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Ain't it "Suite"? Strategic Bundling in the PC Office Software Market

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Abstract

Our paper examines the importance of strategic bundling for the evolution of market structure and the performance of the PC office software market. Using a discrete choice model of product differentiation, we find strong empirical support for negative correlation in consumer preferences over word processors and spreadsheets. Negative correlation between these components creates an incentive for strategic bundling that Microsoft exploited successfully with its office suite products.

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1. Introduction

The purpose of our paper is to analyze the importance of strategic bundling for the evolution of market structure and the performance of the PC office software market, where office software includes word-processors, spreadsheets, presentation software, database management software, and suites.

There were dramatic structural changes in the office productivity software markets in the 1990's. The market grew tremendously from 1991-1998, the period for which we have consistent data. There was a shift from DOS based software programs to WINDOWS based software programs. There was also a shift in market leadership away from Lotus (in the spreadsheet market) and Wordperfect (in the word processor market) to Microsoft. Finally, there was change in marketing strategy from selling components to selling office suites, where the components are integrated together in a single package.

A key hypothesis is that there is negative correlation in demand for word processors and spreadsheets, the two most important components of the office software market. Using a discrete choice model of product differentiation, we find strong empirical support for negative correlation in consumer preferences over word processors and spreadsheets. Negative correlation between these components creates an incentive for strategic bundling that Microsoft exploited successfully with its office suite products. Our empirical results are consistent with the notion that only Microsoft successfully integrated the components into a bundle.

We believe that the contributions of our paper are as follows:

- To the best of our knowledge, we are the first to develop and empirically estimate the correlation in preferences of consumers across products (spreadsheets and word processors in our setting). Using a discrete choice model of product differentiation, we find strong empirical support for the negative correlation hypothesis.

- This paper contributes to the theoretical literature on bundling and oligopoly competition. While there is a significant literature on product bundling by a monopolist, not much has been done on oligopoly incentives (McAfee, McMillan, and Whinston, 1989). Our theoretical model develops a new explanation of strategic bundling incentives in an oligopoly setting.

- The paper also contributes to the literature on the estimation of discrete choice models of product differentiation. We extend the standard model to the case when the unobserved heterogeneity is not independent across products. In our setting, there are spreadsheets, word processors and suites in the product market. Clearly, the unobserved characteristics of a Microsoft Word spreadsheet (Excel) are correlated with the unobserved characteristics of a Microsoft Word Suite package (which includes Excel among other things). Hence, estimation must take account of this dependence. Previous empirical work has not addressed this issue, despite the fact that this phenomenon is not unique to office software.[1]

This paper is related to Liebowitz and Margolis (1999), who previously studied the evolution of word processor and spreadsheet markets. They heuristically argue that Microsoft's dominance of the word processor and spreadsheet markets is due primarily to the Microsoft's component products. We conduct an empirical (econometric) analysis and examine how product quality, bundling, and other factors affect demand in the office software market, a market that includes suites, as well as word processors and spreadsheets. Empirical work on the software industry has focused on the DOS market and on testing for the presence of network effects. See Gandal (1994), Gandal, Greenstein, and Salant (1999).

[1] Crawford (2001) empirically examines the importance of bundling in the cable television industry. He shows that the demand for network bundles is more elastic when there are more networks in the bundle. Our approach differs from his in the sense that (i) we allow for and model the correlation in unobserved characteristics across products and (ii) we model and estimate the correlation in consumer preferences across products.

The paper proceeds as follows. In section 2, we discuss the incentives for strategic bundling. Section 3 discusses the evolution of the PC office software market. Section 4 discusses the data we employ in our empirical analysis. In section 5, we conduct the model we estimate and the estimation algorithm. Section 6 discusses the preliminary empirical results. Section 7 discusses further work on the project.

2. Incentives to Bundle

It is well known that a monopoly can earn additional revenue by either bundling or selling mixed bundles when consumer preferences for the components of the bundle are negatively correlated. Using a simple model of bundling that we develop in Appendix A, we show that a similar result obtains in an oligopoly setting.

Using a duopoly model, we first show that an integrated firm has an incentive to bundle when competing with unintegrated rivals. We then show that when both of the duopolists are vertically integrated, bundling or mixed bundling is a best response for both vendors. Therefore, in equilibrium, both firms offer a bundled product.

The strategic incentives for bundling arise in the model as a consequence of the assumed demand structure of consumer preferences. Implicit is an assumption that the demand for two products is strongly negatively correlated. That is the consumers, who have a high willingness to pay for one of the components, have a relatively low willingness to pay for the other component, and conversely. This negative correlation in preferences enables a vendor offering a bundle to gain a competitive advantage in selling to one group of consumers without sacrificing revenues earned from the other group of consumers.

In section 6, we find empirical support for negative correlation in consumer preferences over word processors and spreadsheets. Our theoretical model suggests that integrated firms will indeed bundle in such a case.

3. Evolution of PC Office Software Market, 1991-1998

At the start of the 1990's, the PC office software market was already well established with a clearly delineated structure. Wordperfect led in the word processor category (Figure 1), Lotus in the spreadsheet category (Figure 2) and presentation graphics, and Borland in database management. These software applications were distinct and sold separately, and overwhelmingly were based on the DOS operating system. The total market for PC office software was approximately $2.6 billion in 1991.

The release of WINDOWS 3.0 in 1990, and subsequent improvements, changed all of this. By 1998, Microsoft dominated the PC office software market. The previously distinct applications were bundled in office suites, and overwhelmingly based on the WINDOWS platform. The size of the market had grown to more than $6 billion in 1998. See figure 3.

There are several distinct phases of development: 1991-92, 1993-94, 1995, and 1996-98. We discuss each of these in turn.

In 1992, WINDOWS surpassed DOS as the platform of choice for PC office applications. (See Figure 4.) This was a period of new product introduction and improvement, as competitors adapted (for better or worse) to the new WINDOWS platform. Microsoft clearly led the introduction in sales of WINDOWS based applications. Competitors were later out of the gate, and experienced more difficulty ironing out the bugs. Reviews generally agreed that the Microsoft products were superior. Nevertheless, the data clearly show that the switch in platforms from DOS to WINDOWS did not eliminate rivals in the spreadsheet and word processing markets.

Microsoft (1991) and Lotus (1992) each introduced office suites for WINDOWS in this period, but these products contributed little to industry revenue. These early office suites contained non-integrated word-processor, spreadsheet, database, and graphics modules that mostly were stripped-down versions of the stand-along products. Microsoft was the first to sell suites; during this period, the main competition to Microsoft Office was single

product applications sold by Word Perfect in the word processing market, and Lotus in the spreadsheet market.

Office suites gathered importance in 1993-94. (See figure 5.) This was a period of continuous product improvement as office software vendors adapted to an improved version of WINDOWS released in 1992. The new generation of suites were more likely to contain full-featured applications, but still lacked significant integration. Microsoft was best positioned in the office suite category because it already had highly-rated versions of key underlying components. Lotus formed an alliance with AmiPro in 1993 to offer a suite containing full-featured spreadsheet and word-processor applications. Microsoft's response in the spring of 1994 shook up the industry. Microsoft Office, containing full-featured versions of its word-processor, spreadsheet, presentation graphics, and database software, was a run away favorite among reviewers. A major reorganization of industry assets followed, as Novell acquired WordPerfect and Borland's QuattroPro to field a competitive full-featured product in late 1994. The reviewers still weren't persuaded, and Novell exited the industry the following year, selling its office software assets to Corel. Meanwhile, Lotus merged with AmiPro. By the end of 1994, WINDOWS dwarfed DOS as a platform for office applications (figure 4), suites had emerged as the most important product category (figure 5), and Microsoft had the dominant product in this category (figure 6).

1995 was a watershed year. Microsoft released WINDOWS 1995 in the summer and followed immediately with powerful new versions of its office applications bundled into Office 95. Competitors were caught off guard and failed to offer new products that took advantage of WINDOWS 95. The market for DOS applications all but vanished, and Microsoft's revenue share of the fast growing WINDOWS based office software market surged upward.

In 1996, the competition struck back. Corel's Wordperfect Suite and Lotus' SmartSuite were well-received and achieved modest market shares (figure 6). This success led to increased price competition (see Figure 7), causing revenue growth to slow for the first

time. Microsoft Office remained the most highly rated office suite among the three, and by the end of 1998 was dominant in the market.

Word Processing and Spreadsheets are by far the most important two components of the PC office software packages — Figure 5 shows that these categories are much larger than the Presentation and Database Management Categories. During the 1991-1998 period, word processors, spreadsheets and suites accounted for more than 90% of PC Office software revenue. We'll focus on these products both in our simple model and in the empirical analysis.

There were essentially three firms in the office software market: Microsoft, IBM/Lotus and Borland/Corel/Novell/WordPerfect (hereafter Corel/WP). These three firms accounted for at least at least 90% of the WINDOWS office software market from 1993-1998 and 94% of all revenues in every year in the spreadsheet, word processors and suite markets combined during the 1991-1998 period. No other firm had more than a negligible market share in any of these markets during the 1991-1998 period. (See figure 3.) Hence we limit our econometric analysis to products offered by these three firms.

4. Data

Our dataset includes the key office software products: spreadsheets, word processors, and suites. Computer hardware (operating systems) and software are complementary products and the benefit from software consumption can only be realized if consumers have an operating system capable of running the particular software package. In order to focus exclusively of software effects, the sample was restricted to spreadsheets, word processors, and office suites that were compatible with the WINDOWS operating system.[2] Packages that were compatible only with the Apple/Macintosh operating system, for example, were not included.

[2] For ease of presentation we refer to WINDOWS for all versions of the WINDOWS operating system made for PCs, including WINDOWS 3.x, WINDOWS95, and WINDOWS98. For the years in which WINDOWS was a graphical user interface that worked with the DOS operating system, we only include products that were made for WINDOWS.

Data on prices and quantities (denoted PRICE and SALES) come from two Dataquest/Gartner Reports on Personal Computing Software, one for the 1992-1995 period and one for the 1996-1998 period.[3] Dataquest/Gartner reports (worldwide) sales and total revenues for each product; hence price is the average transaction price. The variable SALES is the number of units sold (in thousands), and the variable PRICE is the average price.[4]

Data on quality of spreadsheets and word processors (denoted QUALITY) come from Liebowitz and Margolis (1999); they employed reviews that gave numerical ratings, and they normalized the top score to 10 in each year. Given the normalization, these scores are not comparable across years. But this is not important, since the choice set is what is available in a particular year.[5] In the case of suites, QUALITY is the sum of the ratings of the relevant spreadsheet and word processor ratings.[6] For example, the rating for the Microsoft Office Suite is the sum of the rating for Microsoft Excel and Microsoft Word in the same year.[7]

We have an additional variable (denoted SCOPE) that measures the scope of the Suite. (This variable takes on the value zero for spreadsheets and word processors.) The main

[3] The first report was purchased from Dataquest/Gartner; we are grateful to Dataquest/Gartner for supplying us the relevant data from the second report.
[4] In some cases, we need to average over several versions of the product. For example, in some years, the Microsoft office suite comes in separate versions for WINDOWS and WINDOWS95. There is little difference in price between the versions available for various generations of the WINDOWS operating system.
[5] In the case of the LM ratings for Spreadsheets, there are no ratings for 1993 and 1995; fortunately, there are two ratings for 1994 and 1996. We use the first rating for 1994 (which takes place very early in the year) as the rating for 1993; similarly, we use the first rating for 1996 as the rating for 1995. In the case of LM ratings for word processors, there are no ratings for 1996 and 1998. Since there is only a single rating for 1995 and 1997, we average the 1995 and 1997 ratings to obtain ratings for 1996 and use the 1997 ratings for 1998 as well.
[6] We'll also examine an alternative specification where there are two quality variables, one for spreadsheets and one for word processors.
[7] Even if the components had little or no market share, the quality rating for the suite is still the sum of the ratings of the components. Unfortunately, we do not have quantifiable data on the quality of the suite for each year in the sample.

components of the Suites are Word Processors, Spreadsheets and Presentation programs (Powerpoint in the case of Microsoft, Presentations in the case of Corel/WP and Freelance Graphics in the case of IBM/Lotus). For each of the above three components, the variable SCOPE gets 1 point if the full version of the component is included and 0.5 if just a module is included (as was the case in the early years). For additional components in the Suites (such as email programs, etc.), there is an additional 0.25 points with a maximum of 0.5 points, since we don't want the measure to be affected by under-reporting or over-reporting of minor components. In later years, there is integration with Internet Browsers; in such a case, there is an additional point. By 1998, all suites obtain the maximum possible score of 4.5.

Y19XX is a yearly dummy variable for year 19XX; for example, Y1993 is a yearly dummy for 1993. Y1994-Y1998 are similarly defined.

The dummy variable COREL/WP takes on the value one for Corel/WP word processors and suites, since Word Perfect was the leading word processor before the switch from DOS to WINDOWS. Otherwise, this variable takes on the value zero. This measures a reputation effect. The dummy variable IBM/LOTUS takes on the value one for IBM/Lotus spreadsheets and suites, since Lotus was the leading spreadsheet before the switch from DOS to WINDOWS. The variable MICROSOFT takes on the value one for Microsoft brand word processors and spreadsheets, and two for Microsoft suites.

We have an unbalanced panel of 53 model observations. Microsoft offered all three products in every year. In 1993-1995, there were nine products in the sample, as the other two firms offered all three products as well.[8] In 1996-1998, there were six products available in each year, as IBM/Lotus stopped selling word processors and Corel/WP essentially only sold Suites.[9]

Descriptive Statistics are shown in table 1.

[8] In 1992, there were eight products available, since the Corel/WP Suite was introduced in 1993.
[9] Corel/WP had a negligible share of the word processor market in 1996 and a negligible share of the spreadsheet market during the 1996-1998 period.

Variable	Mean	Std. Dev.	Min	Max
SUITE	0.38	0.49	0	1
SPREADSHEET	0.34	0.48	0	1
WORD PROCESSOR	0.28	0.45	0	1
SALES (000s of units)	3385.04	5918.07	46	32683
QUALITY	9.36	0.80	7	10
PRICE ($)	130.67	77.43	23.4	350
MICROSOFT	0.53	0.72	1	2
IBM/LOTUS	0.26	0.45	0	1
COREL/WP	0.19	0.39	0	1
SCOPE	1.33	1.82	0	4.5
Y1993	0.17	0.38	0	1
Y1994	0.17	0.38	0	1
Y1995	0.17	0.38	0	1
Y1996	0.11	0.32	0	1
Y1997	0.11	0.32	0	1
Y1998	0.11	0.32	0	1

Table 1: Descriptive statistics

The potential market for office software is defined to be the number of operating systems sold or distributed via OEMs during the relevant year. Our data on operating systems for 1992 comes from Woroch et al (1995), while our data on operating systems for 1993-1998 comes from a Dataquest report on Operating System Shipments.[10] The data in table 2 show that on average, approximately 80 percent of all consumers with a computer (operating system) purchased an office software product in 1992 and 1993. By 1998, only approximately 50 percent of all consumers purchased an office product. One possible explanation for this decline is that the household market has increased relative to the size of the business market. Indeed, National Telecommunications and Information Administration (NTIA) data show that the percent of households with a personal computer increased in the U.S. from 24.1 percent in 1994 to 36.6 percent in 1997.[11]

[10] The Dataquest reports and the Woroch et al (1995) data delineate between DOS (without WINDOWS) and DOS with WINDOWS, so it straightforward to simply include the latter.
[11] See http://www.ntia.doc.gov/ntiahome/net2/presentation/slide14.html.

Year	A: WINDOWS Sales of Operating Systems	B: Sales of Word Processors	C: Sales of Spreadsheets	D: Sales of Suites	Share of inside goods (B+C+D)/A
1992	11.056	4.650	3.442	0.578	0.784
1993	18.228	6.852	4.640	3.194	0.806
1994	32.107	5.987	5.233	7.689	0.589
1995	54.352	4.693	3.876	12.982	0.397
1996	68.083	2.908	2.979	26.810	0.480
1997	78.406	4.186	2.972	32.977	0.512
1998	89.489	2.091	1.867	38.801	0.478

Table 2: Sales of Operating Systems and Office Software Products (in millions of units), 1992-1998.

5. Discrete Choice Model and Estimation

5.1 Discrete Choice Model

In this section, we specify our discrete choice model. The (random) utility from consumption of a software product is as follows:

(1) Word Processors: $U_{1jkt}=\beta_0 + \beta_1$ PRICE $+ \beta_2$ QUALITY$+ \beta_{3xx}$ Y19XX $+$
β_4 MICROSOFT $+ \beta_5$ COREL/WP $+ \beta_6$IBM/LOTUS $+ \beta_7$ SCOPE $+ \xi_{1jt} + \mu_{1k} + \varepsilon_{1jkt}$
$= \delta_{\text{word processor}} + \mu_{1k} + \varepsilon_{1jkt}$,

(2) Spreadsheets: $U_{2jkt}=\beta_0 + \beta_1$ PRICE $+ \beta_2$ QUALITY$+ \beta_{3xx}$ Y19XX $+$
β_4 MICROSOFT $+ \beta_5$ COREL/WP $+ \beta_6$IBM/LOTUS $+ \beta_7$ SCOPE $+ \xi_{2jt} + \mu_{2k} + \varepsilon_{2jkt}$
$= \delta_{\text{spreadsheet}} + \mu_{2k} + \varepsilon_{2jkt}$,

(3) Suites: $U_{3jkt}= \beta_0 + \beta_1$ PRICE $+ \beta_2$QUALITY $+ \beta_{3xx}$ Y19XX $+ \beta_4$MICROSOFT $+$
β_5 COREL/WP $+ \beta_5$ COREL/WP $+ \beta_6$IBM/LOTUS $+ \beta_7$ SCOPE $+ \xi_{1jt} + \xi_{2jt} + \xi_{3jt} +$
$\varepsilon_{1jkt} + \varepsilon_{2jkt} + \varepsilon_{3jkt}$ $= \delta_{\text{suite}} + \varepsilon_{1jkt} + \varepsilon_{2jkt} + \varepsilon_{3jkt}$.

where j refers to the product, k refers to the consumer, and t refers to time. The β's are parameters to be estimated.[12]

We assume that if consumers make a purchase, they make one of the following purchases: a word processor, a spreadsheet, or a suite.[13,14]

[12] β_{3xx} Y19XX is actually shorthand notation. There is a dummy variable and corresponding parameter for each year (less one) in the estimating equation.

ξ_{ijt} is the average value of the unobserved characteristic of product j in category i (i=1 for word processors, i=2 for spreadsheets, and i=3 for suites). This value is the same for all consumers. In the case of a suite, there are three unobserved product characteristics: one associated with the word processor (ξ_{1jt}), one associated with the spreadsheet (ξ_{2jt}), and one associated with other aspects of the suite (ξ_{3jt}).

ε_{ijkt} represents the distribution of consumer preferences around this mean. This term introduces heterogeneity and its distribution determines the substitution patterns among products. Authors typically assume that the ε_{ijkt} are identically and independently distributed across consumers and products with the extreme value (Weibull) distribution function. In our case, however, there are three unobserved product characteristics for the suite: one associated with the word processor, one associated with the spreadsheet, and one associated with other aspects of the suite. ε_{2jkt} , for example, represents the distribution of consumer preferences around this mean for the unobserved characteristic of the spreadsheet. Clearly the distribution of consumer preferences around the mean of the unobserved characteristic of a Microsoft Word spreadsheet (Excel) are correlated with the distribution of consumer preferences around the mean of (one of) the unobserved characteristics of Microsoft Word Suite package (which includes Excel among other things). Hence, estimation must take account of this dependence. This means that it is possible only to employ numerical estimation.

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[13] If the utility is less than zero, the consumer does not make a purchase.

[14] We do not allow for the possibility that a consumer would purchase both a word processor and a spreadsheet. By restricting the possibilities to (i) a spreadsheet, (ii) a word processor, or (iii) a suite, we are excluding a small group of consumers who might prefer such an option. A simulation using our preliminary estimates indicates that during the 1994-1998, no consumers found it beneficial to buy a combination of products, that is, all consumers bought just a word processor, just a spreadsheet, or a suite. The simulation shows that during 1992 and 1993, about 3% of the consumers preferred a combination over the other options. Hence, this seems like a second-order effect. Including the possibility of purchasing more than one product would require a completely different and much more complicated model.

Previous empirical work has not addressed this issue, despite the fact that it is not unique to office software. We assume that the ε_{ijkt} are distributed normally with mean 0 and variance equal to 1.[15]

The μ_{ik} represent the disutility from getting only one of the components rather than the suite, which includes both components. (Hence there is no μ_{ik} in the utility for suites.) Suppose that μ_{1k} and μ_{2k} are highly correlated in a negative sense. If a consumer has relatively low disutility from just getting a word processor (rather than the bundle when purchasing the suite), he will have relatively high disutility from getting only the spreadsheet. In other words, suppose that a consumer is primarily interested in a word processor but sometimes want to imbed tables and charts in his documents and finds a spreadsheet useful for this but not absolutely necessary. Suppose that if he has both a word processor and a spreadsheet (i.e., a suite), his utility will be 100. Suppose that if instead, he only has a word processor, his utility is 70; this implies a disutility of 30. Since having a spreadsheet is not very valuable to this consumer, suppose that his utility from having spreadsheet only is only 30, so his disutility from losing the word processor is 70. If these preferences are broadly representative, then there will be a negative correlation in (dis)utilities.

Formally, we assume that μ_{1k} and μ_{2k} are normally distributed with the following structure:

$\mu_{1k} = \eta_{1k} + \lambda\theta - \alpha,$
$\mu_{2k} = \eta_{2k} + \lambda\theta - \alpha,$ OR $\mu_{2k} = \eta_{2k} - \lambda\theta - \alpha.$

We assume that η_{1k}, η_{2k}, and θ are i.i.d. normal random variables with mean 0 and variance σ^2; λ and γ are parameters to be estimated. When $\mu_{2k} = \eta_{2k} + \lambda\theta - \alpha$, the correlation between μ_{1k} and μ_{2k} is $\lambda^2/(1+\lambda^2)$. Hence, $\lambda=3$ implies a correlation of 0.9. When $\mu_{2k} = \eta_{2k} - \lambda\theta - \alpha$, the correlation between μ_{1k}, and μ_{2k} is $-\lambda^2/(1+\lambda^2)$. (Here, $\lambda=3$ implies a correlation of -0.9.)

[15] We will not use the integral for the analytic solution, so there is no point in assuming a Weibull distribution, which other authors assumed for ease of calculation.

Note that $E(\mu_{1k})= E(\mu_{2k})= - \alpha$. Hence, the parameter α represents the mean disutility from having one of the components rather than the bundle.

5.2 The Estimation Algorithm

The estimation proceeds as follows:

1. We take a random draw of 50,000 consumers per year. These draws are only taken once and each of our consumers makes a single purchase.[16] For each year, this requires 9 draws per consumer on ε_{1jkt}, ε_{2jkt}, and ε_{3jkt}, one draw per consumer on η_{1k},η_{2k}, and one draw on θ.

2. We first assume initial values for λ and α.

3. We then obtain initial estimates of the other parameters using the estimation algorithm explained below. When the algorithm converges, we compute the value of the objective function.

4. We then obtain updated estimates for λ and α and repeat steps 2-3 until convergence is obtained.

We now explain step 3 in detail. Initial estimates of the "β" parameters (denoted $\hat{\beta}$) come from the Instrumental Variable Regression $\ln(s_j)-\ln(s_o)= \delta_j=x_j\beta + \xi_j$, where s_o is the share of the outside good. Since price is endogenous, we instrument for it in this regression. Following other authors, we use the software quality of other products in the same year and category (word processor, spreadsheet, and suites) as an instrument for price. In years, when there are no other competing products in the category, the quality of the other products is zero. Our initial estimate of ξ is $\hat{\xi} = \delta_j - x_j \hat{\beta}$.

[16] We abstract form the issue of repurchases and upgrades.

Step 3.1 We then minimize the GMM objective function $\hat{\xi}' Z(\Phi)^{-1} Z' \hat{\xi}$ where Z is the matrix of instrumental and exogenous variables, and Φ is a consistent estimate of $E[Z' \hat{\xi} \hat{\xi}' Z]$. This yields new parameter estimates, denoted $\hat{\hat{\beta}}$.

Step 3.2 The simulated market shares are then calculated by comparing the utilities from (1), (2), and (3) where the estimated coefficients ($\hat{\hat{\beta}}$) come from the GMM regression.

Step 3.3 The updating algorithm sets $\delta_{j,new} = \delta_{j,\,old} + \ln(\text{actual market shares}) - \ln(\text{simulated market shares})$. See Berry, Levinsohn, and Pakes (1995) and Nevo (1998) for details.

Step 3.4 We then calculate a new value of $\hat{\hat{\xi}} = \delta_j - x_j \hat{\hat{\beta}}$.

We then repeat steps 3.1-3.4 until convergence is obtained, i.e., until the simulated market shares equal the actual market shares.

6. Preliminary Results

Table three contains our preliminary estimates.

Variable	Coefficient Estimates
Price (β_1)	-0.083
Quality (β_2)	0.90
Microsoft (β_4)	6.35
Corel/WP (β_5)	5.97
IBM/LOTUS (β_6)	5.50
Correlation (λ)	4.25
Disutility (α)	3.33
Scope (β_7)	-1.54
Y1993	-3.31
Y1994	-6.16
Y1995	-9.24
Y1996	-12.57
Y1997	-12.86
Y1998	-13.42

Table 3: Preliminary Parameter Estimates

Notice that all coefficients except for SCOPE have the expected sign. We find that there is negative correlation, i.e., $\mu_{2k} = \eta_{2k} - \lambda\theta - \alpha$ is appropriate. The value of λ implies a correlation coefficient of . This implies that there is a strong negative correlation in demand for word processors and spreadsheets, the two most important components of the office software market.

The yearly dummy variables capture the inside vs. outside valuation year by year. The coefficients associated with the yearly dummies are declining in value. This is in large part due to the fact that the consumer purchases of spreadsheets, word processors and suites divided by the number of operating systems was declining as well. That is more consumers elected not to purchase an office software product in later years. Indeed the correlation between the percentage of consumers choosing to purchase an office software product and the coefficients of the yearly dummy variables is .

The coefficient estimate associated with the variables MICROSOFT, IBM/ LOTUS, and COREL/WP are essentially of the same magnitude. This suggests that while IBM/Lotus

provided significant competition in the spreadsheet category and Corel/WP provided strong competition in the word processor category, neither firm provided significant competition in the suite category.

This suggests that the IBM/Lotus and Corel/WP suites were essentially viewed as offering little more than the relevant component for which the firm was successful in the DOS market. The results are consistent with the notion that only Microsoft successfully integrated the components into a bundle. (Recall that we've controlled for the quality of the components.)

Casual empiricism indeed suggests that the other suites were not integrated as well as Microsoft's suite.[17] Liebowitz and Margolis (1999) note, "When they [Microsoft's competitors] did assemble competing suites, they tended to cobble together products that had little in common." Stan Miastkowski, writes about the 1997 Corel/WP as follows: "Prior versions of WordPerfect Suite showed the results of cobbling together a bunch of disparate applications…"[18] Data compiled from trade journals, as summarized in Appendix B, are consistent with the above assessments.[19]

7. Further Work

Once we have obtained final parameter estimates, we will examine the effects of business strategies by performing counterfactuals. In particular, we will examine how competition in the office software market might have developed if suites had not been introduced.

[17] It is not possible to add integration or cross application compatibility to the data set at this stage since we do not have data on these measures for each year to year. We hope to obtain these data in the future.
[18] See "Corel's Nearly Perfect Suite Spot," available at http://www.byte.com/art/9707/sec11/art4.htm#077ev2t1. Accessed on August 27, 2002.
[19] Indeed, it seems that Microsoft still retains a significant advantage in its ability to integrate the components better than its competitors. ZDNet reviews of the most recent versions of suites, as summarized in Appendix B, suggest that the WordPerfect and Louts suites still do not integrate the components of their suites as well as Microsoft does.

Network effects may be important in this market. If all spreadsheets, word processors, and suites were compatible across firms, none of the firms would have had an advantage due to network effects. According to the trade press, however, the products were not always compatible across firms. In such a case, Microsoft may have had a "network effect" advantage, due to a large installed base. We will examine this issue in future work.

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Appendix: A Simple Bundling Model

Here we introduce a simple model of strategic bundling. The purpose of this model is to build intuition about bundling incentives and the consequences of bundling, to help explain the evolution of the PC office software market.

1. Basic Logit Model

The basic logit duopoly model is our main building block. The model features two differentiated products, a vendor for each, and an outside option. The vendors are indexed $i = 1, 2$. Consumers are willing to pay

$$\frac{1}{\lambda}(U_i + \theta)$$

for product *i*, where λ is a parameter, U_i is a common value, and θ is a private value with a standard double exponential (i.e. Type I extreme value) distribution.[20] The value of the outside option is U_0.

The share of consumers purchasing from vendor *i* is

$$S_i = \frac{e^{U_i - \lambda P_i}}{e^{U_0} + e^{U_1 - \lambda P_1} + e^{U_2 - \lambda P_2}}.$$

where the subscripted *P*'s denote prices.

Assuming zero variable costs, each vendor maximizes revenue in Nash equilibrium. The first-order conditions for equilibrium revenue maximization imply

$$P_i = \frac{1}{\lambda(1 - S_i)}.$$

Therefore, at a Nash equilibrium,

$$S_i = \frac{e^{U_i - U_0 - \frac{1}{1-S_i}}}{1 + e^{U_1 - U_0 - \frac{1}{1-S_1}} + e^{U_2 - U_0 - \frac{1}{1-S_2}}},$$

and

$$\left[\ln S_i + \frac{1}{1 - S_i} - \ln S_0\right] = U_i - U_0,$$

where

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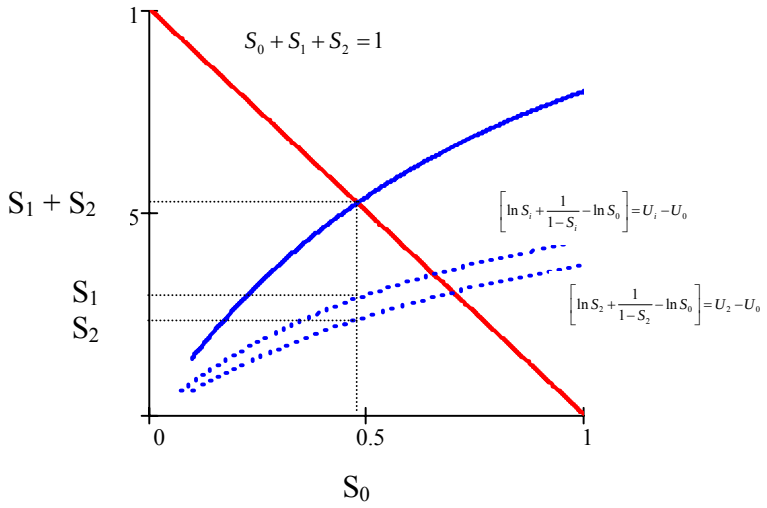
[20] λ can be interpreted as the parameter of a general double exponential distribution function with variance $\frac{\pi^2}{6\lambda^2}$. See Anderson, dePalma, and Thisse (1992, p. 39-42.) Thus the variance of θ in the formulation above is $\frac{\pi^2}{6}$.

$$S_0 = 1 - S_1 - S_2 .$$

The accompanying graph illustrates the determination of equilibrium quantities.



The two upward sloping dotted lines graph the equilibrium consumer shares of vendors 1 and 2, respectively as a function of S_0, and the upward sloping solid line sums the two. Thus the upward sloping "market size locus" graphs $S_1 + S_2$ as a function of S_0. Equilibrium is determined by the intersection of market size locus with the downward "adding up constraint".

It can be deduced from these relationships that an increase in either U_1 or U_2 expands the market, that is, S_0 is decreasing in U_i. Moreover, S_1 is increasing in U_1, and S_2 is decreasing in U_1, and conversely. A vendor with higher quality product raises its price, but by less than the quality increment, thus causing the rival to cut its price in order to stem a loss in market share.

These comparative static results follow immediately from a graphical analysis. An increase in U_1 shifts up the (dotted line) locus labeled $\left[\ln S_1 + \frac{1}{1-S_1} - \ln S_0\right] = U_1 - U_0$, which in turn shifts up the market size locus. The new intersection of the market size locus with the adding-up constraint occurs at a lower value of S_0. Reading off the graph, S_2 must be lower at lower value of S_0, because $\left[\ln S_2 + \frac{1}{1-S_2} - \ln S_0\right] = U_2 - U_0$, and the adding-up constraint implies a higher value of S_1.

Market shares are calculated as $s_i = \frac{S_i}{S_1 + S_2}$, and

$$\left[\ln s_1 + \frac{1}{1-s_1}\right] - \left[\ln s_2 + \frac{1}{1-s_2}\right] = U_1 + U_2.$$

Thus Vendor *i* 's market share of increases with its product quality.

Proposition: An increase in the quality of a product increases its market share and expands the market. The price and purchases of the product increase, while those of the rival decrease.

2. Two Product Categories

Suppose there are two product-categories and two vendors for each kind of product. The vendors are indexed $i = A1, A2$ for product category A, and $j = B1, B2$ for category B.

There are two types of consumers. Type A consumers have a willingness to pay for product *Ai* equal to

$$\frac{1}{\lambda_A}\left(U_i + \theta_i\right)$$

where U_i indicates (vertical) product quality, and θ_i is an idiosyncratic preference parameter with a standard double exponential distribution. Type A consumers also have a common incremental value of β for any variety of product B. Similarly, Type B consumers have a willingness to pay for product B_j equal to

$$\frac{1}{\lambda_B}\left(V_j + \eta_j\right),$$

and incremental value of α for product A.

If the products are sold separately, and the parameters α and β are sufficiently small, then the basic logit model applies to each product category. Vendors of product A sell only to Type A consumers, and likewise for product B. In each market, the price cut necessary to attract the other type of consumer would sacrifice too much revenue.

3. Unilateral Bundling

Next suppose that Vendor 1 is integrated and offers a bundled product at price P_1. The bundle gives Type A consumers an additional value of β, and Type B an additional value of α. These "quality improvements" effectively increase U_1 and V_1. If the markets are symmetric, then the proposition applies to each market. The effect of bundling is to increase the quality of Vendor 1's product in each of the two markets.

More generally, pure bundling is a mixed blessing. On the one hand, bundling offers more value to each customer class at no cost, and thus is a source of competitive advantage. On the other hand, the bundle is sold at a single price, thus preventing price

discrimination between the two types of consumers. If, however, equilibrium prices for products $A1$ and $B2$ (*sans* bundling) are sufficiently close, then unilateral bundling by Vendor 1 must be profitable.

When price discrimination is an attractive revenue-maxizing strategy, then mixed bundling is the more profitable strategy. For example, suppose that A is the high-price product category, and β exceeds α . The firm could sell a bundled product to Type A consumers, maintaining a high price, and continue to sell a stand-alone product B to Type B consumers at a discounted price.[21]

In any case, either a pure bundling strategy or a mixed bundling strategy dominates selling the two products separately.[22] The consequence of bundling is to expand the market share of whichever consumer type is attracted to the bundle. With reference to the graph above, the greater value of the bundle is equivalent to an increase in U_1. Applying the proposition, the firm gains market share while raising its price. The rival loses market share, while the market expands. If a pure bundling strategy is an equilibrium best response, and price discrimination is unimportant, then the firm gains share in both product categories.

4. Competitive Bundling

Now suppose that Vendor 2 is also vertically integrated. Bundling or mixed bundling is now a best response for both vendors. Therefore, in equilibrium, both firms offer a bundled product. The main effect here is to expand the size of the market. Both firms gain sales compared to the no-bundling case, but the effect of bundling on the market shares of the two firms is ambiguous.

5. Key Feature of the Model

The strategic incentives for bundling arise in the model as a consequence of the assumed demand structure of consumer preferences. Implicit is an assumption that the demand for two products is strongly negatively correlated. That is the consumers, who have a high willingness to pay for product A have a relatively low willingness-to-pay for product B, and conversely. This negative correlation in preferences enables a vendor offering a bundle to gain a competitive advantage in selling to one group of consumers without sacrificing revenues earned from the other group.

[21] Clearly the discount must exceed α. Otherwise, the two consumer classes would not separate.

[22] We are assuming that product selection and pricing decisions are simultaneously. Thus, the claim is that bundling or mixed bundling is always a best response to the prices of the rivals in each market. This claim is obvious given of the no-cost competitive advantage that a either a pure or mixed bundling strategy affords.

Appendix B

Product	Integration	Applications	Customization	Basics	Usability
Microsoft Office 4.0	86	90	78	85	89
Lotus Smartsuite 2.1	77	83	62	73	84

Table 4: Reviews from PC World, February 1994

Product	Integration	Applications	Performance
WordPerfect Suite 8	6.7	7.1	5.9
Lotus Smartsuite 97	7.6	7.6	9.6
Office 97 (Professional)	7.6	8.4	9.4

Table 5: Reviews from PC World, February 1998

	Microsoft Office	Lotus Smart Suites	WordPerfect Suite
Value	8	9	8
Productivity	7	8	8
Features	8	6	7
Ease of Use	8	8	7
Cross-Application Compatibility (CAS)	8	5	6
Overall Rating	7.8	7.2	7.2
Overall Rating without CAS	7.75	7.75	7.5

Table 6: Reviews from ZDNet 2001

ZDNet overall ratings are compiled by averaging across all five of the components listed in the above table.[23] The only real difference between the Microsoft suites and the other

[23] The ZDNet Microsoft review is from April 20, 2001, and is available at http://www.zdnet.com/supercenter/stories/overview/0,12069,477325,00.html;

suites is the difference in cross-application compatibility. Here Microsoft continues to receive significantly higher rankings that the other firms.

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the WordPerfect review is from May 2, 2001, and is available at http://www.zdnet.com/supercenter/stories/review/0,12070,475950,00.html ; the Lotus Smart Suite October 24, 2001, and is available at http://www.zdnet.com/supercenter/stories/review/0,12070,476275,00.html.

Figure 1: Word Processor Market:1991
Total Market $952 Million:
DOS $567 Million, WINDOWS (W) $385 Million

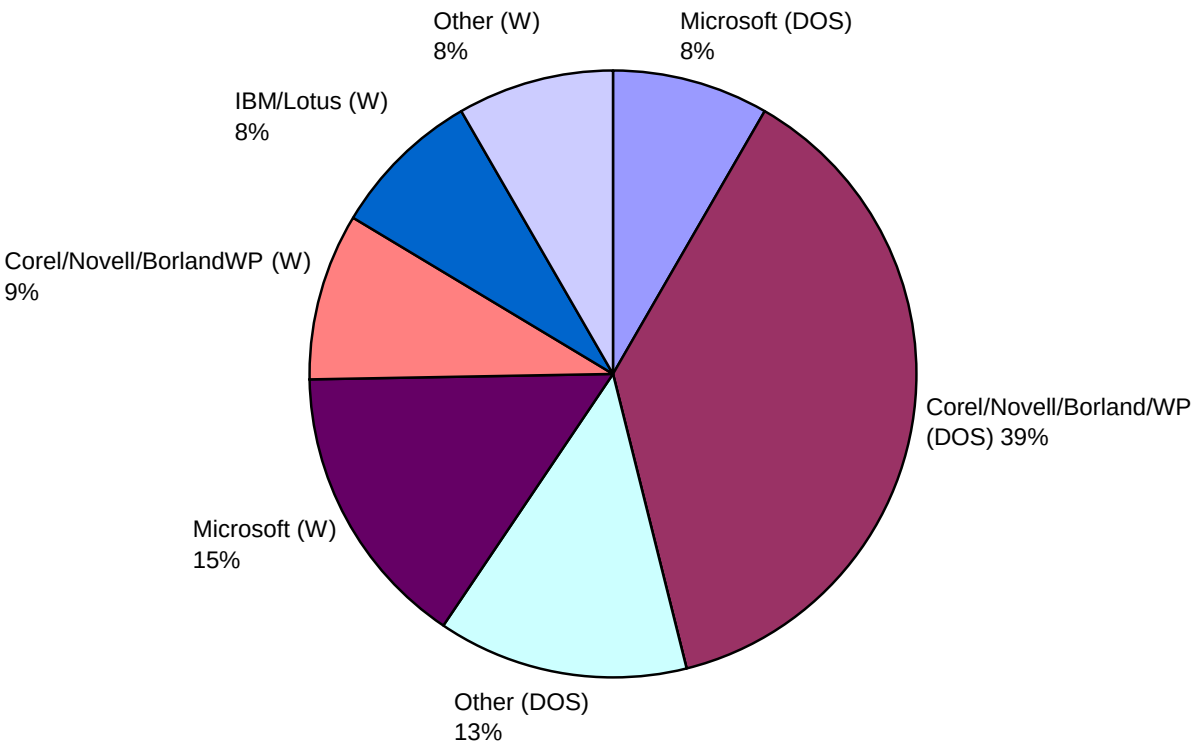

Figure 2: Spreadsheet Market:1991
Total Market $809 Million:
DOS $239 Million, WINDOWS $569 Million

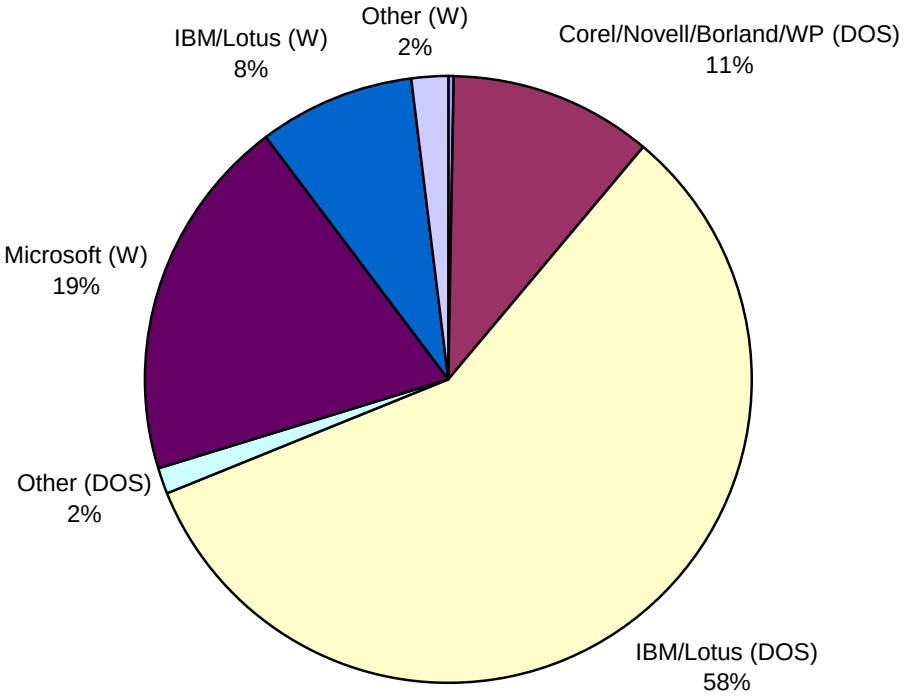

Figure 3: Office Software Revenue for WINDOWS Platform by Firm 1991-1998

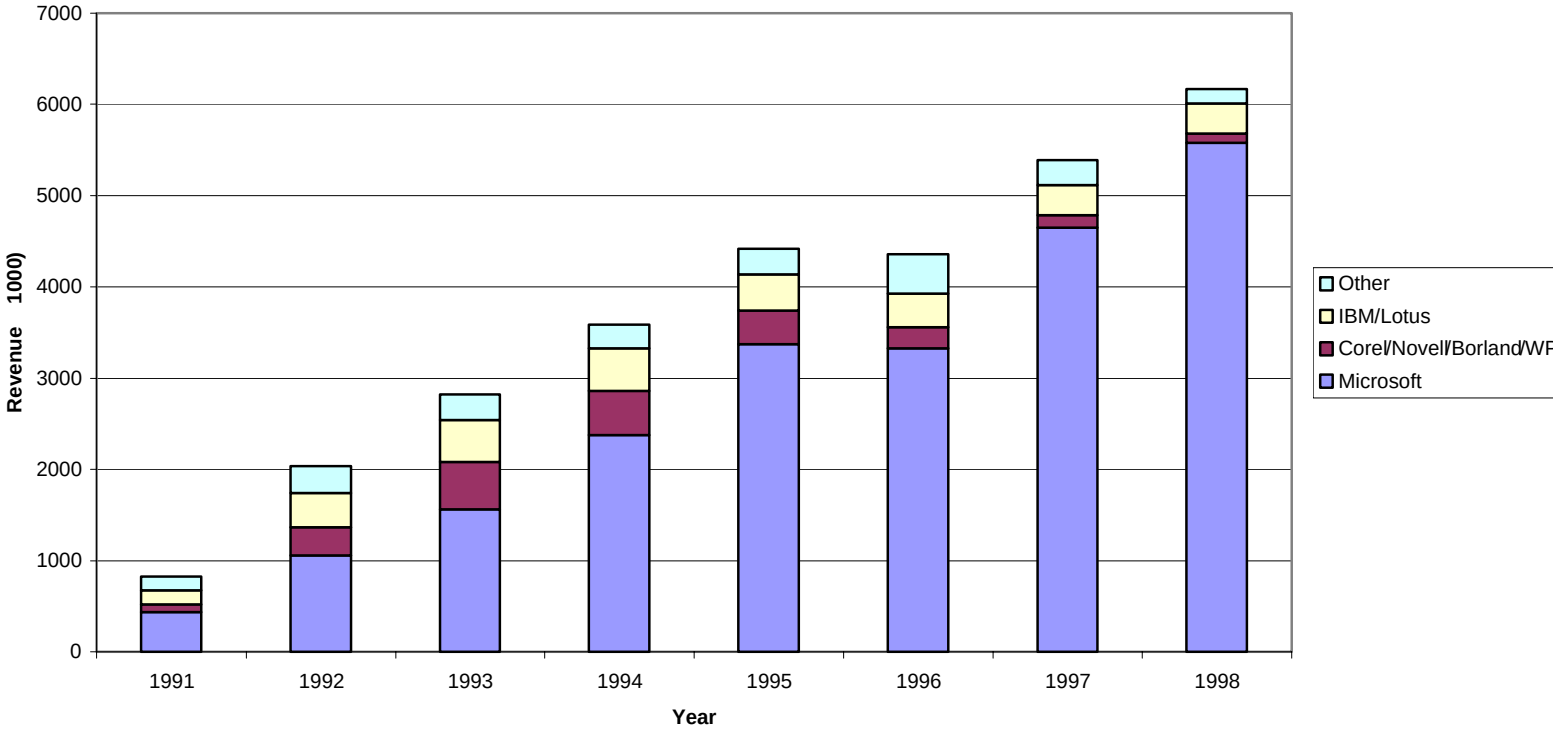

Figure 4: Office Software Revenue by Platform, 1991-1998

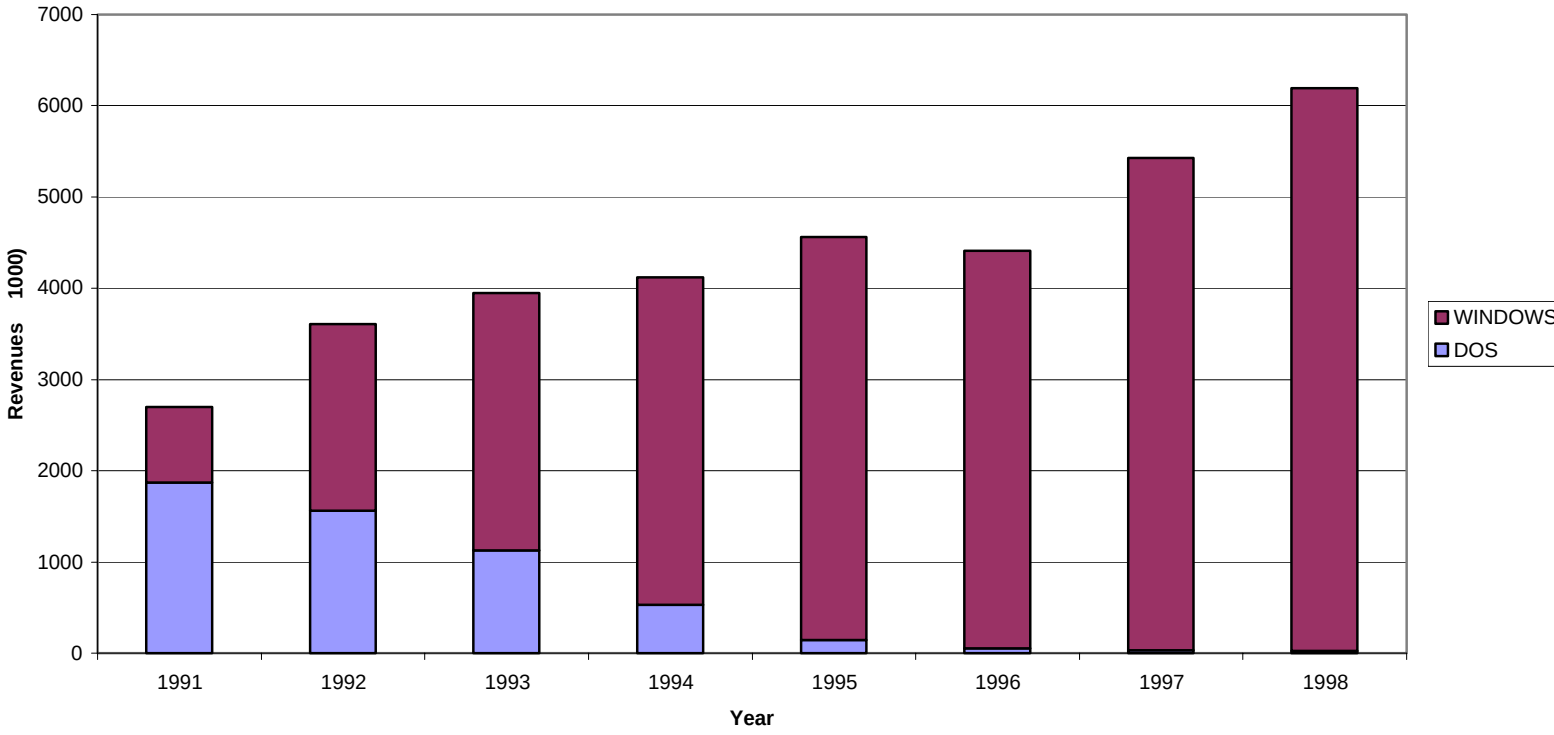

Figure 5: Windows Office Productivity Shares by Category, 1991-1998

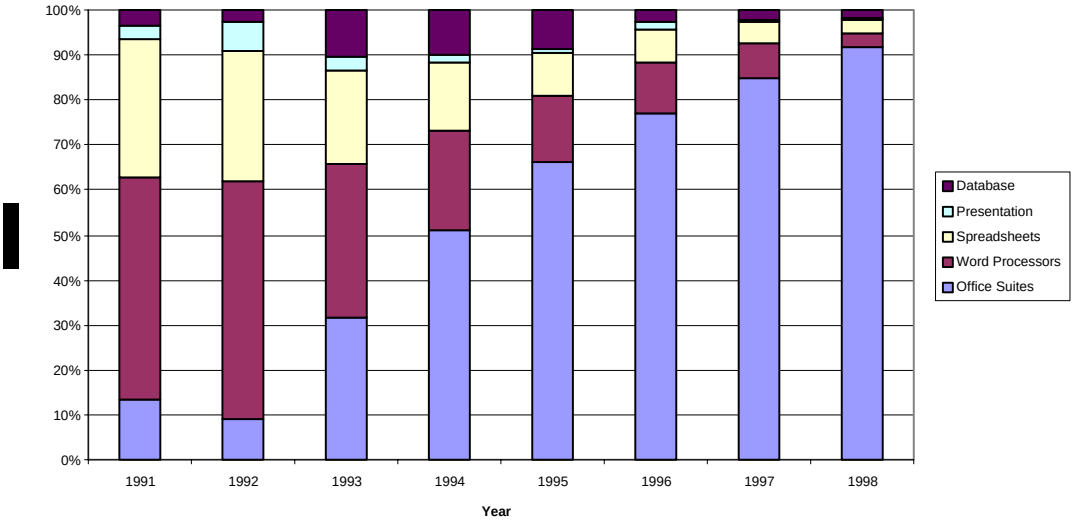

Figure 6: Office Suite Revenue by Firm 1991-1998

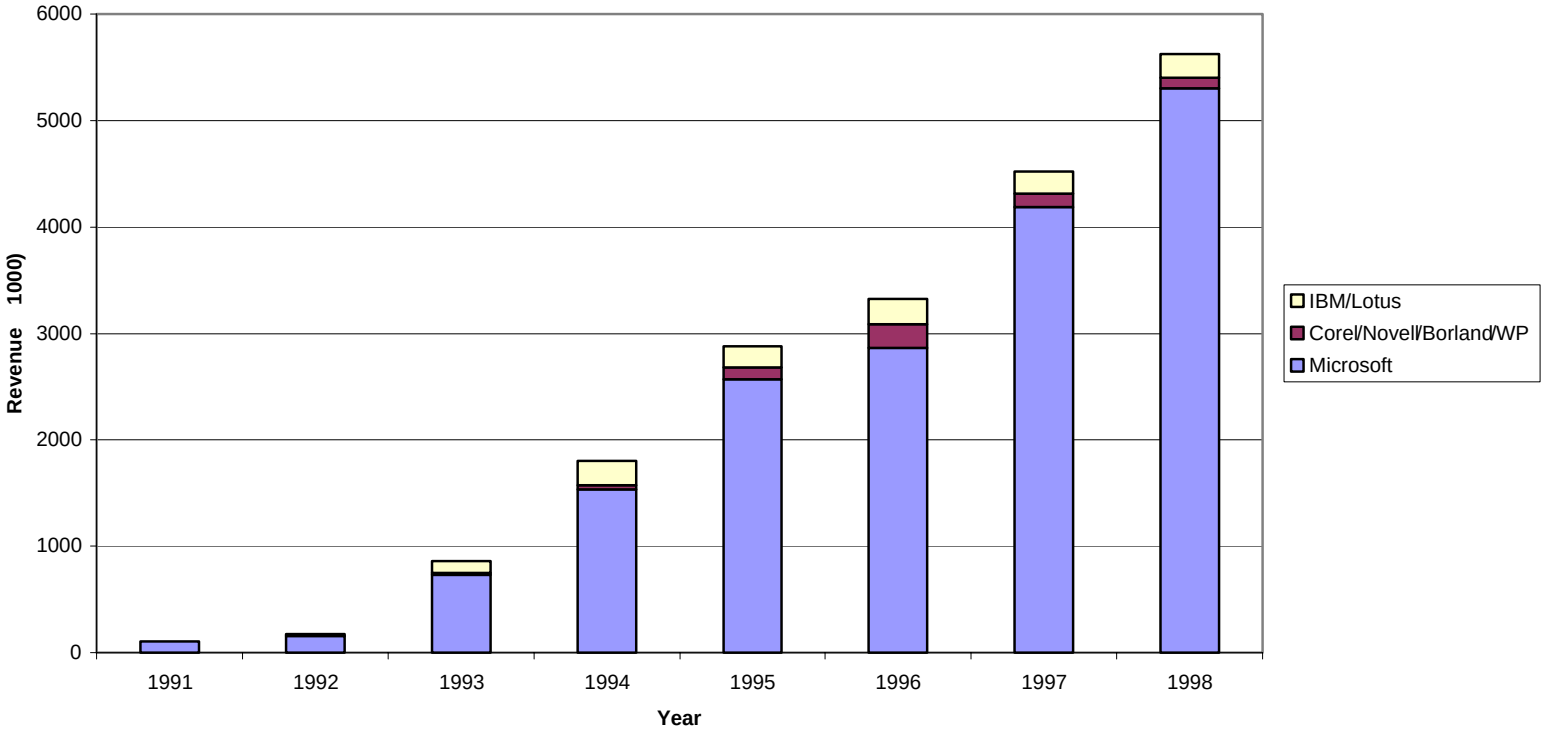

Figure 7: Suite Prices (1993-1998)