Too Many Products: Decentralized Decision-Making in Multinational Firms

Catherine Thomas*
Columbia Business School

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Abstract

I analyze the country-level product ranges offered by multinational laundry detergent manufacturers in Western Europe. Observed product range variation across countries is too great to be the optimal firm-level response to differences in consumer preferences and retail environments. Counterfactual analysis reveals that increased product range standardization would reduce firm costs and increase profits. These findings are consistent with theory models of local agency where decentralized decision-making can lead to too little coordination across divisions even when it is the constrained optimal organizational form. My analysis suggests that organizational structure affects product market outcomes and firm performance.

Keywords: multinational firms, organizational design, firm and product panel data.

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Decentralized decision-making is a widely-observed characteristic of large multidivisional firms. This paper conducts an empirical investigation of the consequences of decentralizing product range choice within multinational consumer goods firms. The setting is the laundry detergents industry in Western Europe. The industry is dominated by a few large multinationals (MNCs), all of which had a similar organizational structure for the time period of this study. While production and R&D were relatively centralized in the region, product-range choices were made at the brand-country level by brand-country managers facing incentives related to the local performance of the brand.

The within-firm product varieties available on supermarket shelves vary substantially across different markets. Even for a given multinational detergent brand, the composition of the product range differs in terms of the number of products and the characteristics of the products sold in each country. Some variation in product range is optimal for the firm due to varying local consumer preferences and differences in the vertical relationship between the firm and the retail sector. At the same time, economies of scale in production create incentives for product range coordination.

This paper shows that the observed variation in products offered by the same firm in different markets cannot be solely attributed to differences in local consumer demand or retail environment. Using a structural model, I estimate the effects on demand and firm profit of an increase in the degree of cross-country standardization in product range. Selling fewer product varieties across a wider set of markets, while keeping the number of products sold in each market constant, does not significantly decrease variable profit. Increased standardization would allow the firms to reduce the total number of product varieties manufactured in the region. At the time of the data used in the study, Procter and Gamble (P&G) could have profitably eliminated up to 20% of the Ariel brand product varieties sold across three Western European countries, and Unilever could have ceased production of up to 30% of the Surf brand product varieties sold in the same markets. Firms are manufacturing too many products, in that reducing the number of product varieties for a given brand would reduce total costs and increase firm-level profits.

Recent developments in the organizational economics theory literature offer an explanation for the observed excessive localization in decentralized firms. The models presented by Alonso *et al.* (2008) and Rantakari (2008) translate most directly to the empirical setting analyzed here. These authors describe how decentralized decision-making can be the optimal organizational form in the context of centrally unobservable local conditions despite a resulting lack of coordination. Excessive localization by decentralized decision-makers is observed in equilibrium due to division manager agency. Applied to the setting examined in this paper, each local manager choosing a range of products for his local market does not consider the full impact of his choices on the costs of the other divisions and the firm as a whole.

The empirical challenge addressed here is establishing that local product range tailoring is suboptimal at the firm level even in the face of the diverse market conditions which prompted the decentralized decision making structure to begin with. To do this, I first measure preference variation across countries, following Nevo (2001), and then control for both demand and retail sector heterogeneity. I estimate a discrete choice random coefficients demand system using data from four Western European markets to estimate local demand. The results establish that underlying consumer preferences for laundry detergent characteristics are significantly different across countries.

Focusing on the Ariel and Surf brands – the two most widely sold brands in the data – a set of alternative product ranges that represent increased firm-level coordination are constructed for each brand in each country where the brand is sold. An alternative product range involves a minor product substitution, when a local product of a given brand and format is replaced with a product that is currently being sold in another market that is of the same brand and format but differs slightly in pack size. For example, at the time of the data used in the data, Ariel sells a 30 washload pack of concentrated liquid in the UK and a 35 washload pack in Germany. Both packs are produced in the same manufacturing plant. One alternative product range for Ariel in the UK hence involves replacing the 30 washload pack with the 35 washload pack.

The analysis holds the number of products sold in each market fixed while allowing firms to reduce the total number of products manufactured in the region. In doing so, the approach controls for cross country variation in the local relationship between manufacturing firms and retailers, and any strategic decisions related to any one firm's size of product line.[1] The effect on brand-level and firm-level variable profit is evaluated for each alternative product range. When an increase in standardization does not decrease local variable profit, and allows the firms to reduce the total

[1] Rather than address whether firms are engaged in product line length competition of the type discussed in Draganska and Jain (2005), or whether retailers and manufacturing firms are price discriminating within-country, for example across brands of differing perceived quality, as in Draganska and Jain (2006), the structure of the counterfactual analysis allows for both to exist in each market.

number of product varieties manufactured in the region, the firm could save the fixed production cost of the local varieties that are no longer produced and also benefit from any lowering of marginal cost due to increased unit production runs.

Existing studies of multiproduct multinational firms include models which explain the number – rather than type – of products sold by a given firm in each national market. Examples include Arkolakis and Muendler (2009), in which differences in the size of the product range result from diseconomies of scope in market entry, and Bernard *et al.* (2010) which includes one-dimensional variation in country-level demand for a firm's products. In these papers, each firm sells its highest productivity products in each country where it operates so that variation in product range composition comes about only through the number of products offered. In contrast, this paper allows for within-firm cross-country variation in the number and types of products marketed resulting from multi-dimensional local heterogeneity. Allowing for heterogeneity has two separate effects. First, the composition of the optimal product range for each market can vary due to the differences in local conditions – the constraints imposed by local retailers, the actions of competitor firms, and variation in underlying local consumer preferences. Second, diverse local conditions prompt the firm to adopt a decentralized organizational form.

The large and growing organizational economics literature on decentralization originates in the work of Jensen and Meckling (1976).[2] Much of the literature on multidivisional firms in economics and accounting takes the presence of division-level agency as a starting point for a discussion of within-firm hierarchies and incentives structures without any empirical evidence of its relevance.[3] This paper establishes that multidivisional firms do not align decision-making by division managers in this empirical setting, consistent with the presence of an underlying agency problem.

A related empirical literature examines different explanations of why firms decentralize decision-making. Examples include Colombo and Delmastro (2004), Acemoglu *et al.* (2007), and Bloom *et al.* (2009) who ascribe variation in organizational form to differences in the firm-level production function such as the operational complexity, distance to technology frontier, and the specific nature

[2] Along with Alonso *et al.* (2008) and Rantakari (2008), other theory papers relating organizational form to information or knowledge asymmetry between local divisions and the coordinating center include Jensen and Meckling (1995), Aghion and Tirole (1997), Baker *et al.* (1999), Hart and Moore (2005), Dessein *et al.*, (2008) and Friebel and Raith (2010). Other strands of the theory literature on organizational form examine the relationship between decentralization and characteristics of firm technology, such as Rajan and Zingales (2001).

[3] Examples of papers in this strand of the accounting literature are: Baiman *et al.* (1995), Bushman *et al.* (1995), Abernethy *et al.* (2004), and Bouwens and van Lent (2007).

of internal technologies, respectively. Guadalupe and Wulf (2010) examine the relationship between firm organizational form and industry-level product market competition. A subset of this literature also establishes a causal effect of organizational form on other aspects of the firm-level production function, such as labor skill mix in Caroli and Van Reenen (2001) and R&D activity in Kastl *et al.* (2008). This paper provides some of the first evidence that the observed firm-level organizational form has consequences for product market-level outcomes that are consistent with predictions drawn from recent theory.

The paper is organized as follows: Section 1 describes how decentralized decision-making about the composition of local product ranges generates the prediction that the firm will manufacture too many products overall. Section 2 contains a brief description of the features of the laundry detergents industry in Western Europe that are relevant to this study. The data used for the analysis are described in Section 3. Section 4 presents the analysis of local demand conditions, the results of which establish that consumer preferences for detergent products differ across countries. Section 5 is an investigation of whether firms can profitably increase cross-country product standardization given the estimated differences in local demand while controlling for the local retail environment. Section 6 concludes.

1 Agency in product range choice

This section describes a simplified model of the local brand manager's choice of the product range $J_{b,c}$, for brand b in country c in a decentralized firm f at any given point in time, illustrating the agency problem associated with this organizational structure when production is centralized. A product, j, is defined here and throughout the paper as a brand, format, and pack size combination.

Firm-level profits are the sum of the revenues generated in each product market for each brand given the range of product varieties on sale in each market, less the centrally incurred fixed and variable production costs.[4] Marginal production costs are assumed to be constant for a given

[4]The major firms in the laundry detergents industry dominate many consumer products industries. Each firm here is assumed, for simplicity, to manufacture and sell product varieties of one product category.

product and there is a per period fixed cost for each product.[5] Firm profits can be written:

$$\Pi_f = \sum_b \sum_c \sum_{j \in J_{b,c}} p_{j,c} q_{j,c} - \left(\sum_{j \in J} \left[mc_j \sum_c q_{j,c} - F_j \right] \right) - F_f \tag{1}$$

where $q_{j,c}$ is the quantity of product j sold in market c and $p_{j,c}$ is its local price. mc_j is the marginal cost and F_j is the fixed cost associated with production of product variety j. Product-level fixed costs are assumed to be independent of the number and identity of the countries in which the product is sold. The firm may incur overhead costs and brand-level fixed costs in each country where the brand is sold; these are summed over brands and denoted F_f. The decision about which brands to sell in each country, and brand-level fixed costs, are assumed to be fixed throughout this paper.

The focus here is on the composition of $J_{b,c}$, given that brand b is present in country c. Each of the large firms in this industry has responded to the challenge posed by variation in local demand conditions by decentralizing some aspect of decision-making to the country level. At the time of the data used in this study, firms employed brand-country managers who were responsible for setting prices and choosing the range of product varieties sold under the brand name in each local market. The brand-country managers faced local incentives, tied to the profits of the brand in their respective markets.[6] The manager's objective function can be written:

$$\pi_{b,c} = \sum_{j \in J_{b,c}} (p_{j,c} - k_{j,c}) \, q_{j,c} \tag{2}$$

Rather than observing the marginal production cost for each product variety, mc_j, the manager observes a unit cost $k_{j,c}$ which is the per unit transfer price for the product in question. Conditional on the product range, $J_{b,c}$, and the product-level transfer prices, $k_{j,c}$, the local manager will set prices to maximize equation (2). Holding fixed the total number of products sold under the brand

[5] If instead economies of scale were modeled as decreasing marginal costs within product variety, the agency costs associated with decentralization would be greater in magnitude since the production runs of each product variety are lower under decentralization.

[6] The empirical implications of this model arise from the fact that local managers do not fully incorporate the effects of their product choices on firm-level costs. A number of different organizational structures could lead to this outcome. I focus here on a model based on localized incentives since this relates most closely to features of the organizational structure in the major firms at this time. Costly communication between local brand managers could generate similar empirical implications.

in each country, $\pi_{b,c}$ is assumed to be maximized under the observed product range $J_{b,c}$.

To illustrate the agency problem in product range choice arising from the decentralized organizational structure which is the focus of this study, it is useful to restrict attention to the question of which one of two alternative products is chosen by the brand-country manager to complete the product range of a given size. One of the products, j', is a standardized product and will be manufactured by the firm in any case since it will be sold in another country market. The other product $\bar{j}$, if chosen, will be a local product, manufactured and sold only in country c. None of the other country marketing divisions will find it profitable to include product $\bar{j}$ in their own product range. Under the assumption that the brand-country manager in country c chooses the product range to maximize equation (2), product range $J_{b,c}$ which includes product $\bar{j}$ will be observed rather than product range $A_{b,c}$ which includes product j' if:

$$\sum_{j \in J_{b,c}} p_{j,c} q_{j,c} - \sum_{j \in A_{b,c}} p_{j,c} q_{j,c} \geq \sum_{j \in J_{b,c}} k_{j,c} q_{j,c} - \sum_{j \in A_{b,c}} k_{j,c} q_{j,c} \tag{3}$$

This inequality demonstrates that the locally-tailored product $\bar{j}$ will be chosen whenever the increase in revenues with the local product relative to the standardized product outweighs the increase in variable costs, as seen by the local manager.

The firm, however, would prefer the local product $\bar{j}$ to satisfy a more stringent criterion to be included in country c's product range. If the product range decision were centralized, and the decision-maker had access to all the relevant information, $\bar{j}$ would be chosen only if the left hand side of inequality (3) exceeded: $F_{\bar{j}} + \sum_{j \in J_{b,c}} mc_j q_{j,c} - \sum_{j \in A_{b,c}} mc_j q_{j,c}$. The firm would manufacture and sell product $\bar{j}$ in market c only when the increase in revenues from including $\bar{j}$ rather than j' exceeded the incremental marginal costs and the fixed costs incurred from producing $\bar{j}$. Specifically, the possibility arises that the brand-country manager will market product range $J_{b,c}$ when the product range $A_{b,c}$ would generate greater firm-level profits whenever:

$$F_{\bar{j}} + \sum_{j \in J_{b,c}} mc_j q_{j,c} - \sum_{j \in A_{b,c}} mc_j q_{j,c} > \sum_{j \in J_{b,c}} k_{j,c} q_{j,c} - \sum_{j \in A_{b,c}} k_{j,c} q_{j,c} \tag{4}$$

While firm-level transfer pricing methods are often fairly opaque, especially at the product level, the first part of the appendix shows that expression (4) may well hold under the two most frequently employed methods of transfer pricing: market price transfer pricing and full cost transfer pricing. If the difference in revenues between $J_{b,c}$ and $A_{b,c}$, as given on the left hand side of inequality (3), lies between the values of the left and right hand sides of inequality (4), the firm will manufacture too many products as a consequence of decentralizing the product range choice decision. That is, reducing the total number of product varieties manufactured within the region would increase firm profit.

This inference guides the counterfactual analysis described in Section 5. To provide evidence that observed product ranges reflect the agency problem described in this section, it is sufficient to show that the firm would be at least as well off under a more standardized product range, reducing total production costs. The laundry detergents industry has some features which facilitate this empirical comparison, but it also presents some challenges. These will be discussed in the following sections.

2 The Laundry Detergents Industry in Western Europe

Laundry detergent, sometimes referred to as heavy duty detergent, typically refers to all washing machine detergents whose primary purpose is the laundering of clothes and other textiles (and excludes fabric softeners and hand washing products). Data from four countries are used in this paper: the UK, Germany, Italy, and Spain. Anecdotal evidence suggests that consumer preferences vary across these countries. Explanations for cross-country differences refer to persistent country-specific laundry habits, reflect differences in washing machine technology such as front- versus top-loading machines, and are also related to the legacies of different brand histories in each country.

The industry is dominated globally and especially within Europe by a small group of large MNCs. A firm-level analysis in this concentrated industry represents a relatively large fraction of the entire market in each country.[7] Table 1 presents some summary statistics about MNC activities in each country at the time of the data used in this study. MNCs sell both country-specific and international brands. Even for international brands, only a fraction of all products manufactured under each brand are sold in more than one country. This is consistent with Broda and Weinstein (2008) who

[7] The Enterprise DG of the European Commission, and others, refer to these firms collectively as "The Big Soapers." P&G and Unilever together have a joint market share of between 20% and 72% in each country in the data.

find that a large fraction of cross-border price differences at the industry level can be attributed to product range composition effects for a broad range of industries. Throughout Europe, the bulk of branded MNC detergents are sold through supermarkets and hypermarkets. Even in Italy and Spain where smaller retail formats are relatively prevalent, 87% and 83%, respectively, of laundry detergent sales are made through supermarkets, hypermarkets and discounters (Euromonitor, 2003). Recent years have seen market-share growth in Europe for private label detergents, competing mainly on price.[8]

The UK market tends to have the greatest product diversity, and relatively recently introduced format varieties – liquids, tablets and capsules – are widespread across MNC brands and private labels. Liquids and concentrated formats were first seen in the 1980s. The tablet format was first introduced by Unilever in the UK in 1998, and was rapidly copied by other firms so that it was widespread in Europe by 1999. Capsules were introduced by P&G in the UK in 2001. The 2003 Euromonitor report on Germany emphasizes that German consumers tend to be price sensitive due both to the widespread presence of hard discounters and also to the recessionary macroeconomic environment at that time. German consumers are also said to use less product per household, mainly because they are more careful about precise dosage due to environmental considerations. Regarding Italian preferences, Euromonitor goes so far as to remark that products marketed as environmentally friendly are "unpopular." As of 2003, capsules were not available in Italy but, following the introduction of the new Marseille (Marsiglia) soap format by a small independent firm, the MNCs offered some of their main brands in this format.

The major firms in this industry are viewed primarily as brand managers and marketers, and there is relatively little publicly available information about the supply side. Of particular relevance to this study is the fact between 2000 and 2003, a brand manager for a given brand in a country was accountable to both a country manager and a regional brand manager, but decisions within brand tended to be made at the country level. Brand-country managers' incentives were related to the local performance of the brand. Both brand-country profit and market share were considered to be important measures of local performance. Production and other functional divisions were more centralized, typically at the regional level.

[8] Supermarkets tend to sell both MNC branded detergents and own label products. Hard discounters (for example, Aldi and Lidl) tend to sell only their private label varieties.

Nonetheless, there is substantial anecdotal evidence that product variety-level economies of scale, either in terms of product-level fixed costs or declining within-product marginal costs, are significant for detergents and in the production of consumer goods in general.[9] An industry wide initiative, described in Drayer (1999), details how firms in the industry together developed a program during the 1990s called "Efficient Consumer Response," one of the four aims of which was the "Efficient Assortment" strategy which aimed to reduce "duplication of SKUs while maintaining the optimal product assortment to meet customers' needs."[10] The increasing prevalence of multilingual packaging in many world markets is indirect evidence that firms find it worthwhile to consolidate production lines to produce one variety for multiple markets when feasible.

In 1999, P&G embarked on its "Organization 2005" global restructuring plan. One of the stated aims was to invest in "cost reduction through the standardization of procedures resulting in better economies of scale" (Euromonitor, 2003).[11] Drayer (1999) describes how P&G aimed to improve supply chain management of the "proliferation of product, pricing, labeling, and packaging variations." He notes that "the bloating of the supply chain with product, together with the proliferation of product variations related to promotions, increased manufacturing costs." In 2000, Unilever launched its "Path to Growth" restructuring program. A further phase of restructuring – Unilever 2010 – was launched in 2004. The goals of these programs included a more streamlined brand portfolio – moving from 1600 brands in 1999 to a target number of 400 by the end of 2004 – and improved global scale, procurement, and media. Euromonitor reports that the goal was to "transform Unilever from 'hopelessly local', as management described it, into a coherent 'multi-local-multinational' organization that can get the balance right between the economic benefits of global scale and the marketing advantages of optimal tailoring to local customers."

EU-wide regulations that have come into force since 1992 mean that there are now fewer differences in chemical composition of detergent product across countries. An EU Commission report

[9] Thomas (2006) estimated some bounds on feasible product level fixed costs under the assumption that marginal costs could be estimated from prices and firm-level first order conditions. This analysis was based on the assumption that the size of the product range was optimal given marginal costs. The inferences made are to be treated with caution since they ignore decentralized price setting which is characteristic of these firms. Nonetheless, the lower bound on the product level fixed cost in each market (extrapolating from the data based on the total number of households in each country) was estimated to be at least 70,000 euros per 8-week period.

[10] One example of the results of this program is from P&G's Head and Shoulders shampoo brand in the U.S.. Cristol and Sealey (2000) note that in the early 1990s, "P&G reduced formulas and packaging variations until the company's total number of hair care SKUs were cut by half." An SKU (stock keeping unit) corresponds to the definition of a product used in this paper.

[11] See Piskorski and Spadini (2007) for a detailed discussion of the evolution of P&G's organizational structure.

remarked in 1991 that "the detergents industry contains large volumes of substantially similar products" (Enterprise DG, EU Commission, 1991). Javorcik *et al.* (2008) comment that economies of scale in detergent production led P&G to consolidate its US production plants from 14 to 4 between the late 1970s and 2005. As of 2003, P&G manufacture of detergents in Europe was fairly geographically concentrated. Liquid products and liquid capsules for all the firm's brands were manufactured in Amiens in France. All powder tablets for all brands were manufactured in Mechelen, Belgium. By far the majority of powder products was manufactured in London, UK.[12] At this time, Unilever's key detergent manufacturing plants in Europe were at Port Sunlight and Warrington in the UK, with some production facilities in Spain and Italy. The production plants tended not to be country-specific and the smaller plants in Southern Europe frequently produced the product varieties sold in the UK.

3 Data

The laundry detergent product data used in the paper come from a panel for each of the four countries, covering the years from 2000 to 2003. They are proprietary data collected by the market research firm Europanel which surveys a representative set of households on their shopping purchases and consumption habits.[13] The UK panel consists of 15,000 households, the German panel of 12,000, the Italian panel 5,000, and the Spanish panel 6,000. Consumers in each country record their purchases and this information is then aggregated to the product level. The data are available for each four-weekly period over the three years.

Each brand-format-pack size level observation includes the physical quantity of product purchased and the total amount spent on the product in a four-week period. Products included in each panel are all products on sale at that time for each of the top 20 brands in a country, where the top 20 is as defined at the end of the three years in question.[14] Also given in the data is the total

[12] P&G also manufactured some powders in Italy and Spain for brands sold only in those countries. Powders tend to have the highest weight to value ratio, so transportation is relatively expensive for these formats.

[13] Europanel is a joint venture between the UK marketing firm TNS and the German marketing firm GfK. The company is careful to ensure that each panel is representative and participants are compensated in non-monetary ways so as not to distort their purchasing behavior. More information on their sampling methods is available at www.europanel.com. Since all household detergent purchases are included in the data, the product level data is comprehensive.

[14] The ranking of brands by market share is more or less constant in each country between 2000 and 2003. Germany is an exception to this since P&G introduced a new brand – Meister Propper – towards the end of the time period.

quantity purchased and amount spent on the entire category of detergent in each time period. In the demand specification in the following section, each household is assumed to purchase either a top 20 brand product or some other product in each time period. The top 20 brands typically make up between 70% and 96% of the total quantity of detergent sold in each country as recorded in the data. Hence the data include product-level information for a large fraction of the total market in each country together with an accurate measure of the total size of each market.

A key feature of the product-level data set is that it demonstrates very clearly the extent to which the product range choices made by brand managers differ across countries. There are many cases where a product appears in one market that is similar but slightly different to a product sold elsewhere. Since production is centralized, this fact is in itself suggestive of some production inefficiency and serves to motivate the product level analysis in Section 5. The existence of very similar products on sale at any one time also provides candidate products to include in alternative product ranges when assessing the impact on firm-level profits of increased standardization. These products are already being manufactured and all the fixed costs of development and production are sunk, so switching existing products in and out of the product range for any one country will not affect total fixed costs at the firm level.

Two smaller miscellaneous data sets are also used in the paper. The first is a conversion table of each format of laundry detergent from weight and volume measures, given in metric units for each country in the data, to the actual number of washloads of detergents contained in each pack. This is used to create a standardized quantity unit.[15] Second, average monthly exchange rates for 2000 to 2003 are used to convert the UK data from pounds into euros. These data came from the website x-rates.com.

For most months in Germany, then, the data set contains product level detail for only 19 brands. New private label brands were also introduced in the data in some countries. In Italy, there appears to be a data issue with the P&G brands Bolt and Ace. The data record them as having identical sales at the product level over the time period. Since this is likely to be an error, the product level data on one of the brands is discarded, effectively, it is included in the outside good. The Italian data thus detail only 19 brands at the product level.

[15] There is an EU regulation to the effect that the number of washloads worth of detergent in each pack must be printed on the outside of the pack. This information was gathered during a series of store visits in the UK and Germany in the summer of 2005.

4 Estimating Local Conditions

Establishing that observed product ranges are suboptimally localized from the firm's perspective requires that the underlying variation in local conditions be measured and then taken into account. The product-level data about consumer purchases in each country are used to estimate local consumer demand in a discrete choice random coefficients framework incorporating both product characteristics and unobserved household attributes, based on McFadden (1974) and Berry, Levinsohn, and Pakes (1995), and following Nevo (2001).[16] As in Brambilla (2007), allowing demand to vary across countries permits a relatively detailed study of the complexities of management practices within these multinational multiproduct firms.

A market is defined as an eight-week period in each country, where two four-week time periods are aggregated to form each market as described in the appendix. The data contain information from 19 markets for the UK, 22 for Germany, 19 for Italy, and 19 for Spain. The conditional indirect utility of household i in country c from using one washload's worth of detergent product j at time t, rather than a detergent product that is not from one of the top 20 brands is made of up of three parts, $\delta_{j,t,c}$, $\mu_{i,j,t}$, and $\epsilon_{i,j,t,c}$:

$$\begin{aligned} u_{i,j,t,c} &= \delta_{j,t,c}\left(\mathbf{X}_{j,t,c}, w_{j,t,c}, p_{j,t,c}, \Delta\xi_{j,t,c}, \boldsymbol{\theta}_1\right) \\ &\quad +\mu_{i,j,t,c}\left(w_{j,t,c}, p_{j,t,c}, \boldsymbol{\nu}_i, \boldsymbol{\theta}_2\right) + \epsilon_{i,j,t,c} \end{aligned} \tag{5}$$

where $\mathbf{X}_{j,t,c}$ is a matrix of zeros and ones constructed to represent the brand and format of product j, together with a constant term. $w_{j,t,c}$ is the pack size of the product in units of the number of washloads found using the format conversion table. $p_{j,t,c}$ is the price per washload in euros.[17] $\Delta\xi_{j,t,c}$ captures any unobserved time-specific deviation in average consumer utility obtained from the product relative to the mean valuation of the brand-format-pack size combination. $\boldsymbol{\nu}_i$ represents unobserved attributes for each household i.

$\delta_{j,t,c}$ is the mean utility experienced from each product, common to all households. It is given

[16] The appendix contains a more detailed description of the estimation process and a description of the instrumental variables strategy.

[17] The UK data is converted to euros using the mean exchange rate between 2000 and 2003. Converting to euros using each time period's exchange rate would introduce a fluctuation in price to the UK data that is not experienced by UK consumers.

by:

$$\delta_{j,t,c} = \mathbf{X}_{j,t,c}\boldsymbol{\beta}_c + \gamma_c w_{j,t,c} + \alpha_c p_{j,t,c} + \Delta\xi_{j,t,c}$$

where the parameters $\boldsymbol{\beta}_c$, γ_c, and α_c together make up the vector $\boldsymbol{\theta}_1$, and are country-specific so that the mean preference for each brand and format can vary across countries. $\mu_{i,j,t,c}$ is a household-level, mean zero heteroskedastic deviation from each country's mean product-level utility which measures the effects of the interactions of unobserved household attributes with the product characteristics pack size and price in the model. This term varies across households within in a country. It is given by:

$$\mu_{i,j,t,c} = \sigma_w \nu_{i,1} w_{j,t,c} + \sigma_p \nu_{i,2} p_{j,t,c}$$

the parameters σ_w and σ_p make up the vector $\boldsymbol{\theta}_2$. The magnitudes of the interaction coefficients do not vary across countries. Each household has the option to purchase the outside good (a product that is not one of the top 20 brands) if it obtains greater utility from doing so than from purchasing one of the products from one of the top 20 brands. Instrumental variables are used to address potential price endogeneity.

Table 2 presents a subset of the parameter estimates for the vector $\boldsymbol{\theta}_1$. The brand-country level estimated coefficients for the P&G brand Ariel and the Unilever brand Surf are shown in the table. These two brands will be the focus of the remainder of the paper since, as mentioned in the introduction, they are the two brands that are sold most widely across the four countries studied. The country-specific mean brand preference parameter estimates tend to be positive and significantly different from zero, suggesting that the average consumer in the relevant country gains positive utility from using one of these particular MNC brands rather than a domestic or private label brand in the top 20 country brands to do one washload of laundry. Consumers in each country tend to value other formats more highly than standard powder, holding price, pack size, and brand constant. The two exceptions to this are that the typical Spanish consumer prefers standard powder to capsules and the typical Italian consumer prefers powders to tablets. Consumers in the UK value newer formats – tablets and capsules – particularly highly on average. Consumers in all countries, and particularly in Spain, attach a large discount to concentrated formats. This is consistent with anecdotal evidence in the Euromonitor reports.[18] The average UK consumer exhibits a slight dislike

[18]Industry sources suggest this could be because consumers are particularly likely to "overdose" with concentrated

of larger pack sizes, all else equal, and the average Spanish consumer prefers a larger pack size. As anticipated, the typical consumer in each country dislikes higher prices.

In the full model specification including the random coefficients, which fits the data better than the version of the model which excludes these coefficients, σ_w is estimated to be -0.002 with a standard error of 0.04, suggesting that there is limited random variation in pack size preference across households in each country. The estimated σ_p coefficient representing the effect of the interaction of an unobserved household attribute and product price is 12.889 and highly significant (the standard error is 3.14). This implies that there is significant variation in price sensitivity within a country across households.

Wald test statistics for the significance of the differences in the estimated relative preferences across the countries are given in Table 3. Ariel was sold in all four countries in the data, and Surf was sold in the UK, Italy and Spain over the three years in question. The estimates in Table 2 and Table 3 reveal that Ariel is significantly more highly valued in the UK than in Germany, Italy, and Spain, significantly more highly valued in Spain than in Germany and Italy, and significantly more highly valued in Germany than in Italy, in each case relative to a local non-MNC brand. Surf is significantly more highly valued in the UK than in Italy and Spain, but the null hypothesis of no significant difference in relative Surf brand value between Italy and Spain cannot be rejected.

Turning to relative format preferences, there is often a significant difference in the relative preference of the average consumer for various formats over standard powder across all pairs of countries. While consumers in all countries have a negative preference for concentrated formats, on a per washload basis consumers in the UK, Italy and Spain have on average a significantly greater dislike for concentrated formats than do consumers in Germany. Spain also has a stronger negative preference for concentrated formats than does each other country. All country-pairs other than Germany and Spain exhibit a significant difference in their average preferences for larger pack sizes. Similarly, all country-pairs other than Germany and Spain are significantly different in the average consumer's price sensitivity. German consumers are most price sensitive on average and Italian consumers are the least price sensitive on average. Last, the Wald test statistics for significant difference in the constant term reveal that consumers on average in the UK have a greater relative

products, using more product than is recommended per washload. This means that, per washload, these formats appear relatively expensive to consumers.

preference for products in one of the top 20 brands that are not MNC brands. This is consistent with UK consumers attaching a relatively high value to domestic supermarket own-brands.

As in Nevo (2000), the own price elasticity for good j allows for more flexibility in substitution patterns than would a logit demand system.[19] Similarly, the own size elasticity for good j at time t – how sensitive product demand is to pack size – is given by:

$$\eta\left(w_{jt}\right)_{jt} = \frac{\delta s_{jt}}{\delta w_{jt}} \frac{w_{jt}}{s_{jt}} = \frac{w_{jt}}{s_{jt}} \frac{1}{ns} \sum_{i=1}^{ns} \gamma_i s_{ijt} \left(1 - s_{ijt}\right) \tag{6}$$

where $\gamma_i = \gamma_c + \sigma_w \nu_{i,1}$ is the household-level size elasticity. Own size elasticities are of particular interest in this study since the counterfactuals involve changing individual product-level pack size, within country. Furthermore, the full model allows the change in market share for product j in response to a change in pack size of any other product – the cross size elasticity – to be a function of household preferences for the product-level characteristics of each product. The demand system is hence flexible enough to allow households to be more likely to switch to similar brand-format-size products in response to a given pack size change.[20]

The results presented in this section attach parameter values to local consumer preferences and reveal that there is significant variation in preferences across countries for observable product characteristics. Together with the actions of local and multinational competitor and retailing firms in each country, consumer preferences determine the local conditions faced by each multinational firm in each of its national markets. Variation in local conditions, across markets and within markets over time, suggests there are significant incentives for a multinational firm to sell a locally tailored product range and to organize its activities so as to be informed about local conditions. The estimated parameter values also permit an evaluation of heterogeneous predicted changes in product-level demand following changes to the composition of the product range choices available in each market.

[19]Product-level price elasticties reflect household-level price elasticities, given by α_i equal to $(\alpha_c + \sigma_p \nu_{i,2})$. Of the α_i coefficients estimated for each household i in each country in this study, only 1%, 3%, 7% and 2% in the UK, Germany, Italy, and Spain, respectively, are positive. This suggests the model does a relatively good job of measuring household-level dislike of high prices.

[20]The appendix contains more detailed information on estimated own price, own size, cross price and cross size elasticities.

5 Increasing product range coordination across countries

5.1 Motivation

Table 1 shows that the multinational brands market a range of local and standardized products in each market. For example, in the UK, there are 66 products sold in a typical time period under one of the three multinational brands available in the UK, but only 14 of these varieties are sold in another market during the same time period. This section analyzes the relative profitability at the firm level of small changes in Ariel and Surf's product ranges in the direction of increased product-range standardization across countries. $J_{b,c}$ denotes the product range on sale in April and June of 2003 for each brand b in each country c. Taking each brand-country pair in turn, same-brand, same-format products on sale in another country were found for all $j \in J_{b,c}$. This allowed the construction of alternative product ranges for brand b in country c; in each alternative, one product $j \in J_{b,c}$ was replaced with a close substitute product, denoted $j\prime$, that was already being sold in another market. An alternative product range is denoted $A_{b,c}$.[21]

Increased product-range standardization increases firm profits if selling $A_{b,c}$ rather than $J_{b,c}$ reduces total costs by more than it decreases revenues. Following the notation in Section 1, the firm could profitably increase product range standardization across countries for brand b if:

$$\sum_{j \in A_{b,c}} p_{j,c}q_{j,c} - \sum_{j \in A_{b,c}} mc_{j,c}q_{j,c} \geq \sum_{j \in J_{b,c}} p_{j,c}q_{j,c} - \sum_{j \in J_{b,c}} mc_{j,c}q_{j,c} - F_j \tag{7}$$

As shown in Section 1, division manager agency means inequality (7) can hold even when the manager has found it optimal to choose the product range $J_{b,c}$. Because the transfer price in place affects the observed product range, $J_{b,c}$, assumed optimal from the point of view of the manager, the transfer pricing mechanism does not play a role in expression (7). Production costs are relevant pieces of information but the intra-firm transfer prices which influence local manager decisions are irrelevant since they net out of firm-level profit.

The analysis will rely on the assumption that competitor firms do not change their own product ranges in response to a product switch for the focal brand. This assumption is made more reasonable

[21] This is only one of many ways to define an alternative product range. The counterfactual design here involves making only one substitution at a time. Alternative specifications could switch pairs of products in and out, or make larger changes to the observed product range.

by the fact that the changes in product characteristics under each substitution are small. The counterfactual design outlined in the following subsection also takes any constraints imposed by the local retail environment into account since the number of products and approximate shelf space requirements are held constant for each brand under each substitution.[22]

5.2 Counterfactual design

Several intermediate steps are required to establish whether expression (7) holds for each observed product range $J_{b,c}$ and the alternative product ranges $A_{b,c}$ using the available data. Each step is outlined here:

First, a new product range means the consumer choice set contains a different set of product characteristics. Using the demand system estimated in Section 4, the quantity demanded of each product can be predicted and then summed over all brand products in the alternative portfolio for any given vector of product prices. The demand system contains a brand-format-size deviation from mean product demand specific to that period that is observed by the firm and not by the researcher, denoted $\Delta\xi_{j,c}$ in equation (5). When estimating demand under each alternative product range, it is assumed that the unobserved product shock is specific to the brand and format and not the pack size, so that $\Delta\xi_{j,c} = \Delta\xi_{j',c}$. This assumption is reasonable if demand shocks reflect local advertising campaigns, which are rarely specific to a product pack size and are more often tied to the product characteristics of the brand and format. The analysis does not require any assumption to be made about the relative magnitudes of unobserved product shocks for the same product sold in two different countries.

The validity of the assumption that $\Delta\xi_{j,c} = \Delta\xi_{j',c}$ is likely to have a limited effect on the findings since the estimated $\Delta\xi_{j,c}$ for products that are sold in each market are very small. Moving from the 10th to the 90th percentile of the distribution of $\Delta\xi_{j,c}$ in each country, across all products and time periods, leads to an increase in utility that is equivalent to a change in pack size of no more than one thousandth of a washload in each country. Moreover, regressing these error terms on a full set of brand-time period and format-time period indicator variables explains 33% of the variation

[22] One additional assumption required is that firms entail no switching costs in making each substitution. Looking back at the data for the entire three year period, it can be seen that firms often switch products over time within each market. The single product substitutions simulated here constitute relatively small changes in product range when compared to the usual changes between two adjacent eight week periods in the data.

in $\Delta\xi_{j,c}$ in the UK, 27% in Germany, 32% in Italy, and 20% in Spain. That is, the error terms are indeed relatively similar for products of the same brand and format in any time period.

Second, a change in product range may lead division managers to alter product-level prices. Nonetheless, the prices currently observed remain within the firm's choice set.[23] Holding competitor prices constant, the firm conducting the switch can generate brand revenues that are at least as high with newly optimized prices as it can with the current product level prices, with product $j\prime$ being priced at the same per-washload price as the product taken out, j. This implies that:

$$\sum_{j\in A_{b,c}} p^*_{j,c}q_{j,c} - \sum_{j\in J_{b,c}} p_{j,c}q_{j,c} \geq \sum_{j\in A_{b,c}} \widetilde{p}_{j,c}q_{j,c} - \sum_{j\in J_{b,c}} p_{j,c}q_{j,c}$$

where $p^*_{j,c}$ denotes the the new optimal price for each product j in the alternative product range and $\widetilde{p}_{j,c}$ is the price currently observed for product j. For expression (7) to hold, it is thus sufficient that the following condition holds:

$$\sum_{j\in A_{b,c}} \widetilde{p}_{j,c}q_{j,c} - \sum_{j\in J_{b,c}} p_{j,c}q_{j,c} \geq \sum_{j\in A_{b,c}} mc_{j,c}q_{j,c} - \sum_{j\in J_{b,c}} mc_{j,c}q_{j,c} - F_j \tag{8}$$

Third, turning to the cost side, the product-level fixed cost of the standardized product $j\prime$ does not appear in expression (8) since it is a sunk cost. The product-level fixed cost F_j of the local product j does appear and is unobserved. However, for any positive fixed cost, expression (8) will hold whenever:

$$\sum_{j\in A_{b,c}} \widetilde{p}_{j,c}q_{j,c} - \sum_{j\in J_{b,c}} p_{j,c}q_{j,c} \geq \sum_{j\in A_{b,c}} mc_{j,c}q_{j,c} - \sum_{j\in J_{b,c}} mc_{j,c}q_{j,c} \tag{9}$$

By looking for counterfactuals in which inequality (8) is satisfied in the absence of any product level fixed cost, it is certain that the inequality will hold in the presence of a positive fixed cost for product j. The two intermediate steps between expressions (7) and (9) have made it more difficult to establish that expression (7) holds for any given alternative product range.

Finally, rather that deriving estimates of product-level marginal costs, it is assumed here that the average marginal cost for the demand in the old and new portfolios are the same. There are

[23] Since price-setting is decentralized and division-managers observe transfer prices rather than marginal costs when setting price, using observed prices to estimate marginal costs is problematic in this setting. It would require assuming prices are set to mazimize firm profits in order to analyze whether or not product range choices are profit maximizing under similarly decentralized decision-making.

two possible objections to this assumption. First, the product coming into the market may have a different marginal cost than the product going out. This presents a concern for the test design only if the new product's actual marginal cost is higher than the marginal cost of the product leaving the market since this would lead to the overestimation of variable profits under the alternative product range. The two products are, however, manufactured in the same production facility and identically produced in each case right up to the point where they are packaged in different sized containers. It seems likely that the washload-level marginal costs of these products will be similar. The second reason is that the reallocation of consumer demand across products in the new product range may shift demand towards higher or lower marginal cost products. Under the counterfactual design used, though, the product substitutions are close enough that the reallocation of demand among other brand products prompted by the substitution is small. For example, in the UK, each product substitution changes the quantity demanded of each other product by a maximum of 5% and most of the changes are less than 1%.[24]

If it is assumed that average marginal cost is equal for each pair of product range choices, then inequality (9) can be rewritten as:

$$\sum_{j \in A_{b,c}} \widetilde{p}_{j,c} q_{j,c} - \sum_{j \in J_{b,c}} p_{j,c} q_{j,c} \geq mc \left(\sum_{j \in A_{b,c}} q_{j,c} - \sum_{j \in J_{b,c}} q_{j,c} \right) \tag{10}$$

In sum, expression (7) will hold whenever expression (10) holds, under the assumptions that average marginal costs are the same for $J_{b,c}$ and $A_{b,c}$ and that the unobserved shock to demand for product j is equal to the unobserved demand shock for product j' in country c.

5.3 Implementation in the data

If revenues increase and quantities fall under the new product range, it is clear that the left hand side of condition (10) is positive and the right hand side is negative, meaning condition (10) is satisfied. If, on the other hand, quantities increase under the new product range, rearranging condition (10)

[24]Thomas (2006) overlooks the implications of intra-firm transfer pricing and uses observed prices and the demand system to back out estimates of marginal costs for each product. While these are more correctly termed estimates of the transfer prices seen by the local division manager, these product level cost estimates are relatively similar across countries for the same product when it is sold in more than one country. This offers some support for the assumption that product-level marginal costs are not significantly different for similar products.

shows that it is satisfied whenever the change in total revenue divided by the change in quantity exceeds marginal cost. Although marginal costs are unobserved, it is reasonable to assume in this differentiated products industry that the observed average price exceeds average marginal cost for the brand in country c in each time period. In this case, the change in total revenue when moving to the alternative product range divided by the change in quantity will exceed marginal cost whenever it exceeds the currently observed average price. Hence, if quantities rise under the alternative product range $A_{b,c}$ then expression (10) is satisfied whenever $\frac{\Delta TR}{\Delta Q} \geq \overline{p}_{J_{b,c}}$, where $\overline{p}_{J_{b,c}}$ is the average price for the brand with the current product range $J_{b,c}$.

The final step in the counterfactual exercise is to take the alternative product ranges under which condition (10) cannot be rejected and ask, in each case, whether the firm can stop making the product removed from the relevant market altogether. This is assumed to be possible if the products switched out of country c do not appear on sale in any of the other countries in the data set. When a product is no longer present in the data set overall, the firm can cease production of the product. Since this test was conducted setting the fixed cost of product j to zero, if the removed product incurred any positive fixed cost of production, $F_j > 0$, the firm is made strictly better off by making the substitution to increase the degree of standardization across countries and reducing the total number of product varieties manufactured in the region, since it no longer incurs these per-period fixed costs.

Table 4 contains the total revenue, quantity and average price currently observed for each brand in each market. The mean, median, standard deviation, and 95% confidence interval constructed are given in the last four columns of the table.[25,26] Confidence intervals for each estimate were found using a Cholesky decomposition of the variance-covariance matrix for the demand system estimated in Section 4. 1000 draws were taken from the joint distribution of the $\boldsymbol{\theta}_1$ and $\boldsymbol{\theta}_2$ parameter estimates pertaining to pack size and format in the relevant market and the brand revenues, quantities and average price were found for each draw.[27]

[25] The magnitude of the estimates given in Table 4 reflect the sample size of households in the product level data rather than the total number of households in each country, but could be scaled up appropriately without changing the results.

[26] The confidence intervals estimated for the Ariel brand revenues, quantities, and average price in Germany are relatively large. This makes it difficult to infer anything about changes in these estimates under any alternative portfolio.

[27] An alternative estimate of the confidence intervals for each estimate would be to draw from a parametric bootstrap based on the distribution of all estimated parameters, including those associated with product characteristics that do not vary with the product substitution such as brand and price. This generates larger confidence intervals. Hence,

5.4 Results

The products substituted out of each market c and the products brought in are described in Table 5 (panel A for Surf and panel B for Ariel), noting that some products were switched out of the market in more than one counterfactual. Each substitution is done in turn, with replacement, and the new market demand estimated using the framework described in Section 4. For each substitution, standard errors and confidence intervals were computed around the new revenue, quantity, and average price estimates as described in the previous subsection. Columns 3 and 4 of each panel show the changes in pack size associated with each substitution. To qualify as a product to be switched into market c, the product had to be absent from market c and differ only slightly from a product being sold in market c. In cases where a product is a format sold only in one of the four countries, for example, liquid soap marsiglia in Italy and gels and pastes in Germany, no counterfactual substitutions were made. Tables 5 and 6 show that for each brand in each country, product substitutions involved both increases and decreases in pack size.

The simulated effects of the product substitutions are summarized in Table 6 (and shown in more detail in Appendix Table 6). Starting with Surf in the UK, the total number of washloads of Surf product sold with each new product range increases slightly in some cases and decreases slightly in some cases. In cases where quantities fall, revenues also tend to fall although, again, not significantly. When quantities rise, the change in total revenues over the change in quantity increases in the case of 3 of the 11 products, although the change in average price is not significant in any case. Condition (10) cannot be rejected for any of the alternative product ranges. This analysis suggests that there are substitutions which allow the firm to remove Surf products from the UK market. The last column in panel A of Table 5 indicates whether a switch satisfying expression (10) means that the product j is no longer present in any market. This is the case for the 31 and 52 washload packs of standard powder and for the 11 and 36 washload packs of tablets. If these products were no longer sold in the UK, Unilever would cease to manufacture them, thereby saving the product-level fixed costs, and be strictly better off. Further analysis reveals that Unilever could remove all four of these products simultaneously and replace them with existing alternative products without significantly reducing variable profits. This implies Unilever is manufacturing too

the conclusions derived under the confidence intervals described here – that product substitutions do not significantly decrease variable profit – will continue to hold with the alternative approach.

many varieties of Surf detergent to sell in the UK market.

Table 6 reveals that substitutions of Surf products in Italy also satisfy condition (10). Of the 10 Surf products switched out of the Italian market in turn, the last column of panel A in Table 5 shows that 3 are now redundant in that they do not appear elsewhere in the data set. The products that can profitably, and simultaneously, removed from the Italian market are the 5 washload pack of standard powder, the 60 washload pack of standard powder, and the 26 washload pack of tablets. There were 8 substitutions conducted for Surf in Spain for the 5 products marketed under this brand at this time. Once more, condition (10) cannot be rejected for each substitution in that none of the switches led to significant changes in variable brand profit. Of the 5 products taken out in turn, one does not appear elsewhere in the data set. This is the 37 washload pack of tablets. These findings suggest that Unilever is also manufacturing too many varieties of Surf detergent to sell in Italy and Spain.

A similar finding emerges for the P&G brand Ariel in the UK, Italy, and Spain. As shown in panel B of Table 5, 7 Ariel products currently on sale in the UK are switched out of the market in at least one product substitution. For each of these switches, the alternative product range does not lead to significant changes in brand quantities, revenues, or average prices. Table 5 indicates that 2 of the 7 products, once removed from the UK market, are no longer present in the data set. The firm can stop manufacturing the 52 washload pack of Ariel standard powder and the 48 washload pack of Ariel tablets, simultaneously replacing these products in the UK market with other already existing products, and be strictly better off.

Relatively few Ariel products are sold in Italy, but close substitute products were found for all products other than the liquid soap marsiglia product. Of the 4 products for which substitutions were found that did not reject condition (10), two products were unique to the Italian market. These were the 12 washload pack of standard powder and the 44 washload pack of standard liquid. Of the 9 Ariel products switched out of Spain, 4 products were redundant in that they did not appear elsewhere. These were the 4 washload pack of standard powder, the 20 and 61 washload pack of standard liquid, and the 37 washload pack of tablets.

Turning to Ariel in Germany, the test design here cannot provide any evidence that the product range is too localized. Many German products are unique formats which are relatively highly valued in that market; for example, Table 2 shows that gel formats are significantly more valuable to the average German consumer than standard powder. This means that no close substitute product from elsewhere could be found to play the role of the alternative product $j\prime$. Substitutions are conducted for the two products where close substitutes could be found, the 15 and 22 washload packs of tablets. Since the estimates for Ariel revenues, quantities, and average prices were not precisely estimated in Table 4, asserting that product substitutions did not violate condition (10) does not permit inferences to be made about the relative merits of alternative product ranges. However, the two products switched out of the German market in these substitutions still appear in the data in other markets. The 15 washload pack of tablets is sold in Spain and the 22 washload pack of tablets is sold in the UK. Even if these products were removed from the German market, the firm would continue to manufacture them and incur the product-level fixed costs.

In sum, for each case other than Ariel in Germany, a subset of products are entirely absent in the data once they are removed from the relevant country-level product range. Of the 8 Surf products removed from each market in turn, 7 products can be eliminated from the region-level product range simultaneously. The 26 pack of Surf tablets removed from the Italian market was used as a substitute product for the 36 tablet pack in UK (which was in turn also used a substitute product in Spain), hence, we cannot conclude Unilever should cease production of the 36 pack in the UK at the same time as making other reductions in the overall product range. Similarly, for Ariel, of the 8 products that could be removed from each country in turn, a total of 6 could be simultaneously taken out of production. (We cannot infer that P&G could simultaneously remove a liquid product from both Italy and Spain, or a tablet product from both the UK and Spain.) The total number of distinct products for Surf and Ariel across the UK, Italy and Spain is 23 and 31, respectively, during this time period. Hence, the analysis suggests up to 30% of the total number of Surf product varieties and up to 20% of the total number of Ariel product varieties manufactured in the region could be removed without significantly reducing variable profits. Saving the fixed production costs on each, or any, of these products means each firm could be made strictly better off be choosing more standardized product ranges in the region.

5.5 Discussion

One potential objection to the inferences made in this analysis is that the model of consumer demand in each country is not estimated precisely enough to reject condition (10) under any product substitution.[28] To address this concern, product substitutions were conducted switching in products sold elsewhere that were not close substitutes for the products leaving the market. Despite the fact that pair-level switches involve only small changes to the overall product range in each country, switching in a very different product did lead to significant changes in brand revenues, quantities, and average prices that meant condition (10) was rejected in some cases.[29] Another set of counterfactuals was constructed where the entire product range of each brand in each country was replaced with the entire brand product range for another country at the prices set in the source country. Under these counterfactuals, the model produced estimates of revenues, quantities, and average prices that were more than two standard errors away from the estimates under the observed product ranges.[30] This provides some reassurance that other than for the Ariel brand in Germany, the demand system estimated in Section 4 captures local tastes and preferences sufficiently well to assess the impact of the constructed counterfactuals on product-level demand.

Putting to one side the assumed structure of preferences modeled in the paper, another possible concern is that a local brand manager does not choose a standardized pack size since this product

[28] The results in the paper rest on the credibility of the estimated demand system. Although the counterfactual analysis involves only marginal changes in the product range available in any one country, the assessment of change in revenues, quantities and average prices with each alternative product range depends on how well the demand system measures consumer reaction to this change. In addition, the demand system does not permit an evaluation of how consumers in each country would react to a major market innovation, such as a new brand or a new format introduction.

[29] For example in the UK, Surf revenues, quantities, and average price with the observed product range are: 14,340 euros, 90,621 washloads, and 0.1582 euros respectively. Using the standard errors given in Table 4, two standard errors on either side of these point estimates give the intervals (12,175-16,505), (72312-108,931), and (0.147-0.169). A substitution which takes out the 36 washload pack of tablets and introduces a 5 washload pack of standard powder gives the following point estimates, with two standard errors on either side given in parentheses: 8312 (6769-9856), 44068 (35955-52181), and 0.189 (0.1845-0.194). This product substitution leads to confidence intervals that do not overlap with the original intervals. Revenues and quantities both fall and the average price rises, meaning that condition (10) does not hold for this substitution.

[30] For example, replacing the UK's Ariel product range with the Ariel product range in Germany, and assuming that UK customers value gel and paste formats in the same way they value capsules, leads to estimates of revenues and quantities sold in the UK that are significantly lower than the estimates revenues and quantities with the current UK product range. Intervals constructed around each point estimate based on two standard errors either side are non-overlapping for revenues and quantities. The average price is not significantly different. Condition (10) does not hold for this alternative product range. In another example, replacing the Ariel product range in Italy with the product range from the UK leads to significantly higher revenues, quantities, and average prices in Italy. However, in this case the number of Ariel products on sale in Italy increases from 5 to 21. Although condition (10) holds here, this substitution would entail a large reconfiguration of retail space, and possibly other unobserved costs.

substitution would entail marketing a product which would either compete directly with a competitor brand or leave the brand without a pack in a very popular size. The set of substitutions for each brand in each country include some that remove a pack size where there is little competition and some that introduce a pack size where there is direct competition, and vice versa. Both cases generate non-decreasing variable profit substitutions. The pack sizes introduced have all been recently present in the relevant country; it is hence unlikely that specific retailer preferences or competitor activities explain the exact composition of the pack sizes currently offered.

If there were variation in organizational form among firms in this industry, it would be possible to examine whether the observed relative coordination and adaptation losses did indeed differ with the choice of organizational form. All of the firms, though, tend to be broadly similar in that they decentralize product range choice to the country level. The two firms studied in this paper do differ in their corporate histories in the region. P&G is widely recognized as a more regionalized firm, having originally entered Europe with a region-level strategy and having a longer history of centralization of certain functions such as R&D. In contrast, Unilever has expanded mostly through acquisition and is regarded as more localized. These corporate legacies suggest there might be cross-firm differences in the extent of cross-country coordination. While the counterfactuals conducted are not exhaustive, in that an alternative product range was constructed only if a very similar product could be found elsewhere, the findings do reveal some interesting cross-brand differences in excessive localization in each country. For example, in the UK, the analysis suggests that one third of local Surf products, 4 out of 12, could be profitably replaced while only 10% of Ariel products, 2 out of 21, are redundant if profitable substitutions are made. In Italy and Spain, the relative magnitude of the within-brand product redundancy is reversed. 40% of Ariel products in Italy and 31% of Ariel products in Spain can be replaced, while only 25% and 20% of Surf products can be replaced in Italy and Spain, respectively. Overall, the Surf brand appears to be particularly localized in that a larger share of the total number of product varieties manufactured in the region could be profitably eliminated.

6 Conclusion

The analysis in this paper provides evidence that decentralization results in a lack of coordination across divisions.[31] Within the same detergent brand, firms manufacture product varieties that are sold in only a subset of markets, and in many cases, in just one national market. This paper attributes product-range variation in excess of the optimal variation given estimated local conditions to the firm's organizational form.

Caves (1996) points out that horizontal MNCs – firms selling similar products in different markets – face significant challenges in organizing production, distribution, and marketing across countries. The choice of which product varieties to sell in each market is one important decision for the firm. Differing local conditions determine the relative value of being multinational. If all countries required entirely different products, there would be no advantage of economies of scale in production. A multinational firm in such an environment might effectively operate as a collection of independent national subsidiaries. At the other extreme, if all consumers had identical tastes across countries and competitors and retailers also behaved identically, there would be no incentive for local adaptation and no particular decision-making role for local division managers. The environment faced by the two firms studied here falls somewhere between these two extremes and the organizational challenges this setting presents are fairly generalizable to horizontal multinationals in other industries.

To test the prediction of excessive product range localization, it was first necessary to allow for diverse local conditions. Most existing empirical studies about horizontal multinational firms treat consumers as identical across countries. This assumption greatly increases the tractability of these complex models but also removes the key motivation for decentralization, a widely observed characteristic of these firms. In this paper, product-level data about the detergents industry allows variation in local conditions to be parameterized using a discrete choice random coefficients demand model. Consumer preferences for detergent characteristics are found to vary significantly across national markets. It is also likely that the interaction between detergent manufacturers and retailers

[31] The theory models which make this prediction demonstrate how decentralization may, nonetheless, be the preferred organizational form since centralization would incur losses from a lack of adaptation that would harm firm profits to a greater extent. The case of Jacobs Suchard described in Dessein *et al.* (2010) provides one example in which an attempt to centralize decision-making to achieve greater coordination incurred costs associated with low quality communication in a situation that appears fairly analogous to the detergents industry setting described here.

differs across countries. To relate the firm's organizational problem to models of the trade-off between coordination and adaptation, it is necessary that local conditions are potentially different across divisions and centrally unobservable.[32] Decentralized decision-making is the observed organizational form, and it seems reasonable in this industry to assume that local brand-country managers learn or gather information about the precise, time-specific, local conditions.

Some tailoring of product range would hence appear to be optimal, but to what extent – and how can firms figure this out? When information about local conditions is distributed among division managers, theory predicts that agency costs will arise. The second part of the analysis in this paper finds empirical evidence consistent with agency in product-range choice due to the decentralization of this decision in the UK, Italy, and Spain for the P&G brand Ariel and the Unilever brand Surf. Controlling for variation in local demand conditions and in the local retail environment, the product ranges marketed for the two brands are too localized. By making small increases in the degree of product range standardization across countries, both firms could reduce the total number of products being manufactured and increase firm-level profits. The results suggest that each firm is manufacturing too many products overall. The empirical findings suggest that multinational firms in consumer goods industries operate at a constrained optimal outcome given the inherent challenges of organizing firm production across markets with diverse local conditions. The results hence demonstrate that firm structure affects product range choice and firm performance.

[32] In the model presented in Alonso *et al.*, (2008), the two divisions' local conditions are equal in expectation since they are both drawn from mean-zero uniform distributions.

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Table 1: Summary of MNC activities in each country

Source: Europanel data set.

	UK	Germany	Italy	Spain
Number of brands detailed in Europanel product-level data set	20	20	19	20
Of which: Number of MNC brands*	7	9	14	13
Of which: Number of international MNC brands**	3	2	4	5
Typical per period number of distinct products detailed in data set***	180	134	154	135
Of which: Number of MNC products	89	72	120	92
Of which: Number of MNC products for international brands	66	42	21	20
Of which: Number of international brands products also on sale elsewhere	14	4	17	20

** Brands manufactured and sold by P&G, Unilever, Henkel and Reckitt Benckiser.*
*** Brands sold in at least one other country in data set*
**** A product is a particular brand, format and pack size combination.*

Table 2: A Subset of Estimated Theta 1 Coefficients, Full Model with Instruments

These estimated brand (format) coefficients can be interpreted as the additional utility the average household obtains by using this particular detergent brand (format) for one washload of laundry rather than one of their country's private label brands (standard powder).
The last three variables are the estimated coefficient associated with pack size (number of washloads), price per washload (euros), and each country's private label brands (the constant term).
The second row contains the standard error estimate for the coefficient given above.
**** indicates the coefficient is significant at the 1% level, ** the 5% level, and * the 10% level.*

Variable	UK	Germany	Italy	Spain
Unilever, Surf*	1.09 ***		0.40 ***	0.19
	(0.17)		(0.11)	(0.23)
P&G, Ariel	2.07 ***	0.71 ***	0.13	1.45 ***
	(0.27)	(0.19)	(0.16)	(0.22)
Liquid	1.11 ***	1.04 ***	0.43 ***	0.00
	(0.26)	(0.12)	(0.09)	(0.11)
Tablet	2.40 ***	1.12 ***	-0.07 ***	0.59 ***
	(0.41)	(0.17)	(0.21)	(0.23)
Capsule	3.14 ***			-0.60 **
	(0.51)			(0.27)
Gels/Other		0.69 ***		
		(0.19)		
Liquid Soap Marsiglia			0.63 ***	
			(0.15)	
Concentrated	-1.37 ***	-0.45 ***	-1.20 ***	-2.44 ***
	(0.31)	(0.13)	(0.25)	(0.39)
Pack Size Coefficient	-0.02 *	0.01	-0.01	0.01 ***
	(0.01)	(0.01)	(0.01)	(0.00)
Price Coefficient	-23.66 ***	-30.21 ***	-19.17 ***	-28.10 ***
	(5.06)	(5.60)	(5.27)	(6.42)
Constant Term Coefficient	1.14	-2.07 **	-1.84	-1.81 **
	(1.70)	(1.04)	(1.13)	(0.74)

**Known as Bio-Presto Surf in Italy*

Table 3: Wald Test Statistics of Differences in Coefficient Estimates Across Countries

	Cross Country Differences					
	UK-Germany	UK-Italy	UK-Spain	Germany-Italy	Germany-Spain	Italy-Spain
Ariel	33.83	51.28	9.41	6.62	13.92	31.32
Surf	-	12.89	11.63	-	-	1.05
Liquid	0.12	5.63	28.90	15.40	57.26	7.01
Tablet	12.25	23.80	40.25	15.40	6.24	3.61
Concentrated format	13.82	0.53	12.86	12.68	34.84	15.78
Pack size	24.32	4.80	12.84	13.93	0.47	17.48
Price	6.14	4.33	3.36	16.43	0.94	19.23
Constant term	17.81	16.51	7.52	0.47	0.26	0.00

Evaluated against an F distribution, where the critical values for F(1,1000) are:

10%	*2.71*
5%	*3.85*
2.50%	*5.04*
1%	*6.66*

Table 4: Revenues, quantities, and average prices for each brand-country under the current product range

This table presents estimates of the brand-country market outcomes under the product range observed in the market
The estimates reflect the sample size of households in the product-level data rather than the total size of the country,
but could be scaled up to the country level.

		Actual	Mean	Median	Std Error	Size of Confidence Interval
Surf in the UK	Revenues, Euros	14,340	13,812	13,908	1,083	3,500
	Quantities, number of washloads	90,621	87,165	88,397	9,155	29,240
	Average price per washload, Euros	0.16	0.16	0.16	0.01	0.02
Surf in Italy	Revenues, Euros	7,275	7,321	7,277	728	2,365
	Quantities, number of washloads	55,106	55,720	55,262	10,168	33,203
	Average price per washload, Euros	0.13	0.13	0.13	0.01	0.04
Surf in Spain	Revenues, Euros	1,108	1,030	1,045	104	350
	Quantities, number of washloads	6,477	6,001	6,084	611	2,072
	Average price per washload, Euros	0.17	0.17	0.17	0.00	0.01
Ariel in the UK	Revenues, Euros	23,041	23,721	23,073	2,089	5,313
	Quantities, number of washloads	95,693	101,315	96,136	16,702	46,015
	Average price per washload, Euros	0.24	0.24	0.24	0.02	0.05
Ariel in Italy	Revenues, Euros	2,355	2,246	2,340	410	1,312
	Quantities, number of washloads	14,536	13,734	14,295	2,386	7,835
	Average price per washload, Euros	0.16	0.16	0.16	0.00	0.02
Ariel in Spain	Revenues, Euros	9,109	9,888	9,236	2,343	6,977
	Quantities, number of washloads	52,845	61,343	53,695	22,706	64,619
	Average price per washload, Euros	0.17	0.17	0.17	0.01	0.05
Ariel in Germany	Revenues, Euros	8,952	11,007	8,880	6,759	21,066
	Quantities, number of washloads	90,405	137,806	89,823	122,487	368,235
	Average price per washload, Euros	0.10	0.10	0.10	0.03	0.08

Table 5: Products to be introduced to each market, and the products they replace

The final column notes whether the product taken out is still present in another market.
If not, the firm can reduce manufacturing costs by no longer manufacturing this product.

Panel A: Surf Products

Country	Format	Pack size taken out	Pack size put in	Source country	Product appears in another country
UK	Standard Powder	9	5	Italy	Y
	Standard Powder	12	8	Spain	Y
	Standard Powder	15	23	Italy	Y
	Standard Powder	31	20	Spain	Y
	Standard Powder	31	41	Spain	N
	Standard Powder	46	33	Italy	Y
	Standard Powder	52	60	Italy	N
	Tablets	11	16	Italy	N
	Tablets	11	18	Spain	N
	Tablets	22	37	Spain	Y
	Tablets	36	26	Italy	N
Italy	Standard Powder	5	9	UK	N
	Standard Powder	5	8	Spain	Y
	Standard Powder	12	15	UK	Y
	Standard Powder	23	31	UK	Y
	Standard Powder	23	41	Spain	Y
	Standard Powder	60	52	UK	N
	Tablets	16	14	UK	Y
	Tablets	16	11	UK	Y
	Tablets	26	22	UK	N
	Tablets	26	37	Spain	Y
Spain	Standard Powder	8	12	UK	Y
	Standard Powder	8	5	Italy	Y
	Standard Powder	20	31	UK	Y
	Standard Powder	41	23	Italy	Y
	Standard Powder	41	60	Italy	Y
	Tablets	18	11	UK	Y
	Tablets	18	26	Italy	Y
	Tablets	37	36	UK	N

Panel B: Ariel Products

Country	Format	Pack size taken out	Pack size put in	Source country	Product appears in another country
UK	Standard Powder	9	5	Italy	Y
	Standard Powder	9	4	Spain	Y
	Concentrated Powder	52	112	Spain	Y
	Standard Powder	52	78	Spain	N
	Standard Liquid	12	44	Italy	Y
	Standard Liquid	12	20	Spain	Y
	Concentrated Liquid	30	35	Germany	Y
	Concentrated Liquid	76	58	Germany	Y
	Tablets	17	15	Germany	Y
	Tablets	48	37	Spain	N
Italy	Standard Powder	5	9	UK	Y
	Standard Powder	12	16	UK	N
	Standard Powder	12	8	Spain	N
	Standard Liquid	12	9	UK	Y
	Standard Liquid	12	20	Spain	Y
	Standard Liquid	44	61	Spain	N
Spain	Standard Powder	4	5	Italy	N
	Standard Powder	8	12	UK	Y
	Standard Powder	8	12	Italy	Y
	Standard Powder	20	31	UK	Y
	Standard Powder	41	24	UK	Y
	Standard Liquid	11	9	UK	Y
	Standard Liquid	20	12	UK	N
	Standard Liquid	20	12	Italy	N
	Standard Liquid	61	44	Italy	N
	Tablets	18	11	UK	Y
	Tablets	37	48	UK	N
	Tablets	37	22	Germany	N
Germany	Tablets	15	11	UK	N
	Tablets	22	17	UK	N
	Tablets	22	48	UK	N
	Tablets	22	37	Spain	N

Table 6: Summary of changes in revenues, quantities, and average prices by brand and country under alternative product ranges

For each brand in each country, this table summarizes the number of alternative product ranges which lead to increases in revenues, quantities and average prices in a typical eight-week period
More details of the results of the substitutions are given in appendix table 5.

	Surf in UK	Surf in Italy	Surf in Spain	Ariel in UK	Ariel in Spain	Ariel in Italy	Ariel in Germany
Number of products in current product range	12	12	5	21	13	5	13
Number of individual product-level substitutions made	11	10	8	10	12	6	6
Fraction of substitutions where pack size increases	0.55	0.60	0.50	0.50	0.42	0.67	0.50
Number of substitutions where revenues increase	5	4	4	5	5	3	3
Number of substitutions where quantities increase	5	4	2	5	5	2	3
Number of substitutions where average price increases	4	3	3	7	8	2	3
Number of substitutions where revenues increase and quantities fall	0	0	0	0	0	0	0
Number of substitutions where quantities increase and the ratio of the change in revenues and the change in quantities exceeds currrent average price	3	3	2	4	5	2	3
Number of substitutions where alternative does not generate significantly lower variable profit where alternative does not make sig less var profit. That is, condition 11 is not violated.	11	10	8	10	12	6	6

NOT INTENDED FOR PUBLICATION

Appendix 1: Agency in product range choice with different transfer pricing methods

When the change in brand-country revenues from including product $\bar{j}$ rather than j' falls between the right and left hand side of inequality (4) then the local manager will choose to include product $\bar{j}$ when the firm would rather he included product j'. This inequality is:

$$F_{\bar{j}} + \sum_{j \in J_{b,c}} mc_j q_{j,c} - \sum_{j \in A_{b,c}} mc_j q_{j,c} > \sum_{j \in J_{b,c}} k_{j,c} q_{j,c} - \sum_{j \in A_{b,c}} k_{j,c} q_{j,c}$$

Zimmerman (1995) notes that the two most frequently observed transfer pricing methods are market price transfer pricing and full cost transfer pricing. Under the first of these, the transfer price observed by the local manager is the marginal cost plus a markup over marginal cost which reflects the price elasticity of demand of the product in an external market. This markup will be denoted η_j and substituted into the above expression. In this case, inequality (4) can be written:

$$\begin{aligned} F_{\bar{j}} + \sum_{j \in J_{b,c}} mc_j q_{j,c} - \sum_{j \in A_{b,c}} mc_j q_{j,c} &> \sum_{j \in J_{b,t,c}} \left(mc_j q_{j,c} + \eta_j q_{j,c} \right) - \sum_{j \in A_{b,c}} \left(mc_j q_{j,c} + \eta_j q_{j,c} \right) \\ F_{\bar{j}} &> \sum_{j \in J_{b,t,c}} \eta_j q_{j,c} - \sum_{j \in A_{b,c}} \eta_j q_{j,c} \qquad (11) \end{aligned}$$

There is potential for suboptimality in product range choice if the fixed cost of production of the local product is higher than the difference in the value of the average markup over marginal cost multiplied by the quantities sold in each case. Since the products in question are very close substitutes, it seems likely that the average value of the markup $\eta_{j,t}$ will be similar in each case. It also seems likely that the total number of units sold under the more standardized product range will be smaller than under the more tailored product range. For a constant η_j and a lower quantity sold under standardized product range, the right hand side of inequality (11) will be positive. The value of the right hand side is increasing in η_j which represents the extent of market power in the external market. For any positive fixed cost there is a range over which inequality (11) will hold, creating the possibility of suboptimal local product ranges, but this range is decreasing in the magnitude of η_j. The more competitive the external market, the smaller is η_j, and the greater the range of revenue differences over which suboptimal choices will be made.[33]

Full cost transfer pricing presents a slightly more interesting case. Under the most straightforward version of this method, the fixed cost of the product is incorporated into the transfer price so that:

$$k_{j,c} = mc_j + \frac{F_j}{\sum_c q_{j,c}}$$

noting that the share of fixed cost allocated into the per unit transfer price is a function of the total quantity of the product produced. Substituting this expression into inequality (4) gives:

$$\begin{aligned} F_{\bar{j}} + \sum_{j \in J_{b,c}} mc_j q_{j,c} - \sum_{j \in A_{b,c}} mc_j q_{j,c} &> \sum_{j \in J_{b,t,c}} \left(mc_j q_{j,c} + \frac{F_j q_{j,c}}{\sum_c q_{j,c}} \right) - \sum_{j \in A_{b,c}} \left(mc_j q_{j,c} + \frac{F_j q_{j,c}}{\sum_c q_{j,c}} \right) \\ F_{\bar{j}} &> \sum_{j \in J_{b,c}} \frac{F_j q_{j,c}}{\sum_c q_{j,c}} - \sum_{j \in A_{b,c}} \frac{F_j q_{j,c}}{\sum_c q_{j,c}} \qquad (12) \end{aligned}$$

Since under the localized product range, country c is the only market in which product $\bar{j}$ is sold, inequality (12) can be written:

$$\begin{aligned} F_{\bar{j}} &> \frac{F_{\bar{j}} q_{j,c}}{q_{j,c}} + \sum_{j \neq \bar{j} \in J_{b,c}} \frac{F_j q_{j,c}}{\sum_c q_{j,c}} - \sum_{j \in A_{b,c}} \frac{F_j q_{j,c}}{\sum_c q_{j,c}} \\ 0 &> \sum_{j \neq \bar{j} \in J_{b,c}} \frac{F_j q_{j,c}}{\sum_c q_{j,c}} - \sum_{j \in A_{b,c}} \frac{F_j q_{j,c}}{\sum_c q_{j,c}} \\ \sum_{j \in A_{b,c}} \frac{F_j q_{j,c}}{\sum_c q_{j,c}} &> \sum_{j \neq \bar{j} \in J_{b,c}} \frac{F_j q_{j,c}}{\sum_c q_{j,c}} \end{aligned}$$

The fixed cost of the local product is entirely borne by the local division in this case, so it cancels out from each side of the inequality. The right hand side of the inequality is the sum of the share of the fixed cost of each product in $J_{b,c}$ borne by the local division, excluding the fixed costs of $\bar{j}$. Expression (4) holds under full cost transfer pricing, then, if the total amount of fixed cost under the local portfolio without the fixed cost of the local product is less than the total fixed cost apportioned to country c under the standardized portfolio. Since the right hand side of the last inequality above

[33] The smaller is η_j, however, the smaller the distortion in price away from optimal price for any given product range choice (Thomas, 2008).

is summed over a smaller number of products, it is quite plausible that the inequality is satisfied.

The entire fixed cost of the local product is passed on to the country level under this transfer pricing scheme. Nonetheless, it is still possible that the additional revenue from marketing the tailored portfolio lies between the two sides of inequality (4), meaning the local manager will suboptimally choose the tailored rather than the standardized product range. That is, there is still a source of inefficiency from the point of view of the firm: this arises because the brand-country manager in country c still does not see the marginal cost for the standardized product, but rather makes his choice based on a transfer price that includes some fraction of the fixed cost of production for that product.

One interesting side note is that under this transfer pricing method, the agency issue around the choice of product range interacts with the pricing distortion arising from decentralization described in Thomas (2008). The brand country manager does not take into account the fact that by choosing the standardized product $j\prime$ he bears a lower per unit fixed cost himself and also generates a lower per unit fixed cost for the other divisions where product $j\prime$ is sold. This affects the extent to which product $j\prime$'s price in other markets is distorted from the firm-level optimal price. Hence there is an interaction between suboptimality of product range choice across divisions and the resulting final product pricing distortions.

This discussion prompts the question of whether the firm can design a transfer pricing mechanism which leads the brand-country managers to select the optimal product range. One possibility would be a transfer pricing scheme that differs when the product is tailored to one market. The firm could use full cost transfer pricing in this case, and use marginal cost transfer pricing whenever the product is sold in more than one country. This may, of course, create additional problems for product range innovation since there is a cost to being the first country to market a product. None of the practitioner literature on transfer pricing provides any suggestion that this sort of method is widely used. Zimmerman (1995) comments that transfer prices are sometimes negotiated between divisions, but does not suggest this takes place in order to mitigate the agency problem outlined here.

Appendix 2: Demand Estimation Detail

Outline of the estimation procedure

The model of consumer behavior outlined in Section 4 is constructed based on the assumption that each household chooses the detergent product that provides it with the highest utility given the range of products available and the characteristics of all of the available products. Each household buys one product in each period; the outside option is purchasing a domestic own-label brand.[34] The product range reflects both the local retail environment and the decisions made by all firms competing in the market. Household-level utility is allowed to vary due to unobserved household-level relative preferences for several detergent characteristics: brand, format, pack size and price. The specification allows for heterogeneity of consumer preferences for brands, formats, pack size and price across each country, and for preference heterogeneity for pack size and price sensitivity to vary by household within each country. The demand estimation procedure follows Berry, Levinsohn, and Pakes (1995) (BLP). This section provides a brief outline and highlights the main points of difference.

First, predicted market shares for each product are derived as a function of $\boldsymbol{\theta}_1$ and $\boldsymbol{\theta}_2$. The market share of each product is then written, using the distribution properties of $\epsilon_{i,j,t,c}$, as a function of product characteristics, unobserved household attributes, and given values of $\boldsymbol{\theta}_1$ and $\boldsymbol{\theta}_2$. The dimensional vector of mean values $\boldsymbol{\delta}$ that equates the predicted market shares to the observed market shares for a given $\boldsymbol{\theta}_2$ is then found. This involves using the contraction mapping suggested by BLP; the "inversion" which allows the model's linear parameters, $\boldsymbol{\theta}_1$ to be expressed in terms of the non-linear parameters, $\boldsymbol{\theta}_2$.

The second step involves using these mean values to construct moment conditions to estimate $\boldsymbol{\theta}_2$ and hence $\boldsymbol{\theta}_1$. The set of moments is based on the market level disturbances $\boldsymbol{\Delta\xi}$. This unobserved product level shock to mean demand is uncorrelated with all of the observed demand characteristics of each product in each market other than price, which is addressed using instruments. This is

[34] Nevo (2000) provides a summary of the role of the outside good in the model. In this context, the outside good excludes all local retailer own brand products that are top 20 brands since all household purchases in the category are included in the data and purchases from the top 20 brands are given at the product level. Retailer own brands in the top 20 are the brand omitted from the matrix of product characteristics. A household is likely to shop in only one or two retailers so they are unlikely to have access to all marketed own brands. For this reason, all own brands are aggregated under the implicit assumption that all households are able to choose from at least one of the supermarket own brands.

one advantage of including brand, format, and pack size indicator variables in the indirect utility function. In versions of the BLP model without brand or format dummies the demand shock may represent an unobserved product characteristic and not a deviation from mean product demand. By contrast, in this paper, none of the observed demand characteristics other than price are correlated with $\boldsymbol{\Delta\xi}$ since they do not vary over time.[35] The error term is $\boldsymbol{\Delta\xi} = \boldsymbol{\omega} = \boldsymbol{\delta} - \mathbf{X}\boldsymbol{\theta}_1$. Interacting this with the set of price instruments $\mathbf{Z}$ gives the moment conditions:

$$G(\boldsymbol{\theta}) = \left(\boldsymbol{\omega}(\theta)' \mathbf{Z}\mathbf{A}^{-1}\mathbf{Z}\boldsymbol{\omega}(\theta)\right)$$

where $\mathbf{A}$ is a weight matrix that is a consistent estimate of $E[\mathbf{Z}'\boldsymbol{\omega\omega}'\mathbf{Z}]$ and $E[G(\boldsymbol{\theta}_0)] = 0$. As in Nevo (2000), $\mathbf{Z\prime Z}$ is used as a weight matrix.

The third step in the process is to construct the GMM objective function from the moment conditions and search over the values of $\boldsymbol{\theta}_2$ to find estimates that minimize the objective function. Each of the moment conditions is assumed to uniquely equal zero at the truth, $\boldsymbol{\theta}_0$:

$$E[G(\boldsymbol{\theta}_0)] = 0$$

A Nelder-Mead (1965) non-derivative "simplex" search algorithm is then used to search over the values of $\boldsymbol{\theta}_2$ to find estimates that minimize the objective function, yielding:

$$\widehat{\theta} = \arg\min_{\theta \epsilon \Theta} G(\theta)' G(\theta)$$

Having estimated the coefficients of the model, the next step is to estimate standard errors. As in Petrin (2002), the asymptotic variance of the $\sqrt{n}\left(\widehat{\theta} - \theta\right)$ is given by

$$(\Gamma'\Gamma)^{-1} \Gamma V \Gamma (\Gamma'\Gamma)^{-1}$$

where $\Gamma = E\left[\frac{\partial G(\boldsymbol{\theta}_0)}{\partial \theta}\right]$ is the gradient of the moment conditions with respect to the parameters estimated at the true parameter values and $V = E\left[G(\boldsymbol{\theta}_0) G(\boldsymbol{\theta}_0)'\right]$. The standard errors reported

[35] Ackerberg and Crawford (2006) discuss conditions where the price coefficient can be consistently estimated when other product characteristics are endogenous. In the demand system here, all other product characteristics are exogenous to the unobserved time-specific demand shock by construction.

in Table 2 (and in the text regarding the standard errors for the estimated $\boldsymbol{\theta}_2$ coefficients) and Appendix Tables 1 to 3 use the consistent estimates $\Gamma\left(\widehat{\theta}\right)$ and $V\left(\widehat{\theta}\right)$ to estimate Γ and V.

The presence of a country-specific constant term in $\mathbf{X}_{j,t,c}$ allows the coefficients in $\delta_{j,t,c}$ to be interpreted as follows: the average consumer in country c obtains an extra $\beta_{b,c}$ in utility from using brand b for one washload of detergent relative to using a domestic own label brand of detergent, gains $\beta_{f,c}$ from using format f rather than standard powder, gains utility γ_c if that washload's worth of detergent comes from a pack which is one washload's worth larger in size, and gains α_c if the washload's worth of detergent is one euro more expensive. This last coefficient estimate is negative in each country, as expected. The random coefficients can be interpreted as follows: a household with an unobserved attribute of ν_1 gains an additional $\sigma_w \nu_1$ of utility from buying a pack that is one washload's worth larger in size. A household with an unobserved attribute of ν_2 gains an extra $\sigma_p \nu_2$ of utility from buying a pack that is one euro more expensive. $\epsilon_{i,j,t,c}$ is a mean zero stochastic term assumed to be distributed i.i.d. with a type 1 extreme value distribution.[36,37]

Appendix Table 5, panel A, presents the average own price and own size elasticities (following equation (6) in the text) for Ariel and Surf products in each country where they are sold and compares the estimates to the elasticities generated by an IV Logit specification where $\mu_{i,j,t,c}$ is equal to zero. The first row for each brand-country gives the number of products on sale. The following rows contain the average estimated own price and own size elasticity across products in that brand, and then the associated product-level standard deviation in these elasticities across estimates. Other than for Surf in Italy, the own price elasticities are higher in the full models than in the IV Logit specification, and the own size estimates vary in magnitude and in sign between the two specifications, revealing the importance of including the random coefficients.

[36] The extent to which I can allow for within-country heteroegenity in preferences is limited by the fact that the product data is aggregated to the country level. Versions of the demand system including different specifications of $\mu_{i,j,t,c}$ were estimated prior to the version presented here. Thomas (2006) contains a specification where observed household characteristics interact with price and pack size, but the small number of countries meant that the role played by observed demographic characteristics was hard to identify in the presence of interaction terms with unobserved household attributes. Another set of estimates were produced including a coefficient in the exponent of pack size to allow for nonlinearity in the marginal indirect utility due to size. This coefficient was estimated to be significant at 0.96. Since this was very close to 1, and the pack size substitutions in the counterfactuals are between very similar pack sizes, the results discussed here are for the demand model with the linear specification of $\mu_{i,j,t,c}$. There are no random coefficients on brands or formats, in part because of the large number of coefficients that this would involve, and also because the counterfactuals involve within-brand-format substitutions.

[37] When $\mu = 0$ in the demand equation, the model reduces to a logit model. Appendix Tables 1 to 3 contain the results of the full model with instruments and the logit model with and without instruments. Appendix Table 4 presents the results of the first stage of the instrumenting strategy with the IV logit specification, by country. For each country, either or both the lagged and substitute prices are significantly associated with current prices.

Panel B of Appendix Table 5 presents some examples of estimates of cross price and cross size coefficients under the IV Logit model and the full model. The full model allows for the market share of all other products to vary in response to a change in the pack size of product j. In the example products, it can be seen that the cross price and cross size elasticities estimated in the full model are greater in magnitude than in the IV Logit model. In addition, the responsiveness of market share to the change in size or price of any one product varies within and across products in each country, and for a given product across countries.

A note on instruments

Including the term $\Delta\xi_{j,t,c}$ to capture unobserved time-specific shocks to mean utility introduces a potential price endogeneity problem. It may well be the case that firms use information related to these shocks when setting price. If so, the unobserved term $\Delta\xi_{j,t,c}$ will be correlated with price and the coefficient estimates will be biased. One example of why this time specific deviation might be correlated with price in this industry is if (unobserved) non-price promotions are timed to coincide with price promotions. For example, say an advertising campaign occurs at the same time as a low detergent price. Demand may increase due to the lower price and also due to the increased product awareness from the advertising campaign. Since the advertising is unobserved, all of the increased demand would be attributed in the model to the lower price. This means that the estimated responsiveness of demand to price would be overstated – it would appear that consumers are more sensitive to price than they actually are. Since advertising and promotional activity are indeed prevalent in this industry, it is important to allow for price endogeneity.

A diagnostic test helps investigate this possibility. The test relies on the intuition that the longer the length of time included in a market observation, the less heavily weighted will be the effects of a short promotion or any temporary shock to demand. In other words, the longer the time period, the smaller the component of the error term attributable to temporary shocks. Since the data span three years, it is possible to study changes in the price coefficient when aggregating the data over different lengths of time in the definition of a single product observation. This test is much like the method used in Hendel and Nevo (2006) to look at the effects of stockpiling on estimation of price elasticities also in the detergents industry. The country specific estimates of the price coefficient do vary as the length of time changes, although this variation is typically less than 10%. The effect of unobserved monthly demand shocks is mitigated somewhat by the decision to aggregate the data to 8-week periods in the main specification. In addition, the main specification employs an instrumental variable strategy.

The necessary property of the demand instruments is that they be uncorrelated with $\Delta\xi_{j,t,c}$ at the true parameter values, $\boldsymbol{\theta}_0$. Three different sets of instruments are employed. The results are qualitatively similar when only the expected utility and substitute price instruments are included. The first set is lagged prices, similar to the approach taken in Asker (2005). While there may be some time-specific deviation in demand in a particular period, it is likely that more fundamental, underlying determinants of product price – for example, cost factors – persist across time periods. Lagged prices will be then be correlated with current prices, but not with the current time-specific deviations in demand since these are mean zero. Thus, prices from previous periods can be used as instruments for current prices. The previous two-month period prices and also the prices from the two-month period prior to that are used as instruments in the main specification.

The second set of instruments employed are the prices of substitute products in the same time period, similar to the approach taken by Hausman *et al.* (1994). Products made by the same firm are viewed as sharing some component of cost which firms take into account when setting prices. As discussed in Section 2, production in this industry tends to be centralized at the firm level, across brands. If unobserved demand shocks are thought to be product specific, the prices of other products made by the same firm will be uncorrelated with these shocks but correlated with product prices. Wherever possible, the price of a similar product made by the same firm but marketed under another brand name is selected as the price instrument. These products would be the most likely to have common costs and the least likely to be correlated with demand shocks which may, for instance, affect all products of the same brand if the unobserved shock relates to an advertising campaign.

Last, a third set of instruments is constructed based on Berry, Levinsohn, and Pakes (1999) and is a measure of "expected utility" which, by construction, is uncorrelated with demand shocks. Running the full model without instruments produces preliminary estimates of $\boldsymbol{\theta}_1$ and $\boldsymbol{\theta}_2$. These estimates, other than the estimated coefficients associated with price, are used to find the expected utility from each product for the average consumer. The price instrument is the linear combination of estimated coefficients and product characteristics averaged over all households, assuming $\epsilon_{i,j,t,c}$ is equal to zero for all i, and crucially, that $\Delta\xi_{j,t,c}$ is also equal to zero. Under the utility specification in the model, firms will set prices so as to capture a share of the value of this expected utility. The vector of expected utilities will therefore serve as a valid instrument for price. It is worth noting, though, that since the non-price characteristics of each product do not vary over time, the only variation over time in these instruments is due to variation in the products offered in a country at different times.

The first stage regression results for the IV Logit specification for each country in turn are given in Appendix Table 4.

Some further implications of the analysis

An implication of the hypothesis explored here is that exclusively local brands make firm-level optimal product range choices since the locally optimal choice is the same as the firm-level choice. Testing this implication is difficult since, by definition, these local brands do not have available products elsewhere to include in alternative product ranges. The advantage of the counterfactual design set out in Section 5 is that alternative product varieties are already being manufactured for cross-country brands so both the costs of product development and fixed costs of production are sunk costs. Without any data on the magnitude of these costs, inferences cannot be drawn about whether increased cross-country standardization would increase firm profit. Nonetheless, feasible alternative product ranges were constructed for local brands in the UK to examine whether observed product ranges maximized variable profit. As an illustration of this, for the national retailer Tesco in the UK, small changes in pack sizes for 4 out of 5 product changes led to reductions in variable profit (but not significantly so). Although one small pack size change led to an increase in variable profit, it could not be concluded that this change was significant and in the absence of any evidence on the fixed cost of manufacturing a new product variety there is no evidence that Tesco's product range is suboptimal given local conditions.

Widening the implications of the analysis in the paper, it is possible to examine the impact on household-level surplus from an increase in product range standardization across countries.

The changes made to each brand's product range here are very small and, importantly, it is not clear how firms would change prices under the alternative product ranges, so any inferences made about the relative welfare effects of multinational firms from this analysis are necessarily limited in scope. Bearing these concerns in mind, the household level expected utility from the observed product range in each country is found as a benchmark surplus level. This is measured as the expected utility, setting the logit error term in equation (5), $\epsilon_{i,j,t,c}$, to zero, that each household would obtain if it were to buy each product less the disutility it gets from having to pay price $p_{j,t,c}$. Multiplying this surplus by the likelihood the household purchases each product, and aggregating over all products, gives the expected surplus for each household from the observed product range. Household-level surplus is also found using this procedure after each product substitution. Each substitution affects the mean household-level surplus and the standard deviation of surplus, but some switches lead to an increase one or both of these measures and others lead to a decrease in one or both. The findings, hence, suggest that households are neither systematically better or worse off when multinationals become more "globalized" by selling a more standardized product range across countries in the region. Thomas (2006) simulates how prices would change in each counterfactual under the assumption that the prices currently observed reflect optimal markups from marginal costs. This analysis also suggests that the welfare effects of increased product-range standardization are heterogenous across households.

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Appendix Table 1: Theta 1 Coefficient Estimates for Different Model Specifications
Brand Dummies

The first row for each brand presents the estimated coefficient. These can be interpreted as the additional utility the average household obtains by using this detergent brand for one washload of laundry rather than one of their country's private label brands.
The second row contains the standard error estimate for the coefficient given above.
**** indicates the coefficient is significant at the 1% level, ** the 5% level, and * the 10% level.*

		OLS Logit	IV Logit	Full Model with Instruments
UK	Persil (Unilever)*	1.74 ***	1.77 ***	2.63 ***
		(0.09)	(0.09)	(0.27)
	Surf (Unilever)	1.03 ***	1.06 ***	1.09 ***
		(0.11)	(0.11)	(0.17)
	Ariel (P&G)	1.15 ***	1.19 ***	2.07 ***
		(0.09)	(0.09)	(0.27)
	Bold (P&G)	1.10 ***	1.13 ***	1.94 ***
		(0.11)	(0.11)	(0.28)
	Daz (P&G)	1.30 ***	1.33 ***	2.01 ***
		(0.12)	(0.12)	(0.23)
	Fairy (P&G)	1.48 ***	1.52 ***	2.49 ***
		(0.12)	(0.12)	(0.29)
	Dreft (P&G)	1.49 ***	1.59 ***	3.63 ***
		(0.30)	(0.30)	(0.57)
	Ecover	1.15 ***	1.23 ***	2.85 ***
		(0.23)	(0.23)	(0.50)
Germany	Sunil (Unilever)	0.28 **	0.29 **	0.63 ***
		(0.13)	(0.13)	(0.19)
	Coral (Unilever)	0.20	0.26 *	1.25 ***
		(0.15)	(0.15)	(0.31)
	Ariel (P&G)	0.05	0.10	0.71 ***
		(0.11)	(0.11)	(0.19)
	Dash (P&G)	-0.71 ***	-0.68 ***	-0.22
		(0.14)	(0.14)	(0.20)
	Meister Propper (P&G)	1.37 **	1.39 ***	1.58 ***
		(0.53)	(0.53)	(0.24)
	Persil (Henkel)*	0.54 ***	0.61 ***	1.07 ***
		(0.15)	(0.15)	(0.22)
	Spee (Henkel)	0.13	0.15	0.52 ***
		(0.15)	(0.15)	(0.19)
	Weisser Riese (Henkel)	0.03	0.05	0.36 *
		(0.17)	(0.17)	(0.21)
	Perwoll (Henkel)	0.24 *	0.29 **	0.97 ***
		(0.14)	(0.14)	(0.23)
Italy	Bio-Presto Surf (Unilever)	0.27 ***	0.27 ***	0.40 ***
		(0.10)	(0.10)	(0.11)
	Ariel (P&G)	-0.09	-0.03	0.13
		(0.18)	(0.18)	(0.16)
	Dash (P&G)	1.12 ***	1.18 ***	1.44 ***
		(0.10)	(0.10)	(0.17)
	Bolt (P&G)	0.19	0.23 *	0.30 *
		(0.14)	(0.14)	(0.16)
	Dixan (Henkel)	0.94 ***	1.00 ***	1.22 ***
		(0.10)	(0.10)	(0.15)
	General (Henkel)	0.10	0.05	-0.17
		(0.16)	(0.16)	(0.21)
	Perlana (Henkel)	0.30 *	0.40 **	0.57 ***
		(0.18)	(0.18)	(0.20)
Spain	Surf (Unilever)	-0.33 **	-0.33 **	0.19
		(0.16)	(0.16)	(0.23)
	Skip (Unilever)	0.97 ***	0.98 ***	1.61 ***
		(0.14)	(0.14)	(0.24)
	Ariel (P&G)	0.62 ***	0.63 ***	1.45 ***
		(0.11)	(0.11)	(0.22)
	Bold (P&G)	-0.12	-0.12	0.63 **
		(0.16)	(0.17)	(0.27)
	Dash (P&G)	-0.37	-0.37	0.00
		(0.26)	(0.27)	(0.26)
	Wipp (Henkel)	0.61 ***	0.62 ***	1.50 ***
		(0.12)	(0.12)	(0.26)
	Dixan (Henkel)	0.41 ***	0.41 ***	0.96 ***
		(0.14)	(0.14)	(0.21)
	Micolor (Henkel)	0.09	0.10	0.96 ***
		(0.15)	(0.15)	(0.26)
	Perlan (Henkel)	-0.25	-0.25	0.45 **
		(0.21)	(0.21)	(0.22)

** The fact that the Persil brand is owned by Unilever in the UK (and France) and by Henkel in Germany is a legacy from World War I.*

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Appendix Table 2: Theta 1 Coefficient Estimates
Format Dummies

The first row for each format presents the estimated coefficient. These can be interpreted as the additional utility the average household obtains by using this detergent format for one washload of laundry rather than standard powder.
The second row contains the standard error estimate for the coefficient given above.
**** indicates the coefficient is significant at the 1% level, ** the 5% level, and * the 10% level.*

		OLS Logit		IV Logit		Full Model with Instruments	
UK	Liquid	0.19	**	0.23	**	1.11	***
		(0.09)		(0.09)		(0.26)	
	Tablet	0.87	***	0.95	***	2.40	***
		(0.08)		(0.08)		(0.41)	
	Capsule	1.29	***	1.41	***	3.14	***
		(0.15)		(0.15)		(0.51)	
	Concentrated	-0.28	***	-0.33	***	-1.37	***
		(0.10)		(0.10)		(0.31)	
Germany	Liquid	0.73	***	0.74	***	1.04	***
		(0.08)		(0.08)		(0.12)	
	Tablet	0.53	***	0.58	***	1.12	***
		(0.12)		(0.12)		(0.17)	
	Gels/other	0.49	***	0.46	***	0.69	***
		(0.16)		(0.16)		(0.19)	
	Concentrated	-0.11		-0.13		-0.45	***
		(0.09)		(0.09)		(0.13)	
Italy	Liquid	0.54	***	0.49	***	0.43	***
		(0.08)		(0.08)		(0.09)	
	Tablet	0.00		0.24		-0.07	***
		(0.18)		(0.18)		(0.21)	
	Liquid Soap Marsiglia	0.80	***	0.74	***	0.63	***
		(0.13)		(0.13)		(0.15)	
	Concentrated	-0.70	***	-0.78	***	-1.20	***
		(0.16)		(0.16)		(0.25)	
Spain	Liquid	-0.20	***	-0.20	***	0.00	
		(0.07)		(0.07)		(0.11)	
	Tablet	-0.27	***	-0.26	**	0.59	***
		(0.10)		(0.10)		(0.23)	
	Capsules	-1.36	***	-1.34	***	-0.60	**
		(0.34)		(0.34)		(0.27)	
	Concentrated	-1.79	***	-1.79	***	-2.44	***
		(0.21)		(0.21)		(0.39)	

Appendix Table 3: Theta 1 Coefficient Estimates
Other Coefficients

The first row for each brand presents the estimated coefficient. These can be interpreted as the additional utility the average household obtains by using a detergent that is in a larger pack size, is one euro more expensive, or is an own-label brand.
The second row contains the standard error estimate for the coefficient given above.
**** indicates the coefficient is significant at the 1% level, ** the 5% level, and * the 10% level.*

		OLS Logit		IV Logit		Full Model with Instruments	
Pack Size Coefficient	**UK**	0.01	***	0.01	***	-0.02	*
		(0.00)		(0.00)		(0.01)	
	DE	0.02	***	0.02	***	0.01	
		(0.00)		(0.00)		(0.01)	
	IT	0.01	**	0.00		-0.01	
		(0.00)		(0.00)		(0.01)	
	ES	0.02	***	0.02	***	0.01	***
		(0.00)		(0.00)		(0.00)	
Price Coefficient	**UK**	-6.06	***	-6.86	***	-23.66	***
		(0.38)		(0.38)		(5.06)	
	DE	-9.77	***	-10.46	***	-30.21	***
		(0.66)		(0.66)		(5.60)	
	IT	-5.78	***	-7.71	***	-19.17	***
		(0.82)		(0.83)		(5.27)	
	ES	-7.09	***	-7.24	***	-28.10	***
		(0.38)		(0.38)		(6.42)	
Constant Term Coefficient	**UK**	-3.62	***	-3.44	***	1.14	
		(0.12)		(0.12)		(1.70)	
	DE	-4.82	***	-4.71	***	-2.07	**
		(0.14)		(0.14)		(1.04)	
	IT	-4.45	***	-4.06	***	-1.84	
		(0.18)		(0.18)		(1.13)	
	ES	-4.61	***	-4.58	***	-1.81	**
		(0.11)		(0.11)		(0.74)	

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Appendix Table 4: First Stage Results for IV Logit, by country

This table presents summary output from the first stage of the IV Logit regression of price on instruments. The specification was run separately for each country.

	UK		Germany		Italy		Spain	
Pack size	0.0002		0.0000		0.0001		0.0000	
	[0.0003]		[0.0000]		[0.0003]		[0.0001]	
Expected mean utility	0.0422		0.0127	*	0.0357		0.0035	
	[0.02614]		[0.0075]		[0.0233]		[0.0163]	
Lagged price, 8 weeks	0.9056	***	0.4737	***	0.5274	***	0.6771	***
	[0.0259]		[0.0187]		[0.0177]		[0.0198]	
Lagged price, 16 weeks	0.4988	***	0.4533	***	0.2531	***	0.3031	***
	[0.0268]		[0.01848]		[0.0173]		[0.0199]	
Substitute product, same time period	0.0187		0.0111	*	0.0534	***	0.0170	***
	[0.0153]		[0.0063]		[0.0111]		[0.0064]	
Constant	-0.0720		0.0269	**	0.0679	***	0.0070	
	[0.0562]		[0.0110]		[0.0231]		[0.0180]	
Brand indicator variables	Y		Y		Y		Y	
Format indicator variables	Y		Y		Y		Y	
Number of observations	3416		2830		2866		2522	
Partial R-Squared of excluded instruments	0.7349		0.8396		0.6051		0.9332	
F-test of excluded instruments	2355.35		3677.51		1091.51		8739.03	
P-value for F-test of excluded instruments	0.000		0.000		0.000		0.000	

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Appendix Table 5: Product-Level Own and Cross Price Elasticities, Own and Cross Size Elasticities

Panel A: *This panel presents the average own price elasticities and average own size elasticities for all Surf products and all Ariel products in each country. The standard deviation across the relevant group is given in the row below.*

	UK		Germany		Italy		Spain	
	IVLogit	**Full model**	**IVLogit**	**Full model**	**IVLogit**	**Full model**	**IVLogit**	**Full model**
Surf								
Number of products on sale	12	12	-	-	12	12	5	5
Average of products' estimated own price elasticity	-1.42	-4.13	-	-	-1.31	-1.26	-1.40	-2.30
Standard deviation across products	*0.48*	*0.37*	-	-	*0.69*	*0.71*	*0.54*	*0.45*
Average of products' estimated own size elasticity	0.28	-0.53	-	-	0.07	-0.19	-0.50	0.31
Standard deviation across products	*0.18*	*0.33*	-	-	*0.05*	*0.13*	*0.28*	*0.18*
Ariel								
Number of products on sale	21	21	13	13	5	5	13	13
Average of products' estimated own price elasticity	-1.76	-4.03	-1.34	-2.36	-1.33	-1.57	-1.48	-2.22
Standard deviation across products	*0.62*	*0.49*	*0.56*	*0.70*	*0.38*	*0.22*	*0.53*	*0.41*
Average of products' estimated own size elasticity	0.31	-0.58	0.93	0.41	0.04	-0.11	0.80	0.51
Standard deviation across products	*0.23*	*0.41*	*0.63*	*0.28*	*0.03*	*0.09*	*0.65*	*0.43*

Panel B: *This panel highlights some examples of the differing estimates of cross price and cross size elasticities resulting from the full model compared to the IV Logit model.*

	IVLogit		Full model		IVLogit		Full model	
Product	Average cross price elasticity across other same-brand country products	Standard deviation across other same-brand country products	Average cross price elasticity across other same-brand country products	Standard deviation across other same-brand country products	Average cross size elasticity across other same-brand country products	Standard deviation across other same-brand country products	Average cross size elasticity across other same-brand country products	Standard deviation across other same-brand country products
Surf 46 washload pack of standard powder in UK	0.0018	0	0.0456	0.0919	-0.0009	0	0.0082	0.0212
Surf 8 washload pack of tablets in UK	0.0046	0	0.0273	0.0550	-0.0002	0	0.0049	0.0127
Ariel 46 washload pack of standard powder in the UK	0.0050	0	0.0296	0.0245	-0.0024	0	0.0046	0.0048
Ariel 22 washload pack of tablets in the UK	0.0218	0	0.0095	0.0078	-0.0010	0	0.0015	0.0015
Ariel 22 washload pack of tablets in Germany	0.0047	0	0.0084	0.0069	-0.0001	0	-0.0024	0.0042

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Appendix Table 6: Total revenues, quantities, and average prices under alternative product ranges

For each brand in each country, this table gives the predicted revenues and quantites sold in a typical eight week period with each alternative product range.
The distribution of these predictions is generated using the simulated asymptotic distribution of the estimated demand parameters
as described in section 5.3 of the paper.
For space reasons, the table contains the point estimate and standard error for each output measure after each substitution.
Means, medians, and confidence intervals are available from the author on request. The same process is also conducted for firm-level profits, aggregating revenues, quantities, and average prices across all firm-brands in any one country. The results all hold at the firm level.

					Brand Revenues		Brand Quantities		Brand Average Price	
Brand	**Format**	**Pack size taken out**	**Pack size put in**	**Source country**	**Actual**	**Std Error**	**Actual**	**Std Error**	**Actual**	**Std Error**
Surf in the UK	Standard Powder	9	5	Italy	14,398	1,032	91,011	8,776	0.1582	0.0053
	Standard Powder	12	8	Spain	14,357	1,071	90,691	9,098	0.1583	0.0055
	Standard Powder	15	23	Italy	14,277	1,112	90,286	9,336	0.1581	0.0054
	Standard Powder	31	20	Spain	14,415	1,057	91,029	8,986	0.1584	0.0054
	Standard Powder	31	41	Spain	14,286	1,096	90,325	9,249	0.1582	0.0054
	Standard Powder	46	33	Italy	14,418	1,068	91,082	9,020	0.1583	0.0054
	Standard Powder	52	60	Italy	14,300	1,091	90,368	9,270	0.1582	0.0054
	Tablets	11	16	Italy	14,264	1,119	90,394	9,280	0.1578	0.0051
	Tablets	11	18	Spain	14,241	1,128	90,322	9,314	0.1577	0.0050
	Tablets	22	37	Spain	14,040	1,160	89,516	9,506	0.1568	0.0047
	Tablets	36	26	Italy	15,964	1,063	103,431	7,731	0.1543	0.0031
Surf in Italy	Standard Powder	5	9	UK	7,265	760	55,073	10,274	0.1319	0.0117
	Standard Powder	5	8	Spain	7,266	756	55,077	10,261	0.1319	0.0118
	Standard Powder	12	15	UK	7,266	751	55,065	10,280	0.1320	0.0120
	Standard Powder	23	31	UK	7,251	774	54,969	10,448	0.1319	0.0120
	Standard Powder	23	41	Spain	7,222	829	54,796	10,785	0.1318	0.0118
	Standard Powder	60	52	UK	7,301	658	55,341	9,514	0.1319	0.0120
	Tablets	16	14	UK	7,284	706	55,133	10,100	0.1321	0.0125
	Tablets	16	11	UK	7,293	685	55,157	10,036	0.1322	0.0128
	Tablets	26	22	UK	7,285	707	55,144	10,087	0.1321	0.0124
	Tablets	26	37	Spain	7,247	779	55,011	10,355	0.1317	0.0116
Surf in Spain	Standard Powder	8	12	UK	1,116	106	6,522	629	0.1711	0.0030
	Standard Powder	8	5	Italy	1,103	102	6,447	598	0.1711	0.0030
	Standard Powder	20	31	UK	1,138	107	6,670	643	0.1706	0.0031
	Standard Powder	41	23	Italy	1,048	110	6,039	641	0.1735	0.0027
	Standard Powder	41	60	Italy	1,190	93	7,067	600	0.1683	0.0041
	Tablets	18	11	UK	1,097	98	6,441	593	0.1703	0.0033
	Tablets	18	26	Italy	1,123	109	6,522	627	0.1722	0.0029
	Tablets	37	36	UK	1,103	104	6,447	611	0.1710	0.0030
Ariel in the UK	Standard Powder	9	5	Italy	23,049	2,086	95,712	16,693	0.2408	0.0152
	Standard Powder	9	4	Spain	23,053	2,084	95,722	16,687	0.2408	0.0152
	Concentrated Powder	52	112	Spain	22,654	5,968	93,293	38,924	0.2428	0.0184
	Standard Powder	52	78	Spain	22,808	2,917	94,249	21,411	0.2420	0.0162
	Standard Liquid	12	44	Italy	22,859	2,182	95,175	16,965	0.2402	0.0149
	Standard Liquid	12	20	Spain	22,984	2,115	95,529	16,781	0.2406	0.0151
	Concentrated Liquid	30	35	Germany	22,951	2,132	95,083	16,999	0.2414	0.0156
	Concentrated Liquid	76	58	Germany	23,202	1,129	96,804	10,523	0.2397	0.0132
	Tablets	17	15	Germany	23,094	2,070	95,841	16,642	0.2410	0.0153
	Tablets	48	37	Spain	23,356	1,903	96,848	16,044	0.2412	0.0155
Ariel in Italy	Standard Powder	5	9	UK	2,348	393	14,505	2,323	0.1619	0.0044
	Standard Powder	12	16	UK	2,344	388	14,480	2,287	0.1619	0.0046
	Standard Powder	12	8	Spain	2,364	432	14,582	2,480	0.1621	0.0050
	Standard Liquid	12	9	UK	2,369	444	14,621	2,569	0.1620	0.0047
	Standard Liquid	12	20	Spain	2,323	347	14,340	2,056	0.1620	0.0050
	Standard Liquid	44	61	Spain	2,300	273	14,206	1,610	0.1619	0.0047
Ariel in Spain	Standard Powder	4	5	Italy	9,115	2,342	52,868	22,701	0.1724	0.0140
	Standard Powder	8	12	UK	9,122	2,341	52,889	22,698	0.1725	0.0140
	Standard Powder	8	12	Italy	9,121	2,341	52,887	22,698	0.1725	0.0140
	Standard Powder	20	31	UK	9,166	2,349	53,110	22,723	0.1726	0.0140
	Standard Powder	41	24	UK	8,991	2,319	52,197	22,598	0.1722	0.0141
	Standard Liquid	11	9	UK	9,099	2,342	52,796	22,706	0.1723	0.0140
	Standard Liquid	20	12	UK	9,057	2,334	52,523	22,674	0.1724	0.0140
	Standard Liquid	20	12	Italy	9,056	2,333	52,518	22,673	0.1724	0.0140
	Standard Liquid	61	44	Italy	8,897	2,211	51,449	21,978	0.1729	0.0144
	Tablets	18	11	UK	9,072	2,346	52,738	22,723	0.1720	0.0140
	Tablets	37	48	UK	9,183	2,360	53,040	22,742	0.1731	0.0140
	Tablets	37	22	Germany	9,012	2,336	52,586	22,700	0.1714	0.0140
Ariel in Germany	Tablets	15	11	UK	8,935	6,724	90,346	122,382	0.0989	0.0270
	Tablets	15	17	UK	8,961	6,775	90,436	122,535	0.0991	0.0259
	Tablets	22	17	UK	8,924	6,720	90,234	122,282	0.0989	0.0264
	Tablets	22	48	UK	9,128	6,969	91,463	123,563	0.0998	0.0252
	Tablets	22	37	Spain	9,054	6,878	91,018	123,102	0.0995	0.0256