Estimating the Strategic Effect of Multi-Market Contact*

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Abstract

Economic theory suggests that cross-market interactions affect the intensity of competition by aggregating Incentive Compatibility Constraints over markets. We build on this insight and develop a structural econometric model of multimarket contact. The model makes it possible to estimate the constraints and to evaluate the effect of their aggregation on the range of sustainable prices. We also derive analytical results that associate the multimarket contact effect with specific features of demand in the relevant industries. This motivates demand estimation as an informative step in the empirical analysis of multimarket contact. Applying the model to an observed case of multimarket contact in the Israeli food sector we find a modest strategic effect on prices and profits.

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1 Introduction

Multimarket contact occurs when the same competitors interact in multiple markets. This phenomenon has raised long-standing concerns regarding an adverse effect on the intensity of competition. The relevant theory is articulated in Bernheim and Whinston (1990, BW90 hereafter) who analyze a repeated game where sustaining prices above competitive levels requires firms to satisfy Incentive Compatibility Constraints (ICC). Multimarket contact allows for an aggregation of such constraints over the markets in which the firm overlaps with a competitor. Whether or not this aggregation allows less competitive outcomes to be supported in equilibrium depends on cost and demand primitives.

This paper proposes an empirical methodology that builds directly on this insight. Our goal is to quantify the strategic effect of multimarket contact across two industries where the same two competitors overlap. In a first step, demand in both industries is estimated following standard methods. Marginal costs are obtained given an assumed (or estimated) competitive conduct characterizing the Data Generating Process. With both demand and cost estimates at hand we calculate firms' ICCs. Finally, we aggregate each firm's constraints over the two industries and compare the equilibrium prices that may be sustained with, and without this aggregation. This comparison reveals the strategic effect of multimarket contact on the intensity of competition.

Supergames of competitive interaction have infinitely-many equilibria. This means that we compare *two sets of outcomes*: the set that is sustainable when firms internalize their multimarket contact, and the set that is sustainable when they ignore it. To facilitate this comparison, in each of the two sets we compute the point that maximizes firms' joint profits and compare prices and profits across these two points. Our assumptions guarantee the uniqueness of these points resulting in well-defined measures of the multimarket contact effect.

While we study multimarket contact rather than mergers, our approach accords well with what Farrell and Baker (2021) describe as "the repeated game approach to coordinated (merger) effects that has dominated the economics discussion of the topic in recent decades.[1]" The essence of that approach is to compare "the worst that might happen" with, and without the merger. Our approach analogously compares the least competitive outcomes possible with, and without firms' internalization of their multimarket contact.[2]

The extant empirical literature on multimarket contact typically estimates the in-sample effect of observed changes in multimarket contact on prices or margins. Our framework in contrast employs out-of-sample calculations of incentive-compatible prices with, and without contact. This strategy complements the traditional paradigm and is particularly attractive in cases where in-sample variation in contact is not available.

[1] The word "merger" in parenthesis was added by us.

[2] See Farell and Baker, Ibid., for a critical discussion of this approach.

Consider a case where the same two firms, a and b, operate in two different industries with rather stable market shares over time. Despite this lack of in-sample variation in the intensity of the multimarket contact, our approach can still assess the scope of its competitive effect. Indeed, we implement our approach to two categories of the Israeli food sector that match this scenario.

Yet another possible application for our method, not pursued in this paper, is to estimate the potential effect of hypothetical multimarket contact — one that is not present in the data, but could be established via a proposed merger. 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 be used to simulate the effect of such mergers.[3]

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

Intuitively, these conditions are sufficient since they imply identification of both demand and marginal costs. Computing the ICC requires the evaluation of variable profit payoffs in three scenarios: on the equilibrium path, in an optimal one-shot deviation, and under a competitive reversion following a deviation. Given demand parameters and identified marginal costs it is possible to compute variable profits under a wide range of scenarios — including those three.

The structural model. The model considers two industries featuring the same two main competitors. Each industry also features a fringe of smaller competitors, assumed to act competitively given any history of the game.[4] Adapting the stylized framework of BW90 to an empirical context poses three challenges. First, products are non-trivially differentiated in the characteristics space whereas BW90 consider homogeneous or symmetrically-differentiated goods only. Second, the empirical context suggests the presence of cost and demand shocks, implying that the stage game is not identical over time. Finally, BW90 allow each firm to sell a single product in each industry whereas the empirical context may have them selling multiple such products.

To incorporate product differentiation we model demand using the familiar Random Coefficient Logit model (BLP95). This requires us to verify that payoff functions generated by this demand system conform to other assumptions imposed in the repeated game framework. We develop

[3]The issue of conglomerate mergers has attracted considerable interest in economics and antitrust. See Ashenfelter, Hosken and Weinberg (2014) for an historical perspective.

[4]This assumption fits the institutional details of our empirical application but may be easily modified to allow such firms to act noncompetitively as well.

methods that check whether such internal consistency holds in a particular application. To deal with the fact that the stage game is not identical over time we assume that firms have bounded rationality: when computing the benefits and costs of deviation, firms assume that current cost and demand conditions shall persist indefinitely, ignoring future shocks. This leads to simple and transparent Incentive Compatibility Constraints that mimic those in BW90.

Finally we deal with the challenge brought about by multi-product firms. The question of interest is whether multimarket contact can allow firms to sustain higher prices. But with multi-product firms, the sense in which prices are "higher" requires a clear definition. Pushing further away from the competitive benchmark need not imply that the firm chooses to increase the prices of all its marketed products.

To succinctly capture the notion of less competitive behavior we restrict attention to price vectors that could have been generated in a static price-setting game where the leading firms' pricing behavior in each industry is governed by a single "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 extent to which multimarket contact can push the sustainable κ values away from zero is our measure of the strategic effect of multimarket contact.

Importantly, the conduct parameter concept is used here merely as a mechanical device that summarizes the distance of market outcomes from the competitive benchmark. It is not used to model firms' actual behavior. Indeed, we model a Supergame of repeated interaction rather than a static game with conduct parameters. Our analysis is therefore not subject to the well-known critique in Corts (1999).

We fix firms' discount factors at a nontrivial value: one under which the least-competitive outcome cannot be achieved in a Subgame Perfect Nash Equilibrium (SPNE) ignoring multimarket contact. Otherwise, multimarket contact has no impact to begin with. We 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 follow BW90 by modeling a Supergame where past actions are perfectly observable before the next period play. Unlike BW90, however, we employ grim-trigger rather than optimal punishments which would be quite complicated to derive in the empirical context. Of note, the grim-trigger mechanism is a staple of the Supergame literature and, in particular, is used in all empirical studies that take Supergames of competitive interaction to data of which we are aware.

Why does demand matter? We employ demand estimates to learn about the consequences of multimarket contact. However, the map from demand primitives to the role played by multimarket contact is quite complicated. 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). This complexity makes it difficult to gain intuition regarding the empirical findings or to have a sense of why demand estimates inform the analysis at all.

To address this challenge we derive a sequence of analytical results and simulations within the structural model. These results establish a property to which we refer as "*symmetric positioning*" as an important driver of the competitive effect of multimarket contact. Denoting the leading firms by a and b, symmetric positioning means that in one market, firm a's ICC can be satisfied at a less-competitive outcome than firm b, while in the other market it is firm b that can sustain a less-competitive outcome than firm a.[5] The simulations then reveal that symmetric positioning is more likely to hold when each firm enjoys a *demand advantage* in a different market. This result connects a specific pattern involving demand primitives with the potency of a multimarket contact effect on competition, shedding some light on this complex relationship.

Empirical application. We apply the model to data from two categories of the Israeli food sector — Packaged Hummus Salad and Instant Coffee — where the same two firms are the market leaders.

We begin by estimating demand in each of the two categories separately.[6] To estimate marginal costs we assume that the data were generated by the competitive benchmark, i.e., Nash in prices, in both categories. This assumption implies price-cost margins that are quite reasonable for the type of products studied in this paper. Of note, other strategies are compatible with our framework. For example, we could assume that the data was generated by some degree of non-competitive behavior, or calibrate it using standard methods.[7]

Finally, we compute the Incentive Compatibility Constraints and the sets of prices that could be sustained in Subgame Perfect Nash Equilibria when firms do, and do not, internalize their multimarket contact. This comparison provides a measure of the strategic effect of multimarket contact. This measure has a clear interpretation even when the actual in-sample behavior is competitive: it informs us regarding the extent to which firms *could push away* from competition and regarding the contribution of multimarket contact to that potential ability.

We find this potential effect to be small in the studies categories: profits and sales-weighted prices could potentially be increased, thanks to multimarket contact, by less than one percentage point. We discuss the intuition underlying this modest effect, owing in part to the role of the competitive fringe, and to the lack of a symmetric "demand advantage" across the two categories.

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

[5] This property can be thought of as mirroring the "symmetric advantage" property in BW90. Our symmetric positioning property is different as it pertains to the ability to satisfy the ICCs rather than to a cost advantage.

[6] This ignores the possibility of a link between the two demand systems. For example, Packaged Hummus Salads and Instant Coffee may be complementary goods, or their demand may be linked via the household's budget constraint. Given the nature of the products, and the relatively small portions of a household's budget constraint spent on them, we view such connections are negligible.

[7] The literature on estimating conduct parameters is vast, see Michel and Weiergraeber (2018) for a recent example. Yet another possibility is to calibrate costs to match some external data source on profit margins as in Bjornerstedt and Verboven (2016).

Relationship to the literature. Some early analyses of multimarket contact include Edwards (1955) and Kahn (1961).[8] Empirical work has generally focused on regressing a measure of competition intensity on measures of multimarket contact, exploiting in-sample variation. The measures of competition intensity often include prices, margins, or conduct parameters estimated from structural models. Some studies use alternative dependent variables such as patent citations or measures of market share stability.

Most, but not all of these studies have found an adverse effect of multimarket contact on the intensity of competition across a wide range of industries. Examples include airlines (Evans and Kessides (1994), Sin et al. (2010), Ciliberto and Williams (2014), Ciliberto et al. (2019)), banking (Heggestad and Rhoades (1978), Whitehead (1978),Mester et al. (1986), Gelfand and Spiller (1987), De Bonis and Ferrando (2000), Hatfield and Wallen (2022)), cement (Jans and Rosenbaum (1997), Ghemawat and Thomas (2008)), chemicals (Scott (2001)), mobile telephony (Parker and Röller (1997), Domínguez et al. (2016)), freight railroad (Pus (2018)) and retail lumber (Khwaja and Shim (2017)).[9]

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 to data. To the best of our knowledge, this is the first empirical study of multimarket contact to take this approach.

The theory literature on Supergames of competitive interaction is vast and a complete survey of it is outside of 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 pricing. Porter (1983) and Green and Porter (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 i.i.d. demand shocks and show that those are negatively correlated with the sustainable price level. Abreu (1986) and Abreu (1988) derive 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 (2022) study the stability of the 1990s Vitamin cartels. Miller et al. (2021) 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, focuses on a different question — the strategic role of multimarket contact — motivating methodological departures.

[8] See Evans and Kessides (1994).

[9] Multi-industry studies include Feinberg (1985) and Strickland (1985). Another important line of research focuses on experimental research designs including Feinberg and Sherman (1985), Feinberg and Sherman (1988), and Phillips and Mason (1992).

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. Section 2.3 adds the demand side via the Random coefficient Logit model, and reports simulation results that connect the symmetric positioning property to underlying demand primitives. Taken together, these components result in a structural model of supply and demand with multimarket contact that can be taken to data.

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 both markets $m = 1, 2$. Each market also features a competitive fringe. In each market there are also additional (different) competitors that are assumed to form a competitive fringe. Fringe firms offer minimal product differentiation and set prices to maximize their profits given rivals' prices. The set of competitors in each of the two industries is depicted in Figure 1.

We maintain several assumptions that are ubiquitous in the Supergame literature. In particular we assume that past actions are perfectly observed before the next period play.[10] Deviations from equilibrium-path pricing result in reversion to competitive pricing — i.e., Nash-Bertrand pricing — forever. We also maintain that marginal costs are constant in output, and consider fixed costs, entry and exit decisions to be exogenous.

The stage game. In stylized Supergame models the stage game is often assumed to be identical over time. This assumption considerably facilitates the exposition but is inconsistent with an empirical setup that admits seasonality effects and random shocks to cost and demand.

We do not assume that the stage game is identical over time but rather that firms are characterized by bounded rationality: when computing the discounted payoff streams associated with specific actions the firms assume that current cost and demand conditions shall prevail indefinitely. This simplification results in Incentive Compatibility Constraints that look exactly like those in BW90. We could instead allow firms to compute expectations of payoff streams with respect to future shocks. This would complicate the math considerably and would not necessarily be more reasonable than to assume that firms make simplified, approximate calculations.

This approach results in different calculations of the effect of multimarket contact in every period, which is a month in our empirical application. If this assumption was strongly misspecified we would have expected to see considerable variation in these estimated effects depending on the month in which they were calculated. This is not the case: as we show in Section 3 we

[10] 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.

obtain the same qualitative (and very similar quantitative) conclusions irrespective of the month in which the calculation is performed.

Another challenging aspect of our empirical application 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. In our empirical context each firm sells multiple, non-symmetrically differentiated products in each market. It is then not immediately clear how to rank sustainable prices.

To address this challenge we define a one-dimensional statistic that captures, in each market, the extent of departure of a given price vector from the competitive benchmark of Nash Bertrand pricing. We denote this statistic by $\kappa_m \in [0,1]$ where again $m = 1,2$ denote the two markets. We then compute the set of vectors (κ_1, κ_2) that can be supported in equilibrium with multimarket contact, and the set that can be supported without it. We learn about the strategic effect of multimarket contact by comparing these two sets.

This is accomplished by restricting firms' strategies in the following fashion. Consider an equilibrium characterized by some vector $(\kappa_1, \kappa_2) \in [0,1]^2$. On the equilibrium path, prices 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. As the κ parameters increase towards 1 we push away from the competitive benchmark towards less competitive outcomes. Off the equilibrium path, firms revert to 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 rank vectors of supra-competitive prices. This stands in contrast to the conventional use of conduct parameters in the empirical literature, i.e., a static model approximation to the true, dynamic pricing behavior (Bresnahan (1989)). We, in contrast, study a Supergame. Our approach is therefore not subject to the familiar problems associated with conduct parameters (Corts (1999)). But our approach does come with a cost: in determining the sets of prices that may be supported with and without multimarket contact, we must restrict attention to price vectors that can be generated by the conduct parameter device.[11] We denote the price vector charged on the equilibrium path by p^{κ_m}.

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

[11] 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.

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

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 pertaining to firm a's rivals' prices. 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 fringe 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 its variable profits, $\sum_{j \in \mathcal{J}_{f,m}} v_j(p_f, p_{-f}^{NB,m})$.

Incentive Compatibility Constraints. Consider a set of strategies for all firms such that market m's prices are given by p^{κ_m} if no deviation took place in a previous period, and by $p^{NB,m}$ otherwise. These strategies constitute an SPNE of the supergame if an Incentive Compatibility Constraint (ICC) holds for each of the firms a and b. ICCs are only defined for the two leading firms since all other firms are Nash players given any history.[12]

We first define ICCs that obtain when firms *do not internalize their multimarket contact* so that the strategic considerations of each market are analyzed separately. 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 p^{κ_m} to be sustainable in equilibrium, the following ICC must hold for each firm $f \in \{a, b\}$:

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

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.[13] 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.[14] The price vector $\hat{p}_f^{\kappa_m} = argmax_{p_f} \Pi_{f,m}(p_f, p_{-f}^{\kappa_m})$ is firm f's optimal deviation from the equilibrium path: it maximizes its flow payoff given that its rival adheres to the equilibrium pricing prescribed by κ_m. Following such a deviation, the

[12]Since prices are strategic complements, if the leading firms depart from the competitive benchmark and sustain $\kappa_m > 0$, then the prices of fringe firms would also exceed their Nash-Bertrand levels.

[13]This is the actual payoff of the firm. Note that 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 prices.

[14]See BW90 for a discussion of the possibility that a firm applies different discount factors in different markets.

firm would garner the Nash-Bertrand payoffs indefinitely.

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 allows the ICC to hold:

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

where we use the shorthand expressions $\hat{\Pi}_{f,m} \equiv \Pi_{f,m}(\hat{p}^{\kappa_m}_f, p^{\kappa_m}_{-f})$, $\Pi_{f,m} \equiv \Pi_{f,m}(p^{\kappa_m})$, and $\Pi^{NB}_{f,m} \equiv \Pi_{f,m}(p^{NB,m})$.

The quantities $\hat{\Pi}_{f,m}, \Pi_{f,m}$ and $\Pi^{NB}_{f,m}$ (i.e. the flow payoffs associated with staying on the equilibrium path, with a one shot deviation, and with the competitive reversion, respectively) are evaluated given the prevailing cost and demand conditions in the relevant period. These payoffs will therefore be different across time periods. But the bounded rationality implies that firms, at any point in time, act as if these quantities will be stable forever. As a consequence, only these three quantities appear in the ICC, and no expectations over future shocks are necessary.

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 obtain the ICCs when firms *do internalize their multimarket contact*. Following BW90, this changes the strategic interaction considerably. Firm a may now expect a Nash-Bertrand reversion in *both markets* if it were to deviate in just one of them. Anticipating this, the firm 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 faces a single constraint defined over both markets:

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

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

Definition 2. *(Equilibria absent multimarket contact). If firms do not internalize their multimarket contact, a (κ_1, κ_2) outcome is supported in an SPNE 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 compares the set of (κ_1, κ_2) vectors that can be supported in equilibrium with multimarket contact to the set that can be supported without it. In the following subsection we impose shape restrictions on payoff functions that sharpen the characterization of these sets.

2.2 Additional structure and analytical results

We derive a sequence of analytical results that characterize the sets of supportable (κ_1, κ_2). The results also establish the role of a property to which we refer as "symmetric positioning" in determining the impact of multimarket contact.

We impose shape restrictions on the functions describing firms' flow profits on the equilibrium path, and in an optimal one-shot deviation, respectively. The restrictions are summarized in Assumption 1 below and focus on the relationship between those profits and the level of κ_m. To facilitate the exposition we rewrite firm f's profit functions (with a slight abuse of notation) to explicitly depend on this parameter: $\Pi_{f,m}(\kappa) \equiv \Pi_{f,m}(p^\kappa)$, $\hat{\Pi}_{f,m}(\kappa) \equiv \Pi_{f,m}(\hat{p}^\kappa_f, p^\kappa_{-f})$.[15]

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 $(ii) - (iv)$ of Assumption 1 are testable and we indeed verify that they hold in our empirical application. Stronger assumptions — the concavity of equilibrium path profits and the convexity of the deviation profits — are made in BW90 (noting that BW90 do not have a κ parameter and so the concavity and convexity in their work is with respect to prices). The shape restrictions stated here are therefore both testable, and in line with the literature.

Below we shall introduce the assumption that demand follows the Random Coefficient Logit (RCL) model (Berry (1994), BLP95). Internal consistency 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 the shape restrictions. It is therefore important to test these restrictions when taking the model to data.

We use the 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 $m = 1, 2$. 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. 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 $\pi'(0) = \hat{\pi}'(0)$.

For convenience we define the function $\phi_{f,m}(\kappa) \equiv \pi_{f,m}(\kappa) - (1-\delta)\hat{\pi}_{f,m}(\kappa)$. Firm f's ICC in market m absent multimarket contact (equation (1)) can now be rewritten as:

[15] 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.

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

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 when* $\kappa \in (0, 1]$.

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 stems from firm's ICC holding at κ, and the last inequality following from the 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 challenging in the sense of requiring increasing levels of the discount factor. This 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 $\tilde{\kappa} < \kappa$.

With these insights we next define the supportable departure from competition when firms do not internalize their multimarket contact.

Definition 3. *(Largest sustainable departures from competition absent multimarket contact). 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 largest 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. Satisfying both firms' constraints requires taking the minimum over the κ levels where their individual ICCs hold in each market. Taking the minimum is justified by the single crossing property established in part (iii) of the Lemma: satisfying a constraint at a given value of κ guarantees that it is satisfied at any smaller value.

The conduct levels that are sustainable absent multimarket contact are illustrated in Figure 2. Conduct levels for market 1, κ_1, are displayed on the horizontal axis and conduct levels for market 2, κ_2, are shown on the vertical axis. The origin $(0,0)$ corresponds to the Nash-Bertrand competitive benchmark.

The vector $\kappa_a(\delta)$ denotes the largest κ values that satisfy firm a's ICCs in each of the two markets, while $\kappa_b(\delta)$ holds the same information for firm b. The vector $\kappa(\delta)$ captures the largest departure from the competitive benchmark that is feasible in equilibrium as it satisfies both firms' constraints. This is the vector defined in part (*ii*) of definition 3. The region colored in orange represents the entire set of conduct levels that can be sustained in equilibrium.

The figure presents an illustrative example where each firm is able to support a larger κ level than its rival in a different market (specifically, firm a can support a larger κ than firm b in market 2, while the opposite is true for market 1). We shall later define this property "symmetric positioning" and establish its relevance to the study of multimarket contact.

We next define the set of κ vectors that can be supported in equilibrium when multimarket contact is internalized.

Definition 4. *(Largest sustainable departures from competition with multimarket contact). Given 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):

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

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

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

(iii) Define the set of κ vectors that satisfy both firm's constraints (and can therefore be sustained in equilibrium):

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

(iv) Define the boundary of $S(\delta)$, $B(\delta)$, 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* $\kappa_2 = 1$

Note that the boundaries referred to in Definition 4 are sets of vectors where the constraints are binding. To complete the characterization of supportable prices given multimarket contact we introduce an additional Lemma.

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

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

(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 top-left, the figure displays firm a's constraint under multimarket contact. The green curve is the Boundary $B_a(\delta)$ of (κ_1, κ_2) vectors that satisfy the firm's ICC when it internalizes the multimarket contact and aggregates its constraints over the two markets. The complete set of vectors satisfying this ICC, $S_a(\delta)$, is simply the area inside this green curve. The figure shows that the set $S_a(\delta)$ is compact and convex, per part (*ii*) of the Lemma. Finally, the blue dot is $\kappa_a(\delta)$, the largest vector that satisfies firm a's ICCs absent multimarket contact. It lies on the $B_a(\delta)$ Boundary as guaranteed by part (*i*) of the Lemma. The top-right part of 3 shows the same information for firm b.

The bottom panel of Figure 3 displays the intersection of the two firms' constraints. The region indicated by orange lines is 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 sustainable when firms internalize their multimarket contact. Any point within this region can be supported in an SPNE when multimarket contact is allowed to affect firms' strategic considerations. The set $B(\delta)$ is the boundary of this "orange" region. Strictly inside this boundary lies the blue dot, indicating the vector $\kappa(\delta)$: the largest supportable vector *absent multimarket contact* (see Definition 3).

To summarize the illustrative example in Figure 3, when firms internalize their multimarket contact, they may sustain any vector inside the set $S(\delta)$ (indicated by the orange lines) in an SPNE of the game. In contrast, if they do not internalize it, they may sustain $\kappa(\delta)$, indicated by the blue dot, and any vector smaller than it.

In this illustrative example, the largest vector that is sustainable absent multimarket contact, the blue dot, lies strictly inside the boundary of sustainable vectors given multimarket contact. This indicates that such contact enhances firms' strategic ability to push further away from the competitive benchmark. As we shall see below, however, this will not always be the case. Whether or not $\kappa(\delta)$ lies strictly inside the boundary $B(\delta)$ will depend on whether a symmetric positioning property, to be formally defined below, holds.

We finally note on a technical aspect of the Boundaries $B_a(\delta), B_b(\delta)$ and $B(\delta)$. Figure 3 shows that each such Boundary is "backward-bending" in the sense of containing some vectors that are dominated by other vectors on the same Boundary. For completeness, we prove that this backward-bending property holds in general in Appendix A, noting that it has little bearing on the analysis.

Quantifying the strategic effect of multimarket contact. With multimarket contact, any vector in the set $S(\delta)$ (the region indicated by orange lines in the bottom panel of Figure 3) can be supported in an SPNE. Without it, any vector $\tilde{\kappa}$ such that $\tilde{\kappa} \leq \kappa(\delta)$ can be supported where $\kappa(\delta)$ is the blue dot.

Both cases feature infinitely-many equilibria. Absent an equilibrium selection mechanism, we cannot determine the precise effect of multimarket contact. As a simple example, it may be the case that the firms end up at the competitive benchmark origin, $\kappa = (0,0)$, with or without multimarket contact, in which case there is clearly no actual effect on competition.

Our approach is therefore informative about the strategic effect of multimarket contact, revealing information about what it allows firms to achieve, independently of the question of what they achieve in practice. This is not a unique aspect of our framework but rather a fundamental aspect of the theory in BW90 on which we build.

To concisely summarize this potential impact we compare the least-competitive outcome that may be obtained with multimarket contact to the least competitive outcome that may be obtained without it. This approach is also consistent with familiar practices.[16] We therefore compute, in each of the two sets of outcomes (i.e., the set of outcomes supportable with multimarket contact and the set that is supportable without it), the vector that maximizes the joint profits for firms a and b — and compare these two vectors in terms of prices and profits.

We define the vector (κ_1, κ_2) that maximizes the joint profit with multimarket contact by:

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

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. The next Lemma establishes that $\hat{\kappa}(\delta)$ is unique, and lies on the Boundary of supportable vectors given multimarket contact.

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

Proof. Since by Assumption 1 total profits increase with κ in each market, continuity of $\phi_{f,m}$ implies that $(\hat{\kappa}_1, \hat{\kappa}_2) \in B(\delta)$. 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 Boundary of supportable vectors when searching for the one that maximizes the sum of profits for firm a and firm b when multimarket contact is internalized.

[16] See Farrell and Baker (2021) and our discussion in the introduction.

The implications of Lemma 3 are displayed in Figure 4. Here, again, the set $S(\delta)$ of vectors that are sustainable in equilibrium given multimarket contact is the region indicated by orange lines. The Boundary of this set, $B(\delta)$, is again the lower envelope of the green and yellow curves (indicating firm a and firm b's Boundaries, $B_a(\delta)$ and $B_b(\delta)$, respectively). The vector $\kappa(\delta)$ is the blue dot and captures the largest departure from competition, and hence the maximal level of joint profits, attainable absent multimarket contact. The red dot is $\hat{\kappa}(\delta)$: the joint-profit maximizing vector under multimarket contact defined in (9).

Consistent with Lemma 3, this red dot is located on the Boundary $B(\delta)$. Our analysis of multimarket contact focuses on comparing prices and profits at the "blue dot" to those at the "red dot."

Gains from multimarket contact. We complete the analytical characterization of the strategic impact of multimarket contact by exploring some of its determinants. Following BW90 we begin by stating an irrelevance result, capturing situations where multimarket contact has no effect on firms' ability to push away from the competitive benchmark.

Lemma 4. *An Irrelevance Result: If 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. The Lemma has a highly stylized flavor. In an empirical setup, we never expect markets to be exactly identical. The question of interest is, therefore, what type of differences in primitives across markets gives rise to substantial gains from multimarket contact?

To better gauge this issue we formally define the concept of symmetric positioning and establish its role in determining the potential gains to firms 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 means that each firm can sustain a larger departure from competition than its rival in a different market. This is the case depicted in Figures 2-3: in market 1, the ICC of firm b is sustained at a larger departure from competition than the ICC of firm a, whereas in market 2 it is firm a that can sustain a larger departure from competition. Asymmetric positioning implies, instead, that one firm can sustain larger departures from competition *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 $\kappa(\delta) \in B(\delta)$.*

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: $\kappa_f(\delta) \in B_f(\delta)$ and $\kappa_f(\delta) \in S_g(\delta)$. Therefore, $\kappa_f(\delta) \in S(\delta)$. By Definition 4(iv), $\kappa(\delta) \in B(\delta)$.

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 $\kappa(\delta) \notin B_1(\delta) \bigcup B_2(\delta) \Rightarrow \kappa(\delta) \notin B(\delta)$. □

The significance of Corollary 1 is as follows. When asymmetric positioning holds, the least-competitive vector that can be supported without multimarket contact, $\kappa(\delta)$, lies on the Boundary of the supportable vectors with multimarket contact. This implies that the extent to which multimarket contact can help firms push away from competition is limited: it can only be realized via movements along the Boundary, rather than via movements to the Boundary. In contrast, with symmetric positioning, the supportable $\kappa(\delta)$ vector in the absence of multimarket contact lies strictly inside the $B(\delta)$ Boundary. This suggests a more substantial scope for firms' gains from such contact. As already noted above, this situation is illustrated in Figure 3.[17]

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 this symmetric positioning property with underlying economic primitives, and, specifically, with features of demand. Absence such connection, it is difficult to appreciate intuitively how an estimated demand system helps one uncover the potential gains from multimarket contact. In the next subsection we address this issue while introducing the final building block of our model: the demand side.

2.3 Demand

Having completed the description of the model's supply side, namely, the Supergame framework, we now turn to demand. We model the demand in each of the two industries separately following the familiar Random Coefficient Logit model (Berry (1994), BLP1995). Let the indirect utility function of consumer i from purchasing product j, in each industry $m \in \{1, 2\}$ (omitting industry and time indices) be 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

[17] Recall that parts of the Boundary $B(\delta)$ are dominated by other feasible points as discussed above. This, however, does not matter for the interpretation of Corollary 1 since we also know from Lemma 3 that the joint profit maximizing point $\hat{\kappa}(\delta)$ lies on the Boundary.

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 fringe firms are also present in each industry. Each fringe firm may carry a portfolio of differentiated products, but is assumed to do it in one of the two industries only. Consumers can also choose the "outside option" of not consuming any product from the relevant industry. The standard normalization of the mean utility from the outside option applies: $u_{i0} = \epsilon_{i0}$.

With normally-distributed random coefficients, the indirect utility 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 to be independent and identically-distributed across both consumers and product characteristics. The parameter σ^p captures taste heterogeneity with respect to price. The indirect utility is separated 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 indirect utility function can be further 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,

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

Having completed the description of the structural model, we next turn to a discussion of its estimation and the manner by which it reveals the strategic effect of multimarket contact.

2.4 Using the model to estimate the strategic effect of multimarket contact

As a first step, the demand parameters θ are estimated in each of the two markets separately. This is done via a standard GMM approach given product-level data on prices, quantities, product characteristics and instrumental variables affecting prices but not the utility errors ξ.

Estimation of the firms' Incentive Compatibility Constraints requires not only the estimated demand parameters $\hat{\theta}$ but also marginal cost estimates. Those may be obtained in several ways. For concreteness, we explain how marginal costs were estimated in our empirical application, and then briefly discuss alternative strategies that may be more appropriate in other applications.

In the food sector application we backed out marginal costs assuming that the behavior observed in the data follows the competitive benchmark, i.e., Nash-Bertrand pricing. In this case, the vector of first-order conditions over all products of all firms, in each of the industries, takes a familiar form:

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

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 determined from (12) given prices p and the demand parameters θ. The matrix $\mathcal{S}$ contains market share derivatives such that $S_{jk} = -\partial s_k(p,\theta)/\partial p_j$.

An estimate of the vector of marginal costs, $\hat{mc}$, can therefore be obtained by plugging the estimated demand parameters $\hat{\theta}$, the observed market shares s, and the observed prices p into (13). The matrix $\mathcal{S}(p;\hat{\theta})$ is also required and it is estimated via standard simulation methods applied to the market share equation (12). As discussed in section 3 below, in our application the price-cost margins $(p - \hat{mc})/p$ implied by this procedure were quite similar to the margins normally expected for the relevant type of products. We therefore carried those estimated marginal costs forward to the remainder of the analysis.

With demand estimates $\hat{\theta}$ and marginal cost estimates $\hat{mc}$ in hand it is possible to estimate firms' Incentive Compatibility Constraints. Using (13) again we obtain margins and variable profits under the Nash-Bertrand competitive benchmark, revealing $\Pi(0)$. The FOCs in (13) are also used to evaluate how prices would look like if firms switched to an SPNE where, on the equilibrium path, they moved away from competitive pricing by an extent captured by $0 < \kappa \leq 1$. This is done by placing κ on the off-(block) diagonal elements of Ω and calculating the resulting hypothetical price equilibrium and the variable profits $\Pi(\kappa)$ on that equilibrium path. Finally, we solve for each firm's optimal deviation from that equilibrium and obtain an estimate of the deviation payoffs $\hat{\Pi}(\kappa)$.

We thus estimate the equilibrium path payoffs $\Pi(\kappa)$ and deviation payoffs $\hat{\Pi}(\kappa)$ for each firm, in each market, at specific levels of the departure from competition κ. We use those to form polynomial approximations of the functions $\Pi(\kappa)$ and $\hat{\Pi}(\kappa)$, allowing us to evaluate those payoff functions at any value of κ between 0 and 1.

We next fix 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 then perform numeric evaluations of the largest κ levels that satisfy each firm's individual ICCs when it ignores multimarket contact (equation (1), i.e., $\kappa_f(\delta)$ per Definition 3).

We also calculate the Boundary of κ vectors that satisfy the firm's ICC when it internalizes its multimarket contact (equation (3)), $B_f(\delta)$ per Definition 4. We then intersect both firm's constraints to obtain $\kappa(\delta)$ and $B(\delta)$. On the Boundary $B(\delta)$ we perform a numeric grid search for the vector that maximizes joint profits, $\hat{\kappa}(\delta)$. Finally, we compare prices and profits at the vectors $\kappa(\delta)$ and $\hat{\kappa}(\delta)$ to obtain our measure of the multimarket contact effect. Appendix B provides additional computational details regarding these tasks.

Alternative strategies. Above we have described the procedure we implemented in our application to the Israeli food sector. It turned out, in this case, that a Nash-Bertrand assumption yielded estimated margins that accorded well with our institutional knowledge.

It therefore seemed appropriate to consider the competitive benchmark as the true Data Generating Process. The analysis was therefore motivated as follows: while the data was generated by the competitive benchmark, we examine the extent to which firms *could* push away from it towards less competitive outcomes, focusing on the impact of multimarket contact on this ability.

This exercise informs us regarding the potential harm to competition from multimarket contact. It is of value to learn about that potential harm even if it is not currently realized. For example, it could be that firms are currently deterred from pursuing less competitive equilibria, even if they are feasible in the sense of satisfying ICCs. Or, firms may currently find it difficult to coordinate on such feasible outcomes. The analysis reveals the magnitude of the harm to consumers if those circumstances were to change.

In other applications it may not be appropriate to treat the competitive benchmark as the DGP. Our framework can then admit alternative assumptions. For example, one may obtain the estimated marginal costs $\hat{mc}$ by calibrating them using crude data on margins (Bjornerstedt and Verboven (2016), Eizenberg et al. (2021)), or perform the analysis under different assumptions regarding the DGP as may seem appropriate. Computation of the feasible sets of outcomes with, and without multimarket contact would then follow exactly as prescribed above.

2.5 Simulation analysis

As a final step before taking the model to data we conduct a series of simulations. First, as a matter of internal consistency, we examine whether the shape restrictions on the profit functions (Assumption 1) are maintained when demand is given by a Random Coefficient Logit (RCL) model of demand. Second, we evaluate the impact of multimarket contact at different demand parameter values to gauge the relationship between demand primitives and our object of interest.

The complete details regarding the simulations are provided in Appendix C. The main insights are the following:

1. The shape restrictions of Assumption 1 are often, but not always, maintained in simulations of the RCL model.

2. Whether *symmetric positioning* holds depends on demand parameters.

3. Fixing a specific industry 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, as price sensitivity in the industry increases, one firm's market-specific ICC (equation (1)) binds at a higher level of κ while the other firm's ICC binds at a lower level of κ.

4. Again fixing an industry and all other parameters, increasing the mean or the standard deviation of the utility associated with one firm's brand increases the maximal κ level at which this firm's individual ICC holds while also lowering this maximal κ for its rival.

The first point implies that maintaining internal consistency requires one to check whether these restrictions hold at the estimated demand parameters $\hat{\theta}$, as this is not automatically guaranteed. In practice, the polynomial approximations of the functions $\Pi(\kappa)$ and $\hat{\Pi}(\kappa)$ make it possible to evaluate their derivatives at any κ in the $[0, 1]$ interval and to directly check parts (ii)-(iv) of Assumption 1. We indeed verify that these hold in our empirical application.

The second point highlights a concrete sense in which demand estimation informs the study of multimarket contact. As we have seen, the magnitude of the multimarket contact effect is closely related to the presence of *symmetric positioning*. The simulations show that whether or not this property holds depends on estimable demand parameters.

This idea is reinforced by the third and fourth points that describe specific channels via which demand parameters affect the ICCs. The fourth point motivates the following thought exercise: fixing some baseline demand parameters θ, let us start increasing the mean utility associated with brand a in market 1 until (i) brand a becomes more popular than brand b in that market, and (ii) firm a can satisfy its individual ICC in market 1 at a higher κ level than firm b. Next, we start increasing the mean utility associated with brand b in market 2. We do this until brand b becomes more popular than brand a in market 2, and firm b is able to sustain a higher κ in market 2 relative to firm 1.

At this point, symmetric positioning holds (each firm can support a higher level of κ than its rival in a different market) *and* each firm enjoys a demand advantage in a different market. This association, along with Corollary 1, suggests a connection between demand primitives and the strategic impact of multimarket contact. If one observes that each firm enjoys a strong demand advantage in a different market, this could potentially flag (though by no means guarantee) a substantial multimarket contact effect.

The simulations therefore offer some insight into the complicated relationship between underlying demand primitives and the strategic impact of multimarket contact.

3 Empirical application: the food sector

We now apply the model developed in section 2 to data from the Israeli food sector with a focus on packaged goods sold at supermarkets. The application involves the *Packaged Hummus Salad* and *Instant Coffee* categories. Both categories share the same two prominent competitors. Each category also features smaller and different competitors. This situation matches the framework developed above, depicted in Figure 1.

We first describe the data and the estimated demand models, leaving additional details to Appendix D. Monthly data for both categories come from Nielsen and cover the 43 months from January 2012 to July 2015. The level of observation is UPC-category-month. We observe the brand name and the manufacturer as well as total sales in both monetary and unit terms. Monthly average prices are computed by dividing total (deflated) sales revenue by quantity. The UPC name is used to derive information on product characteristics, as elaborated below.

Demand: Packaged Hummus Salad. Demand follows the Random Coefficient Logit model per section 2.3. The product characteristics x included in the utility function are brand dummies (for the main brands), 42 month dummies, and dummy variables for product characteristics. Examples of such characteristics are "spicy," "pine nuts," "masabacha" (a middle eastern condiment), and "tahini" (implying the presence of extra tahini in the product). These variables were coded by mining the text of the product name at the UPC level for relevant information. Random coefficients were allowed on price, and on brand dummies for firms a and b.

UPCs pertaining to small packages (less than 300 grams) were removed as we judge them to be weak substitutes to the category's main products. We aggregate the UPCs up to unique combinations of brand, month and the characteristics. After removal of such aggregated products with very low sales we are left with a total of 2,031 observations. Product j's market share in month t is computed by dividing the total quantity sold q_{jt} by M_t, the market size. Market size is modeled as the aggregate monthly consumption of all prepared (chilled) salads, approximated using a variety of media and data sources.[18]

All product characteristics, except price, are indicator variables. Employment of the differentiation instruments proposed by Gandhi and Houde (2019) is therefore not practical. We nonetheless employ a battery of instruments to deal with the endogeneity of prices. First, we use the number of competing products with identical characteristics. Those should affect markups, and therefore prices, consistent with BLP1995 and Berry and Haile (2014). We also use cost shifters as instruments and specifically include interactions of the global price of chickpeas with specific product characteristics, and interactions of the VAT rate with indicators for particular producers and other product characteristics.

[18]As noted above we refer to Appendix D for additional details and discussion of the sample and data processing.

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 to engage in Retail Price Maintenance or to control the location of products on retailers' shelves. We interact a post-January 2015 dummy variable with leading firms' dummies, allowing their pricing strategies to be deferentially affected by the law.[19] In total we use 13 excluded instruments, generating over-identifying restrictions.

Estimation results are reported in Table 1. Generally speaking, mean utility coefficients on product characteristics and on brand dummy variables (left panel) are precisely estimated, and so are the price sensitivity parameters. The leading firms' brand dummies have rather similar mean utility coefficients, and small (and statistically insignificant) random coefficients, so that neither firm appears to enjoy a clear demand advantage over its rival. The median own-price demand elasticity is (-3.2).

The demand system was estimated given demand-side moments only, making no assumptions on supply-side behavior. Combining the estimates with our assumption that the data were generated by a Nash-Bertrand equilibrium we obtain a median price-cost margin of 0.21 which is quite reasonable: Eizenberg et al. (2021) report, based on conversations with people familiar with the industry, that typical markups on the products they study, i.e., packaged goods sold in Israeli supermarkets, are on the order of 0.15-0.25. The implied marginal costs are positive for all products. The Nash-Bertrand assumption therefore appears reasonable.

As a descriptive exercise we next examine a counterfactual: given the demand estimates and maintaining that the data were generated by a Nash equilibrium in prices (i.e., $\kappa = 0$), we compute counterfactual prices and variable profits given κ values of 0.1 and 1, where $\kappa = 1$ reflects the least competitive conduct, in each of the 43 sample months. We conclude that even a radical increase in κ, from 0.1 to 1, results in a rather limited effect on profits. The largest increase in firm a's profits, over the 43 months, is merely 0.16%, and the median increase over these months is 0.13%. Firm b's profits increases are larger, but still modest relative to the stark increase in κ: the maximal increase in its profits is 3.86% with a median increase of 2.39%.

This preliminary analysis provides some perspective on the extent to which multimarket contact could affect profits in our application. Multimarket contact may increase the values of κ that can be sustained in equilibrium. But even if κ were to increase considerably, the effect on profits would be limited. This modest effect is consistent with the relatively elastic demand and with the presence of the competitive fringe. We return to this issue below.

Demand: Instant Coffee. Here again we define product characteristics based on the presence of particular traits as evident in the product name (examples being "decaff," "frozen," and "dry") and aggregate UPCs up to unique combinations of brand, month and the characteristics. A

[19]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 (in Hebrew), May 2018 (link).

subset of these characteristics, along with brand and month dummies, are included in the utility function. The outside option is defined as the consumption of Black Coffee and Tea. We remove UPCs that included a "gift" component (e.g., coffee sold with a gift of waffles) and again products with very small market shares.

To guarantee non-negative marginal costs for all products, we found it useful to drop from our sample the six most expensive observations, or 0.4% of the original observations, resulting in a sample size of 1,514. Incorporating supply-side moments into the estimation of demand would have likely disciplined markups and marginal costs, rendering this product removal unnecessary. Given our Nash-Bertrand assumption we could have incorporated supply-side moments based off of the First Order Conditions in (13). This practice is often very helpful as discussed extensively by Conlon and Gortmaker (2020). Nonetheless, our framework in general does not require an assumption on the competitive conduct observed in the data and is also consistent with alternatives such as estimating or calibrating it. This motivates our choice to estimate demand independently of supply side restrictions, as in Nevo (2001).[20]

Random coefficients were again allowed on price and on the two leading brands' 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) and the post-food law dummy variable for a total of 12 excluded instruments.

Estimation results are reported in Table 2. Firm a enjoys a larger mean utility dummy coefficient (β) than firm b, but the opposite is true for the estimated standard deviation (σ) on those brand dummies. Therefore, again, no firm appears to enjoy a clear demand advantage over its rival. Also similarly to the Packaged Hummus Salad category, the median own-price elasticity is (-3.5), and the median price-cost margin is 0.20.

Again in line with the analysis of the Packaged Hummus Salad category, shifting the parameter κ from 0.1 to 1 in a counterfactual analysis does not result in considerable increases in profits. Firm a's median flow profit increase over the sample months is 0.5%, whereas that of firm b is 1.2% . Recall that these figures can be viewed as a rough upper bound on the extent to which multimarket contact may increase firms' profits. The estimation of this effect is taken up next.

The strategic effect of multimarket contact. We next apply the structural model to analyze the strategic effect of multimarket contact on prices and profits in the two categories. Maintaining the assumption that the data were generated by a Nash-Bertrand competitive benchmark, we examine the set of less competitive equilibria that could be sustained — and quantify the extent to which multimarket contact expands this set.

[20]Unlike that study, we have no access to cross-sectional data variation. The availability of aggregate data with time-series variation only makes identification more challenging. Identification is however supported by the presence of a rich set of instruments. We also found it helpful to include certain brand dummies, and not others, in the utility function, as discussed in detail in Appendix D.

We begin by fixing a nontrivial value for the discount factor δ that guarantees that firms cannot sustain the least competitive outcome ($\kappa = 1$) absent multimarket contact. To this end we set $\delta = 0.14$. It is important to put this low value in context: first, this is the minimum value of the "nontrivial" discount factors across 43 sample months. On average across these months, the nontrivial discount factor is much higher at 0.43. Setting it at 0.14 throughout the analysis is done for convenience only.

Second, and more importantly, several authors have noted that the workhorse Supergame model with grim trigger responses yields remarkably low threshold discount factors. Shapiro (1989) finds that the least competitive outcome may be sustained even in the presence of hundreds of firms in a repeated Cournot game with standard discount factors.[21] Rotemberg and Saloner (1986) suggest that a higher threshold discount factor would emerge if the competitive reversion was finite rather than infinite. In a similar vein, Farrell and Baker (2021) propose to remedy the low threshold value of the discount factor by introducing uncertainty.[22]

Following much of the literature, and for tractability, we maintain the grim-trigger, infinite-horizon nature of the competitive reversion. Note that our goal is not to estimate the discount factor but rather to quantify the strategic effect of multimarket contact. An alternative approach could set a "desirable" discount factor level such as 0.9, and then introduce a length of the competitive reversion phase (or an amount of uncertainty following Farrell and Baker (2021)) that would allow a nontrivial analysis of multimarket contact. This would result in a much more complicated model without much added insight.[23]

Results: Sustainable outcomes with and without multimarket contact. Figure 5 provides a graphical representation of each firm's estimated ICCs, with and without accounting for multimarket contact. The figure pertains to the analysis in a particular sample 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 to simplify their calculations by assuming that current cost and demand conditions shall prevail indefinitely. As a consequence, our estimates of the supportable κ levels are month-specific. Figures analogous to Figure 5 that are produced in other sample months look qualitatively similar.

The left-hand panel of the figure displays firm a's constraints. The vertical axis pertains to values of κ ranging from 0 to 1 in the Packaged Hummus Salad (hereafter "Hummus") market while the horizontal axis displays values for the Instant Coffee (hereafter "Coffee") market, respectively. The competitive benchmark corresponds to the origin with $\kappa_{hummus} = \kappa_{coffee} = 0$.

[21] See pages 365-366 of that handbook chapter. That analysis assumed linear demand and constant marginal costs.

[22] In their framework, a firm's decision to adhere to the equilibrium could result in a competitive reversion with probability p, a deviation would be noticed with probability r, and firms may be able to switch from a competitive reversion back to the equilibrium path with probability q. See also Green and Porter (1984).

[23] If the true discount factor is larger than the one we use, the least competitive outcome may be easily sustained even without multimarket contact rendering the strategic effect of the contact negligible. Our finding, reported below, that this strategic effect is small is therefore robust to the possibility that the true discount factor is larger than the one we use.

The blue dot is the vector $\kappa_a(\delta)$ per Definition 3. This vector shows the largest departures from the competitive benchmark that satisfy firm a's ICC in each market, ignoring multimarket contact. The green curve represents the $B_a(\delta)$ Boundary 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 $B_a(\delta)$ Boundary is guaranteed by Lemma 2(i). The right-hand panel shows the same information for firm b, where its Boundary $B_b(\delta)$ is shown in yellow.

An important insight from Figure 5 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 can support a larger κ value (0.50) than firm b (0.18). In the Coffee market, these roles are reveresed and firm b can sustain a larger κ (0.62) than firm a (0.20).

While Figure 5 provides information on each firm's individual ICCs, it is only when both firms' constraints are satisfied at a particular $(\kappa_{coffee}, \kappa_{hummus})$ vector that this vector can be sustained in an SPNE. With this in mind, Figure 6 presents the intersection of these constraints.

The blue dot in Figure 6 is $\kappa(\delta)$: the largest conduct vector that can be supported in an SPNE when firms do not internalize their multimarket contact. Following Definition (3), this vector is obtained 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 in Figure 5). The Boundaries $B_a(\delta)$ (green curve) and $B_b(\delta)$ (yellow curve) from Figure 5 are presented here again.[24] The region indicated by orange lines is $S(\delta)$: the set of vectors that can be sustained in equilibrium under multimarket contact. These are the vectors that satisfy both firms' constraints. The boundary of this region is denoted $B(\delta)$ per Definition 4.

The blue dot, $\kappa(\delta)$, lies strictly inside this set, i.e., it does not lie on the boundary $B(\delta)$. This follows directly from Corollary 1 given the *symmetric positioning* property. The distance of the blue dot from this boundary captures the strategic effect of multimarket contact.

It remains to translate this distance into more transparent economic terms: prices and profits. We therefore 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 the two 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 boundary $B(\delta)$.[25]

We next compute equilibrium prices and profits at this red dot (least competitive outcome with multimarket contact) and compare them to prices and profits at the blue dot (least competitive outcome absent contact). This is done in each of month-specific analyses, $t = 1, ..., 43$. Table 3 shows the gains in profits when moving from the blue dot to the red dot, in percentage terms.

[24] Given the different scale, these curves may appear to be visibly different than those displayed in Figure 5, but the two figures present exactly the same curves.

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

The maximum impact over the sample months is between 0.35 to 0.47 percent, depending on whether we look at firm a's profits, firm b's profits, or their combined profits. The strategic impact of multimarket contact on profits in the studied application is therefore modest.

Table 3 also shows that the profit impact does not vary much across the 43 month-specific analyses. Recall that we perform the analysis in each month assuming that firms ignore any future changes to cost or demand when calculating the discounted payoffs from staying on the equilibrium path vs. deviating from it. If violations of this bounded rationality assumption were quantitatively important, we might have expected the profit impact to display considerable variation among the 43 different calculations.

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 impact is small: the maximum (over the 43 months) price increase is again less than one percent in both categories.

While the estimated impact of multimarket contact does not display strong variation across the 43 month-specific analyses, it is of interest to inspect this variation from another perspective. The profit impact is always very small, but Tables 3-4 show that on the 37th sample month it drops to zero. Per Corollary 1, a near-zero effect is particularly likely with asymmetric positioning. We should therefore expect asymmetric positioning to hold in that sample month. Indeed, Figure 7 shows that asymmetric positioning holds in month 37.

Consequently, Figure 8 shows that both the blue dot and the red dot are on the boundary of supportable outcomes given multimarket contact and are very close to one another. The small distance between these points is consistent with the approximately zero profit effect of multimarket contact.[26]

To further explore the connection between the symmetric positioning property and the magnitude of the multimarket contact effect we define an index of the degree of symmetric (or asymmetric) positioning to which we refer as an "asymmetry indicator":

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

When the asymmetry indicator takes positive values, the same firm (either a or b) can satisfy its individual ICCs at a larger κ value than its rival in both markets implying that *asymmetric positioning* holds. Negative values imply that in each of the two markets, a different firm can satisfy its constraint at a larger κ, implying *symmetric positioning*. The magnitude of the index in absolute value reflects the magnitude of such tendencies.

Figure 9 provides a scatter plot over the 43 month-specific analyses. The value of the asym-

[26] Also note that moving from the blue dot to the red dot means moving slightly closer to the competitive benchmark in the Instant Coffee market while pushing a bit further away from it in the Packaged Hummus Salad market. This is consistent with the minor price *reduction* in the former category and the minor price increase in the latter shown on Table 4.

metry index is displayed on the horizontal axis, and the potential gain from multimarket contact (the potential increase to the firms' combined profit, in percentage terms) is on the vertical axis. The figure reveals that firms cross into asymmetric positioning territory in a single month only, resulting in near-zero gains. Indeed, this is month 37 as discussed above. Second, we observe a negative slope: the greater is the degree of symmetric positioning, the larger are the potential gains from multimarket contact. The figure thus highlights the role of the symmetric positioning property in determining the scope of the multimarket contact effect, consistent with Corollary 1.

Along the way, we have seen that the analytical results from section 2.2 hold in our empirical application. For example, we have seen in Figure 5 that $\kappa_f(\delta) \in B_f(\delta)$, as implied by Lemma 2(i); in Figure 6 that $(\hat{\kappa}_1, \hat{\kappa}_2) \in B(\delta)$ per Lemma 3; and again in Figure 6, that symmetric positioning results in $\kappa(\delta) \notin B(\delta)$ per Corollary 1. This is not surprising: these analytical results hold under the shape restrictions on profit functions in Assumption 1, and in our empirical application we are able to verify that those shape restrictions hold.

Why is the effect of multimarket contact small? What might explain the modest strategic effect of multimarket contact in our application? First, the descriptive counterfactual analysis described above revealed that even if firms were able to switch from a very small value of κ to a very large one, the effect on their profits would still be rather small.[27]. This suggests a modest upper bound, right at the gate, on the extent to which multimarket contact could benefit firms in the current application. This limited effect is likely related to the elasticity of demand, and to the presence of a competitive fringe. The fringe constraints the market power of the two large firms such that even if those firms' ICCs were relaxed, prices could not increase by much.

Importantly, our assumption that those fringe players always act competitively is not dictated by our methodology. It is motivated by institutional details. These firms have much smaller market shares than those of the leading two firms, and often do not spend much on advertising. The framework developed in this paper can easily accommodate other assumptions regarding the behavior of firms that are present in just one of the markets in question.

Yet another explanation for the small effect of multimarket contact is associated with the demand primitives. As discussed above, we find that neither firm appears to enjoy a clear demand advantage over its rival in either market. The theory and simulations of section 2 suggest that one way to generate strong symmetric positioning — and hence a potentially large effect of multimarket contact — is to have each firm enjoying a demand advantage in a different market, which does not seem to happen here. Indeed, while the symmetric positioning property does hold in our application, it is not strong (recall the negative-yet-small values of the asymmetry index in Figure 9).[28]

[27] This small effect is not dictated by the model but rather a result that holds specifically in this empirical application. For example, in some of the simulations we performed prices went up by 5 percent, a sizable effect, as κ increases from 0 to 1.

[28] It is nonetheless important to note that having each firm enjoying a demand advantage in a different category is neither necessary

4 Concluding remarks and additional applications

We develop an empirical methodology to study the strategic effect of multimarket contact on competition. We depart from previous studies in that we do not estimate the in-sample causal effect of multimarket contact and instead take the theory of Bernheim and Whinston (1990) to data. We show how to estimate the components of firms' Incentive Compatibility Constraints and to aggregate them over the markets where firms overlap. This reveals the extent to which multimarket contact allows less competitive outcomes to be sustainable in equilibrium.

Applying the method to two categories of the Israeli food sector we find this strategic effect to be small. Our framework sheds light on this small effect and explains it as a consequence of a relatively elastic demand, the presence of a competitive fringe, and specific features of demand in the two categories.

Applications, limitations and possible extensions in future work. In addition to studying multimarket contact that is present in the data, as performed here, our framework also allows an out-of-sample study of multimarket contact. A natural example is the analysis of counterfactual cross-category mergers.

The idea is depicted in Figure 10. Let firms a and b be the major competitors in market 1, whereas firms b and c are the major competitors in market 2. Now suppose that firm a proposes to acquire firm c. This hypothetical merger does not alter the concentration level in either market, but does generate multimarket contact. Our framework can be used to evaluate the strategic effect of such contact, allowing regulators to examine a specific theory of harm: that the newly-created multimarket contact would hamper competition across the two markets.

We can accommodate this scenario as follows. Our framework allows us to compare the (jointly) most profitable sustainable departure from competitive pricing that when firms do not internalize their multimarket contact, $\kappa(\delta)$, to that available when they do internalize it, $\hat{\kappa}(\delta)$. We can interpret the merger depicted in Figure 10 as potentially allowing the firms to shift from $\kappa(\delta)$ towards $\hat{\kappa}(\delta)$.

In such a hypothetical merger analysis it may be important 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 pre-merger and post-merger discount factors.

Yet another avenue for future research is related to analytical and simulation results developed as part of the structural model. The essence of the empirical exercise is to transform demand estimates into conclusions on the effect of multimarket contact. This map is far from obvious but our analysis sheds some light on these complex relationships. In particular, we provide some

nor sufficient for symmetric positioning to hold.

comparative statics analysis showing how changes in particular demand parameters may affect the scope of impact from multimarket contact.

We believe that much progress is still needed on this front since results of this nature can inform practical antitrust analysis even without taking our structural model to data. For example, the analytical and simulation results suggest that a merger between firms a and c in Figure 10 may have a stronger anti-competitive effect if, for example, firm a has a demand advantage over firm b in market 1 but firm b has a demand advantage over firm c in market 2 (cautioning, again, that such a demand pattern is neither necessary nor sufficient to generate a strong multimarket contact effect). Agencies often obtain a qualitative sense of such demand primitives without resorting to an econometric analysis, and so they may be able to determine if such concerns arise in a particular proposed merger.

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A Additional proofs

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. □

Backward-bending Boundaries. Returning to Figure 3, consider for example $B_a(\delta)$, the boundary of the set of vectors that satisfy firm a's ICC under multimarket contact, displayed as the green curve on the top-left panel of the figure. Let us focus on the intersection of this green curve with the horizontal axis. This point ($\kappa_1 = 0.18, \kappa_2 = 0$) is clearly dominated by points obtained by increasing κ_2 from zero, in the sense that such points allow for a greater departure from competition in market 2 while holding fixed the departure from competition in market 1. As the picture shows, many of those superior points are feasible in the sense that they also lie on or inside the green curve. In fact, entire portions of the green curve boundary are dominated by other points on or below the frontier. We next prove that this property holds in general.

Proof of the backward-bending property. We'll show that the backward-bending property holds for m=1. The proof for m=2 is identical. First, we assume that $\kappa_{f,1}(\delta) < 1$. Consider the point $(\kappa_{f,1}(\delta), 0)$. Then $\phi_{f,1}(\kappa_{f,1}(\delta)) + \phi_{f,2}(0) = 0 + 0 = 0 \Rightarrow (\kappa_{f,1}(\delta), 0) \in F_1(\delta)$. Since $\phi'(0) > 0$, there exists $\epsilon > 0$ s.t. $\phi_{f,2}(\epsilon) > 0 \Rightarrow \phi_{f,1}(\kappa_{f,1}(\delta)) + \phi_{f,2}(\epsilon) > 0 \Rightarrow$ there exists $\alpha > 0$ s.t. $\phi_{f,1}(\kappa_{f,1}(\delta)+\alpha)+\phi_{f,2}(\epsilon) = 0$ (in this case $(\kappa_{f,1}(\delta)+\alpha, \epsilon) \in F_1(\delta)$) or $\phi_{f,1}(1)+\phi_{f,2}(\epsilon) > 0$ (in this case $(1, \epsilon) \in F_1(\delta)$). Thus, we found a point on the frontier which strictly dominates the point $(\kappa_{f,1}(\delta), 0)$, which implies the backward-bending property. □

B Computational details

Counterfactual Prices. We discuss here two important computational tasks involving counterfactual prices. The first is the computation of p^κ: the equilibrium-path price vector corresponding to a κ-level departure from competitive pricing. Recall that the pricing First Order Conditions are:

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

As described in section 2.3, these conditions allow us first to back out marginal costs. Assuming that the Data Generating Process involves a Nash-Bertrand pricing equilibrium, the matrix Ω is block-diagonal. The RHS of B.1 is calculated by plugging in observed prices p, observed market shares s, and a numerical approximation of the market share derivative matrix $S(p;\hat{\theta})$ where $\hat{\theta}$ are the estimated demand parameters. Marginal costs estimates are then obtained by $\hat{mc} = p - \left(\Omega \odot \mathcal{S}(p;\hat{\theta})\right)^{-1} s$.

With the marginal costs $\hat{mc}$ in hand, we can calculate counterfactual price vectors corresponding to a wide range competitive schemes, captured by values of the parameter κ that are substituted into off-diagonal elements of Ω. Specifically, we set $\Omega_{j,k} = \kappa$ for every product pair j, k such that one of these products is sold by firm a and the other one is sold by firm b. Denote the relevant ownership matrix by Ω^{κ}.

We solve for prices that make B.1 hold at such values of κ. A straightforward and familiar approach for calculating these counterfactual prices is to iterate on the FOCs as follows:

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:

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

4. Iterate until convergence, i.e. until iteration i such that $p^{i+1} \approx p^i$.

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.[29] We begin by rearranging equation (B.1).

$$\left(\Omega^{\kappa} \odot \mathcal{S}(p;\theta)\right)(p - \hat{mc}) = s(p) \tag{B.3}$$

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:

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

1. Begin with an initial guess for prices
2. Calculate the left hand side of (B.3) at those 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.

The procedure above proved highly effective in computing p^{κ}.

The second task is to compute firm f's deviation price vector, $\hat{p}^{\kappa}_{f}$. This is the price vector that maximizes firm f's profits if all other firms adhere to the equilibrium-path price vector p^{κ}. These deviation prices need to be computed separately for firm $f = a$ and for firm $f = b$.

To that end, we substitute into (B.1): (i) the estimated $\hat{mc}$, (ii) the ownership matrix Ω^{κ}, and (iii) the price vector p^{κ}_{-f}, i.e., the equilibrium-path prices for all firms but firm f.

For firm f's prices we substitute an initial guess: a 10 percent price cut relative to its observed sample prices. We then iterate on the portion of (B.1) relating to the firm's FOCs until convergence: i.e., until we find a price vector for firm f that maximizes its profits, holding other firms' prices fixed.

Unlike the first task (computing the p^{κ} that solves the FOCs of all firms), in this task we found that the iteration works well.

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 $\kappa \in [0, 1]$.

At a particular value of κ, we compute counterfactual prices as described above. At those prices we compute hypothetical market shares and, given the estimates of marginal costs $\hat{mc}$, we compute variable profits $\pi(\kappa)$. At the counterfactual prices we also numerically compute each firm's optimal deviation given that other firms adhere to the equilibrium indexed by κ. This allows us to also compute $\hat{\pi}(\kappa)$, the firm's optimal deviation profit.

So far we explained how to produce $\pi(\kappa)$ and $\hat{\pi}(\kappa)$ for a specific value of κ. To approximate those payoffs as functions of κ, we use a polynomial approximation. 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.

We examine the accuracy of the polynomial approximations via the following tests:

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. Indeed, we found that the differences are on the order of 1e-09 or less.

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. Across the ten random values of κ, the maximal deviation between the direct calculation and the polynomial approximation was again on the order of 1e-09.

We therefore determine that the approximations perform well.

Calculating κ_a, κ_b and the boundary B. At the nontrivial value for the discount factor δ discussed in the text, we calculate $\kappa_a(\delta)$ and $\kappa_b(\delta)$ as follows. Recall from Definition 3 that $\kappa_f(\delta) = (\kappa_{f,1}(\delta), \kappa_{f,2}(\delta))$ is the vector of κ levels that make firm $f's$ ICCs bind in each of the categories, 1 and 2, respectively, when the firm does not internalize the multimarket contact.

Let $\rho_\pi(f, m)$ and $\rho_{\hat{\pi}}(f, m)$ be the vectors of coefficients from the polynomial approximation of the equilibrium-path and deviation payoff functions for firm f in category m, respectively (recall that those are month-specific in our application). We obtain a polynomial approximation of firm $f's$ ICC function $\phi_{f,m}(\kappa_m)$ via the coefficients $\rho\phi(f, m) = \rho_\pi(f, m) - (1 - \delta)\rho_{\hat{\pi}}(f, m)$. Finally, we use a numeric solver to solve for the roots of the approximated $\phi_{f,m}$.[30]

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.

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

[30] The nontrivial choice for δ, along with the single crossing property in Lemma 1, guarantee that we find a unique such root in the $[0, 1]$ interval. This root is therefore the unique solution to $\kappa_{f,m}(\delta)$.

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

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.

As expected, all prices are higher under the $\kappa = 1$ regime. Prices increase substantially (by about 3-5 currency units) for products by firms a and b (products 1-5 in Market 1 and products

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

1-4 in Market 2) and only marginally for products of the other firms. This makes sense: firms a and b compete less aggressively in the $\kappa = 1$ regime than in the $\kappa = 0$ regime, whereas the other firms always act like nash competitors, and their prices increase slightly only becuase prices are strategic complements.

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 1 for firms a and b.

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 $B(\delta)$ boundary 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, respectively.

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 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

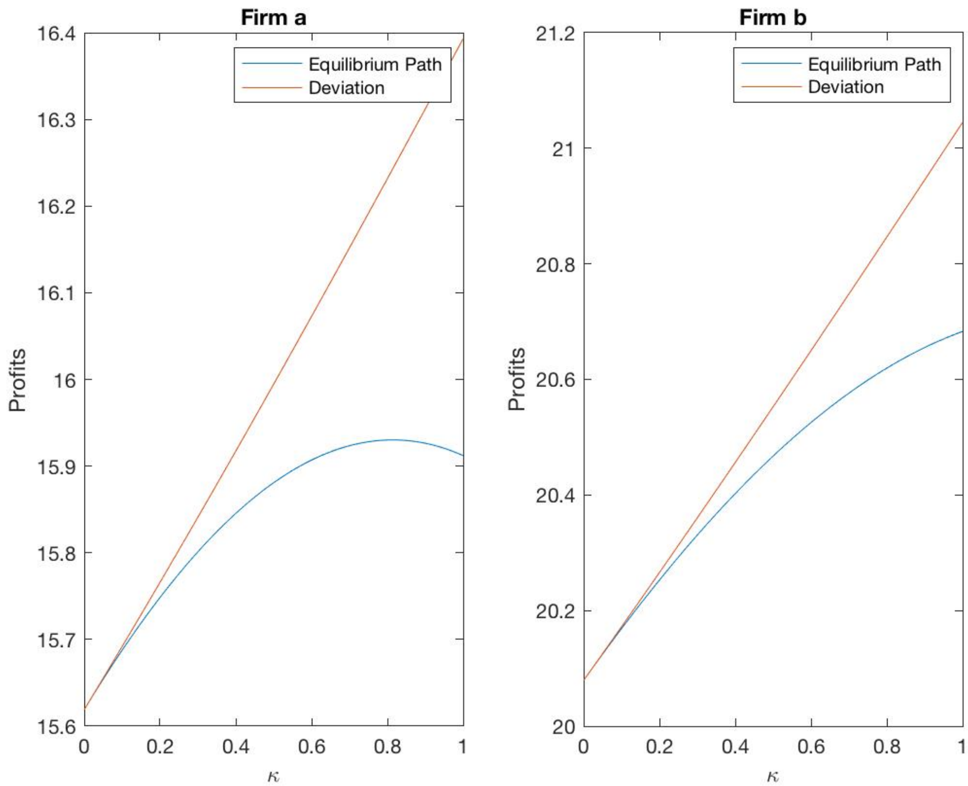

Figure C1: Equilibrium-path profits and deviation profits, market 1

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 analysis of multimarket contact.

The consequences of symmetric vs. asymmetric positioning are shown next. Figure C3 plots the κ boundaries $B_a(\delta)$ (green) and $B_b(\delta)$ (yellow) when $\sigma_p = 0.6$ (in market 1) and $\beta_b = 3$ (in market 2), i.e. at the baseline parameter values. The combined boundary $B(\delta)$ is the boundary of $S(\delta)$, i.e. the boundary of the intersection between $S_a(\delta)$ and $S_b(\delta)$ (equivalently: the upper

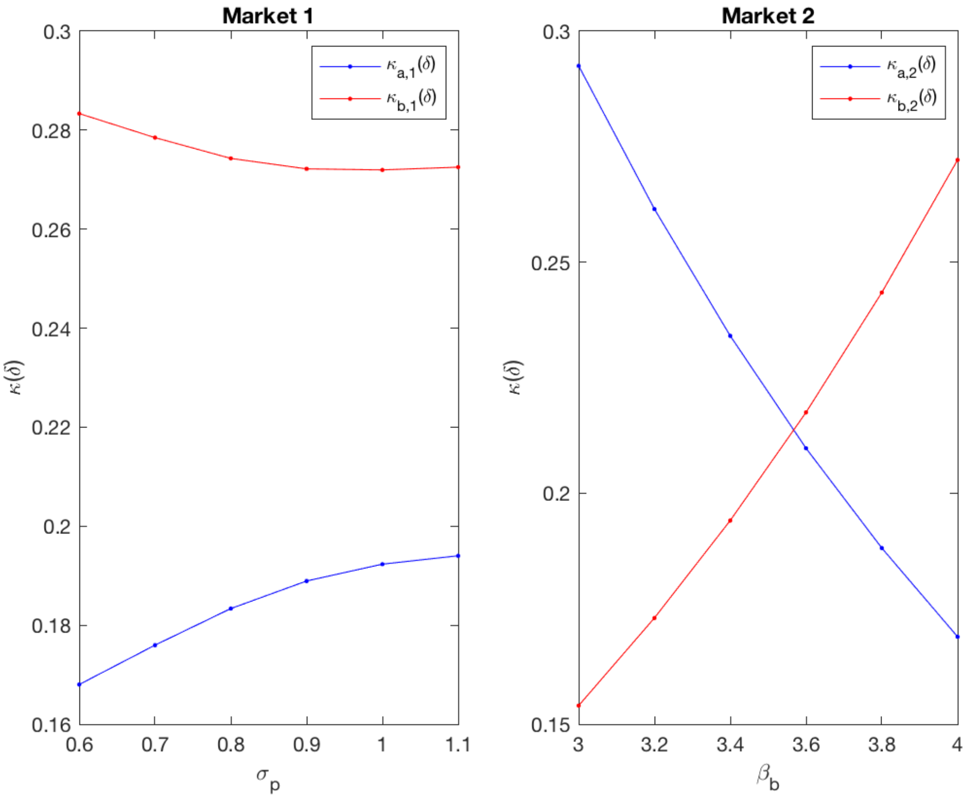

Figure C2: Left: $\kappa_{a,1}(\delta), \kappa_{b,1}(\delta)$ at different values of σ_p. Right: $\kappa_{a,2}(\delta), \kappa_{b,2}(\delta)$ at different values of β_b.

envelope of the green and yellow curves). On this $B(\delta)$ boundary 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 $\sigma_p = 1.1$ (in market 1) and $\beta_b = 4$ (in market 2). 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.

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.

In the simulation exercise above we have verified that these restrictions are satisfied by the

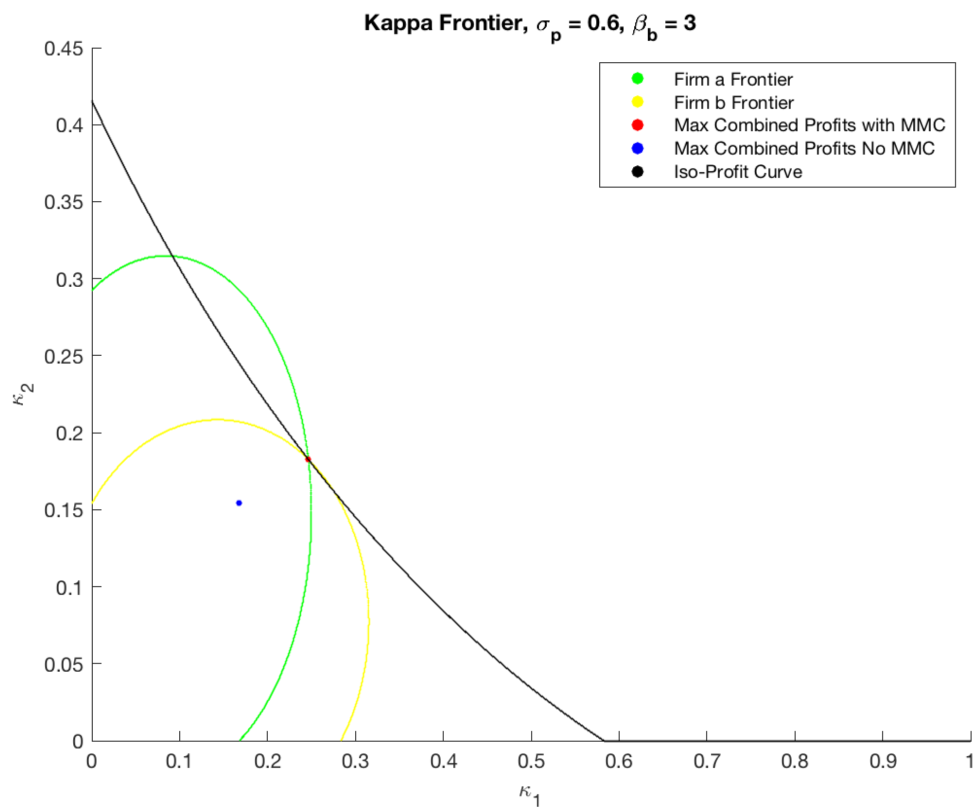

Figure C3: κ Frontier, Market 1: $\sigma_p = 0.6$, Market 2: $\beta_b = 3$

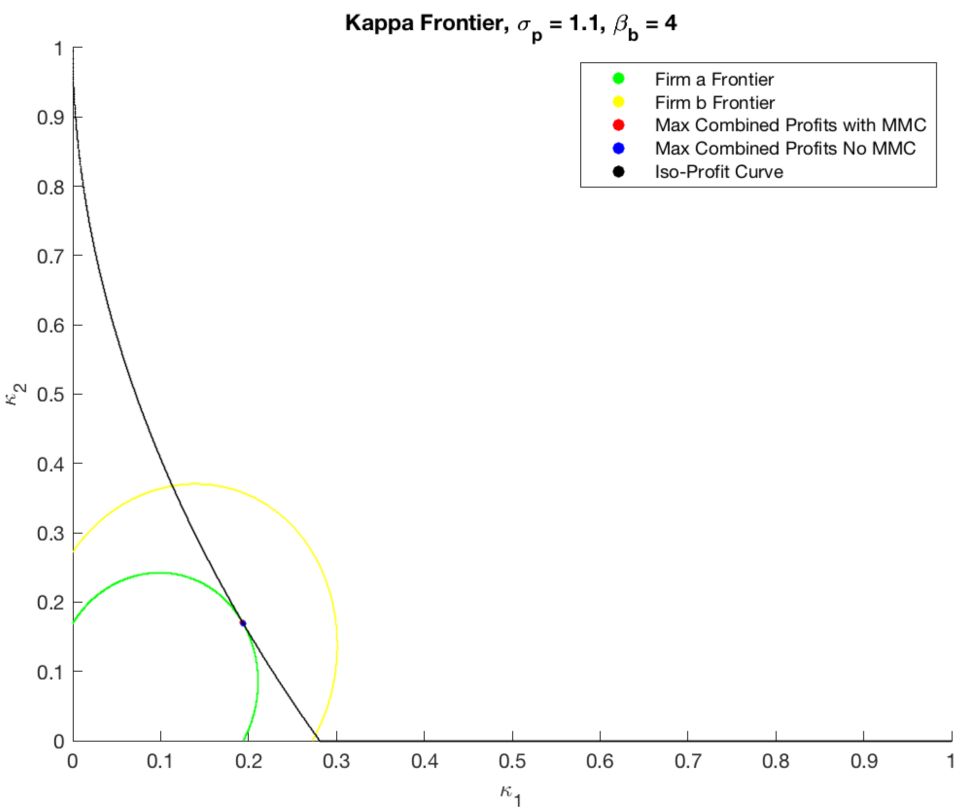

Figure C4: κ Frontier, Market 1: $\sigma_p = 1.1$, Market 2: $\beta_b = 4$

Random Coefficient model, at the parameter values of the baseline simulation. Importantly, we have found in other simulations 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 simulations above demonstrated that whether symmetric or asymmetric positioning holds 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.

In particular, the simulation exercise demonstrated that increasing either the mean or the standard deviation of the utility associated with a firm's brand dummy increases the κ level that can satisfy this firm's ICC in the relevant market, while lowering the corresponding κ value of its rival. As discussed in the main text, this means that if each firm enjoys a strong demand advantage in a different market, it may be more likely that symmetric positioning — and hence more sizable gains from multimarket contact — obtain.

To further validate this pattern we perform the analysis over 20 additional sets of market fundamentals. Those are created via two "baseline markets" corresponding to the baseline simulated market considered above, and then further creating 5 different "submarkets" from each by altering either the marginal costs or the demand parameter for some of the products' characteristics.

In each of these 20 markets we perform the exercise above: holding all parameters fixed, we increase either the mean or the standard deviation of firms' brand utility dummies. The pattern reported above (increasing the supportable κ for the firm in the relevant market while lowering the supportable κ of its rival) was observed in each of those simulations.

While we find this evidence quite convincing, it motivates additional work aiming to uncover the relationship between demand primitives and the strategic impact of multimarket contact.

D Additional details regarding the empirical application

D.1 Packaged Hummus Salad

Market size. We define the market size in month t, M_t, as the total monthly consumption of packaged salads, approximated as 1 kilogram for each person. This approximation is motivated by a couple of media sources. According to the Israeli business media outlet Globes, in 2013, total sales of prepared salads were 749.9 million NIS, while total Hummus sales were 377 million NIS.[31] Hummus therefore accounted for 50.2% of the prepared salads category, and we approximate

[31] http://www.globes.co.il/news/article.aspx?did=1000909731, accessed July 26th 2021.

prepared salad consumption as twice the amount of total Hummus consumption.[32] The Israeli media outlet Walla reported in 2001 that an Israeli person consumed 5.5 kilograms of Hummus a year.[33] We therefore approximate total prepared salad consumption to be twice that amount, i.e., about 11 kilograms a year, or, about 1 kilogram a month.

It remains to obtain monthly population figures and multiply them by 1 kilogram to determine the monthly market size M_t. The Israeli Central Bureau of Statistics (ICBS) website reports the numbers of persons residing in Israel at the end of 2011 and 2015 (7,838,600 and 8,463,400, respectively) and we linearly interporlate between these two figures for a monthly series.[34]

Data processing. For each UPC we compute the package size in kilograms by dividing the monthly quantity by the monthly number of product units sold. We drop UPCs with a package size below 0.3 kilogram. Those account for 23 percent of UPCs but only 4.7 percent of quantity sold. Packaged hummus salad is most often sold in 0.5 kilogram packages and smaller containers are often more expensive and used as snacks. We therefore do not consider those as direct competitors for the bulk of the products sold in our sample and hence remove them, effectively allow their consumption to be a part of the outside option. We also drop UPCs with a recorded revenue of zero (2,379 UPCs out of a total of 25,121 UPCs).

Still at the UPC level, we define product characteristics as indicators taking the value 1 if certain terms appear in the UPC name, and zero otherwise. The characteristics (*spicy*, *cress*, *pine nut*, *tahini*, *masabacha* (a mideastern condiment) and *other condiments*) and their estimated mean utility coefficients are displayed in Table 1. *Other condiments* takes the value 1 if the product name contains words indicating the presence of egg, olives, za'atar, ful, matbucha (the latter three being mideastern condiments), lemon, mushrooms, onion, pepper, olive oil, and also if the product name contains the word "pickled" or "sour." These terms appear in Hebrew and the coding takes into account multiple spelling options when relevant.

Products were defined by aggregating over individual UPCs up to unique combinations of brand, month and the characteristics listed above. Prices were obtained by dividing total revenue by total quantity (in kilograms). Revenues were deflated using the Israeli CPI series such that all prices are expressed in constant (January 2012) NIS.[35] Products with a market share below 1e-5 were dropped from the sample, eliminating 450 observations. This results in a total of 2,031 observations on which the demand model is estimated (see Table 1).

In the utility function we include indicators for the characteristics described above, as well as firm (brand) dummies. The latter were included for firms a and b that are the largest players and

[32]This assumes that the quantity share of Hummus within prepared salads can be well approximated by its value share, which we believe is reasonable.

[33]https://news.walla.co.il/item/36880, accessed on July 28th 2021.

[34]https://www.cbs.gov.il/he/Statistics/Pages/%D7%9E%D7%97%D7%95%D7%9C%D7%9C%D7%99%D7%9D/%D7%9E%D7%97%D7%95%D7%9C%D7%9C-%D7%A1%D7%93%D7%A8%D7%95%D7%AA.aspx?r=ea3bd53b-b8ef-4c4a-8f6f-8eb5e8cdb84f&uptodate=1, accessed on July 26, 2021.

[35]The CPI series was downloaded on July 28 2021 from the ICBS website at https://www.cbs.gov.il/he/publications/madad/doclib/2019/price01a/a3_1_h.pdf.

whose leading position in both the Packaged Hummus Salad and the Instant Coffee categories is the focus of this study; and also for firms *c*-*i* where those are the third-to-eighth largest firms in terms of revenue in the Packaged Hummus Salad category. Also included are interactions of the *spicy* product characteristic with firms *a*, *b* and *c* dummies, and interactions of a linear time trend with the *spicy* and *tahini* characteristics. Finally, 42 month dummies are included to absorb month-specific demand effects, among them seasonality effects.

The instruments for price were discussed in the main text and include: a measure of the number of competing products with identical characteristics; interactions of the VAT rate with the spicy, masabacha, and cress characteristics dummies; interactions of the VAT rate with dummies for firms *a*, *b* and *c*; interactions of the global chickpea price with the pine nut, tahini and the "other condiments" characteristics dummies; and interactions of the food law dummy with dummies for firms *a*, *b* and *c*. 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.[36] Chickpea prices were obtained from reports by the USDA, National Agricurlture Statistics Service.[37] Chickpea prices were reported is USD to hundredweight (CWT) and were converted to prices per kilogram by dividing through by 45.4. Chickpea prices are reported in three categories: "all," "large," and "small" and we only use the "all" category prices. The food law was described in the main text.

D.2 Instant Coffee

Market size. We define the market size in month t, M_t, as the total monthly consumption, in kilograms, in the Instant Coffee, Black Coffee, and Tea categories as defined by Nielsen. We obtain this total amount by aggregating monthly quantities over the three categories. The implication is that the outside option in our model consists of consuming Black Coffee, Tea and a small set of Instant Coffee products which we drop from our analysis as explained below. Of note, Instant Coffee and Black Coffee were deemed to be separate markets by the Israel Antitrust Authority, motivating our treatment of Instant Coffee as a well-defined market.[38]

Data processing. Similarly as with the Packaged Hummus Salad category, we drop UPCs with small package sizes (below 100 grams). Such products are expensive (per-kilogram) and serve a somewhat different purpose than the typical products in our sample. We also drop products for which the UPC name suggests the inclusion of a gift. Those gifts range from cups

[36] Source: the Israeli Tax Administration website at `https://www.gov.il/he/departments/publications/reports/vat-history`, last accessed on September 9 2022.

[37] `https://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1002`, last accessed on July 21 2019.

[38] Source: `https://www.gov.il/he/departments/legalInfo/monopolyaliyat`. Further support for this view is available in a recent article in the Israeli business media outlet Globes. The article refers to three primary segments of the Israeli coffee market: capsules, instant coffee and black coffee. The outlet interviewed a CEO of a major company explaining his focus on capsules and black coffee since "...the instant coffee category has not demonstrated growth in the past decade." Source: `https://www.globes.co.il/news/article.aspx?did=1001425850`.

to honey or chocolate items that are added to the Instant Coffee product. We do not, however, drop UPCs where the nature of the "gift" appears to be an additional quantity of the Instant Coffee product sold.

We further draw on UPC names to define dummy variables for characteristics, where the characteristics include: *dry*, *frozen*, *decaff*, *premium*, *grained*, *golden*, *country*, *can*, and *delicate*.[39]

Again we aggregate UPCs up to unique combinations of brand, month and the characteristics listed above. Deflated prices were computed in the same manner as in the Packaged Hummus Salad category, and here too we eliminate products with a market share below 1e-5 from the sample. As discussed in the text, to keep the implied (by Nash-Bertran pricing) marginal costs positive we also drop six products for which the computed price exceeded 290 NIS per kilogram. This resulted in a total of 1,514 observations employed in estimation.

In the utility function we include dummy variables for the *decaff*, *delicate*, *dry*, *grained* and *golden* characteristics as shown in Table 2, as well as firm (brand) dummies. In the Packaged Hummus Salad category each firm typically sells its products under a single brand name, whereas in the Instant Coffee category a firm may sell products under multiple brand names. In the case of a large firm such as firms a or b, the consumer is aware of both the firm and the particular brand name. Smaller firms may be less familiar on their own, but consumers are likely recognize a specific brand name they sell. In light of this, we include mean utility dummy variables for firms a and b. Dummies indicated by c, d and e in Table 2 refer to three brands that are sold by other firms and, ignoring brands sold by firms a and b, carry the highest brand-level revenue in the category (noting that brand d is a private label of a major chain, and we use a dummy variable for products for which this chain is defined as the seller). In addition, as in the Packaged Hummus Salad category, 42 month dummies are also included.

Price instruments in the Instant Coffee category include: interactions of the minimum wage with with firm a and brand e dummies;[40] interactions of the exchange rate (Euro for NIS) with dummies for firm a, firm b and the firm producing brand c;[41] interactions of the post-food law dummy with dummies for firm a and for one of its brands; an interaction of the VAT with a dummy for a prominent brand of firm b; an interaction of the Israeli corporate tax rate with a dummy for firm d;[42] and interactions of the raw coffee price with dummies for firm b, for the producer of brand c, and for a brand of firm a (where in all those cases, the terms are also

[39]The dummy variable *Premium* takes the value of 1 if the UPC name contains the words "Delux," "Platinum," "Selection" or "Rich" (in Hebrew). *Golden* applies when the UPC name contains the words "golden," "gold" or "karat." *Country* applies to UPC names containing the words "Afrikan," "Colombian" or "Brazilian."

[40]The minimum wage was 4,100 NIS at the beginning of the sample period, and then increased to 4,300 NIS on October 2012 and to 4,650 NIS on April 1st 2015. Source: the Israeli National Insurance website, `https://www.btl.gov.il/Mediniyut/GeneralData/Pages/%D7%A9%D7%9B%D7%A8%20%D7%9E%D7%99%D7%A0%D7%99%D7%9E%D7%95%D7%9D.aspx`, accessed on September 16 2022.

[41]We downloaded monthly averages of the exchange rate from the Israeli Central Bank's website at: `https://www.boi.org.il/he/Markets/ForeignCurrencyMarket/Pages/average.aspx`, accessed on August 4th 2021.

[42]The corporate tax rates were 25 percent in 2012-2013 and 26.5 percent in 2014-2015. Source: page 2 of a publication by the Israeli parliament (Knesset) downloaded from `http://fs.knesset.gov.il/globaldocs/MMM/8a5ae43b-ebf3-e511-80d6-00155d0204d4/2_8a5ae43b-ebf3-e511-80d6-00155d0204d4_11_10583.pdf` on August 4th 2021.

interacted with $(1 - decaff)$ so they effectively take the value 1 only for non-decaff products).[43]

[43] Daily coffee prices, in USD per pound, were downloaded from Macrotrends at `https://www.macrotrends.net/2535/coffee-prices-historical-chart-data`, last accessed on August 3rd 2021.

E 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	7.511
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	0.747	0.187					
b_spicy	0.875	0.157					
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 a 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	-0.683	1.230	a	6.516	0.412	0.921	2.974
decaff	2.240	0.529	b	1.431	1.923	5.500	2.637
delicate	-0.164	0.120					
dry	1.516	0.390	**Price sensitivity**				
grained	-0.989	0.128					
golden	0.833	0.318		α	SE	σ_p	SE
c	6.209	0.453		-5.125	1.133	1.468	0.499
d	-0.725	0.367					
e	6.945	0.722					
Observations	1,514						

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	0.39	0.30	0.34
2	0.46	0.34	0.39
3	0.46	0.32	0.38
4	0.41	0.34	0.37
5	0.32	0.32	0.32
6	0.40	0.35	0.37
7	0.37	0.31	0.34
8	0.38	0.33	0.35
9	0.16	0.16	0.16
10	0.18	0.18	0.18
11	0.34	0.28	0.30
12	0.41	0.30	0.35
13	0.37	0.30	0.33
14	0.35	0.28	0.31
15	0.47	0.29	0.35
16	0.21	0.18	0.19
17	0.30	0.23	0.25
18	0.29	0.24	0.26
19	0.21	0.15	0.18
20	0.19	0.13	0.16
21	0.34	0.26	0.29
22	0.28	0.19	0.22
23	0.23	0.16	0.19
24	0.18	0.13	0.15
25	0.15	0.12	0.13
26	0.32	0.25	0.28
27	0.29	0.23	0.25
28	0.30	0.21	0.25
29	0.18	0.16	0.17
30	0.01	0.03	0.02
31	0.13	0.10	0.12
32	0.23	0.17	0.20
33	0.31	0.26	0.28
34	0.22	0.20	0.21
35	0.22	0.22	0.22
36	0.36	0.25	0.29
37	0.00	0.00	0.00
38	0.25	0.22	0.24
39	0.17	0.13	0.14
40	0.06	0.06	0.06
41	0.13	0.11	0.12
42	0.12	0.12	0.12
43	0.16	0.17	0.17
Maximum impact	0.47	0.35	0.39

Notes: The percentage difference in profits between the $\kappa(\delta)$ and the $\hat{\kappa}(\delta)$ vectors, 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	0.46	0.51
2	0.50	0.50
3	0.48	0.56
4	0.31	0.67
5	0.23	0.75
6	0.32	0.65
7	0.34	0.52
8	0.33	0.60
9	0.11	0.40
10	0.11	0.45
11	0.34	0.49
12	0.38	0.46
13	0.34	0.54
14	0.33	0.42
15	0.53	0.32
16	0.16	0.26
17	0.31	0.21
18	0.25	0.33
19	0.25	0.13
20	0.26	0.10
21	0.38	0.32
22	0.32	0.18
23	0.32	0.15
24	0.24	0.11
25	0.21	0.10
26	0.39	0.32
27	0.38	0.35
28	0.41	0.24
29	0.22	0.27
30	-0.03	0.10
31	0.20	0.10
32	0.34	0.17
33	0.33	0.29
34	0.26	0.30
35	0.18	0.44
36	0.43	0.26
37	0.03	-0.04
38	0.27	0.41
39	0.28	0.13
40	0.06	0.10
41	0.17	0.09
42	0.06	0.31
43	0.10	0.44
Maximum impact	0.53	0.75

Notes: The percentage difference in the sales-weighted average price between the $\kappa(\delta)$ and the $\hat{\kappa}(\delta)$ vectors, 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.

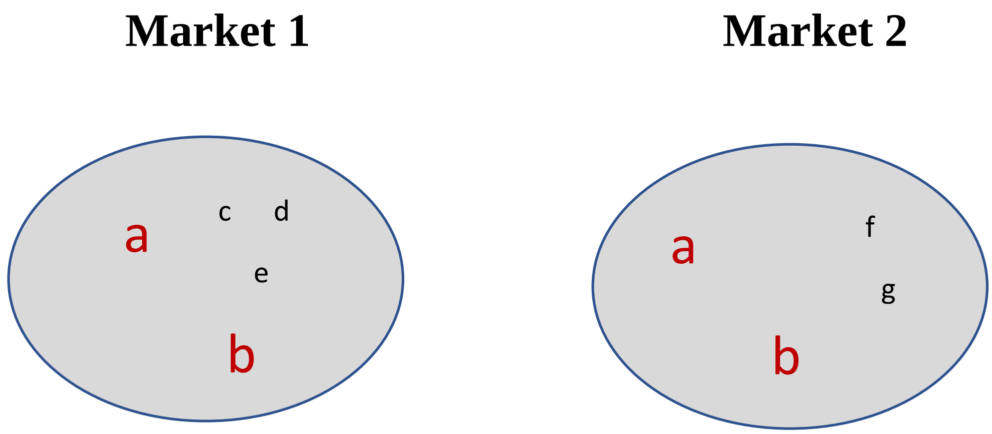

Figure 1: Firms' presence within and across markets. Firms a and b are present in both markets while firms c, d, e and f, g form competitive fringes in market 1 and market 2, respectively.

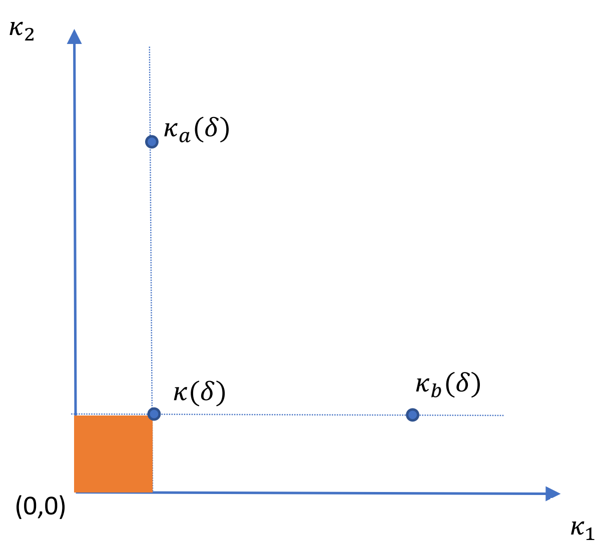

Figure 2: An illustrative example of the largest supportable κ vectors absent multimarket contact

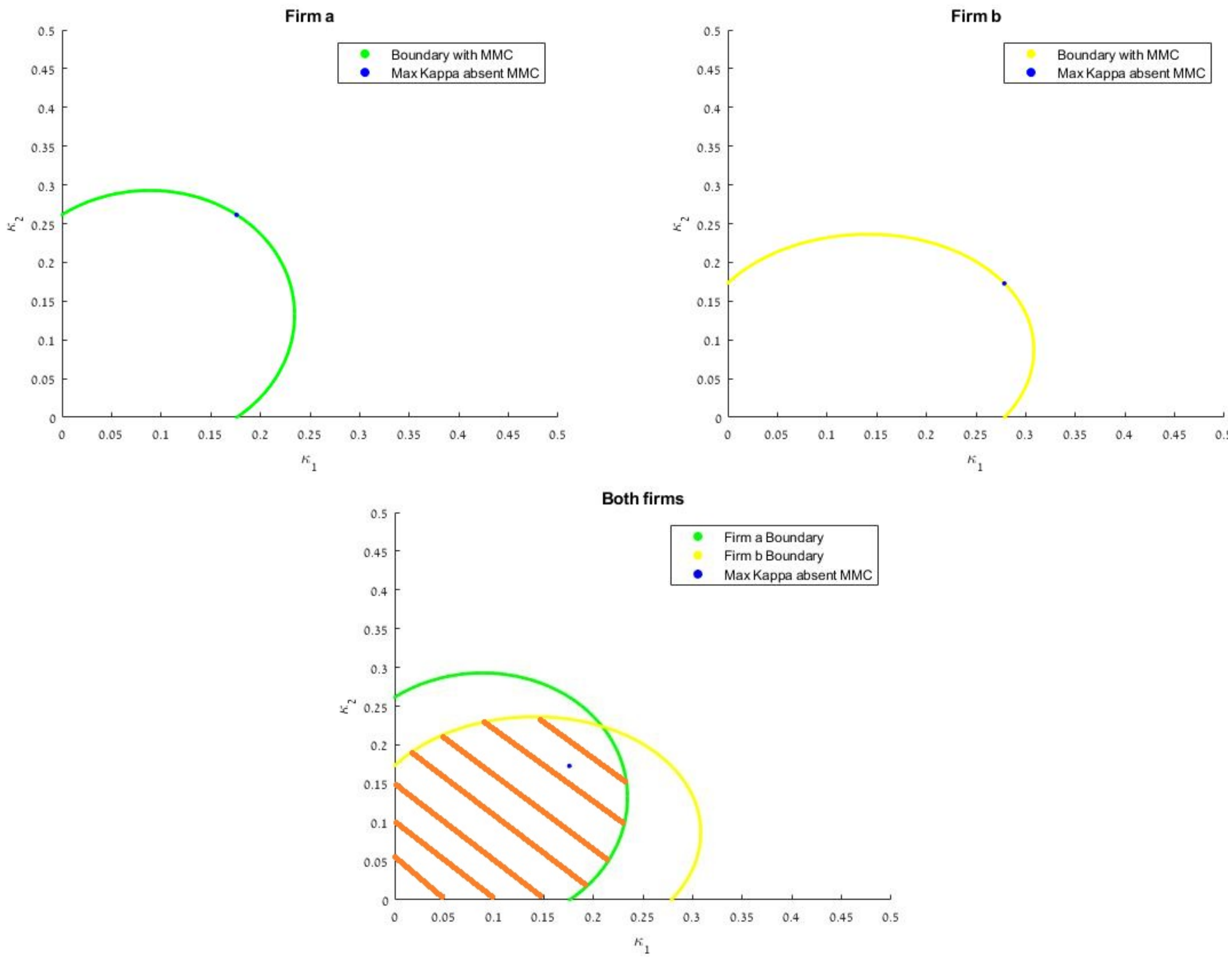

Figure 3: An illustrative example of supportable κ vectors with multimarket contact

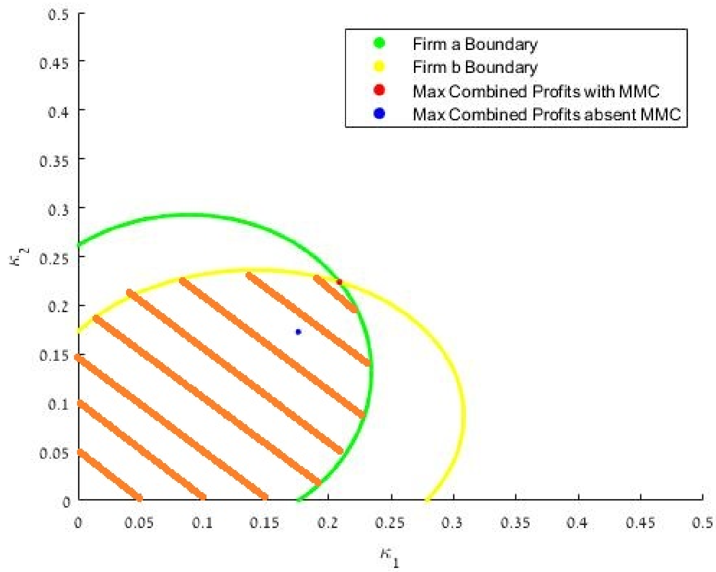

Figure 4: An illustrative example of $\kappa(\delta)$ and $\hat{\kappa}(\delta)$: joint profit maximizing vectors without, and with multimarket contact, respectively

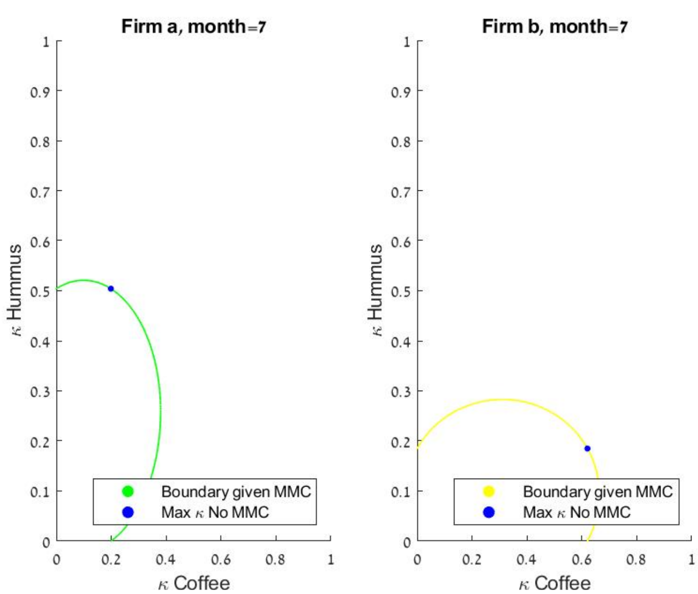

Figure 5: Firms' individual ICCs, with and without multimarket contact

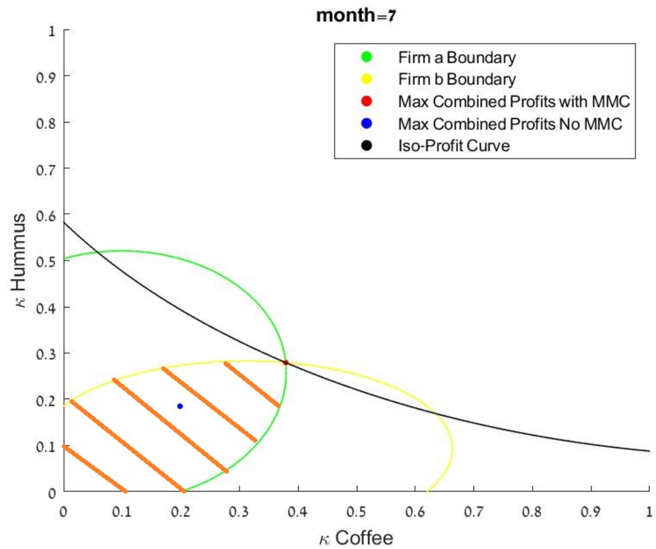

Figure 6: Intersecting both firms' ICCs, with and without multimarket contact

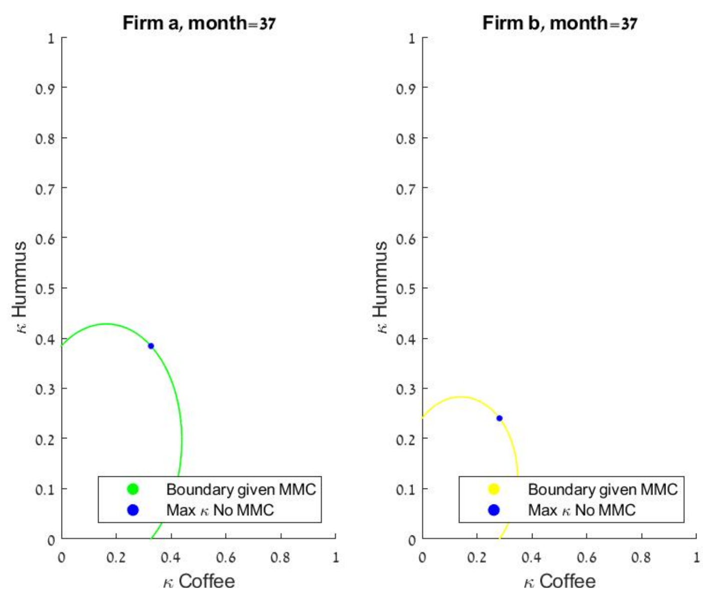

Figure 7: Firms' individual ICCs in month 37

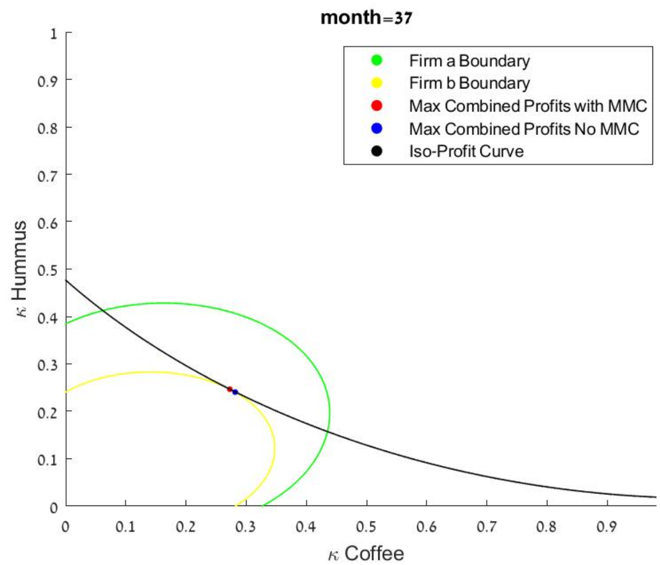

Figure 8: Intersecting both firms' ICCs in month 37

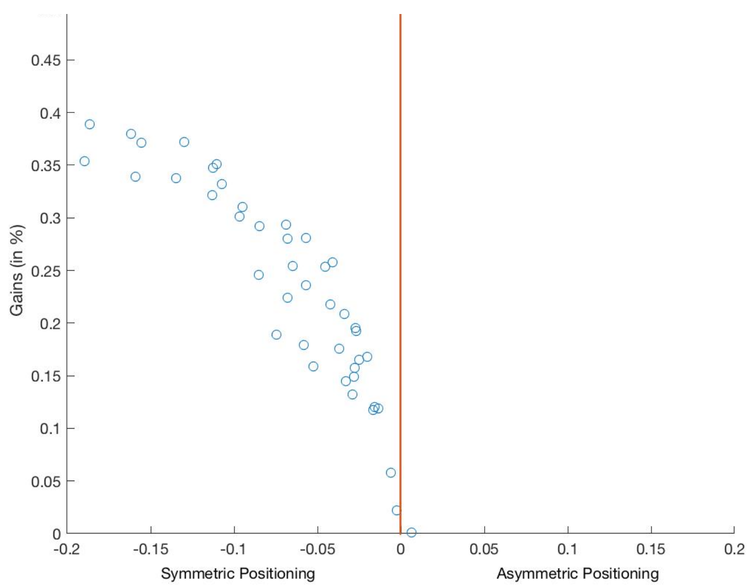

Figure 9: The magnitude of the symmetry / asymmetry property and its relationship to the potential gains from multimarket contact over the 43 month-specific analyses

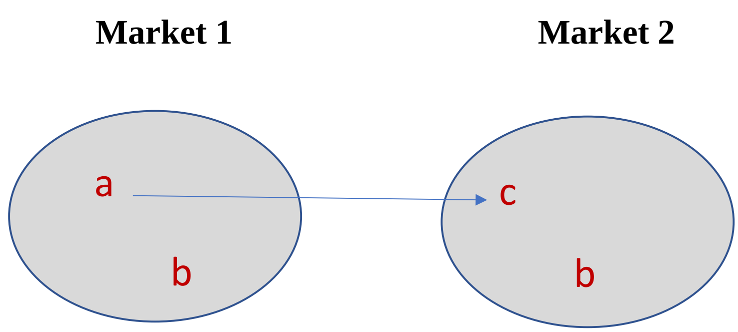

Figure 10: A hypothetical merger generating multimarket contact