11. Ruebeck article 25/6/02 3:08 pm Page 119

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Interfirm Competition, Intrafirm Cannibalisation and Product Exit in the Market for Computer Hard Disk Drives

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Abstract: Intrafirm "cannibalisation" of a product's demand by the firm's own products is found to have a more robust and significant relationship to the probability of its withdrawal than does interfirm competition from other firms' products.

I INTRODUCTION

Multiproduct firm behaviour, in particular the firm's internalisation of cross-price effects between its products, has proven to be a challenge for theoretical study, and there is little empirical literature to serve as a guide. The market for computer hard disk drives is one in which product exit is observed frequently. It is also especially well-suited for econometric analysis due to the highly quantitative nature of hard disk drives' characteristics and buyers' quantitative evaluation of them. A discrete hazard model is used to estimate the relationship between a product's exit from its submarket and measures of interfirm competition and intrafirm cannibalisation.

The results show that, while both interfirm competition and intrafirm cannibalisation impact product withdrawal, cannibalisation is by far the more important factor. Its role is strong and robust to the specification. In a time-varying hazard specification, age beyond one year has no impact on product

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11. Ruebeck article 25/6/02 3:08 pm Page 120

withdrawal. Neither does overpricing have a significant effect, in contrast to previous findings in other product markets.

II PRODUCT DIFFERENTIATION AND SHRINKING LOCAL MARKETS

Vertically differentiated products are those for which consumer utility is defined to be

$$U = \theta s - p$$

where s is the quality level of the product and p is its price. For disk drives, "quality" will be the capacity of the disk drive. Other examples of vertically differentiated product features are a light bulb's longevity, the octane rating of a gallon of gasoline, and a physician's success rate. Each buyer's value of θ indicates his willingness to pay for improved capacity and is measured in dollars per megabyte. The distinguishing feature of vertical product differentiation is that all buyers agree that higher capacity drives are better; they only differ in their willingness to pay for another megabyte.

The disk drive market is one in which major differentiation across the *entire* disk drive market is uni-dimensional and vertical, in megabytes of drive capacity. Yet in the sub-markets that cover smaller regions of characteristic space, the differentiation is multi-dimensional: these additional dimensions can have either horizontal differentiation (e.g. manufacturer) or vertical differentiation (e.g. speed). Therefore, Section III defines submarkets in terms of similar capacity drives while leaving the formal description of product differentiation within submarkets unspecified. This appears justified by the observed clustering of drives in easily defined submarkets and the theoretical fact that even a little horizontal competition can substantively change market behaviour.[1] Additional support comes from the remarks of market experts (Porter, 1979 - present) and the quantitative results of hedonic price regressions in Ruebeck (2000). It is also telling that several firms may produce a drive of capacity s – in fact, *one* firm may even produce more than one drive of capacity s. Vertical differentiation in a single dimension does not effectively capture these features of the market.

[1] The usual practice with multi-characteristic products is to collapse the various characteristics into a single (hedonic) price index, e.g. Bresnahan (1987). Feenstra and Levinsohn (1995) estimate an econometric specification with multi-dimensional differentiation. For theoretical discussions of the effects of horizontal as well as vertical differentiation and multi-dimensional vertical differentiation, see Shaked and Sutton (1987), Anderson, Depalma, and Thisse (1992), or Anderson, Goerce, and Ramer (1997).

A downturn in local market demand inevitably occurs in hard disk drive submarkets due to falling prices of disk drives in more technologically advanced submarkets. Theory, though, is unclear on the subject of what effect either increased competition or increased cannibalisation should have on the likelihood of withdrawal. More rivals' products near drive *i* (competition) may mean that it has a low price-cost margin due to lower market share and will sooner reach zero profit. As well, if a multiproduct firm withdraws products that are generating positive profits (to increase the firm's total profits), then we should expect both increased interfirm competition and intrafirm cannibalisation to increase the likelihood of product exit. Yet with more models near *i* made by other firms, the firm producing *i* may be less likely to capture the resulting increase in demand per product if it removes *i*. It is also not obvious whether more of the firm's own products near *i* indicates "too many" similar products or market power (which the firm may want to continue to exploit). Finally, having several drives located near each other may benefit the firm's reputation in the eyes of local buyers.

Although the literature has not yet addressed this question directly, Ghemawat and Nalebuff (1990) find that in a declining industry, when two single-product firms differ in production capacity, the result is that the larger firm will decrease its production capacity before either firm exits. Their result is conceptually similar to the prediction that the multiproduct firm with more products is the first to withdraw one of them. This matches nicely with the empirical results presented below, as well as the predictions of a stylised model in Ruebeck (2000). In that model, multiproduct firms are assumed to produce uniformly symmetrically differentiated products and find a Cournot-Nash equilibrium. Market structure is exogenous. As demand decreases across markets the marginal effect on one of the firm's products of both (a) a marginal increase in the products available from this firm and (b) a marginal increase in the products available from a rival firm have negative effects on the profit of the firm's products, but the own increase in products is stronger—due to the internalisation of the cross-price effect.

III THE EMPIRICAL MODEL AND MARKET STRUCTURE VARIABLES

The effects of product, firm, and local market characteristics on the probability of a product's exit are measured using a probit specification with the dependent variable, y_{it}, equal to 1 if the observation of model *i* at time *t* is the last for which positive quantity is observed, and equal to 0 for other observations of positive quantity. Observations in which quantity is zero are not included in the estimation. Thus the model of exit is:

$$y_{it} = \begin{cases} 1 & \text{if } x_{it}\beta + u_{it} > 0, \\ 0 & \text{otherwise} \end{cases}$$

where x_{it} is the vector of explanatory variables for model i at time t, β contains the associated parameters, and u_{it} is i.i.d. normal (the CDF of which is $\Phi(\cdot)$). The estimation then maximises the likelihood function

$$L = \prod_{y_{it}=0} \Phi(-x_{it}\beta) \prod_{y_{it}=1} (1 - \Phi(-x_{it}\beta)) \quad (1)$$

The explanatory variables x_{it}, listed in Table 1, include measures of local and market-wide competition, measures of product i's level of technological sophistication relative to all other drives available at t, and measures of i's relative price at t. Others' work that has considered product exit are Stavins (1995), who focuses on product-level effects versus firm-level effects, and Greenstein and Wade (1998), who investigate similarities between variables in their determination of product location and exit. Lerner (1995) investigates the effects of financial constraints on competition using disk drive data and employs some similar techniques in submarket definition.

Any drive produced at time t which has the same diameter as i and whose capacity is within 20 per cent of drive i's capacity (measured in megabytes) will be defined to be in the same submarket as i. For example, the competition faced by drives of capacity 200MB is those drives with capacities between 180MB and 220MB.[2] The variables which capture local market structure follow from this definition. Intrafirm cannibalisation (ndOwn) is measured as the number of local models produced by the same firm that produces i, and interfirm competition (ndOth) is measured as the number of local models produced by rival firms. Other variables capture the local Herfindahl index (the sum of squared firm market shares), the number of local firms, the share of local revenues brought in by the firm that produces drive i, and the quantity of all drives sold near i.

Drawing the local market boundary of drive i at 10 per cent or 40 per cent of its capacity generates similar but somewhat weaker results as compared to those presented in Section V, while using a cutoff of 0.5 per cent, 1 per cent, or 50 per cent produces still weaker results. The significance of the findings with a 20 per cent boundary suggests that this is the market's own definition of local competition. Lerner, using disk drive data from Porter during the 1980s employed similar definitions of local markets.

[2] I assume, as do Lerner (1995, 1997) and Thomas (1999), that there is little competition across drive diameters because disk drives are generally bought for a computer design that require drive bays of a certain physical size.

11. Ruebeck article 25/6/02 3:08 pm Page 123

Table 1: *Variables that Characterise a Drive Model*

yq	year and quarter of the observation (91 to 93.75)
mbytes	capacity of the drive in megabytes
stdlmb	linear map of log(mbytes) into [0, 1] interval for each yq
price	price of drive in dollars
age, ageSq	the time since the model was first shipped and its square
ageN	age by year: age < 1, 1 ≤ age < 2, ..., 4 ≤ age < 5, age ≤ 5
diam	diameter of the drive: 2.5", 3.5", or 5"
coname	firm that sells the drive
coAge	age of the firm that sells the drive

Competitive	Cannibalistic	Demand	
ndOth			# nearby models made by other firms
	ndOwn		# nearby models made by producer of *i*
ndrPer			nearby market revenue share of producer of *i*
	shfirm		drive *i*'s share of its firm's revenue
caTotI			any introductions at *t* by producer of *i*
nf			# nearby firms
rH			local Herfindahl index
		quantity	# drives sold, in thousands

Note: Market variables used in probits as determinants of drive *i*'s probability of exit: indications of *inter*firm competition ("Competitive" forces), *intra*firm competition ("Cannibalistic" forces), and local demand ("Demand") near drive *i*.

IV THE DATA

The data set covers drives sold from the first quarter of 1991 through the last quarter of 1993. Due to the rapid pace of innovation in this market, the characteristics of drives were highly inferior to today's disk drive specifications. It is also true that the buyers of disk drives have always largely been computer manufacturers. According to Porter, these "OEM" (original equipment manufacturer) sales accounted for about 80 per cent of drives purchased during the time period under study.

Two data sets were combined for this analysis. Price and quantity information are from Olley and Himmelberg (1995), who use data collected by a market research firm from both manufacturers and buyers of hard drives with the goal of reproducing average transaction prices of selected drives from seven US manufacturers whose total output covers about 90 per cent of sales in the US disk drive market. Information was collected for drives produced in the twelve consecutive quarters of 1991, 1992, and 1993. Average transaction prices and total quantities shipped were recorded at the product level along with drive name, first month and year of shipment (which for many drives is before 1991), and a few technical characteristics (physical height and disk diameter, and the number of platters in the enclosure). Additional technical specifications are from annual databases obtained from Porter, which attempt to cover the entire drive industry.

Table 2: *Summary Statistics*

Variable	*N*	*Mean*	*StDv*	*Min*	*Max*
price	892	445	419	60.5	2663
mbytes	892	380	491	20	3022
age	871	1.61	1.54	0	9
ageSq	871	4.95	9.78	0	81
IageN_1	892	0.39	0.49	0	1
IageN_2	871	0.27	0.45	0	1
IageN_3	871	0.17	0.37	0	1
IageN_4	871	0.07	0.26	0	1
IageN_5	871	0.05	0.22	0	1
IageN_6	871	0.04	0.19	0	1
I[2.5" diam]	892	0.21	0.41	0	1
I[3.5" diam]	892	0.59	0.49	0	1
I[5.25" diam]	892	0.2	0.4	0	1
I[Conner]	892	0.15	0.36	0	1
I[IBM]	892	0.07	0.26	0	1
I[Micropolis]	892	0.1	0.3	0	1
I[Maxtor]	892	0.12	0.33	0	1
I[Quantum]	892	0.2	0.4	0	1
I[Seagate]	892	0.28	0.45	0	1
I[Western Digital]	892	0.07	0.26	0	1
Exit	871	0.1	0.3	0	1
ndOwn	871	1.97	1.26	1	7
ndOth	871	4.99	3.22	0	16
shfirm	871	6.42	9.18	0.003	73
ndrPer	871	33.2	27.3	0.3	100
nf	871	3.87	1.38	1	6
rH	871	0.439	0.21	0.197	1
quantity	871	0.073	0.14	0.0001	0.81
stdlmb	871	0.536	0.25	0	1
caTotI	871	0.85	0.36	0	1
coAge	871	12.4	7.37	3.75	37.5

Each observation used for analysis combines these two data sets to include information in a particular quarter about a particular drive: its (uncensored) first shipment date, its transaction price, the quantity sold during that quarter, and the drive's technical specifications. The technical specifications do not change over time, a drive is not included in the estimation until its quantity is positive, and it is removed when quantity becomes zero.

Summary statistics appear in Table 2. Often in the empirical analysis logs are taken (indicated by an "l" prefix), as is customary in the hedonic literature. Doing so seems particularly appropriate with disk drive capacity because the size of relevant comparison intervals naturally increases as drive size increases: the comparison between a 120MB drive and a 140MB drive should be similar to the comparison between 1.2GB and 1.4GB drives.

V THE EFFECT OF MARKET STRUCTURE ON PRODUCT FAILURE

The results of estimating the effects of product, firm, and local market characteristics on the probability of product exit in the specification of Equation (1) are reported in Tables 3 and 4. The most striking feature is the robustness of the intrafirm cannibalisation variables, ndOwn and shfirm, in the prediction of exit.

Market Structure: Intrafirm Versus Interfirm Effects

While the number of the firm's own drives that compete with drive *i* at time *t*, ndOwn, has a consistently positive effect on exit, the number of rivals' competing drives, ndOth, does not significantly affect drive *i*'s likelihood of failure. Intrafirm effects appear to be more important when considering local competition. Revenue shares also illustrate the importance of intrafirm over interfirm effects. Model *i*'s share of its firm's revenues at time *t*, shfirm, has a negative effect on the likelihood of its exit. Although not significant when including the age of the firm in the regression (column 5 of Table 3), it is highly significant when firm dummies are included (in Table 4). Note, too, that controlling in this manner for product *i*'s importance to firm revenues does not diminish the significance of the cannibalistic effect, ndOwn. The relationship between product *i*'s exit and its firm's percentage share of the local market's revenues at *t*, ndrPer, also is negatively related to exit (Table 3). It would appear that if a product is manufactured by a firm with local market power, that product is less likely to exit the market. The relationship, however, becomes insignificant when firm dummies are included (Table 4). Thus, in relationship to a product's exit, the importance of drive *i* to firm profits at time *t* (shfirm) varies between *and* within firms in the sample while the importance of the firm's local market power at time *t* (ndrPer) appears only to vary across firms.

11. Ruebeck article 25/6/02 3:08 pm Page 126

Greenstein and Wade find that the introduction of a new mainframe computer near model *i* by the same firm that produces *i* increases the probability of exit, but the use of similar variables to predict disk drive exit shows no consistent relationship. Unreported results included indicators of intra- and inter-firm introductions nearby. For example, the variable caTotI, which indicates the existence of *any* introduction (nearby or not) by the firm that produces *i* at time *t*, does not have a consistently significant relationship with exit, as reported in Tables 3 and 4. Thus it does not appear that firms in this market are systematically introducing new products and then retiring older ones. Firms are introducing better drives, perhaps to keep pace with demand and technological change, rather than in anticipation of dropping older drives.[3]

Tables 3 and 4 show that there is a strong relationship between the age of a drive and the likelihood that it will be withdrawn, but that this effect decreases over the drive's age. Not only is the non-linearity evidenced by the significance of ageSq, but also by allowing the relationship with model age to take the more flexible form specified in column 1 of Table 4. In fact, F-tests for differences among these indicators Iage_1 … Iage_6 confirm that there is *no* significant difference in the likelihood of exit after the drive has been sold for one year. It is simply that drives are unlikely to exit in the first year of availability. Considering others' results, the significance of age is not surprising. The sign on age matches results in the probits of Stavins' study of exit in the PC market, and in Greenstein and Wade's study of mainframe computers' exit. Of more importance is the *non*-existence of a model age effect after the first year on the market. What we are seeing is *little* effect of increasing age, once a product has proven itself. After being on the market for a year, the features and market variables are what determine product exit. It may take a year for the firm and/or the buyers to learn enough about a model to decide whether or not it belongs on the market given its features and the features of other models nearby.

Residuals and signed squared residuals from quarterly hedonic price equations are included in column 4 of Table 4 to compare the disk drive market to the results Stavins finds in the personal computer market. Her interpretation of their significant positive coefficients in the prediction of product exit was that models with unexplained excess quality-adjusted price were more likely to be withdrawn (and thus the residuals, although not econometrically identified, were associated with high producer costs, not high

[3] Informal conversation with a former executive at one of the firms in the sample during the time period studied confirms this characterisation, as well as firms' determination of product location and withdrawal separate from the pricing decision.

Table 3: *Estimated Coefficients in Varying Hazard Rate Model of Product Exit*

Dependent Variable 1 if Exits	(1) *Cannibalistic Effect*	(2) *Competitive Effect*	(3) *Together, with Controls*	(4) *Own-firm Introductions*	(5) *Firm Age*
ndOwn, firm's local models	0.14 (0.046)**		0.19 (0.057)**	0.19 (0.058)**	0.21 (0.057)**
ndOth, others' local models		0.012 (0.019)	0.037 (0.033)	0.038 (0.034)	0.03 (0.034)
shfirm, *i*'s % share of firm revenue			–0.61 (0.30)*	–0.58 (0.31)†	–0.38 (0.31)
ndrPer, firm's % share of local revenue			–0.94 (0.35)**	–0.92 (0.35)**	–0.82 (0.35)*
rH, local Herfindahl index			1.152 (0.56)*	1.159 (0.57)*	1.211 (0.57)*
quantity, quantity of drive *i* sold			–4.16 (1.99)*	–4.28 (2.01)*	–5.97 (2.15)**
standardized lmbytes, range [0, 1]	–0.88 (0.27)**	–0.9 (0.27)**	–0.8 (0.30)**	–0.82 (0.31)**	–1.11 (0.33)**
age, time since 1st shipment in years	0.48 (0.10)**	0.44 (0.10)**	0.54 (0.10)**	0.54 (0.10)**	0.58 (0.11)**
ageSq, age squared	–0.04 (0.014)**	–0.038 (0.014)**	–0.049 (0.014)**	–0.049 (0.014)**	–0.057 (0.014)**
caTotI, has firm introduced?				0.093 (0.22)	
coAge, age of this firm in years					–0.041 (0.013)**
Constant	–1.84 (0.24)**	–1.54 (0.24)**	–2.12 (0.47)**	–2.19 (0.50)**	–1.58 (0.50)**
Log Likelihood	–246	–250	–213	–213	–208
Observations	871	871	871	871	871

Note: The dependent variable is 1 if the observation is the last quarter in which the drive is observed and 0 otherwise. † = significant at 10 per cent level; * = 5 per cent level; ** = 1per cent level. Standard errors are in parentheses.

consumer value). In this market, we instead see that they are not significantly related to exit. This contrast with results from the personal computer market may be explained by considering the differences in the depth and type of knowledge that buyers have about computer and disk drive products. As compared to the personal computer, it is easier for buyers to collect information about disk drives and it is easier for the econometrician to specify and measure models' characteristics. We would thus expect to find few disk drives that are over- or under-priced compared to their costs. Product exit occurs *before* they become over-priced because buyers easily understand

11. Ruebeck article 25/6/02 3:08 pm Page 128

Table 4: *Estimated Coefficients in Varying Hazard Rate Model of Product Exit*

Dependent Variable: 1 if Exits	(1) *General Hazard Rate*	(2) *Quadratic Hazard Rate*	(3) *Own-firm Introductions*	(4) *Hedonic Residuals*
ndOwn, Firm's local models	0.24	0.24	0.24	0.25
	(0.071)**	(0.069)**	(0.069)**	(0.075)**
ndOth, Others' local models	–0.0015	–0.0031	–0.0013	–0.037
	(0.038)	(0.037)	(0.037)	(0.042)
shfirm, Drive's % share of	–1.16	–1.21	–1.21	–1.21
firm revenue	(0.44)**	(0.45)**	(0.45)**	(0.466)**
ndrPer, Firm's % share	–0.48	–0.55	–0.54	–0.38
of local revenue	(0.38)	(0.38)	(0.38)	(0.42)
rH, Local Herfindahl index	0.88	0.79	0.81	0.63
	(0.61)	(0.60)	(0.60)	(0.63)
quantity, Quantity of drive *i* sold	–3.52	–2.62	–2.68	–2.88
	(2.54)	(2.45)	(2.46)	(2.64)
Standardised lmbytes, range 0 to 1	–0.95	–0.76	–0.79	–0.89
	(0.38)*	(0.38)*	(0.38)*	(0.40)*
age, time since first		0.78	0.78	0.79
shipment in years		(0.12)**	(0.12)**	(0.13)**
ageSq, age squared		–0.073	–0.074	–0.076
		(0.015)**	(0.016)**	(0.016)**
IageN_2, I[1 ≤ age < 2]	1.25			
	(0.23)**			
IageN_3, I[2 ≤ age < 3]	1.34			
	(0.24)**			
IageN_4, I[3 ≤ age < 4]	1.60			
	(0.32)**			
IageN_5, I[4 ≤ age < 5]	1.71			
	(0.33)**			
IageN_6, I[age > 5]	1.63			
	(0.40)**			
caTotI, Has firm introduced?	0.24		0.21	0.21
	(0.26)		(0.25)	(0.27)
lpV, log-log hedonic resids by year				0.14
				(1.56)
lpVSq, log-log hed. resids by year sqd				–7.36
				(6.51)
I[Micropolis]	–2.11	–2.03	–1.91	–2.94
	(0.94)*	(0.91)*	(0.92)*	(0.99)**
I[Maxtor]	–0.94	–0.92	–0.81	–1.37
	(0.52)†	(0.51)†	(0.52)	(0.56)*
I[Quantum]	–1.97	–1.86	–1.79	–2.64
	(0.75)**	(0.74)*	(0.74)*	(0.81)**
I[Seagate]	–3.18	–3.04	–2.95	–4.09
	(0.92)**	(0.90)**	(0.90)**	(0.98)**
I[Western Digital]	1.66	1.67	1.63	1.99
	(0.46)**	(0.45)**	(0.46)**	(0.48)**
I[IBM]	–12.6	–11.87	–11.2	–16.2
	(4.34)**	(4.17)**	(4.25)**	(4.60)**
coAge, Age of this firm in years	0.39	0.36	0.34	0.50
	(0.14)**	(0.14)**	(0.14)*	(0.15)**
Constant	–4.86	–4.51	–4.55	–5.38
	(1.07)**	(1.03)**	(1.04)**	(1.11)**
Log likelihood	–187	–190	–190	–174
Observations	871	871	871	825

Note: The constant term represents a drive manufactured by Conner, and in column 2 of less than one year age. For additional notes, see Table 3.

11. Ruebeck article 25/6/02 3:08 pm Page 129

disk drives' value. On the other hand, in the personal computer market it is not as easy for either the buyer or the econometrician to judge product quality. Thus, inferior personal computers periodically survive long enough to be overpriced (having high hedonic residuals); at that point they are more likely to exit.

There is also not a significant relationship between exit and drive diameter, either by itself or interacted with ndOwn. This result supports the pooling of drives across diameter in Tables 3 and 4. Consider also that during this time period the 5.25" drives are a declining market, the 3.5" segment is a strong, dominant market, and 2.5" drives are a growing market. Then the insignificance of drive diameter supports the generality of the cannibalistic-versus-competitive results for submarkets in different stages of the product life cycle. Further regressions in Ruebeck (2000) reinforce the robustness of these results.

Marginal Effects: Comparative Importance of Cannibalisation

Table 5 details the marginal effects on exit in the specification of column 5 in Table 3. (The marginal effects using the specifications of the other columns of Tables 3 and 4 are similar.) Noting that the average probability of exit observed in the data is 10 per cent = 0.10, we can see that the cannibalisation variables have effects of economically significant magnitude. An increase in the number of own nearby drives, ndOwn, by 1 produces a 10 per cent change in the likelihood of exit (0.01/0.10). An increase of one percentage point in the share of firm revenues produced by drive i produces a 5 per cent change in the likelihood of exit (0.005/0.10).

Although in the case of ndOwn this is a 50 per cent increase in the variable's average value and in shfirm this is about a 15 per cent increase, it is still a larger change in the probability of exit than that produced by increasing the firm's share of the local market by 50 per cent (multiply 0.0005 by half of 33.2). The measure of local competition, the Herfindahl index, ranges from 0 to 1 and its reciprocal is the number of "equivalent firms" (in the sense of symmetric Cournot oligopolists) in the local market. The observed average, then, is 1/0.439 = 2.3 equivalent firms. Increasing this by 1 equivalent firm brings the Herfindahl index to 1/3.3 = 0.3. This change in market structure causes the same change in the likelihood of exit (0.01, a 10 per cent change) as does increasing the own number of products: (0.439-0.3)0.07 = 0.0097. The number of other firms' drives, ndOth, has already been noted to have a coefficient that is not significantly different from zero in Tables 3 and 4, and the point estimate of its marginal effect is also about an order of magnitude smaller than the marginal effect of ndOth on exit.

Table 5: *Marginal Effects on Exit in Column 5 of Table 3*

Variable	*Mean Value, in Table 2*	*Change in Variable*	*Predicted Probability of Exit Increased by*
ndOwn, number of own nearby drives	1.97	1	0.01
shfirm, % share of firm revenues	6.42	1	–0.005
ndrPer, firm's share of local market	33.2	1	–0.0005
rH, local Herfindahl index	0.439	1	0.07
coAge, firm age in years	12.4	1	–0.002

Note: The mean value of exit in Table 2 is 0.10, so an increase of 0.01 (the rightmost column of this table) represents a 10 per cent increase in the likelihood of exit. The calculations are performed at the average values of the regressors. The Herfindahl index has a range of [0,1].

VI CONCLUSIONS

A robust relationship has been found between greater local market intrafirm competition and a higher probability of product exit. In contrast, the number of competitors' models does not significantly affect exit. As in other existing studies of product-level exit, the discussion here is lacking a structural model of the forces which determine the timing of product exit, but the theoretical work which bears on single- and multi-product firms supports the finding of significant intrafirm cannibalisation effects. A model of symmetric Cournot oligopolists (Ruebeck 2000) predicts that cannibalisation should have the stronger effect on profits and thus also on exit. Shaked and Sutton's (1990) two-parameter model of a three-product, two-firm market indicates that a firm with more products (two of them) withdraws one of its products before a firm with fewer products (one of them). Ghemawat and Nalebuff's analysis of credible firm exit by single-product duopolists indicates that the larger firm will decrease its production capacity before either firm exits.

Finally, there is some relationship between these results and merger policy. The question often arises whether the forces that might drive other non-merging firms out of the market are stronger or weaker than the incentives for the newly merged firm to thin out its product line. These empirical results suggest the latter possibility as likely: if intrafirm cannibalisation has a stronger relationship to product withdrawal, then it is the newly merged firm's products that will be more likely to be thinned out as a result of increasing concentration.

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11. Ruebeck article 25/6/02 3:08 pm Page 132