Portfolio Effects and Firm Size Distribution: Carbonated Soft Drinks*

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Abstract: We use rich brand level retail data to demonstrate that the firm size distribution in Carbonated Soft Drinks is mainly an outcome of the degree to which firms own a portfolio of brands across segments of the market, and not from performance within segments. In addition, while the number of firms in each segment is limited by segment size relative to sunk cost and competition in a segment, idiosyncratic firm effects make some firms more likely to participate in any given segment. This feature of the industry is the key to modelling firm size distribution in Carbonated Soft Drinks.

I INTRODUCTION

In this paper we model firm size distribution in Carbonated Soft Drinks using Sutton (1998). Rather than looking for an exact size distribution, he derives a lower bound to firm size distribution that will hold in any industry where firms operate over segments, or islands. The lower bound is an outcome of a sequence of deterministic entry games across segments. Theoretically, coverage of segments becomes more important than the details of events within segments in determining firm size distribution. Empirically, this has been validated for the US Cement Industry (Sutton, 1998), the Spanish Retail Banking Sector (De Juan, 1999), and the Italian Motor Insurance Industry (Buzzacchi and Valletti, 1999). These studies find that firm size is mainly determined by the degree to which a firm has a presence across many

geographical locations. To be a large firm in the industry requires a presence over many geographical locations, or segments. In keeping with Sutton's (1998) theory, heterogeneity in the degree to which firms participate over segments of a market can by itself explain most of the observed firm size distribution in these industries.

In this paper we wish to model firm size distribution in Carbonated Soft Drinks as an outcome of the degree to which firms cover vertical (flavour, packaging, diet attributes) segments of the market, using retail brand data described in Section II. In Section III of the paper we show that the different degree to which firms operate over segments of the market places Sutton's (1998) mathematically predicted lower bound on the shape of the firm size distribution of Carbonated Soft Drinks. This portfolio effect explains most of the actual firm size distribution.

In Section IV of the paper we model the factors that characterise firm entry across our segments. We find that segment size relative to the sunk cost, and competitive conduct among firm populations limit the number of firms that enter a segment. We also find that idiosyncratic firm characteristics make some firms more likely to have taken up a position in any given segment. This latter feature of the industry is the key to modelling firm size distribution in Carbonated Soft Drinks. The skewness results mainly from the heterogeneous take-up of segments, and not from firm performance within certain segments. So while Coca-Cola has on average 52 per cent of the Carbonated Soft Drinks retail market in Ireland over the period 1992-1997, its dominance does not result from its performance in the Cola market. Rather its success lies in the establishment of a portfolio of brands across 91 per cent of segments. Key brands include Fanta in Orange, Sprite in Lemonade, and Lilt in Mixed Fruit in addition to its Coca-Cola brand. Small firms can co-exist with large firms in this market by operating with popular brands within one or two segments.

II DATA DESCRIPTION

AC Nielsen of Ireland has collated a panel database of all brands in Carbonated Soft Drinks distributed throughout Irish retail stores for use in our empirical analysis. The evolution of the Irish retail grocery market structure from the early 1970s is described in Walsh and Whelan (1999a).[1] The database provides bi-monthly population data spanning October 1992 to

[1] The introduction of foreign competition into the chain store market, which induced structural upheaval in the market, did not take place until the end of 1998. Both international and national companies distributed their brands throughout a retail structure that was very stable through the period analysed in this paper.

Table 1: *Firm Roles (R) and Brands (B) in Segments of Carbonated Drinks, Oct. 1992-May 1997*

	Cans		Standard		1.5 Litre		2 Litre		Multipk Cans	
	R	(B)	R	(B)	R	(B)	R	(B)	R	(B)
Regular Cola	4	(7)	6	(11)	3	(3)	4	(5)	2	(6)
Diet Cola	3	(5)	2	(3)	2	(4)	3	(5)	2	(5)
Regular Orange	4	(6)	5	(13)	4	(6)	4	(5)	3	(5)
Diet Orange	1	(3)	1	(1)	1	(1)	2	(3)		
Regular Lemonade	2	(4)	3	(7)	2	(4)	2	(4)	1	(2)
Diet Lemonade	1	(2)	1	(1)	1	(2)	1	(2)	1	(2)
Regular Mixed Fruit	6	(8)	7	(21)	6	(7)	5	(9)	1	(1)
Diet Mixed Fruit	1	(2)	1	(1)	1	(1)	1	(1)		

Total Number of Firm Roles = 100   Total Number of Brands = 178

March 1997 for 178 brands, identified for 13 firms and 40 product characteristics within Carbonated Soft Drinks. We are bound by a contract of confidentiality with AC Nielsen not to reveal information not otherwise available on the market.

We have extensive bi-monthly brand level information regarding brand retail price (average of individual brand prices across all stores selling the brand, weighted by brand sales share within the store), sales units (in ml) and value (in £000), firm attachment and their vertical (flavour, packaging, and diet) characteristics. An interesting feature of the AC Nielsen data is their identification of various segments within the market for Carbonated Soft Drinks, which group clusters of brands by various vertical attributes. AC Nielsen identify 40 segments: 4 flavours (Cola, Orange, Lemonade and Mixed Fruit), by 5 different packaging types (Cans, Standard Bottle, 1.5 Litre, 2 Litre and Multi-Pack of Cans) and 2 different sweeteners, diet and regular. Packaging format is recognised as a crucial feature of this market by the industry. Over 90 per cent of cans and standard bottles are impulse buys distributed through small corner stores and garage forecourts rather than chain stores. In contrast, the majority of 2 litre and multi-pack cans are distributed through one-stop supermarket shops. The industry has clearly introduced different packaging to satisfy different consumer needs within both the impulse and one-stop shopping segments (Walsh and Whelan, 1999a and 1999b).

We define the firm business as Carbonated Soft Drinks, but within this market firms take up various positions or "roles" across vertical segments. So if a firm operates in all segments, it has adopted 40 different roles. Details of

the segments and associated number of firm roles and brands they host are set out in Table 1. Interestingly, there are only 100 roles taken up, on average, by the 13 firms. If every firm operated in every segment we would have 13 roles in each of the 40 segments giving a total of 520 roles. There is a very heterogeneous and a persistent pattern in the take up of roles by firms across vertical segments. This will be shown to be a key structural feature of the industry in determining the limiting firm size distribution.

III FIRM SIZE DISTRIBUTION IN CARBONATED SOFT DRINKS

The key structural feature of Sutton's (1998) theory of limiting firm size distribution is the arrival, in the history of a defined market, of a number of discrete investment opportunities (segments) over an infinite period for firm populations. Assuming opportunities of equal size arrive and can only be filled by one firm, the market begins with a single firm of size 1. Each subsequent opportunity is taken up by either a new firm or existing firm. If opportunities were taken up in succession by new firms, the resultant limiting size distribution will display perfect equality between firms of size 1. Differences in firm size emerge when firms have taken up a different portfolio of opportunities or, what Sutton labels, roles in the market. Sutton (1998) puts weak restrictions on the form of the entry game into each of these segments as they arrive in the history of the market to model a lower bound on the size distribution of firms in a market.

Sutton (1998) derives his lower bound within a game-theoretic model using a *Symmetry Principle* when modelling deterministic entry processes across the segments of the market.[2] This ensures that all potential entrants are treated equally in their probability of taking up a position or role in a segment. In the limit, this allows a prediction on the lower bound to firm size distribution, or a minimal degree of skewness between firms.

In the lower bound, unequal firm size distributions at the product level can only be driven by the heterogeneous take-up of roles across segments. Firm size distribution is based on a simple count of roles across segments and is restricted to a lower bound Lorenz curve that graphs the fraction of top k ranking firms in the population N of firms, k/N, against their corresponding share of market assets given by the k-firm concentration ratio, C_k, that satisfies,

$$C_k \geq \frac{k}{N}\left(1 - \ln \frac{k}{N}\right) \tag{1}$$

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[2] The Symmetry Principle is based on the Harsanyi and Selten (1988) concept of symmetry and subgame consistency.

Heterogeneous participation of firms across segments dictates a lower bound to firm size distribution in a market that is associated with a measure of inequality that is approximately equal to a Gini coefficient of 0.5.

If there is a size advantage so that bigger firms in the market are more likely to take up a role in a segment, this has the effect of introducing greater heterogeneity between firms in the market and so the resulting Lorenz curve will not violate the predicted lower bound. Moreover, the lower bound predicts the minimal degree of skewness between firms assuming all roles, both within and across all segments, are of equal size. It is clear that in fact, the size of firm roles may be very different within a segment (difference in the degree of short-run price competition), and hence across segments, which introduces additional heterogeneity between firms in the market and so greater skewness. Thus, the actual firm size distribution that allows for roles of different sizes will result in a Lorenz curve that lies above that based on a pure count of roles. This is the basic proposition in the theorem of majorisation: the Lorenz curve associated with the actual distribution based on sales will be further away from the diagonal than that induced by measuring size as a pure count of roles (Marshall and Olkin, 1979).

The actual firm size distribution observed in the Carbonated Soft Drinks market is illustrated in Figure 1, both for the average over the five-year period and for each bi-monthly period. This measures firm size as total firm sales in the business of Carbonated Soft Drinks, and plots the fraction of top k ranking firms in Carbonated Soft Drinks, k/N, against their corresponding market share in Carbonated Soft Drinks. N is the total number of firms and C_k describes the k-firm sales concentration ratio in the market. For example, the top two firms collectively account for on average, 73 per cent of the market. We do not observe a violation of the predicted lower bound in our scatter of points in any bi-monthly period. The corresponding Gini coefficient measure of inequality is 0.72, which clearly exceeds the mathematically predicted lower bound.

We now examine whether the presence of firms operating over vertical segments in Carbonated Soft Drinks places this lower bound on the shape of the firm size distribution. Each firm has only one role in each of the segments in which it is active. A count of roles in the Carbonated Soft Drinks market indicates the number of segments across which a firm operates. Firm operations over vertical segments (flavour, packaging, diet attributes), on average, range from 2 to 91 per cent with a tendency for higher ranked firms to cover relatively more segments in Carbonated Soft Drinks. Measuring firm size purely as a count of roles, such that the size of a firm is just the total number of segments over which it operates, gives a firm size distribution where heterogeneity in firm size can only result due to firms participating in

Figure 1: *Actual Firm Size Distribution in the Irish Carbonated Soft Drinks*

Firm Size Distribution in Carbonated Drinks:
Average over Oct. 1992-March 1997
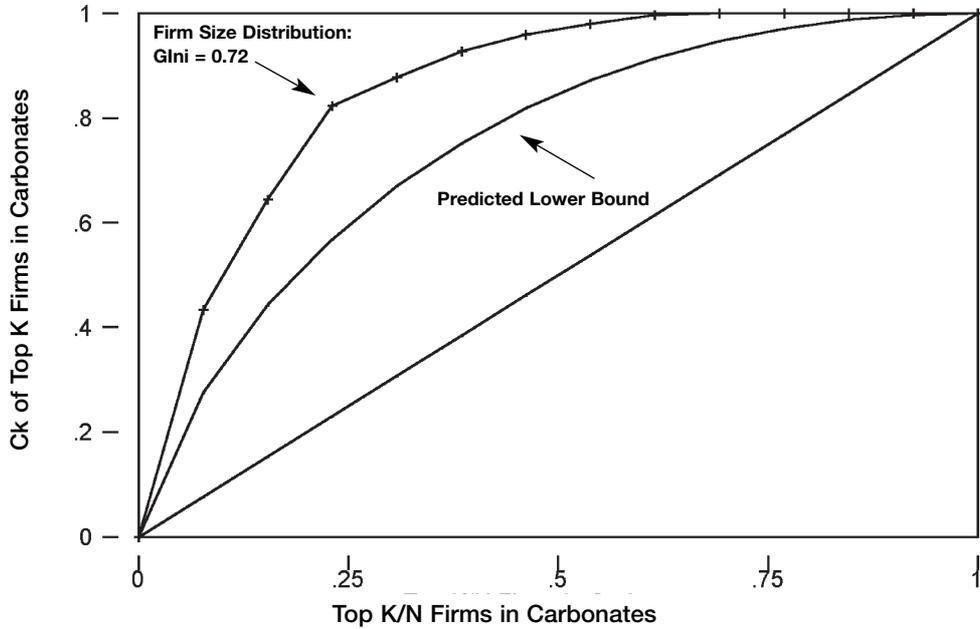
Firm Size Distribution in Carbonated Drinks:
Bi-Monthly: 1992-March 1997
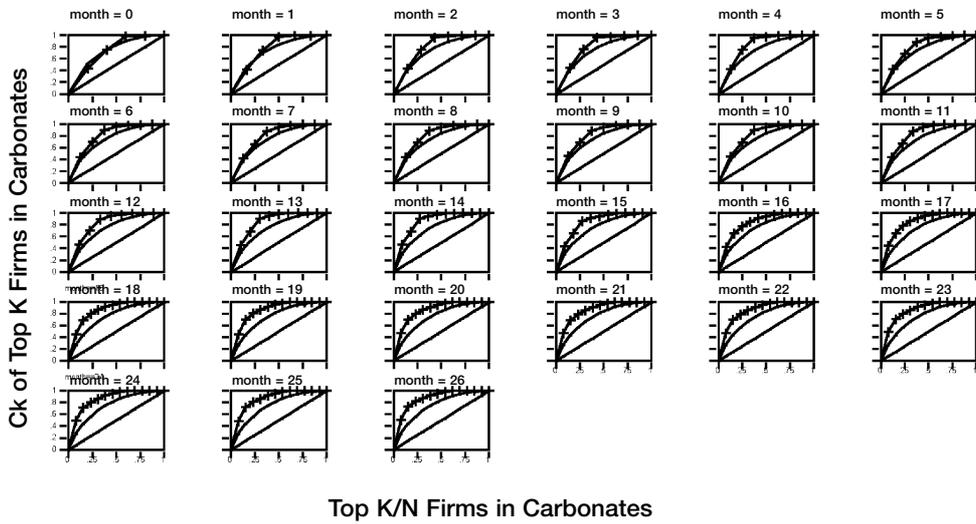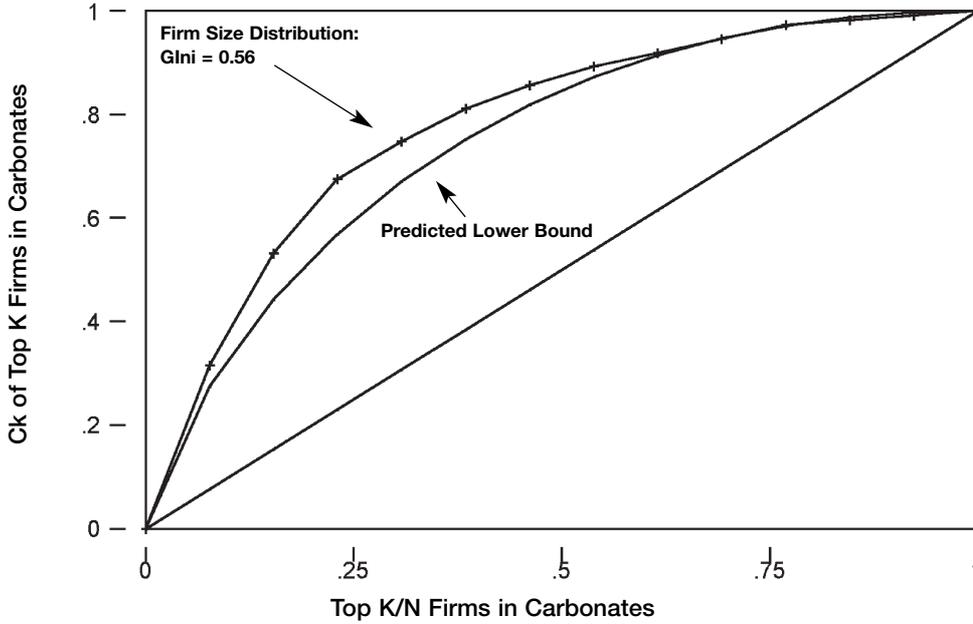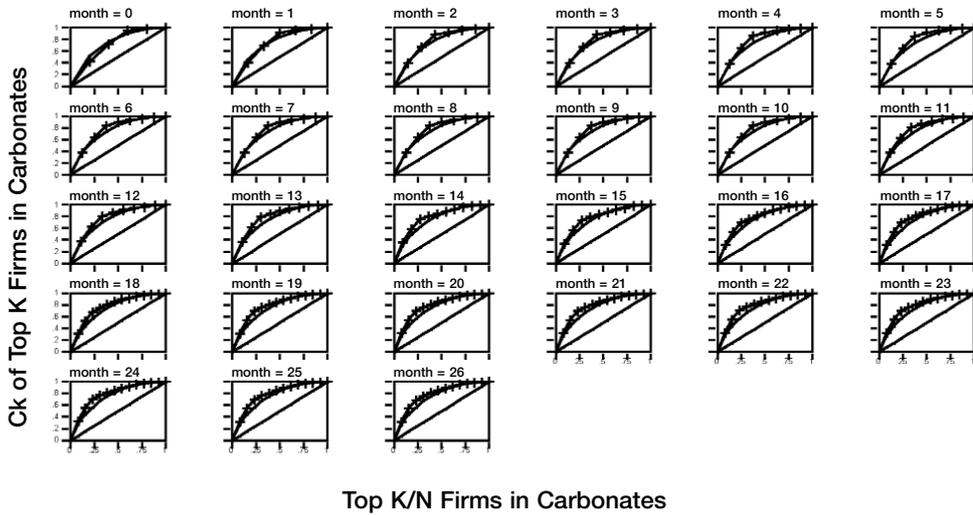
Figure 2: *Firm Size Distribution Based on a Count of Roles over 40 Segments*
(Flavour by Packaging by Diet)

Firm Size Distribution in Carbonated Drinks:
due to Coverage of Segments: Bi-Monthly Average for Oct. 1992-March 1997

Firm Size Distribution in Carbonated Drinks:
due to Coverage of Segments: Bi-Monthly Oct. 1992-March 1997

Top K/N Firms in Carbonates

a different number of segments within Carbonated Soft Drinks. Figure 2 illustrates the size distribution of firms on the basis of a count of roles across vertical segments (flavour, packaging, diet attributes), within Carbonated Soft Drinks on average over the five-year period, and for each bi-monthly period. The fit of the data to the theoretically predicted lower bound Lorenz Curve is remarkably tight for each and every period. Firm size inequality is driven only by the heterogeneous operation of firms across vertical segments, corresponds to a Gini coefficient of 0.56, and lies above the mathematically derived lower bound predicted in Sutton (1998). The actual size distribution in Figure 1 which allows for the fact that roles can be of different size both within and across segments, with a corresponding Gini coefficient of 0.72, is above that observed for the size distribution based on a count of roles across 40 vertical segments.

IV MODELLING FIRM PARTICIPATION IN SEGMENTS OF CARBONATED DRINKS

The key structural aspect that needs to be modelled to explain firm size distribution is simply the participation rates of firms across segments. As indicated in Figure 2, participation rates have been very stable over the five-year period examined. Although there is little variation in participation rates by firms over time, we do have variation in firm participation across the 40 segments. In addition, the number of roles within segments is surprisingly concentrated, as documented in Table 1. In this section we model the heterogeneous take-up of roles by firms in the history of the market in the spirit of the seminal work by Bresnahan and Reis (1991).

They estimate discrete game-theoretic entry models to relate shifts in market demand to changes in the equilibrium number of firms. Bresnahan and Reis (1991) use a cross section of 202 geographically concentrated markets to conduct this empirical comparative static exercise. In competitive regional markets, variations in the number of incumbent firms and market size would identify firm's fixed costs relative to demand as stated by the Traditional Limit Theorem, see Sutton (1991). In oligopolistic regional markets, anticipated competitor behaviour can also act as a barrier to entry. As in Sutton (1991) the expectation of ex-post entry price and non-price competition also drives equilibrium concentration. The problem is that competitive conduct among entrants and potential entrants is hard to measure empirically. They impose structure motivated from theory to control for such omitted variable bias in order to identify firm's fixed costs relative to demand using data on number of incumbent firms and market size in oligopolistic markets.

We wish to model the heterogeneity in the take-up of firm roles across segments that result from strategic conduct among the firms and different segment sizes relative to sunk costs in Carbonated Soft Drinks. Our cross section is in terms of vertical segments rather then geographical regions. We estimate a simple discrete choice model of firm entry to evaluate the impact of segment size (£000) relative to sunk cost (median firm size in segment, £000) on participation rates, while controlling for unobserved but deterministic segment and firm specific effects. We use segment dummies to control for heterogeneous competitive conduct within segments, and firm dummies to control for the possibility that some firms may have a strategic advantage in taking up roles across the segments relative to other firms. We estimate the following linear probability model,

$$P\{F_{rs} = 1 \mid X_f\} = G(\beta_0\, Size_s\, /\sigma_s + \beta_1\, S_s + \beta_2\, F_f) \tag{2}$$

Where F_{rs} adopts a value of 1 if a firm has a role in a segment, and 0 otherwise. The participation rates of firms in segments vary substantially across firms, but have little variation over time and so we model the average participation rate over the five-year period. The participation rate is modelled to depend upon segment size (£000) $Size_s$ relative to sunk costs σ_s (proxied with median firm size in a segment, £000) averaged over the period in question. Unobservable segment and firm characteristics are controlled for with a dummy variable for each segment, S_s, and for each firm, F_f, in the business of Carbonated Soft Drinks. Having data on segment market size, sunk costs and role attachment to firms allows us control for strategic conduct in this way.

Table 2 presents the results of our empirical analysis. All explanatory variables are highly significant. Transforming the coefficients of our regression into marginal effects on the estimated participation of firms in segments, we first compute the predicted number of firms in each segment that is driven by segment size relative to sunk costs, controlling for other factors. Clearly the relationship between numbers of firms in a segment and segment size relative to sunk cost is shifted by the strategic conduct of firms. The true partial relationship is illustrated in Figure 3, where we observe as segment size relative to sunk costs rise, the number of roles in a segment increases at a diminishing rate.

In a similar way, we transform the coefficients of our firm dummies to ascertain whether certain firms are estimated to have a greater probability of entering a given segment, controlling for other factors. Using the estimated probability, we predict the number of segments that a firm would be expected to capture out of the possible 40 segments. This is plotted against the rank of firms in the Carbonated Soft drinks market in Figure 4. The negative

Table 2: *Firm Participation in Segments – Logit Regression Results*

Dependent Variable = 1 if Firm Participates in a Segment over period October 1992-March 1997, = 0 Otherwise	
Pseudo R^2	0.60
Constant	−5.4
	(2.9)*
Segment Size/Median Firm Size in Segment	0.19
	(3.1)*
Segment Dummies	YES
Firm Dummies	YES
No. Observations	481
Log Likelihood	−102.39

Figure 3: *The Predicted Number of Firms in Segment (Roles) by Segment Sales/Sunk Costs, Average over October 1992-March 1997*
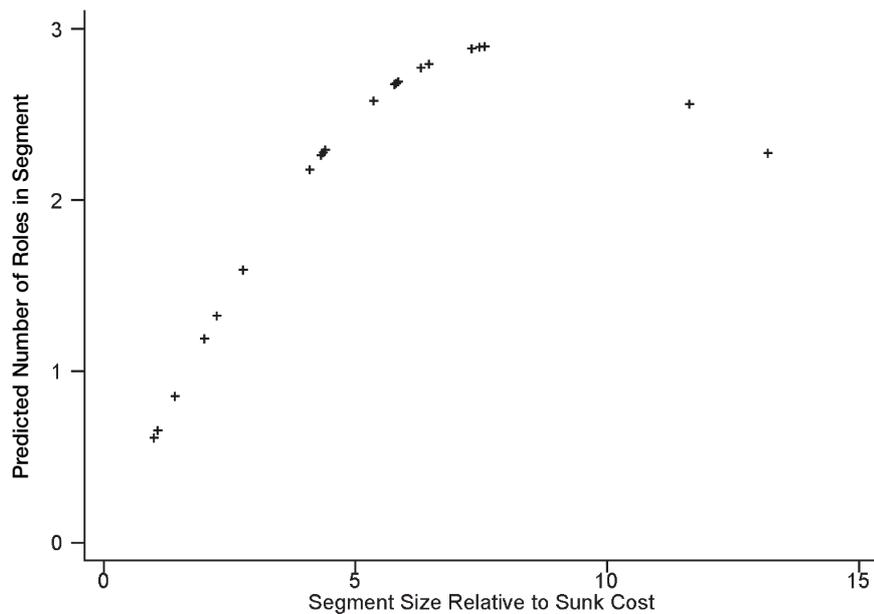
relationship is indicative of the fact that the larger firms in the market have, on average, taken up more roles over segments historically. Such firm specific effects may reflect some sort of strategic advantage from advertising, first mover advantage or scope economies. It may simply be that the firm has been in the market longer.

This latter effect clearly leads to the skewed firm size distribution observed in Carbonated Soft Drinks. Coca-Cola is ranked one in the Carbonated Soft Drinks retail market in Ireland over the period 1992-1997, but its dominance does not result from its performance in the Cola market. Rather its success lies in the establishment of a portfolio of brands across 91 per cent of vertical segments. Small firms can co-exist with large firms in this market by operating only in a few of the concentrated segments.

Figure 4: *The Predicted Number of Roles by Firm Rank, average over October 1992-March 1997*
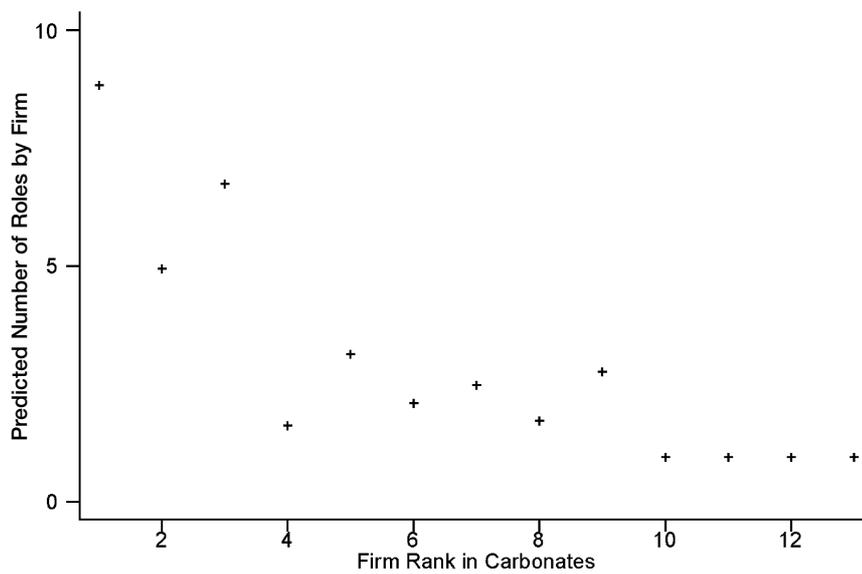
V CONCLUSION

We document how the different degree to which firms participate over vertical segments places Sutton's (1998) mathematically predicted lower bound on the shape of the firm size distribution in Carbonated Soft Drinks. The key structural feature that explains firm size distribution is the heterogeneous take-up of roles by firms across vertical segments during market evolution. At the brand level one can see turbulence in the data. Yet, all this bi-monthly micro-economic activity within segments does not override the persistence and stable firm size distribution at the product level that results from heterogeneous firm participation rates across segments.

While the number of firms in each segment is small, we find that as segment size relative to sunk costs rise, the number of roles in a segment increases at a diminishing rate. We also estimate that firm specific effects have induced certain firms in Carbonated Soft Drinks to be more likely to have taken a role in any given segment historically. Such firm specific effects may reflect some sort of strategic effect, or may simply be due to the firm being in the market longer. The size of firm portfolios is the key to understanding the firm size distribution observed in Carbonated Soft Drinks.

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