



NORTH-HOLLAND

Assessing the Relationship between the User-Based Market Share and Unit Sales-Based Market Share for Pirated Software Brands in Competitive Markets

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ABSTRACT

This article argues that in a competitive software market, in the presence of differential piracy and brand switching among the various brands within a software product category (e.g., spreadsheets), there may be no relationship between market estimates based on unit sales and the user base of a software brand (e.g., Lotus 1-2-3). Hence, marketing strategies developed for the software brand based on unit sales-based market share may be misleading. To support our argument and to quantify the relationship between unit sales-based market share and the user-based market share, we first extend a diffusion modeling approach for pirated software product categories to model the legal and illegal adoption dynamics of a software brand within a software product category. Second, to examine empirically the relationship between the user-based market share and the unit sales-based market share for a brand, we consider the diffusion of the major brands of two types of software product categories, spreadsheets and word processors, in the United Kingdom. Results indicate that in the product category of spreadsheets, for Lotus 1-2-3, the user-based market share was always less than the unit sales-based market share. On the other hand, in the product category of word processing software, the user-based market share for WordPerfect was always greater than the unit sales-based market share. Marketing implications of these results for Lotus spreadsheets, Novell WordPerfect, and the software industry are discussed. © 1997 Elsevier Science Inc.

Introduction

Software piracy by computer users has been identified as a major problem facing the software industry worldwide ([1], pages 44–49) [2–4]. However, in a competitive market, software brands (e.g., different types of spreadsheets) offered by various firms may not be equally pirated. Thus, the actual user base for a software brand (e.g., Lotus 1-2-3) may comprise a different mix of both buyers and pirates than its competitors.

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TABLE 1
Unit Sales-Based and User-Based Market Shares in a Hypothetical Software Product Category

Software brand	Unit sales	User base	Market share		Ratio of user-based share to unit sales-based share
			Unit sales (%)	User base (%)	
A	100	100	25	19.6	0.78
B	100	140	25	27.5	1.10
C	100	180	25	35.3	1.41
D	100	90	25	17.6	0.70
Total	400	510	100	100	

Furthermore, because both buyers and pirates may also switch brands, the switching dynamics may influence the ultimate mix of buyers and pirates for each software brand. In the presence of such adoption dynamics there may be no relationship between market share estimates based on unit sales and the user base. Hence, marketing strategies developed on the unit sales-based market share may be misleading. That is, the differential level of piracy for each competitor may imply different strategic marketing policies for its brand.

For example, Table 1 includes data for four brands in a hypothetical software product category. All four brands have the same unit sales of 100 units. Because of differential piracy and brand switching, however, their user base is different. Although the user base for Brand A remains at the same level as its unit sales (despite piracy and brand switching), the user base for Brand B is 140. It is 180 for Brand C and 90 for Brand D. The last column in this table gives the ratio between market shares based on user base and unit sales ranging from 1.41 for Brand C, 1.10 for Brand B, 0.78 for Brand A, and 0.70 for Brand D.

Although the four brands have the same unit sales-based market share, their user-based market share ranges from a high of 35.3% for Brand C to a low of 17.6% for Brand D. Given the data in Table 1, a critical question is which software brand will be more successful in the long run?

This is not an easy question to answer. Consider, for example, Brand C, which has the largest user base. One may argue that this brand may be the most successful brand in the long run, depending upon how the firm offering this brand monopolizes its user base. Its larger user base suggests that its brand is perhaps of better quality. Depending upon cost of switching, the firm may also be more successful in introducing and marketing its new generations to its larger user base. On the other hand, considering the fact that this brand has the largest user base, one may also question its pricing policy. It is possible that although this brand is of better quality, it may be priced too high as compared to the competing brands, causing many potential users to pirate it. One may also suggest that, as compared to other brands, Brand C is the easiest software to copy and pirate. Hence, the company needs to examine its anti-piracy protection mechanisms implemented in the software. Finally, one may also suggest that this brand is targeted at a market segment that is more likely to pirate.

Similar arguments can be made about Brand B. But, what about Brand D? It also sells 100 units, but only 90 users use it. That is, more people buy this brand than use it. There may be two possible explanations for this. First, some consumers who purchase this brand do not use it. Alternatively, if we assume that everyone in this market uses this type of software, it is obvious that buyers of this brand switch over to other brands.

Like Brand C, one can draw inferences regarding the pricing, positioning/segmentation, and quality aspects of this software.

It is clear from the above discussion and Table 1 that in the presence of differential piracy and brand switching, market share estimates based on unit sales may not be very helpful to a software company in assessing its relative performance in the marketplace. A firm must develop market share estimates based on user base to assess the relative merits of its software offering and the associated marketing strategy.

To quantify and illustrate empirically the relationship between the user-based market share and the unit sales-based market share we examine the diffusion of major software brands for two software product categories—spreadsheets and word processors—in the United Kingdom. To keep the analyses meaningful, we assume that there are only two brands competing in each software category: Lotus 1-2-3 and Other Spreadsheets for spreadsheets, and WordPerfect and Other Word Processors for word processing software.

Our selection of the above two software product categories is motivated by the results reported by Givon, Mahajan, and Muller [5]. Proposing a diffusion modeling approach to track shadow diffusion (i.e., illegal diffusion of a product parallel to its legal diffusion) of a software product category, they report that a significant amount of piracy existed for these two software product categories in the United Kingdom. To analyze the relationship between user-based market share and the unit sales-based market share for a brand, we extend their model to study the adoption and piracy dynamics for the various brands within a product category. As discussed below, our results suggest that Lotus 1-2-3 and WordPerfect exhibited diffusion dynamics similar to Brands D and C, respectively, in Table 1.

Diffusion Model for Pirated Software Brands in Competitive Markets

Figure 1 depicts a diffusion process that includes piracy and switching dynamics between two brands. More specifically, this diagram depicts the diffusion for one brand (Brand 1), and a similar flow diagram can be developed for the other brand (Brand 2). This flow diagram is an extension of the model proposed by Givon et al. [5]. Their model, developed to examine the adoption dynamics of a product category, does not consider piracy and brand switching between brands within a product category. Figure 1 explicitly recognizes differential piracy and brand switching between two brands in a software product category.

Figure 1 also includes various analytical expressions for different diffusion flows. The argument for time t is dropped in Figure 1 for convenience. To better explicate the various flows in Figure 1, let:

- $N(t)$ = cumulative number of microcomputer owners at time t ,
- $U_1(t), U_2(t)$ = number of legal users of software Brands 1 and 2, respectively, at time t ,
- $W_1(t), W_2(t)$ = number of illegal users of Brands 1 and 2, respectively, at time t ,
- $X_1(t), X_2(t)$ = cumulative number of buyers of Brands 1 and 2, respectively, at time t ,
- $Y_1(t), Y_2(t)$ = cumulative number of pirates of Brands 1 and 2, respectively, at time t ,
- $Z_1(t), Z_2(t)$ = number of users (both legal and illegal) of software Brands 1 and 2, respectively, at time t , (e.g., $Z_1(t) = U_1(t) + W_1(t)$),
- $Z(t)$ = number of legal and illegal users of both brands at time t , $Z(t) = Z_1(t) + Z_2(t)$,

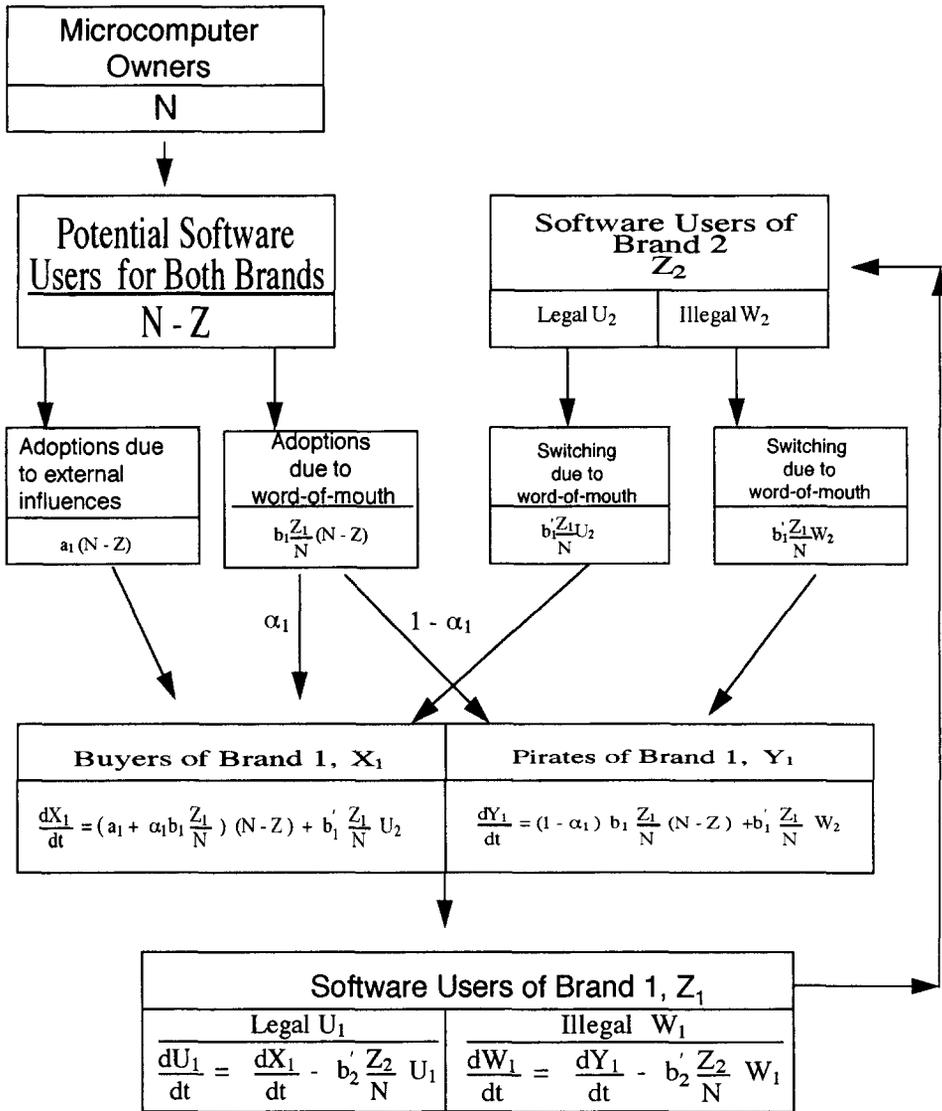


Fig. 1. Buyers, pirates, legal and illegal users in the diffusion process of a software brand in a competitive market with two competitors.

- a₁, a₂ = coefficient of external influence for Brands 1 and 2, respectively,
- b₁, b₂ = coefficient of imitation representing the word-of-mouth influence of users of software Brands 1 and 2, respectively, on the potential software users,
- b'₁, b'₂ = coefficient of brand switching that indicates the influence of users of Brand 1 (Brand 2) on the users of Brand 2 (Brand 1),
- α₁, α₂ = coefficient representing proportion of potential software users influenced by word-of-mouth who purchase Brand 1 and Brand 2, respectively; (1-α₁) and (1-α₂) represent the proportions that pirate Brands 1 and 2, respectively.

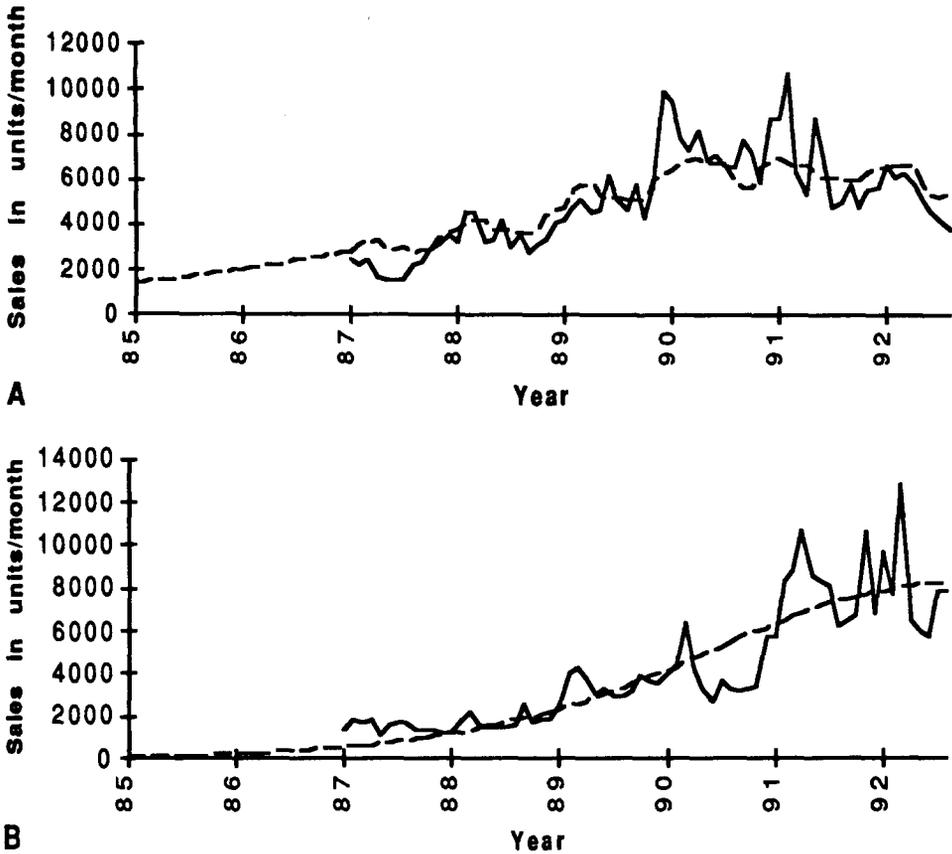


Fig. 2. Legal unit-sales of (A) Lotus 1-2-3 and (B) other Spreadsheets brands in the United Kingdom: actual (solid lines) and estimated (dashed lines).

Note the following adoption dynamics in Figure 1.

POTENTIAL USERS

At any time t , there are $N(t) - Z(t)$ number of potential users for both software brands.

BUYERS AND PIRATES

At any time t , $a_1(N(t) - Z(t))$ potential software users buy the software Brand 1 due to external influences. Similarly, of all the potential users who adopt software Brand 1 because of the word-of-mouth influence of users of Brand 1 (i.e., $b_1(Z_1/N)(N - Z)$), proportion α_1 purchases the software Brand 1 and $(1 - \alpha_1)$ pirates it.

The users of Brand 1 influence the legal users of Brand 2 to brand switch and buy Brand 1. At any time t , $b'_1(Z_1/N)U_2$ represents the number of legal users of Brand 2 who switch and buy Brand 1. Similarly, users of Brand 1 influence illegal users of Brand 2 to switch and $b'_1(Z_1/N)W_2$ number of them pirate Brand 1.

Hence, the growth of both buyers and pirates of Brand 1 is not only determined by how many potential users buy or pirate Brand 1 but also how many brand switch from Brand 2 to Brand 1. The following differential equations represent the growth of buyers and pirates of Brand 1 over time.

Buyers of Brand 1:

$$\frac{dX_1(t)}{dt} = \left(a_1 + \alpha_1 b_1 \frac{Z_1(t)}{N(t)} \right) (N(t) - Z(t)) + b'_1 \frac{Z_1(t)}{N(t)} U_2(t) \quad (1)$$

Pirates of Brand 1:

$$\frac{dY_1(t)}{dt} = (1 - \alpha_1) b_1 \frac{Z_1(t)}{N(t)} (N(t) - Z(t)) + b'_1 \frac{Z_1(t)}{N(t)} W_2(t) \quad (2)$$

and $X_1(0) = 0$ and $Y_1(0) = 0$.

LEGAL AND ILLEGAL USERS OF BRAND 1

At any time t , because some buyers of Brand 1 may switch to Brand 2 due to the influence of users of Brand 2, the number of legal users comprises only the buyers who do not brand switch to Brand 2. Similarly, the number of illegal users of Brand 1 consist only of the pirates who do not switch to Brand 2 due to the influence of users of Brand 2. The following differential equations provide the growth of legal and illegal users of Brand 1 over time.

Legal Users of Brand 1:

$$\frac{dU_1(t)}{dt} = \frac{dX_1(t)}{dt} - b'_2 \frac{Z_2(t)}{N(t)} U_1(t) \quad (3)$$

Illegal Users of Brand 1:

$$\frac{dW_1(t)}{dt} = \frac{dY_1(t)}{dt} - b'_2 \frac{Z_2(t)}{N(t)} W_1(t) \quad (4)$$

and $U_1(0) = W_1(0) = 0$.

Equations (1) through (4) describe the diffusion process that captures differential piracy and brand switching for Brand 1. Note that summation of Equations (1) and (2) provides the total adoption of Brand 1 at any time t . That is,

$$\frac{dX_1(t)}{dt} + \frac{dY_1(t)}{dt} = \left(a_1 + b_1 \frac{Z_1(t)}{N(t)} \right) (N(t) - Z(t)) + b'_1 \frac{Z_1(t)}{N(t)} Z_2(t) \quad (5)$$

If there is no brand switching, i.e., $b'_1 = b'_2 = 0$, then there is no difference between buyers and legal users, and between pirates and illegal users. Then, Equation (5) reduces to

$$\frac{dZ_1(t)}{dt} = \left(a_1 + b_1 \frac{Z_1(t)}{N(t)} \right) (N(t) - Z(t)). \quad (6)$$

Equation (6) is the Bass diffusion model [6] with a time-varying market potential and describes the diffusion of Brand 1. Similarly, in the absence of piracy and with no brand switching (i.e., $\alpha_1 = 1$ and $b'_1 = 0$), Equation (1) also reduces to the Bass model with a time-varying market potential for Brand 1.

Like Givon et al. [5], Equations (1) through (4) can be used to assess the influence of pirates on the legal diffusion of Brand 1 and the ratio between buyers and pirates over time. The unit sales-based market share is given by $X_1(t)/(X_1(t) + X_2(t))$ and the user-based market share is given by $Z_1(t)/Z(t)$. The ratio of illegal to legal users is given

by $W_1(t)/U_1(t)$ and the ratio of pirated to legal adoptions in each period is given by $dY_1(t)/dX_1(t)$. Like Equations (1) through (4), we can also write equations for the diffusion of Brand 2. These equations are given by:

Buyers of Brand 2:

$$\frac{dX_2(t)}{dt} = \left(a_2 + \alpha_2 b_2 \frac{Z_2(t)}{N(t)} \right) (N(t) - Z(t)) + b_2' \frac{Z_2(t)}{N(t)} U_1(t) \quad (7)$$

Pirates of Brand 2:

$$\frac{dY_2(t)}{dt} = (1 - \alpha_2) b_2 \frac{Z_2(t)}{N(t)} (N(t) - Z(t)) + b_2' \frac{Z_2(t)}{N(t)} W_1(t) \quad (8)$$

Legal Users of Brand 2:

$$\frac{dU_2(t)}{dt} = \frac{dX_2(t)}{dt} - b_1' \frac{Z_1(t)}{N(t)} U_2(t) \quad (9)$$

Illegal Users of Brand 2:

$$\frac{dW_2(t)}{dt} = \frac{dY_2(t)}{dt} - b_1' \frac{Z_1(t)}{N(t)} W_2(t) \quad (10)$$

Equations (1) through (4) and Equations (7) through (10) provide the necessary model to study the diffusion of pirated software in a competitive market with two competitors. Following the rationale underlying these equations, similar differential equations can be written for more than two competing software brands.¹

User-Based Market Share versus Unit Sales-Based Market Share

To illustrate the relationship between market shares based on unit sales and user base, we examine the diffusion of major software brands for two software product categories—spreadsheets and word processors—in the United Kingdom.

The monthly shipment data for the various brands for these two software categories were bought from Market Analysis Information Database (MAID) in London. These data, for the 68 periods from January 1987 through August 1992, are included in Table 2 and shown in Figures 2 and 3. The monthly shipment data on DOS-based microcomputers used by Givon et al. [5] were also employed in this study to include $N(t)$, the cumulative number of microcomputer owners, in Equations (1)–(4) and (7)–(10). In fact, Givon et al. [5] report that the following parameters for the estimated Bass model describe the growth of DOS-based microcomputers in the UK: $\hat{p} = .00037$; $\hat{q} = 0.0316$; $\hat{m} = 15,386,100$; and $R^2 = .897$.

¹ The modeling approach, the data used, and the results derived in this article are not without limitations. Like the model suggested by Givon et al. [5], the proposed model assumes one adoption (legal or illegal) per microcomputer owner at a time (i.e., the consumer may adopt one brand and then switch to another). Furthermore, it does not consider repeat purchases, site licenses (multiple users per software adoption), software upgrades, or possession of multiple microcomputers per user. There may also be some seasonality present in the data.

Figure 1 assumes that when legal users switch their current brand, they purchase the competing brand (rather than pirate it). Similarly, when illegal users switch their current brand they pirate the competing brand (rather than buy it). A model can be specified to accommodate this assumption. This model, including several additional parameters, did not provide significantly better fit to our data.

TABLE 2
Actual Monthly Legal Unit Sales of Competitive Products for Spreadsheets and
Wordprocessing Software in the United Kingdom

Month	Year	Spreadsheet			Wordprocessing		
		Lotus 1-2-3	Others ^a	Total	WordPerfect	Others ^b	Total
1	1987	2,406	1,405	3,811	543	4,642	5,185
2	1987	2,216	1,903	4,119	715	5,099	5,814
3	1987	2,406	1,728	4,134	578	5,716	6,294
4	1987	1,633	1,823	3,456	891	5,333	6,224
5	1987	1,620	1,119	2,739	658	4,346	5,004
6	1987	1,529	1,601	3,130	772	4,983	5,755
7	1987	1,601	1,681	3,282	575	4,724	5,299
8	1987	2,190	1,723	3,913	804	4,976	5,780
9	1987	2,297	1,362	3,659	722	4,487	5,209
10	1987	2,861	1,429	4,290	638	4,331	4,969
11	1987	3,152	1,400	4,552	844	4,492	5,336
12	1987	3,580	1,269	4,849	538	4,336	4,874
1	1988	3,267	1,191	4,458	1,357	4,310	5,667
2	1988	4,531	1,688	6,219	816	4,948	5,764
3	1988	4,574	2,266	6,840	1,742	6,485	8,227
4	1988	3,181	1,625	4,806	1,309	4,538	5,847
5	1988	3,379	1,529	4,908	1,505	4,673	6,178
6	1988	4,158	1,471	5,629	1,342	5,357	6,699
7	1988	2,992	1,491	4,483	1,149	5,136	6,285
8	1988	3,555	1,611	5,166	1,232	6,227	7,459
9	1988	2,831	2,599	5,430	1,156	5,940	7,096
10	1988	3,156	1,756	4,912	1,371	7,232	8,603
11	1988	3,378	1,902	5,280	1,293	7,803	9,096
12	1988	4,143	1,890	6,033	1,340	6,662	8,002
1	1989	4,261	2,484	6,745	3,125	9,520	12,645
2	1989	4,758	4,116	8,874	3,108	9,783	12,891
3	1989	5,051	4,284	9,335	3,468	10,448	13,916
4	1989	4,498	3,868	8,366	3,627	8,795	12,422
5	1989	4,617	3,037	7,654	3,637	9,907	13,544
6	1989	6,161	3,382	9,543	3,205	8,243	11,448
7	1989	5,135	2,916	8,051	4,067	8,683	12,750
8	1989	4,649	2,972	7,621	3,660	8,478	12,138
9	1989	5,731	3,102	8,833	3,909	12,007	15,916
10	1989	4,299	3,877	8,176	4,595	12,913	17,508
11	1989	5,643	3,633	9,276	3,736	11,236	14,972
12	1989	9,984	3,526	13,510	3,402	9,528	12,930
1	1990	9,456	4,025	13,481	3,503	12,572	16,075
2	1990	7,882	4,454	12,336	5,109	11,954	17,063
3	1990	7,310	6,401	13,711	4,751	12,658	17,409
4	1990	8,189	4,358	12,547	4,265	8,700	12,965
5	1990	6,873	3,326	10,199	3,486	8,696	12,182
6	1990	7,108	2,749	9,857	4,756	9,553	14,309
7	1990	6,592	3,636	10,228	3,335	8,214	11,549
8	1990	6,517	3,364	9,881	4,063	8,920	12,983
9	1990	7,704	3,166	10,870	3,925	6,562	10,487
10	1990	7,141	3,312	10,453	5,241	7,339	12,580
11	1990	5,918	3,391	9,309	5,024	7,442	12,466
12	1990	8,716	5,709	14,425	4,762	8,371	13,133

continued

TABLE 2
Continued

Month	Year	Spreadsheet			Wordprocessing		
		Lotus 1-2-3	Others ^a	Total	WordPerfect	Others ^b	Total
1	1991	8,717	5,711	14,428	4,762	8,373	13,135
2	1991	10,680	8,388	19,068	5,822	9,272	15,094
3	1991	6,342	8,820	15,162	4,952	8,423	13,375
4	1991	5,335	10,675	16,010	4,262	7,762	12,024
5	1991	8,753	8,539	17,292	3,773	6,533	10,306
6	1991	6,815	8,311	15,126	4,472	7,237	11,709
7	1991	4,759	8,073	12,832	3,425	5,518	8,943
8	1991	5,008	6,266	11,274	4,836	5,674	10,510
9	1991	5,794	6,456	12,250	3,766	6,087	9,853
10	1991	4,789	6,705	11,494	4,555	6,227	10,782
11	1991	5,531	10,599	16,130	3,650	7,985	11,635
12	1991	5,620	6,885	12,505	3,406	8,752	12,158
1	1992	6,617	9,696	16,313	4,948	6,041	10,989
2	1992	6,110	7,726	13,836	6,469	7,250	13,719
3	1992	6,294	12,800	19,094	10,260	8,856	19,116
4	1992	5,748	6,457	12,205	14,048	10,562	24,610
5	1992	5,136	6,008	11,144	14,054	9,836	23,890
6	1992	4,524	5,749	10,273	14,911	9,060	23,971
7	1992	4,240	7,890	12,130	14,851	7,763	22,614
8	1992	3,784	7,871	11,655	11,511	8,303	19,814

^a Includes QuatroPro, Supercalc, Excel, Logistix, Multiplan, etc.

^b Includes MS Word, Wordstar, Macwrite, Lucoscript, Lotus Ami, etc.

PARAMETER ESTIMATION

The implementation of Equations (1)–(4) and (7)–(10) requires estimation of parameters a_1 , a_2 , b_1 , b_2 , b'_1 , b'_2 , α_1 , and α_2 . Like Givon et al. [5], we used a quasi-Newton nonlinear least squares algorithm included in the NAG library No. E04JAF [7] to estimate these parameters. Using the available data on microcomputer owners and software buyers of competing brands (e.g., Lotus 1-2-3 and Other Spreadsheets), this procedure minimizes the total sum of squared errors for the software buyers.

It should be noted that direct use of Equations (1)–(4) and (7)–(10) would require information on pirates, $Y_1(t)$ and $Y_2(t)$, and legal and illegal users, $U_1(t)$, $U_2(t)$, $W_1(t)$, and $W_2(t)$, which is not available. However, the eight equations (1)–(4) and (7)–(10) can be technically written as two equations of $dX_1(t)/dt$ and $dX_2(t)/dt$ in terms of lagged variables $X_1(t)$ and $X_2(t)$ eliminating all other variables. The resultant equations can then be used to minimize the total sum of squared errors for software buyers to estimate the various parameters.² The algorithm searches for the values of the parameters that minimize the total sum of squared errors. Because the optimal values can depend on initial values provided for these parameters in the algorithm, several different initial values of these parameters were used to check the convergence of the final estimates.

RESULTS

Table 3 provides the parameter estimates for the two product categories. Figures 2 and 3 show the model fits to the data. Once the coefficients a , b , b' , and α were known for each brand, the unit sales were also predicted for the months before the

² The derivations to show these relationships are similar to the derivations reported by Givon et al. [5] and are available from the authors.

TABLE 3
Parameter Estimates for the Diffusion of Competitive Products for Spreadsheets and Word Processing Software in the United Kingdom

Parameter	Spreadsheets		Word processing software	
	Lotus 1-2-3	Others	WordPerfect	Others
Coefficient of external influence a	.000010	.000031	.000010	.000393
Coefficient of internal influence b	.930155	.456800	.162788	.119290
Switching coefficient b'	.017441	.081773	.028979	.000010
Coefficient of legal buying α	.080622	.002889	.072824	.148164
Explained variance	.684	.746	.674	.472

period for which data were not available for each brand. These are also plotted in Figures 2 and 3.

Table 3 provides some interesting insights about the piracy and brand switching dynamics for the various brands. Consider, for example, spreadsheets. The coefficient for legal buying $\alpha = .08$ for Lotus 1-2-3 and $\alpha = .003$ for Other Spreadsheets. These values suggest that, as compared to Other Spreadsheets, there was less piracy for Lotus 1-2-3 (i.e., the value of $(1-\alpha)$ for Other Spreadsheets is greater than the value for Lotus 1-2-3). As shown in Figure 4A, the ratio of legal buyers to pirates stabilized around 12 for Lotus 1-2-3 and 18 for Other Spreadsheets.

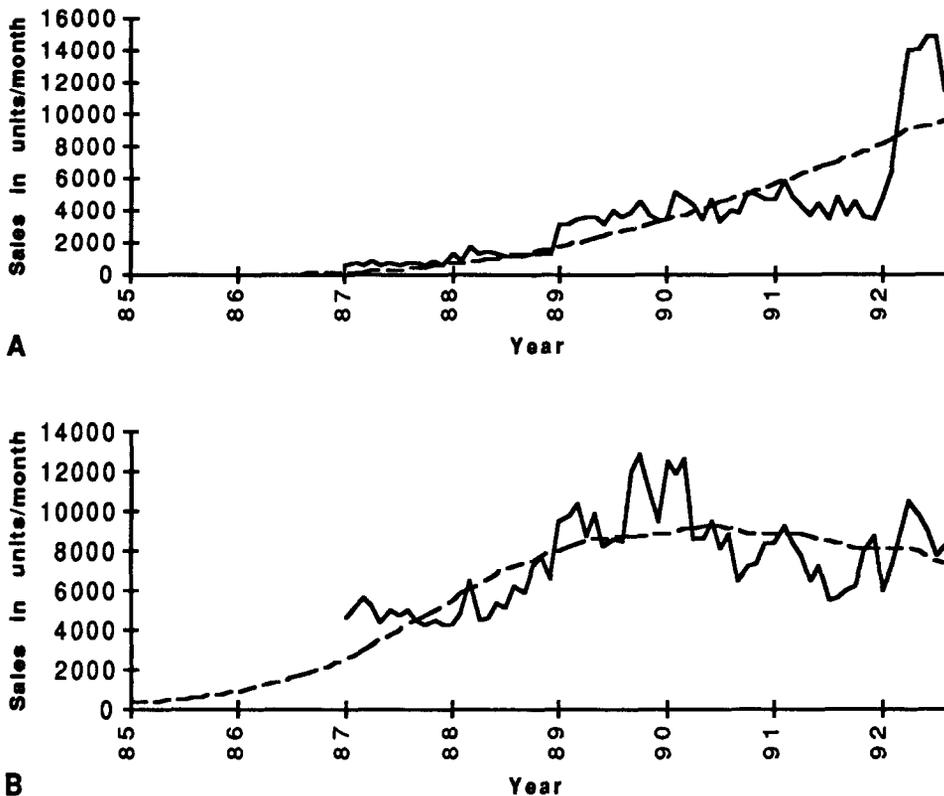


Fig. 3. Legal unit-sales of (A) WordPerfect and (B) Other word processing software in the United Kingdom: actual (solid lines) and estimated (dashed lines).

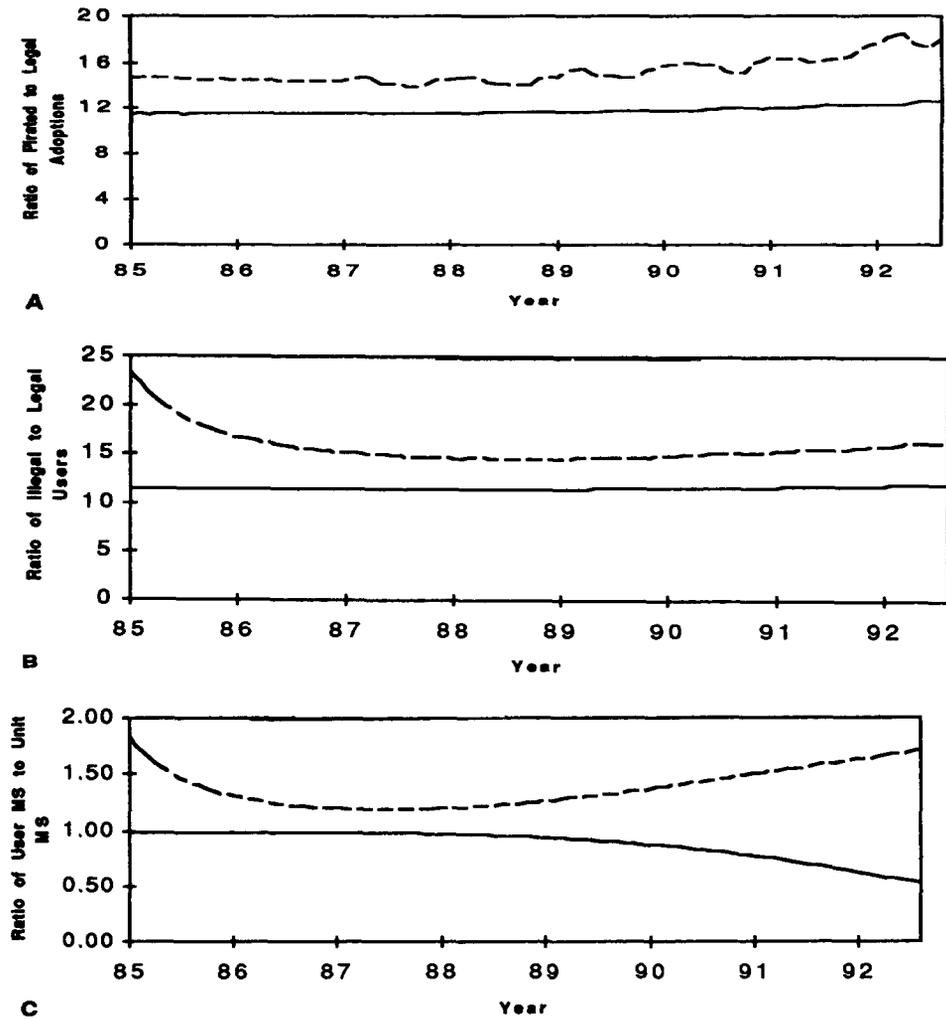


Fig. 4. Legal and shadow diffusion dynamics of Spreadsheets in the United Kingdom (A) Ratio of pirated to legal adoptions; (B) ratio of illegal to legal users; (C) ratio of user-based market share to predicted unit-based market share. Legend: Lotus 1-2-3 (solid lines) and Others (dashed lines).

Note in Table 3 that $b' = .017$ for Lotus 1-2-3 and $b' = .082$ for Other Spreadsheets. Because b' captures the brand switching influence of the users of a brand on the users of the competing brand, these coefficients suggest that more users of Lotus 1-2-3 were likely to switch to Other Spreadsheets than vice versa. Figure 4B shows that the ratio of illegal to legal users stabilized around 18 for Other Spreadsheets and 10 for Lotus 1-2-3.

The above trends, based on the relative values of α and b' , suggest that the potential users of spreadsheets were more likely to pirate Other Spreadsheets (than Lotus 1-2-3) and users of Lotus 1-2-3 were also more likely to switch to Other Spreadsheets. Hence, because of these trends, Other Spreadsheets were more likely to have a higher user base than their unit sales, and Lotus 1-2-3 was more likely to have a lower user base than its unit sales.

The ratio of user-based (legal and illegal) market share to predicted unit sales-based (legal only) market share for spreadsheets in the United Kingdom is plotted in Figure 4C. This figure clearly indicates that the ratio between the user-based market share and the unit sales-based market share was always less than one for Lotus 1-2-3 and greater than one for Other Spreadsheets.

The values of switching coefficient b' and the coefficient of legal buying α for word processors also provide some interesting insights for the diffusion of WordPerfect and Other Word Processors. The coefficient α is .07 for WordPerfect and .15 for Other Word Processors (word processing software). These values suggest that, compared to Other Word Processors, potential users were likely to pirate WordPerfect more than Other Word Processors. At the same time, the values of $b' = .03$ for WordPerfect and $b' \cong .00$ for Other Word Processors suggest that the users of WordPerfect were more likely to influence users of Other Word Processors to switch than vice versa. These trends collectively suggest that because of relatively higher piracy and brand switching away from Other Word Processors, WordPerfect was likely to have a larger user base than its unit sales.

Figure 5C confirms this result. As shown, the ratio between market shares based on user base and unit sales was always greater than one for WordPerfect. It was always less than one for Other Word Processors. Figure 5 also shows that the ratio of pirates to buyers stabilized around nine for WordPerfect and five for Other Word Processors. Similar values are observed for the ratio between illegal and legal users.

Figures 4 and 5 clearly indicate that, in the presence of differential piracy and brand switching, the ratio between the user base and unit sales is not one. Furthermore, because of the dynamic nature of piracy and brand switching, this ratio may change over time.

Discussion and Conclusions

In the last 20 years, several studies have established and challenged the relationship between market share and profitability [8]. Wind and Mahajan [9] have pointed out that in addition to the unit of measurement (unit versus dollar sales), a number of other factors can impact the estimated value of market share. Chief among these factors are: (1) product definition (brand, product line, strategic business); (2) market definition (broadly versus narrowly defined, e.g., market for soft drinks versus cola drinks); (3) time frame (short-term versus long-term); and (4) scope of the denominator (all brands versus selected brands).

The objective of this article was to argue that, in the presence of differential piracy and brand switching, in addition to unit or dollar sales, unit of measurement for market share for software brands should also include the user base. The user base provides a critical measure of brand acceptance that a firm can use to strategically manage its "customers" for long-term profitability.

To facilitate the estimation of market share based on user base for a brand, this article extended the diffusion modeling approach suggested by Givon et al. [5] to consider explicitly differential piracy and brand switching among brands in a software product category. The approach provided a mechanism to quantify the relationship between market shares on unit sales and the user base.

This modeling approach was used to analyze the diffusion of Lotus 1-2-3 versus Other Spreadsheets and WordPerfect versus Other Word Processors in the United Kingdom. The results indicate that, as compared to Other Spreadsheets, the ratio of market share estimates based on user base and unit sales was less than one for Lotus

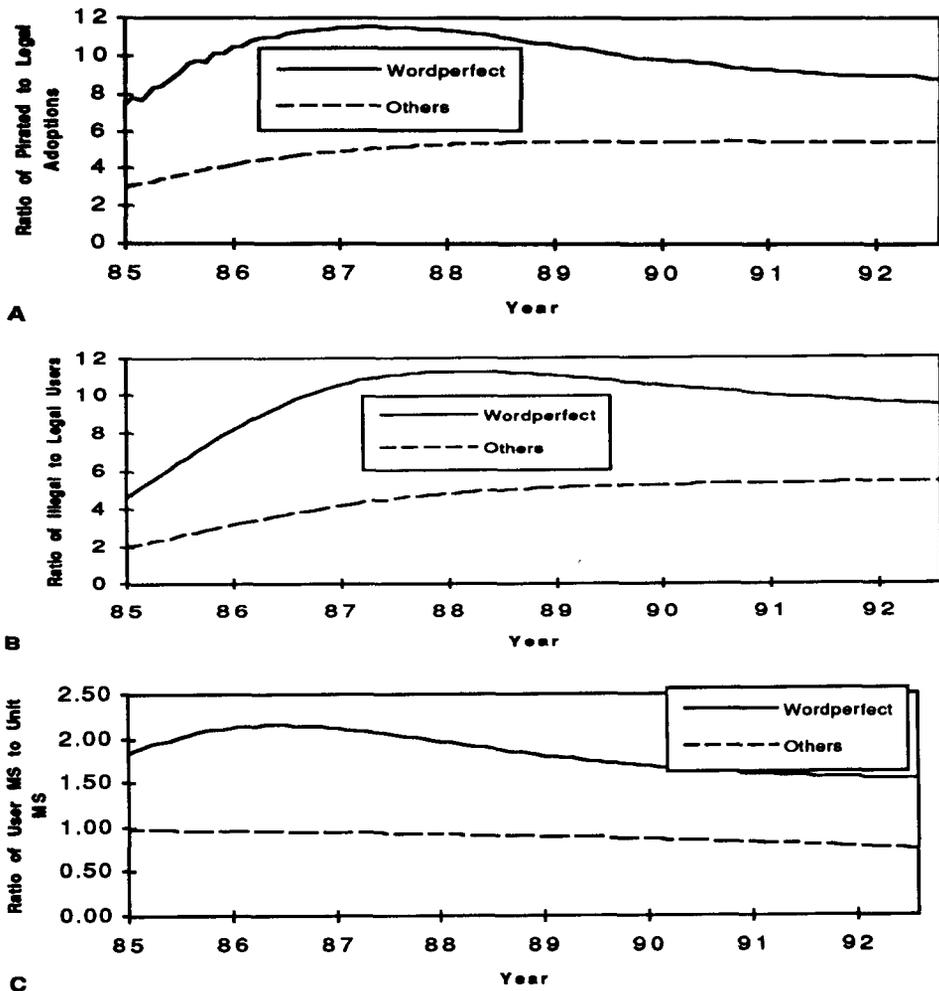


Fig. 5. Legal and shadow diffusion dynamics of word processing software in the United Kingdom (A) Ratio of pirated to legal adoptions; (B) ratio of illegal to legal users; (C) ratio of user-based market share to predicted unit sales-based market share.

1-2-3 and, as compared to Other Word Processors, this ratio was greater than one for WordPerfect. These results should be of interest to Lotus 1-2-3 and Novell WordPerfect. A critical question for Lotus 1-2-3 is, why is the user base smaller than unit sales, despite piracy? Why are adopters of Lotus 1-2-3 switching to Other Spreadsheets? Similarly, a strategic question for Novell WordPerfect is how should it take advantage of its larger user base for long-term competitive advantage? Such questions should be of importance to any software company in a competitive market that faces piracy and brand switching. In fact, several software companies, such as Microsoft, are developing their market penetration strategies by understanding the dynamics of units sold and user base [10].

It should be mentioned that it is not the objective of this article to advocate piracy. As summarized by Givon et al. [5], several marketing instruments (e.g., software bundling, complimentary services, sampling, etc.), as well as legal actions, are currently being used by software firms to manage piracy. With Internet distribution of software,

it is possible that piracy may not be an issue in the future. Until that time, however, the role of pirates in the diffusion of software may be underestimated as suggested by the proposed model and the analyses in this article. As exemplified by data for Brands B and C in Table 1, in the presence of brand switching and piracy, firms that can take advantage of the user base generated by these two dynamics will be the winners.

Finally, although in this article we considered the diffusion of two popular software products, there is no reason to believe that the proposed model is not also applicable to some other software products. Depending upon the availability of data, more complex models can be developed that accommodate assumptions made in the proposal model and analyses (see footnote 1). Furthermore, the focus of this article is on piracy by users and potential users. The article does not focus on pirated software sold by illegal or legal distributors.

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