Too Many Products:

Decentralized Decision-Making in Multinational Firms

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Online Appendix

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:

$$\begin{aligned} F_{\bar{j}} + \sum_{j \in J_{b,c}} mc_j q_{j,c} - \sum_{j \in A_{b,c}} mc_j q_{j,c} &> \sum_{j \in J_{b,t,c}} \left(mc_j q_{j,c} + \eta_j q_{j,c} \right) - \sum_{j \in A_{b,c}} \left(mc_j q_{j,c} + \eta_j q_{j,c} \right) \\ F_{\bar{j}} &> \sum_{j \in J_{b,t,c}} \eta_j q_{j,c} - \sum_{j \in A_{b,c}} \eta_j q_{j,c} \end{aligned} \quad (1)$$

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 (1) 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 (1) 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.[1]

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:

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

$$F_{\bar{j}} > \sum_{j \in J_{b,c}} \frac{F_j q_{j,c}}{\sum_c q_{j,c}} - \sum_{j \in A_{b,c}} \frac{F_j q_{j,c}}{\sum_c q_{j,c}} \quad (2)$$

Since under the localized product range, country c is the only market in which product $\bar{j}$ is sold, inequality (2) can be written:

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

$$0 > \sum_{j \neq \bar{j} \in J_{b,c}} \frac{F_j q_{j,c}}{\sum_c q_{j,c}} - \sum_{j \in A_{b,c}} \frac{F_j q_{j,c}}{\sum_c q_{j,c}}$$

$$\sum_{j \in A_{b,c}} \frac{F_j q_{j,c}}{\sum_c q_{j,c}} > \sum_{j \neq \bar{j} \in J_{b,c}} \frac{F_j q_{j,c}}{\sum_c q_{j,c}}$$

The fixed cost of the local product is entirely borne by the local division in this case, so it cancels

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

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 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.[2] 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

[2] 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.

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 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.[3] 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 $E[\mathbf{Z}'\boldsymbol{\omega}\boldsymbol{\omega}'\mathbf{Z}]$ and $E[G(\boldsymbol{\theta}_0)] = 0$. As in Nevo (2000), $\mathbf{Z}\prime\mathbf{Z}$ 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

[3] 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 Petrin (2002), the asymptotic variance of the $\sqrt{n}\left(\widehat{\theta}-\theta\right)$ is given by

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

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 $V = E\left[G\left(\boldsymbol{\theta}_0\right)G\left(\boldsymbol{\theta}_0\right)'\right]$. The standard errors reported 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.[4,5]

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

[4]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.

[5]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.

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.

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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