frontier of supportable conduct vectors when searching for the one that maximizes the sum of profits for firm a and firm b when multimarket contact is internalized.

Lemma 4. *An Irrelevance Result: Assuming markets* $m = 1, 2$ *are identical (firms may differ from one another), there are no potential gains from multimarket contact.*

Appendix A provides a proof of this result, which is similar to the irrelevance result in BW90, except that the result here does not require firms to be identical. While Lemma 4 tells us when multimarket contact carries zero potential gains to firms, it has a highly stylized flavor: in an empirical setup, we never expect markets to be truly identical. The question of interest is, therefore, what type of differences in primitives across markets give rise to substantial gains from multimarket contact?

To better gauge this issue, we next define the concept of symmetric vs. asymmetric positioning and establish its role in characterizing the potential gains from multimarket contact.

Definition 5. *Given a fixed discount factor δ, firms a and b display symmetric positioning across the two markets if one of the following conditions holds:*
(i) $\kappa_{a,1}(\delta) > \kappa_{b,1}(\delta)$ *and* $\kappa_{a,2}(\delta) < \kappa_{b,2}(\delta)$
(ii) $\kappa_{a,1}(\delta) < \kappa_{b,1}(\delta)$ *and* $\kappa_{a,2}(\delta) > \kappa_{b,2}(\delta)$

Symmetric positioning implies that one firm can sustain a larger departure from competition in one market (by virtue of satisfying its ICC at a less competitive regime) than its rival, whereas the other firm enjoys this "advantage" in the other market. This is the case depicted in Figures 2-3. Asymmetric positioning implies, instead, that one firm can sustain higher conduct parameters *in both markets* relative to its rival.

Our main analytical result now follows:

Corollary 1. *Firms a and b display asymmetric positioning if and only if $\kappa(\delta) \in F(\delta)$.*

Proof. Assume initially markets are in asymmetric positioning. Then by definition $\kappa_{f,1} \leq \kappa_{g,1}$ and $\kappa_{f,2} \leq \kappa_{g,2}$ for $f, g \in a, b$, thus: $\kappa(\delta) = \kappa_f(\delta)$. By Lemma 2: $\kappa_f(\delta) \in F_f(\delta)$ and $\kappa_f(\delta) \in S_g(\delta)$. Therefore, $\kappa_f(\delta) \in S(\delta)$. By Definition 4(iv), $\kappa(\delta) \in F(\delta)$.

Now assume symmetric positioning. Assume also WLOG $\kappa_1(\delta) = \kappa_{a,1}$ and $\kappa_2(\delta) = \kappa_{b,2}$. Then: $\kappa_{b,1} > \kappa_{a,1}$ and $\kappa_{a,2} > \kappa_{b,2}$, which by Lemma 2(iii) implies $\kappa(\delta) \notin F_1(\delta) \bigcup F_2(\delta) \Rightarrow \kappa(\delta) \notin F(\delta)$. $\square$

The significance of Corollary 1 is the following: when firms display asymmetric positioning, the least-competitive conduct vector supportable when they do not internalize multimarket contact, $\kappa(\delta)$, lies on the frontier of the supportable vectors when firms do internalize it. This implies a limited scope for a contribution of multimarket contact to profits: that contribution can then only be realized via movements along the frontier, rather via movements to the frontier.

In contrast, with symmetric positioning, the supportable $\kappa(\delta)$ vector in the absence of multimarket contact lies strictly inside the $F(\delta)$ frontier, suggesting a more substantial scope for firms' gains from such contact. As already noted above, this situation is illustrated in Figure 3.

Corollary 1 provides guidance regarding the sources of firms' potential gains from multimarket contact. However, it is still not clear, at this point, how to connect the symmetric positioning property with underlying economic primitives, and, specifically, those associated with the demand system. Absence such connection, it will be difficult to appreciate intuitively how an estimated demand system helps one uncover the potential gains from multimarket contact.

In the next subsection we complete the model description by addressing these issues. We first introduce the final building block of our framework: a model for the demand side. We then explore, via simulations, how demand primitives within the RCL model drive the presence, or lack thereof, of the symmetric positioning property. Along the way, we also show how to test the shape restrictions of Assumption 1 given demand parameter values.

2.3 Demand

The Random Coefficient Logit model (Berry 1994, BLP 1995) is the canonical econometric framework for modeling and estimating differentiated-product demand systems. In this section, we briefly review the model, and show how its estimated parameters can be used to infer the components of the firms' ICCs, enabling our analysis of the potential impact of multimarket contact. We also demonstrate, via simulation, the relevance of the information embedded in the estimated demand model to the multimarket contact analysis.

In a given industry $m \in \{1, 2\}$, the indirect utility function of consumer i from product j, omitting the industry index, is given by:

$$u_{ij} = x_j \beta_i - \alpha_i p_j + \xi_j + \epsilon_{ij}, \tag{10}$$

where x_j is a vector of product characteristics, p_j is the product's price, and ξ_j captures the value of product characteristics that are unobserved to the econometrician, but are observed by consumers and firms. The parameters β_i are random utility weights placed by consumers on the observed product characteristics, while α_i represents the heterogeneous price sensitivity. The idiosyncratic term ϵ_{ij} has the familiar Type-I Extreme Value distribution.

Recall that each of the two firms a and b has a portfolio of differentiated products in each of the two industries. Additional multi-product firms are also present in each industry. Consumers can also choose the "outside option" of not consuming any product from the relevant industry. We follow the standard normalization for the utility from the outside option: $u_{i0} = \epsilon_{i0}$.

With normally-distributed random coefficients, the utility function can be re-written as:

$$u_{ij}(\zeta_i, x_j, p_j, \xi_j; \theta) = \underbrace{x_j \beta + \alpha p_j + \xi_j}_{\psi_j} + \underbrace{\sigma^p p_j \nu_i^p + \sum_{k=1}^{K} \sigma^k x_j^k v_i^k}_{\mu_{ij}} + \epsilon_{ij}, \tag{11}$$

where $\zeta_i \equiv (v_i, \{\epsilon_{ij}\}_{j \in J})$ are the idiosyncratic utility shifters, with v_i being a vector of standard-normal variables (assumed IID across both consumers and product characteristics). The parameter σ^p captures taste heterogeneity with respect to price. We separate the utility into a mean-utility component ψ_j, and a household-specific term $\mu_{ij} + \epsilon_{ij}$. Defining $\theta_2 \equiv (\alpha, \sigma')'$ and conditioning on ψ_{jt}, the utility function can be expressed as $u_{ij}(\zeta_i, x_j, p_j, \psi_j; \theta_2)$. The demand parameters are $\theta = (\beta', \alpha, \sigma')'$.

Applying the market share equation (Berry 1994) we obtain the market share of product j,

$$s_j(x, p, \psi, v; \theta_2) = \int \frac{exp[\psi_j + \mu_{ij}(x_j, p_j, v_i; \theta_2)]}{1 + \sum_{m \in J} exp[\psi_m + \mu_{im}(x_m, p_m, v_i; \theta_2)]} dP_\nu(\nu_i). \tag{12}$$

The parameters θ can be estimated via GMM as is standard in the literature (BLP95). We provide additional details on estimation in the empirical application section below.

Computing firms' ICCs given an estimate $\hat{\theta}$. Given estimates of the demand parameters θ, we can compute margins and variable profits under a wide range of competitive scenarios. As familiar, Nash-Bertrand margins are implied by the system of First-Order Conditions:

$$p - mc = \Big(\Omega \odot \mathcal{S}(p; \theta)\Big)^{-1} s(p; \theta), \tag{13}$$

where Ω is the block-diagonal Ownership matrix satisfying $\Omega_{jk} = 1$ if goods j, k are produced by the same firm, and zero otherwise. The vector s contains market shares that are evaluated via a simulation estimator for (12), given prices p and the estimate $\hat{\theta}$. The matrix $\mathcal{S}$ contains market share derivatives that are similarly evaluated via simulation.

Consistent with our subsequent empirical analysis, we assume that the data were generated by this competitive behavior, and use (13) to back out the marginal costs mc given observed prices p, observed market shares s, and the estimated $\hat{\theta}$. We also obtain a direct estimate of $\Pi(0)$, firms' variable profits under this Nash-Bertrand competitive benchmark. Recall that this is just one of many possible strategies with respect to the treatment of the true DGP.[14]

Placing some value $0 < \kappa \leq 1$ on the off-(block) diagonal elements of Ω, the same FOCs can be used to evaluate how prices and margins would look like if firms switched into an SPNE where, on the equilibrium path, they move away from the competitive pricing by an extent captured by κ. This provides an estimate of the variable profits $\Pi(\kappa)$ on the equilibrium path, if firms were indeed to switch to that equilibrium. Finally, we numerically solve for each firm's optimal deviation from that equilibrium and obtain an estimate of the deviation payoffs $\hat{\Pi}(\kappa)$.

Given these quantities, and a "non-trivial" value of the discount factor δ — one that does not support the least competitive equilibrium, $\kappa = 1$, in either market, absent multimarket contact — we can evaluate the supportable departures from the competitive benchmark, with and without multimarket contact, by calculating $\kappa(\delta)$ and $F(\delta)$ as defined in section 2.2.

[14] For example, one may obtain a measure of the true intensity of competition by calibrating it using crude data on margins (Bjornerstedt and Verboven 2016, Eizenberg, Lach and Yiftach 2021), or perform the analysis of multimarket contact under different assumptions regarding the DGP to obtain a sense of robustness.

The calculation of $\kappa(\delta)$ and $F(\delta)$ involves some additional details. In particular, counterfactual prices and margins need to be obtained at many levels of $\kappa \in [0, 1]$ so that the largest κ that satisfies the ICCs can be numerically obtained. In practice, those are computed over a discrete grid of κ values, and that grid is then used to generate polynomial approximations of the underlying functions. Computing counterfactual price equilibria also involves some computational details. We expand on those computational aspects in Appendix B.

Simulating the model. Leading to the empirical analyses in section 3 below, we conduct a series of simulations of the model with several goals in mind. First, we examine whether the shape restrictions placed on the profit functions in Assumption 1 are maintained when the functions are generated by a Random Coefficient Logit (RCL) model of demand. Second, by carefully altering the parameters of the demand system, we seek guidance regarding the underlying features of demand that determine the potential impact of multimarket contact.

Complete details regarding the simulations are available in Appendix C. The main insights from the simulations are the following:

1. The shape restrictions of Assumption 1 are often, but not always, maintained in simulations of the RCL model. Therefore one should verify whether these restrictions hold at the estimated parameter values $\hat{\theta}$ when taking the model to data. Appendix C shows how to implement this verification in practice.

2. Whether symmetric, or asymmetric positioning holds depends on demand parameters. This is the concrete sense in which demand estimation informs the study of multimarket contact.

3. Fixing a specific industry, $m = 1$ or $m = 2$, and holding all other parameters fixed, increasing the value of either the mean α or the standard deviation σ^p of consumers' price sensitivity affects the two firms' ICCs in *opposite directions*. That is, for a fixed level of the discount factor, it allows one firm's market-specific ICC (equation (1)) to hold at a higher level of κ, and the other firm's ICC to hold at a lower level of that parameter.

4. Again fixing the discount factor and the industry, increasing the mean utility or the standard deviation associated with one firm's brand dummy, holding all other parameters fixed, allows this firm's ICC to hold at a higher conduct level κ, while lowering the maximal κ level that sustains the ICC of the other firm.

The third finding is of particular interest. It suggests that if one firm enjoys strong brand preferences in industry 1, while the other firm enjoys such advantages in industry 2, we are more likely to witness *symmetric positioning* in the sense of Definition 5. By Corollary 1 we are then more likely, thought not guaranteed, to see substantial gains from multimarket contact.

The simulations therefore establish a connection between underlying demand primitives, on the one hand, and the potential impact of multimarket contact, on the other hand. If firms a and b each enjoy a "demand advantage" over the other in a different market — where "demand advantage" is defined as having stronger brand preferences compared to the rival — then multimarket contact is more likely to generate considerable gains. This sharpens the intuition underlying our approach, since it clarifies at least one sense in which estimating the demand systems in both industries can help learn about the scope of the multimarket contact effect.

3 Empirical application: the food sector

We now take the model developed in section 2 to data via an application to the Israeli food sector, focusing on packaged goods sold at supermarkets. Our application involves the *Packaged Hummus Salad* and *Instant Coffee* categories. Both categories share the same two prominent competitors, but each category features additional, different competitors. Those categories therefore match the situation depicted qualitatively in Figure 1, and the framework developed above.

Data. The data come from Nielsen and cover the two product categories mentioned above. These data are monthly and pertain to the 43 months from January 2012 to July 2015. The level of observation is UPC-category-month, where the information includes the UPC's name, from which we derive important information regarding characteristics. We also observe the brand name and the manufacturer, as well as total sales in both monetary terms, and in units. We compute the monthly average price by dividing total sales revenue by quantity.

We describe our analysis in two stages. First, we present the demand modeling and estimation results for each of the two categories. Second, we employ the methodology developed above to make inference on the potential impact of multimarket contact across the two categories.

Demand estimates: Packaged Hummus Salad. We model the demand in this category via the Random Coefficient Logit framework introduced above. The product characteristics x included in the utility function are brand dummies, 42 month dummies, and dummy variables for product characteristics. Examples of such characteristics are "spicy," pine nuts, masabacha (a middle eastern condiment), and tahini (relating to the presence of extra tahini in the product). The presence of such product features was determined by mining the text of the product name at the UPC level. Random coefficients were allowed on price, and on brand dummies for firms a and b.

We aggregate the UPCs up to unique combinations of brand, month and the characteristics, yielding a total of 2,031 observations over the 43 sample months. The market size was determined by considering the potential consumption of all prepared (chilled) salads. Denoting the month-t aggregate potential consumption by M_t, product j's market share was computed by dividing the total quantity sold q_{jt} by M_t. To arrive at M_t, we used a variety of media sources to determine: the typical annual consumption of Hummus per person, the share of Hummus consumption out of total consumption of chilled salads, and the population size.

The characteristics space is discrete rather than continuous, prohibiting the employment of the differentiation instruments proposed by Gandhi and Houde (2016) to address the endogeneity of prices. We nonetheless employ a battery of useful instruments. First, we use the number of competing products with identical characteristics. Those should affect markups, and therefore prices, consistent with Berry, Levinsohn and Pakes (1995) and the identification results in Berry and Haile (2014).

Second, we use cost shifters as instruments. In particular, we include interactions of the world chickpea price with the pine nut, tahini and "other condiments" characteristics, and interactions of the VAT rate with dummy variables for the leading producers and for the "masabacha," "spicy" and "cress" characteristics.[15]

Finally, we exploit a discrete shift in the regulation of the Israeli food sector in January 2015, when the "Food Law" went into effect. This law placed substantial restrictions on the ability of large suppliers, as defined in the law, to engage in Retail Price Maintenance (RPM) or to control the placement of products on retailers' shelves. We interact a post-January 2015 dummy variable with leading firm dummies, thereby allowing the pricing strategies of different firms to be differentially affected by the law.[16] In total, we use 13 excluded instruments, generating over-identifying restrictions, noting that we have three random coefficients.

Estimation results are reported in Table 1. Generally speaking, coefficients on product characteristics and on brand dummy variables (left panel) are precisely estimated, and so are the price sensitivity parameters α and σ^p.

Demand estimates: Instant Coffee. To model demand in this category, we again define product characteristics based on the presence of particular traits as evident in the product name (examples being "decaff," "frozen," and "dry") that are included in the utility function along with brand and month dummies. We again aggregate the UPCs up to unique combinations of brand, month and the characteristics. The outside option was defined as the consumption of Black Coffee and Tea.

While we do not impose supply-side moments, our analysis requires that the estimated demand elasticities imply non-negative marginal costs for all products at all possible conduct modes. To this end, we found it necessary to drop from our sample the six most expensive observations, or

[15]The VAT rate at the beginning of the sample period was 16 percent. It was increased to 17 percent on September 1st, 2012, and was then increased again, to 18 percent, on June 2nd, 2013, where it stayed through the end of our sample period. Source: the Israeli Tax Administration (click here).

[16]The "Food Law" was a response to a major public protest in 2011 that prompted the government to seek strategies to reduce the cost of living. Source: Globes, an Israeli media outlet, May 2018 (click here).

0.4% of the original observations, resulting in a sample size of 1,515.[17]

Random coefficients were again allowed on price and on the leading brand dummies. Instrumental variables included interactions of various brand dummies with cost shifters such as the minimum wage, the Israeli company tax, and the global price of raw coffee (for non-decaff products only). Various brand dummies were also interacted with the exchange rate (Euro for NIS), the post-food law dummy variable, the firms' revenue in other categories (computed from market-level data, of the same nature as described above, for 40 categories of the Israeli food sector), and the global price of sugar. In total, this yielded 14 excluded instruments. Estimation results are reported in Table 2.

Estimating the potential impact of multimarket contact. To analyze the potential effect of this multimarket contact on prices, we follow the model of Section 2. In particular, we maintain the assumption that the behavior observed in the data fits the competitive benchmark with $\kappa = 0$, i.e., that the data were generated by Nash-Bertrand competition. We then ask whether less competitive pricing equilibria could potentially be sustained, and whether multimarket contact expands the set of such sustainable outcomes.

Our approach requires fixing a "nontrivial" value for firms' discount factor: one that does not support the least competitive equilibrium in the absence of multimarket contact. This level is fixed at $\delta = 0.15$, a much lower value than that set in standard macroeconomic models. As Rotemberg and Saloner (1986) note, the threshold discount factor that satisfies ICCs should be low in models that assume grim-trigger responses to deviations from the equilibrium, as opposed to models that allow such responses to last for a finite number of periods.

In other words, a more realistic model with a finite response phase would correspond to higher discount factor levels. Following much of the literature, and for simplicity, we maintain the infinite-horizon nature of the competitive reversion, acknowledging that this produces artificially low threshold discount factors. Note that our goal is not to estimate the discount factor but rather to obtain some measure of the potential effect of multimarket contact.

Results: supportable equilibria with and without multimarket contact. Figure 4 provides a graphical representation of each firm's ICCs, with and without accounting for multimarket contact. The figure pertains to the analysis as performed in a particular month ($t = 7$). Recall that in each month, firms are assumed to evaluate the benefits of staying on the equilibrium path, versus those of deviating from it, and simplify their calculations by assuming that current cost and demand conditions shall prevail indefinitely. As a consequence, our estimates of the supportable κ levels depend on the month in which the calculation is performed.

The left-hand panel of Figure 4 displays firm a's individual constraints. The vertical (horizon-

[17] We also found that including specific brand dummies, but not others, was useful for obtaining precise estimates. Fine tuning of the demand estimation in this category is ongoing. Importantly, those modeling choices appear to have little effect on the economic quantities of interest such as elasticities and markups.

tal) axis pertains to values of κ ranging from 0 to 1 in the Hummus (Coffee) market, respectively. Recall that per our assumption, firms' actual behavior in the data follows the competitive benchmark which corresponds to the origin with $\kappa_{hummus} = \kappa_{coffee} = 0$.

The blue dot corresponds to $\kappa_a(\delta)$, per Definition 3. This vector shows the largest $(\kappa_{hummus}, \kappa_{coffee})$ levels that satisfy firm a's ICC in each market, ignoring multimarket contact. The green curve represents the $F_a(\delta)$ frontier of $(\kappa_{coffee}, \kappa_{hummus})$ vectors that satisfy firm a's combined ICC when it does internalize the multimarket contact (see Definition 4). The presence of the blue dot on the $F_a(\delta)$ frontier is not a coincidence: it is guaranteed by Lemma 2(i). The right-hand panel shows the same information for firm b (with the frontier $F_b(\delta)$ shown in yellow).

An important insight from Figure 4 is that the *symmetric positioning* property (Definition 5) holds in our application. Comparing the "blue dots" in those two figures, we see that in the Hummus market, absent multimarket contact, firm a's (b's) ICC sustains a κ value of approximately 0.55 (0.20), respectively. In the coffee market, the supportable κ values are about 0.2 for firm a, and 0.6 for firm b. Simply put: in each market, a different firm can sustain a larger κ value than its rival.

While Figure 4 provides useful information on each firm's individual ICCs, it is only when the constraints of *both firms* are satisfied at a particular vector $(\kappa_{coffee}, \kappa_{hummus})$ that this vector can be said to be supported in an SPNE of the Supergame. So, to appreciate the potential impact of multimarket contact, we need to examine the intersection of these constraints, presented next in Figure 5.

The blue dot in Figure 5 is $\kappa(\delta)$: the largest conduct vector that can be supported in an SPNE when firms do not internalize their multimarket contact. As shown in Definition (3), this vector is given by taking, in each market, the minimum of the largest κ values that satisfy the two firm's individual ICCs (i.e., the blue dots of Figure 4). The frontiers $F_a(\delta)$ (green curve) and $F_b(\delta)$ (yellow curve) from Figure 4 are presented here again.[18] The combined frontier $F(\delta)$ (Definition 4) is the boundary of $S(\delta)$, i.e., it is the boundary of the set of vectors that lie inside *both* the green the yellow curves.

Note that the blue dot, $\kappa(\delta)$, is inside the frontier $F(\delta)$, rather than on it, i.e., $\kappa(\delta) \notin F(\delta)$. This follows directly from Corollary 1, given that the symmetric positioning property holds as we have seen above. The distance between $\kappa(\delta)$ — the largest discrepancy from competitive pricing in the absence of multimarket contact — and the frontier $F(\delta)$ captures the *potential impact* of multimarket contact on the intensity of competition.

It remains to translate this distance into clear economic terms: prices and profits. Following the methodology laid out in section 2, we compute $(\hat{\kappa}_1(\delta), \hat{\kappa}_2(\delta))$: the vector, among all those that can be supported in an SPNE given multimarket contact, that maximizes the sum of both

[18] Given the different scale, these curves may appear to be visibly different than those displayed in Figure 4, but the two figures present exactly the same curves.

firms' profits over the two markets. This vector, defined in (9), is indicated in the figure by the red dot. Consistent with Lemma 3, the red dot is unique and rests on the $F(\delta)$ frontier.[19]

We next compute equilibrium prices and profits at this "red dot" and compare them to prices and profits at the "blue dot" in each of the 43 month-specific analyses, $t = 1, ..., 43$. Table 3 shows the percentage difference in profits between $\kappa(\delta)$ ("blue dot," capturing the largest combined profits for the two firms absent multimarket contact) and $\hat{\kappa}(\delta)$ ("red dot," capturing the largest combined profits with multimarket contact). The maximum impact over the 43 sample months is about 0.5 percent, whether we look at firm a's profits, firm b's profits, or their combined profits. These calculations reveal that the potential impact of multimarket contact is small in the studied application.

Table 3 also shows that the profit impact does not vary that much across the 43 month-specific analyses. This is important: remember that we perform our analysis in each month separately, each time assuming that firms ignore any future changes to cost or demand when calculating the benefits of adhering to the equilibrium path vs. deviating from it. If violations of this bounded rationality assumption were quantitatively important, we would have expected the profit impact to vary widely among the 43 different calculations. Reassuringly, this does not happen.

Table 4 completes the picture by displaying the potential impact of multimarket contact on prices. In each of the 43 month-specific analyses we compute the potential impact on each category's sales-weighted average price. As with profits, this potential impact is small, and does not vary widely across months. The maximum (over the 43 months) change is 0.6 percent (0.77 percent) for the Packaged Hummus Salad and the Instant Coffee categories, respectively.

While the impact on both prices and profits does not vary widely across the 43 month-specific analyses, it is of interest to inspect this variation from another perspective. The impact is always very small, but Tables 3-4 show that on a couple of instances, it drops very close to zero. Recall that a near-zero effect is particularly likely with asymmetric positioning, since the scope of the effect is considerably limited in that case. One may expect, therefore, that the near-zero values correspond to month-specific analyses that cross into the asymmetric positioning territory.

To explore this conjecture, we define a quantitative index of the degree of symmetric (or asymmetric) positioning, to which we refer as a "symmetry indicator":

$$\big(\kappa_{a,1}(\delta) - \kappa_{b,1}(\delta)\big) \cdot \big(\kappa_{a,2}(\delta) - \kappa_{b,2}(\delta)\big).$$

When the symmetry indicator takes positive values, the same firm (either a or b) enjoys an "advantage" in both markets, where by "advantage" we refer to the ability to satisfy the firm's market-specific ICC at a higher level of κ. This means that *asymmetric positioning* holds. When the index takes negative values, it means that each firm enjoys the "advantage" in a different

[19] The figure also presents an "iso-profit" curve pertaining to the aggregated profits of the two firms over the two industries.

market, implying *symmetric positioning*. The magnitude of the index in absolute value informs us, additionally, regarding the magnitude of this effect.

Figure 6 provides a scatter plot over the 43 month-specific analyses. The value of the symmetry indicator is displayed on the horizontal axis, and the potential gain from multimarket contact (computed as the potential contribution to the firms' combined profit, in percentage terms) is on the vertical axis. Two insights emerge: first, there is only one month where firms display asymmetric positioning, and, as expected, the gains are near-zero in this case. Second, we observe a negative slope: the greater is the degree of symmetric positioning, the larger are the potential gains from multimarket contact.

Figure 6 highlights the importance of the symmetric positioning property in determining the scope of the potential effect of multimarket contact. This is consistent with Corollary 1. In fact, along the way, we have seen that our analytical results (section 2.2) are verified in our empirical application. For example, we have seen in Figure 4 that $\kappa_f(\delta) \in F_f\delta)$, as implied by Lemma 2(i); in Figure 5 that $(\hat{\kappa}_1, \hat{\kappa}_2) \in F(\delta)$ per Lemma 3; and again in Figure 5, that symmetric positioning results in $\kappa(\delta) \notin F(\delta)$ per Corollary 1.

Recall that these analytical results were obtained given high-level shape restrictions on profit functions in Assumption 1. In our empirical application, we are able to verify that those shape restrictions hold in the same fashion as we did in the simulation analysis (see Appendix C for details). In fact, in both the Hummus and the Coffee categories, and in each of the 43 months, we have verified that a stronger restriction holds: profits on the equilibrium path (deviation profits) are concave (convex) in κ. All analytical results should then hold in the empirical application — and we have seen, indeed, that this is the case.

What might explain the small potential effect of multimarket contact? Since the assumptions of section 2 hold in our empirical application, we can use the analytical results of that section to shed light on this issue. The small magnitude could imply that symmetric positioning, while present in the studied case (as demonstrated visibly above), is not strong.

The simulation exercises discussed in section 2.3 suggested that one way to generate strong symmetric positioning is for each firm to enjoy a substantial "demand advantage" over its main rival in a different category. In our application, the estimated coefficients on firms a and b's brand dummies do not reveal such a pattern. At least in this sense, the small estimated effect of multimarket contact is not surprising.

4 Concluding remarks and additional applications

This paper studies the impact of multimarket contact on the intensity of competition. In contrast to the extant empirical literature, we do not estimate the causal effect of multimarket contact by exploiting observed variation in it. Instead, we take the theory of Bernheim and Whinston (1990) to data to evaluate the potential effect of such contact.

This theory clarifies the strategic effect of multimarket contact on firms' Incentive Compatibility Constraints. We show how to estimate the components of firms' ICCs, allowing us to aggregate them over the markets where firms interact. We then directly check whether this aggregation allows higher prices and profits to be sustained in equilibrium.

The empirical analysis reveals that the potential impact of multimarket contact in two categories of the Israeli food sector is small. Our analytical framework clarifies what primitive features of the demand system can give rise to substantial gains from multimarket contact. By estimating the demand in the relevant categories, we allow such primitives to inform the analysis of the competitive impact of multimarket contact. The analytical results therefore guide and help in the interpretation of the empirical estimates, and provide an intuition for the small magnitude observed in our empirical analysis. In particular, we associate this finding with the lack of a symmetric "demand advantage" whereby each brand would have enjoyed stronger consumer preferences in a different category.

Additional applications and extensions. In addition to studying multimarket contact that is present in the data, as performed above, our framework also allows the study of multimarket contact that could be established via hypothetical cross-category mergers.

The idea is depicted in Figure 7: suppose that in the data, firms a and b are the major competitors in market 1, whereas firms b and c are the major competitors in market 2. Now, however, firm a proposes to acquire firm c. This hypothetical merger does not alter the concentration level (measured by, say, the HHI) in either market. The antitrust authority may still be concerned, however, that the resulting multimarket contact could hamper competition across the two markets. Our framework can be used to evaluate that potential impact, allowing regulators to examine this specific theory of harm.

We can accommodate this scenario by re-labeling some of the terms used above. In the analysis presented in this paper, we compared the largest departure from competitive pricing that is available when firms do not internalize their multimarket contact, $\kappa(\delta)$, to the frontier of possible departures available when they do internalize it, $F(\delta)$. We can interpret the merger depicted in Figure 7 as follows. Initially, multimarket contact is absent — so $\kappa(\delta)$, computed exactly as shown above, captures the largest departure from competitive pricing that can be supported in equilibrium. Following the merger, multimarket contact is established, opening the frontier of possibilities $F(\delta)$ — which ,again, would be computed in exactly the same fashion.[20]

Additional extensions of the work presented in this paper include augmenting the Supergame

[20] In a hypothetical merger analysis, one may wish to consider the possibility that firms a and c have different discount factors. This may give rise to a range of predictions, based on different underlying assumptions on the discrepancy between these two discount factors, pre-merger, and on the post-merger discount factor of the merged firm.

to incorporate more sophisticated mechanisms such as asymmetric information and complex treatment of time-series variation in cost and demand conditions. We leave such extensions to future work.

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A Proof of Lemma 4

Proof of Lemma 4. When markets are identical, $\kappa_{f,1} = \kappa_{f,2}$ for $f = a, b$. Hence $\kappa(\delta) = \kappa_a(\delta)$ or $\kappa(\delta) = \kappa_b(\delta)$. Assume WLOG $\kappa(\delta) = \kappa_a(\delta)$. If $\kappa_{a,1} = \kappa_{a,2} = 1$ then obviously there are no gains from multimarket contact. Assume $\kappa_{a,1} < 1$. Then firms are in "asymmetric positioning," hence by Corollary 1 $\kappa(\delta) \in F(\delta)$. Since $\phi_{a,m}(\kappa)$ is differentiable and $\kappa_{a,1} < \kappa_{a,1} \leq 1$, we get that the firm's combined frontier $F(\delta)$ is differentiable at $\kappa(\delta)$, with a slope equal to -1 (by the identical market assumption, $F(\delta)$ is symmetric about the 45° line). Since the slope of the iso-profit curve of the objective function of multimarket contact profits at $\kappa(\delta)$ is: $-\frac{\pi'_{a,1}(\kappa_1(\delta))+\pi'_{b,1}(\kappa_1(\delta))}{\pi'_{a,2}(\kappa_2(\delta))+\pi'_{b,2}(\kappa_2(\delta))} = -1$ as well, by convexity of $S(\delta)$ this is a necessary and sufficient condition for the firm's maximization problem in (9). We get $\kappa(\delta) = \hat{\kappa}(\delta)$, and thus there are no gains from multimarket contact. $\square$

B Computational details

Counterfactual Prices. Recall that the pricing First Order Conditions are:

$$p - mc = \Big(\Omega \odot \mathcal{S}(p;\theta)\Big)^{-1} s(p) \tag{B.1}$$

As described in section 2.3, these conditions allow us first to back out marginal costs, and then calculate counterfactual price vectors corresponding to a wide range competitive schemes, modeled via changes to off-diagonal elements in the ownership matrix Ω. A straightforward approach for calculating these counterfactual prices is the following:

1. Begin with an initial guess for prices p^0

2. Evaluate the right hand side of (B.1) at the estimated $\hat{\theta}$ and p^0

3. Update the price vector using:

$$p^1 = mc + \Big(\Omega \odot \mathcal{S}(p^0;\hat{\theta})\Big)^{-1} s(p^0) \tag{B.2}$$

4. Iterate until convergence

We found, however, that this approach often failed to converge to a price vector that solves (B.1). The problem appears to be in the inversion of the matrix $\Omega \odot \mathcal{S}(p;\theta)$: after a small number of iterations this matrix becomes close to singular. To deal with this issue, we took an alternative route that eliminated the need for inverting this matrix.[21] We begin by rearranging equation (B.1).

[21] See also Conlon and Gortmaker (2020).

$$\Big(\Omega \odot \mathcal{S}(p;\theta)\Big)(p - mc) = s(p) \tag{B.3}$$

Note that both sides of (B.3) depend on the price vector p, and the right-hand side depends only on consumer demand. We apply the following iteration method:

1. Begin with an initial guess for prices
2. Calculate the left hand side of (B.3) using these prices
3. Find a new price vector, which equates the market shares $s(p)$ to the left hand side calculated in step 2
4. Iterate until convergence of both prices and market shares, that is, the right and left hand sides of (B.3) should equalize.

Approximating Profit Functions. To calculate $\kappa_{m,f}(\delta)$, as well as the frontier F_f, we must know the equilibrium and deviation flow payoffs $\pi(\kappa)$ and $\hat{\pi}(\kappa)$ for each $\kappa \in [0, 1]$. Since the method presented above produces those payoffs for a specific value of κ, we use a polynomial approximation of the payoff functions. In particular, we calculate these functions for $\kappa \in 0.1, 0.2, ...1$, and use the single 9^{th} degree polynomial approximation for these values for the rest of our analysis. For each of these approximations we conduct the following tests to check for their validity:

1. We look at the two differences $\pi(0) - \hat{\pi}(0)$ and $\pi'(0) - \hat{\pi}'(0)$. The results in section 2.2 imply these differences should equal zero. Since the point $\kappa = 0$ is not included in the set of points that we use for approximating the functions, this is a valid test.
2. We look at a set of 10 random values of κ ranging from 0 to 1, and calculate the difference between the profits as calculated directly using the iteration method above to the profits implied by the polynomial approximation.

Using these tests, we found that the approximations perform well.

C Simulations: a detailed description

This appendix section provides details on the simulations described in section 2.3. We set the stage by presenting one "baseline" simulation in detail. We then generate additional simulations by altering the parameters of this baseline simulation.

A baseline simulation. We begin by setting the market fundamentals and the demand parameters $\theta = (\alpha, \beta, \sigma)$ for each market, presented in Tables C1 and C2.

Product	Firm a	Firm b	Char1	Char2	Char3	Char4	Char5	Char 6	MC
1	1	0	1	0	0	0	0	1	79.71
2	1	0	0	1	0	0	0	1	45.93
3	0	1	1	0	0	0	1	0	73.51
4	0	1	1	0	0	1	0	1	78.70
5	0	1	1	1	0	0	1	0	67.43
6	0	0	0	1	0	0	0	0	55.12
7	0	0	1	0	0	0	0	0	53.91
8	0	0	1	0	1	1	0	1	79.22
9	0	0	1	0	1	0	0	0	52.61
10	0	0	0	0	0	0	1	0	48.98
11	0	0	1	1	1	0	0	1	75.84
β	5	4	4	3	1	2	1	2	-
σ	1	2	0	0	2	2	0	0	-
$\alpha = -3$	-	-	-	-	-	-	-	-	-
$\sigma_p = 0.6$	-	-	-	-	-	-	-	-	-
$\beta_0 = -4$	-	-	-	-	-	-	-	-	-

Table C1: Market 1 Fundamentals, baseline simulation

Product	Firm a	Firm b	Char1	Char2	MC
1	1	0	1	0	27.71
2	1	0	0	1	20.21
3	0	1	1	1	26.33
4	0	1	1	0	27.48
5	0	0	0	1	24.98
6	0	0	1	1	22.25
7	0	0	1	0	21.99
β	2	3	1	1	-
σ	1.5	2	0	0	-
$\alpha = -1.5$	-	-	-	-	-
$\sigma_p = 0.5$	-	-	-	-	-
$\beta_0 = -2$	-	-	-	-	-

Table C2: Market 2 Fundamentals, baseline simulation

As seen in the tables, this simulation features eleven products in market 1, and seven products in market 2. The columns "Firm a" and "Firm b" present the value of these firms' brand dummies: i.e., they tell us which products were produced by firms a and b, respectively. In market 2, for example, each of these firms offers two products. The columns Char1-Char-6 represent six additional product characteristics, all of which are captured by dummy variables. Including the firm a and firm b dummies, we therefore have a total of eight product characteristics in market 1, and four product characteristics in market 2. The MC column provides the marginal cost associated with each product. The marginal costs for markets 1 and 2 were generated from a uniform distribution in [45,90] and [20,30], respectively. Total market size (i.e. number of consumers) is set to 10,000,000 in each of the two markets.

Recall that β_k constitutes the mean utility value of product characteristic k, whereas σ_k is the standard deviation of consumers' normally-distributed tastes about that mean (i.e., the "random coefficient"). Similarly, α and σ_p are the mean and standard deviation of consumers' price sensitivity. The tables indicate that we allow random coefficients on the two brand dummies and on price in both markets, and in market 1, allow them additionally on the Char3 and Char4 characteristics. The parameter β_0 captures the mean utility from the outside option.

We follow the method outlined in Appendix B above to compute two sets of equilibrium prices in each market, one with $\kappa = 0$, and one with $\kappa = 1$ (i.e., corresponding to the most-competitive, and to the least-competitive static equilibria, respectively). Those prices are shown in Table C3.

Product	Market 1 ($\kappa = 0$)	Market 1 ($\kappa = 1$)	Market 2 ($\kappa = 0$)	Market 2 ($\kappa = 1$)
1	94.01	98.17	44.42	48.04
2	57.21	59.82	34.78	37.64
3	89.25	93.02	42.29	47.07
4	95.99	99.14	43.75	48.71
5	82.65	86.13	34.38	34.48
6	63.14	63.24	31.22	31.33
7	61.90	61.99	30.91	31.02
8	89.58	89.85	-	-
9	60.40	60.46	-	-
10	56.79	56.89	-	-
11	87.25	87.48	-	-

Table C3: Prices, baseline simulation

Following the description in Appendix B, we next approximate the profits on the equilibrium path, as well as the deviation profits, for each firm $f \in \{a, b\}$ in each of the two markets, for all $\kappa \in [0, 1]$. Figure C1 plots the equilibrium path profits, and the deviation profits in market 2 for firms a and b. It is easy to see that π is concave while $\hat{\pi}$ is convex. As discussed in section 2, these are even stronger conditions than those required by Assumption 1. It follows that our analytical results hold at the parameters of the baseline simulation.

Setting both firms' discount factor to $\delta = 0.1$, we use these approximations to calculate $\kappa(\delta)$, the largest conduct vector that is supportable absent multimarket contact, and $\hat{\kappa}(\delta)$, the point on the $F(\delta)$ frontier that maximizes the sum of profits for firms a and b with multimarket contact.

Our next step, and the main objective of the simulation exercise, is to trace the impact of changes to the baseline parameter values on the levels of κ that can be supported, with and without multimarket contact. We begin, in market 1, by increasing the value of the dispersion of price sensitivity σ_p from its baseline value of 0.6 to 1.1, using 0.1 increments. The left-hand side of Figure C2 shows the impact of this increase on $\kappa_{a,1}(\delta)$ and $\kappa_{b,1}(\delta)$: the largest values of κ that satisfy firms a and b's ICC in market 1, absent multimarket contact.

The figure shows that increasing σ_p, holding all other parameters fixed, affects firms' ICCs in opposite directions: it causes firm a's ICC to hold at increasing values of κ, while firm b's ICC

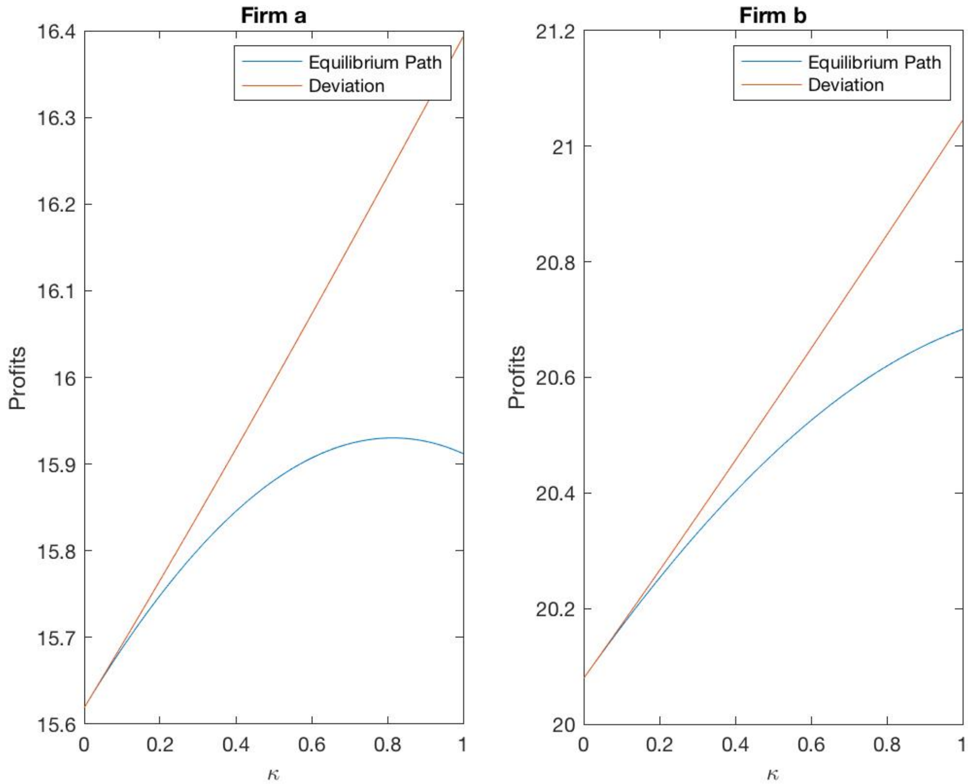

Figure C1: Equilibrium-path profits and deviation profits, market 1

is satisfied at decreasing values of κ. As discussed in section 2.3, this appears to be a rather general pattern in the simulations we have experimented with.

The right-hand side of Figure C2 performs a similar exercise in market 2, where again we start with the baseline parameter values, but this time increasing the value of β_b, the mean utility associated with firm b's brand, from 3 to 4 at increments of 0.2. Similarly as before, this affects the supportable κ values of the two firms in opposite directions. Specifically, firm b's ICC is relaxed (i.e., it can hold at higher values of κ), while firm a's ICC become more stringent. Again referring to the discussion in section 2.3, this appears to be a rather general pattern: increasing either the mean utility, or the random coefficient associated with a firm's brand dummy relaxes the ICC for this firm, while tightening the ICC for its rival.

Another insight from figure C2 is that markets can satisfy either the symmetric or the asymmetric positioning properties depending on parameter values. Specifically, when $\beta_b \in \{3, 3.2, 3.4\}$, symmetric positioning is displayed, but a switch to asymmetric positioning obtains for $\beta_b \in \{3.6, 3.8, 4\}$. Whether symmetric or asymmetric positioning holds is therefore driven by estimable demand parameters. This is a concrete sense in which demand estimates inform the

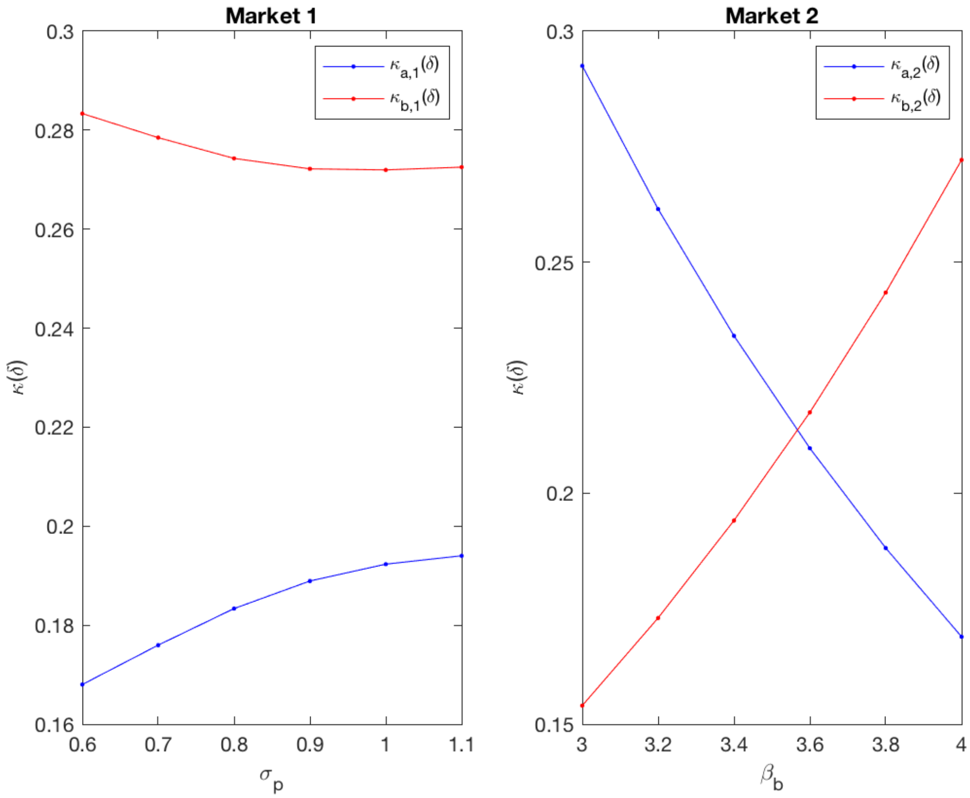

Figure C2: Left: $\kappa_{a,1}(\delta), \kappa_{b,1}(\delta)$ at different values of σ_p. Right: $\kappa_{a,2}(\delta), \kappa_{b,2}(\delta)$ at different values of β_b.

analysis of multimarket contact.

The consequences of symmetric vs. asymmetric positioning are shown next. Figure C3 plots the κ frontiers $F_a(\delta)$ (green) and $F_b(\delta)$ (yellow) when $\sigma_p = 0.6$ and $\beta_b = 3$. The combined frontier $F(\delta)$ is thus the boundary of $S(\delta)$, i.e. the boundary of the intersection between $S_a(\delta)$ and $S_b(\delta)$. On this $F(\delta)$ frontier we find the red dot, indicating the conduct vector that maximizes the combined profits of firms a and b with multimarket contact. The blue dot maximizes these profits absent multimarket contact.

Since we are in a symmetric positioning case, Corollary 1 tells us that, given the high-level conditions of Assumption 1 (which we have verified to hold in the simulation), we should expect the blue dot to lie inside the frontier. Indeed, the figure shows us that this is the case. In contrast, Figure C4 plots the same information for a parameter combination that satisfies *asymmetric positioning* where $\sigma_p = 1.1$ and $\beta_b = 4$. Now the blue dot does lie on the $F(\delta)$ frontier, again consistent with Corollary 1, and in fact almost coincides with the red dot, leaving a very minor scope for an impact of multimarket contact on the competitive regimes that can be supported in equilibrium.

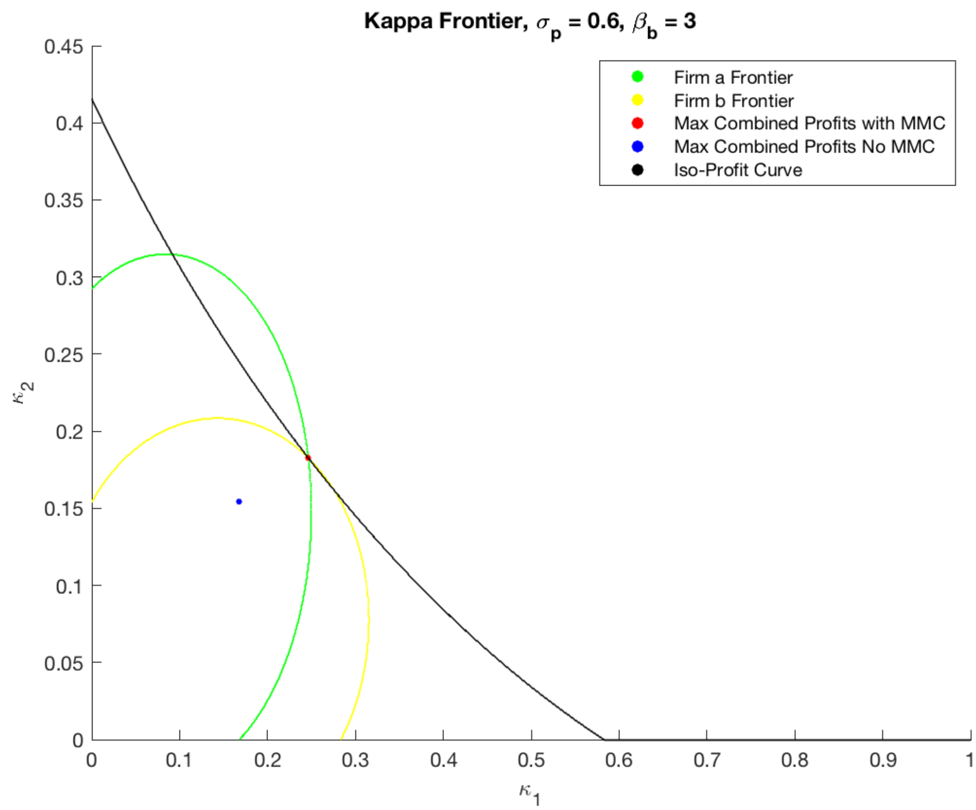

Figure C3: κ Frontier, Market 1: $\sigma_p = 0.6$, Market 2: $\beta_b = 3$

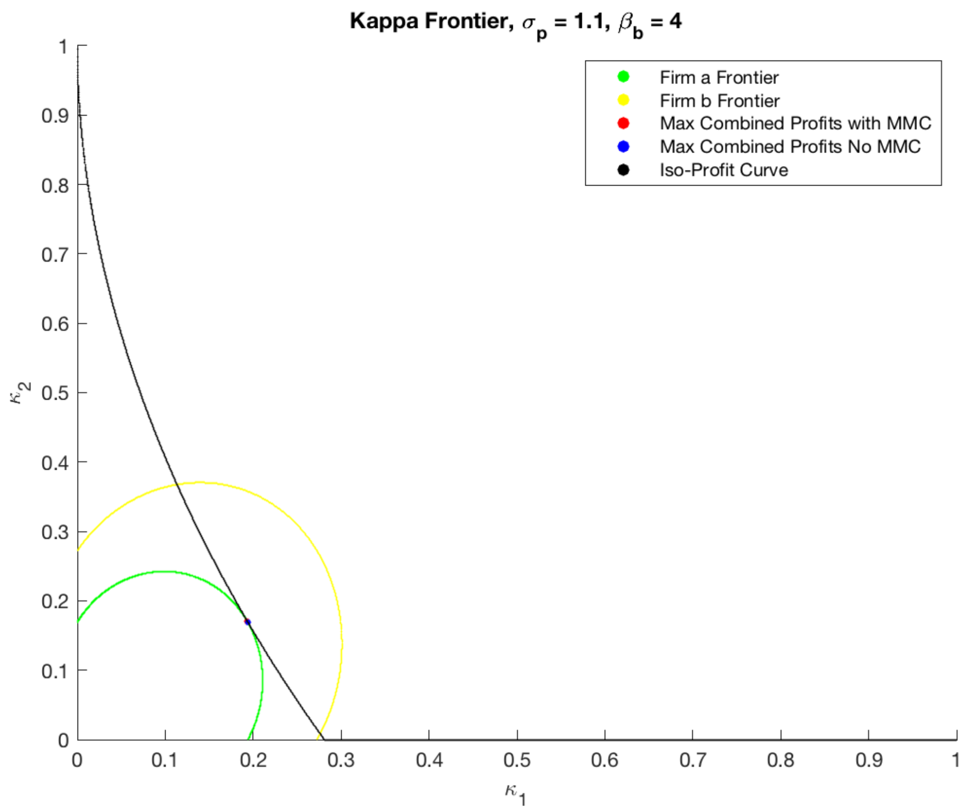

Figure C4: κ Frontier, Market 1: $\sigma_p = 1.1$, Market 2: $\beta_b = 4$

Takeaways. In section 2.2 we presented analytical results, focusing on the role played by the symmetric positioning property on the potential gains from multimarket contact. These results were obtained under shape restrictions on firms' profit functions.

The simulation exercise above demonstrated, first, that these restrictions are satisfied by the Random Coefficient model, at the parameter values of the baseline simulation. It then showed that whether symmetric or asymmetric positioning prevails is determined by the demand parameters, and that these properties, in turn, determine the scope of the potential impact from multimarket contact. This exercise sheds light on the relationship between the underlying demand structure and the analysis of multimarket contact.

Additional Simulations. To further validate these results, we perform a variety of different simulations by changing the market fundamentals described above. In particular, we change the number of products in each market, the number of fringe competitors, marginal costs and the parameter values. So far, this ongoing work suggests that the patterns demonstrated above are generally present in these additional simulations as well.

Importantly, we have found that the restrictions of Assumption 1 can be violated at some demand parameters. This suggests that one cannot simply assume that these restrictions hold, and instead these conditions should be verified, much in the spirit of what was shown in the baseline simulation above.

The empirical method of estimating the potential impact of multimarket contact, presented in section 2.3 can be applied even if these restrictions do not hold. What is lost, however, is the ability to draw on our analytical results, primarily, Corollary 1, in interpreting the relationship between the estimated parameters and the estimated potential impact of multimarket contact.

D Tables and Figures

Table 1: Demand estimates: Packaged Hummus Salad

Characteristics w/o random coefficients			**Characteristics with random coefficients**				
	β	SE		β	SE	σ	SE
Constant	-2.626	1.157	a	6.002	0.894	0.024	11.998
spicy	-1.201	0.179	b	5.769	0.595	0.109	7.512
cress	-1.018	0.156					
pine nut	-0.288	0.232	**Price sensitivity**				
tahini	-0.974	0.139					
masabacha	-0.286	0.195		α	SE	σ_p	SE
other condiments	-1.241	0.151					
spicy_trend	0.943	0.470		-3.082	0.836	0.926	0.379
Tahini_trend	1.597	0.421					
c	2.728	0.139					
d	1.722	0.159					
e	2.806	0.142					
f	0.617	0.114					
h	6.434	1.375					
i	1.754	0.303					
a_spicy	0.875	0.157					
b_spicy	0.747	0.187					
c_spicy	1.203	0.183					
Observations	2,031						

Notes: Utility parameter estimates. See text for description of product characteristics. The letters a-i represent a selected set of brand dummy variables, where the a and b brands also have estimated random coefficients. The a, b and c brands were interacted with the "spicy" dummy variable. The spicy and Tahini characteristics were interacted with the time trend. Dummy variables for 42 months were included but not reported. Source: authors' estimates implied by the data and model assumptions.

Table 2: Demand estimates, Instant Coffee

Characteristics w/o random coefficients			**Characteristics with random coefficients**				
	β	SE		β	SE	σ	SE
Constant	-0.948	1.891	a	6.400	0.782	0.693	8.451
decaff	2.118	0.830	b	2.303	2.095	4.152	2.427
delicate	-0.180	0.128					
dry	1.443	0.632	**Price sensitivity**				
grained	-0.979	0.129					
golden	0.797	0.574		α	SE	σ_p	SE
c	6.141	0.701		-4.849	1.933	1.356	0.877
d	-0.671	0.429					
e	6.742	0.796					
Observations	1,515						

Notes: Utility parameter estimates. See text for description of product characteristics. The letters a-e represent brand dummy variables, where a and b are the two leading manufacturers. A selected set of additional brand dummies denoted c, d, e are included (see text). Dummy variables for 42 months were included but not reported. Source: authors' estimates implied by the data and model assumptions.

Table 3: The potential impact of multimarket contact on profits (%)

Sample month	Firm a	Firm b	Combined profits, firms a and b
1	0.44	0.36	0.39
2	0.53	0.41	0.46
3	0.52	0.38	0.44
4	0.46	0.41	0.43
5	0.34	0.37	0.35
6	0.43	0.41	0.42
7	0.41	0.37	0.38
8	0.42	0.38	0.40
9	0.13	0.12	0.12
10	0.16	0.15	0.16
11	0.37	0.32	0.34
12	0.45	0.36	0.40
13	0.41	0.36	0.38
14	0.39	0.33	0.36
15	0.53	0.35	0.42
16	0.23	0.21	0.22
17	0.33	0.26	0.29
18	0.31	0.27	0.29
19	0.22	0.18	0.20
20	0.20	0.16	0.18
21	0.38	0.31	0.34
22	0.31	0.22	0.25
23	0.25	0.20	0.22
24	0.19	0.15	0.17
25	0.17	0.14	0.15
26	0.36	0.30	0.32
27	0.32	0.26	0.29
28	0.33	0.25	0.28
29	0.19	0.18	0.18
30	0.01	0.03	0.02
31	0.14	0.12	0.13
32	0.25	0.19	0.22
33	0.33	0.30	0.32
34	0.24	0.23	0.23
35	0.21	0.23	0.22
36	0.40	0.29	0.34
37	0.00	0.00	0.00
38	0.26	0.25	0.26
39	0.19	0.15	0.16
40	0.07	0.06	0.06
41	0.14	0.12	0.13
42	0.08	0.07	0.08
43	0.14	0.15	0.14
Maximum impact	0.53	0.41	0.46

Notes: The percentage difference in profits between the $\kappa(\delta)$ and the $\hat{\kappa}(\delta)$ vector, capturing the potential impact of multimarket contact, is presented. The analysis was performed separately in each sample month. The bottom row shows the maximum impact over the 43 month-specific analyses. Source: authors' estimates implied by the data and model assumptions.

Table 4: The potential impact of multimarket contact on prices (%)

Sample month	Packaged Hummus Salad	Instant Coffee
1	0.50	0.53
2	0.55	0.51
3	0.51	0.57
4	0.33	0.68
5	0.21	0.77
6	0.32	0.67
7	0.35	0.54
8	0.35	0.62
9	0.10	0.23
10	0.11	0.31
11	0.36	0.51
12	0.41	0.47
13	0.36	0.55
14	0.36	0.43
15	0.60	0.31
16	0.18	0.25
17	0.35	0.20
18	0.27	0.33
19	0.26	0.14
20	0.27	0.11
21	0.43	0.30
22	0.37	0.16
23	0.32	0.17
24	0.23	0.13
25	0.23	0.09
26	0.43	0.31
27	0.41	0.34
28	0.46	0.23
29	0.21	0.29
30	-0.03	0.10
31	0.22	0.09
32	0.37	0.15
33	0.34	0.31
34	0.28	0.31
35	0.13	0.47
36	0.48	0.25
37	0.01	-0.01
38	0.25	0.43
39	0.30	0.13
40	0.07	0.08
41	0.16	0.12
42	0.05	0.16
43	0.07	0.35
Maximum impact	0.60	0.77

Notes: The percentage difference in the sales-weighted average price between the $\kappa(\delta)$ and the $\hat{\kappa}(\delta)$ vector, capturing the potential impact of multimarket contact, is presented for each of the two categories. The analysis was performed separately in each sample month. The bottom row shows the maximum impact over the 43 month-specific analyses. Source: authors' estimates implied by the data and model assumptions.

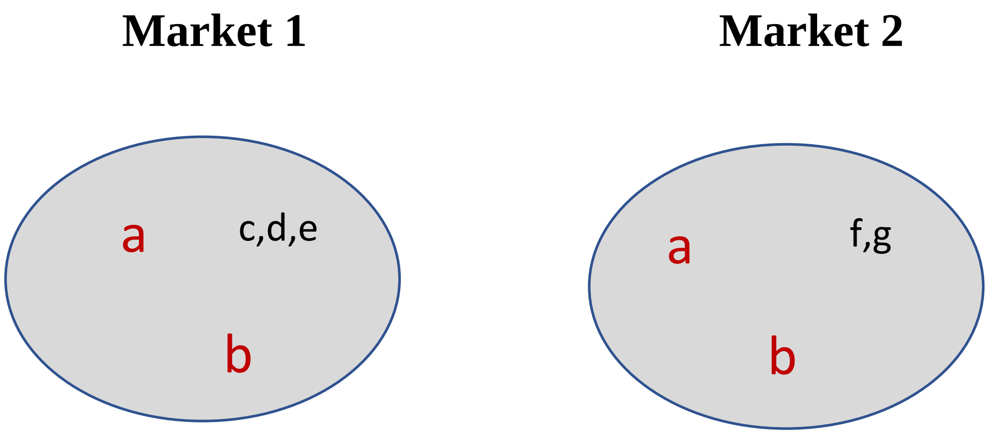

Figure 1: Firms' presence within and across markets

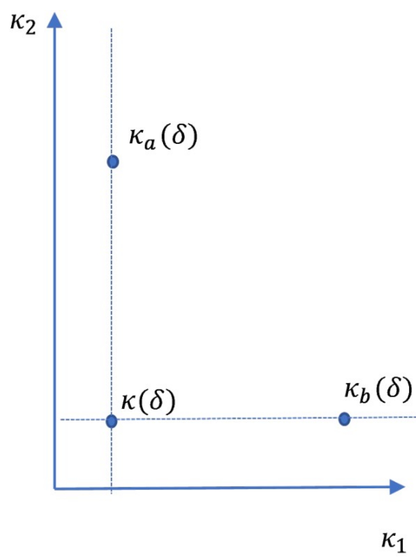

Figure 2: Largest supportable κ vectors absent multimarket contact

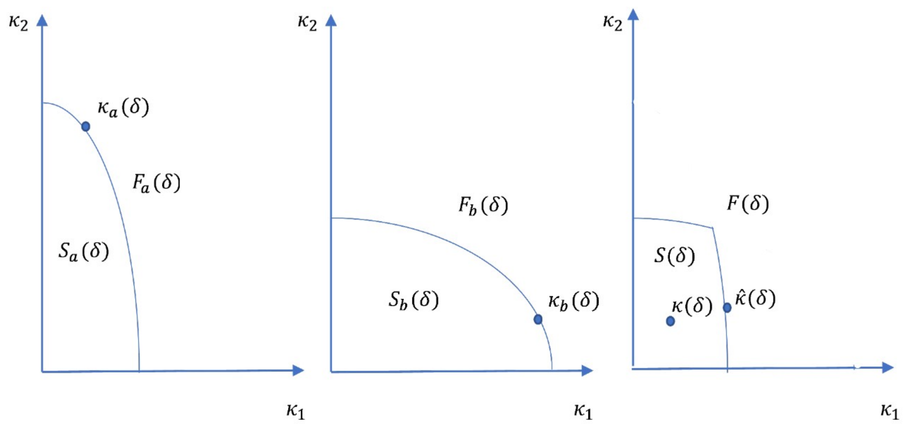

Figure 3: Supportable κ vectors with multimarket contact

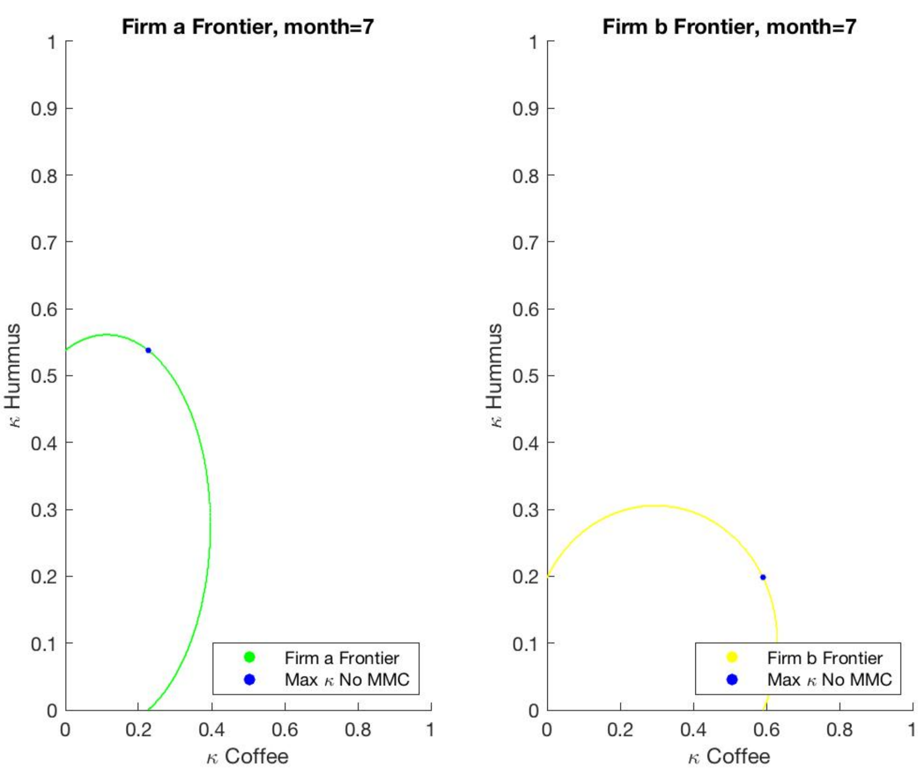

Figure 4: Firms' individual ICCs, with and without multimarket contact

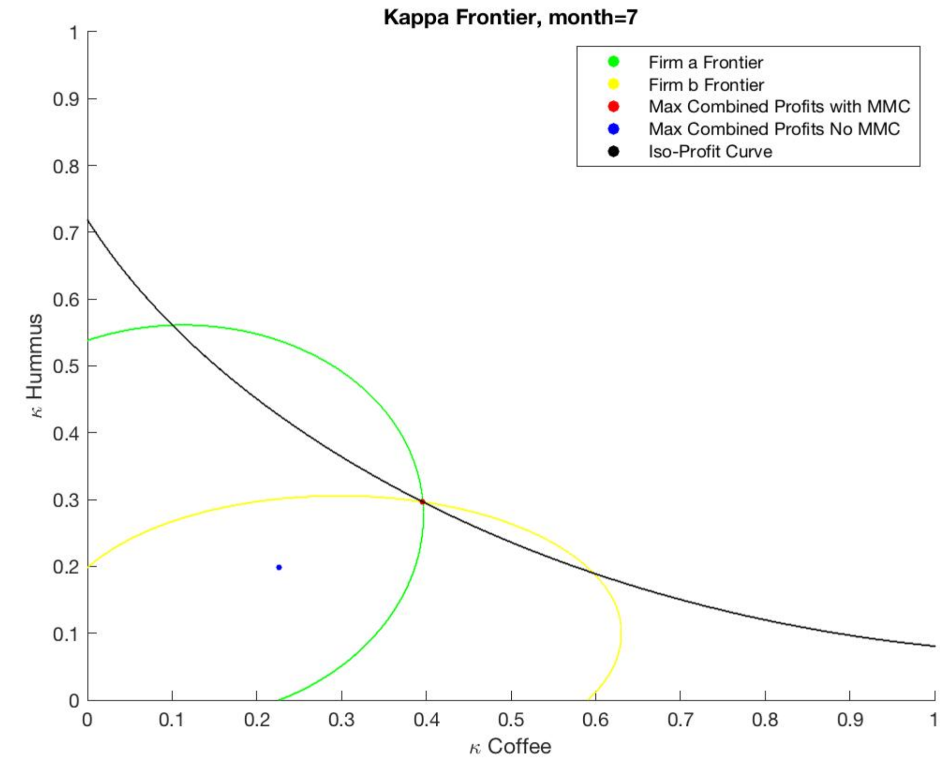

Figure 5: Intersecting both firms' ICCs, with and without multimarket contact

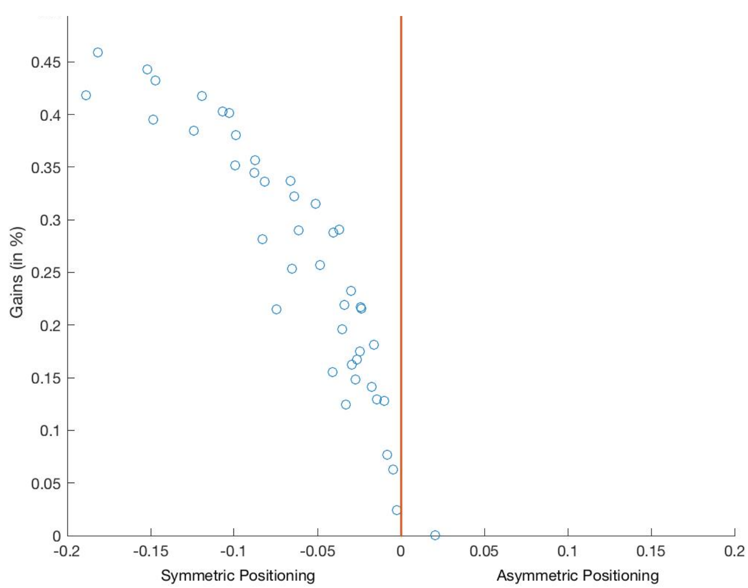

Figure 6: The magnitude of the symmetry / asymmetry property and its relationship to the potential gains from multimarket contact over the 43 month-specific analyses

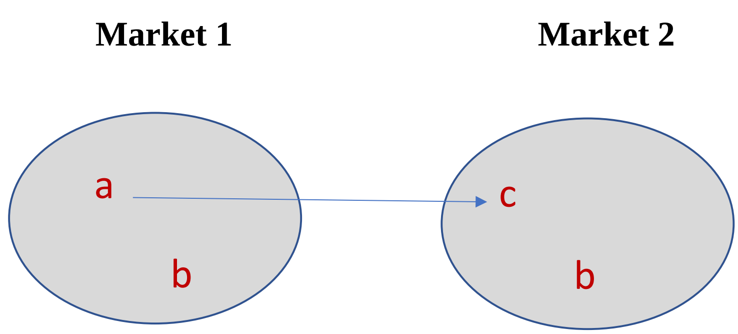

Figure 7: A hypothetical merger generating multimarket contact