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The Market for Software in the U.S.

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Abstract: The US market for software is investigated for the period 1964 to 2000. exploring the impact of price and non-price variables on software demand. and the impact of R&D and productivity on software supply. Software sales are positively associated with advertising, they are negatively affected by a rising consumer credit to GDP ratio. and are highly responsive to disposable income. Supply has been driven by productivity improvements.

Keywords: Software. demand. supply, non-price competition

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1. Introduction

The use of computers and software for personal and business applications has grown so phenomenally, that it is described correctly as a revolution. In 2000, the U.S. software industry generated gross domestic income valued at $245.6 billion, and employed around 1.6 million workers. According to the U.S. Census Bureau (2000), 30 percent of the U.S. population owned a personal computer in 1997 and this proportion is expected to continue to grow solidly. Use of computers is however much more extensive than home computer ownership. For example, 72 percent of the U.S. population used the Internet in 2000. Leading software developers, such as Microsoft and Adobe, have now become household names.

Given the growing importance of software to the world of work, and increasingly to the sphere of entertainment, it is rather surprising that relatively little is known about the market for software. While several studies have explored the impact of information technologies on productivity (e.g. Lehr and Lichtenberg 1999, Triplett 1999 and Liu *et al.* 2004), there are, to our knowledge, no empirical studies of software demand. Consequently, little is known about the responsiveness of software demand to price

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changes, and vital factors such as income and advertising activities. Further, non-price competition is an important driver in the software industry, with competition fuelled by increases in innovation rather than decreases in price.[1] Accordingly, it is important to investigate also the responsiveness of a software firm's sales with respect to changes in R&D expenditure.

Analysis of software demand is important also for antitrust policy. For example, it is claimed that the change in competition from traditional price to non-price channels is not being recognized by the antitrust enforcement authorities, and that the courts are guided too much by the theory of price competition (Jorde & Teece, 1991). One consequence is that the current objective of solely promoting present consumer welfare should be replaced by innovation and its rapid diffusion as the goal of antitrust policy (Jorde & Teece, 1991). If this is adopted then consumer welfare will be enhanced long term through productivity growth driven by innovation and its rapid and profitable commercialization (Jorde & Teece, 1991).

The aim of this paper is to explore the market for software by identifying the determinants of software demand and to provide estimates of key elasticities relating to the demand for software, and exploring the responsiveness of supply to research and development and productivity. The software market is discussed briefly in section 2, while the empirical methodology is presented in section 3. The data are discussed also in section 4. Section 5 presents the results, together with interpretation.

2. The Market for Software

Modern economies can be partitioned broadly into two different production sectors. These are the traditional or resource intensive sector where bulk goods are processed and, the high technology or 'know how' intensive sector where products are created from knowledge (Arthur 1996). Typical activities in the traditional sector include bulk processing of grains, livestock, heavy chemicals, metals and ores, foodstuffs and retail

[1] In 1985, Microsoft spent $17m on R&D. By 2002 this rose to $4,307m (source, http://www.microsoft.com/msft/history.htm)

goods. The non-traditional or high technology sector of the economy comprises products such as pharmaceuticals, aircraft and missiles and telecommunications equipment. These activities typically have research and development costs that are large relative to their unit production costs. The high technology sector includes also the vital computer hardware and software industries.

Software is a durable good in that it has an expected life of at least three years. However, unlike other durable goods, such as refrigerators, air conditioners, space heaters etc. software is replaced more rapidly. Software is an important investment used extensively for business applications, as well as a major consumer item. The software market covers a broad range of products, from work based applications like spreadsheets, word processors and a range of graphical and analytical applications, to communications software such as email and internet, as well as the rapidly expanding home entertainment applications including gaming.

3. Empirical Methodology

The empirical exploration involves the estimation of demand and supply functions for software assuming that the software market is in equilibrium. The demand for software can be represented by a standard demand function:

$$D_t = f(P_{ot}, P_{ct}, Y_t, A_t, Z_t) \qquad (1)$$

where D denotes demand for software, P_o is the own price of software, P_c is the price of computers, Y is real disposable income, A is advertising, and Z is a vector of other factors deemed to influence the demand for software, such as credit conditions and the opportunity cost of holding durable goods. The time period is denoted by the subscript t.

A functional form has to be chosen in order to estimate equation 1. The exact form of the software demand function is unknown and must be estimated. Several alternative specifications were explored, such as the linear and log-linear, but the log-log form appears to be the most suitable and the results from this specification are the only ones reported here.

Software and computers are complements. Consequently, a negative association is expected between computer prices and software. Income is expected to have a positive association with the demand for software. Advertising plays a pivotal role in the software industry and is an important factor in non-price competition. Advertising is expected to have a positive association with software sales.

In addition to the demand function, we estimate also a supply function given by:

$$S_t = f(P_{ot}, RD_t, K_t) \quad (2)$$

where S_t denotes supply of software at time period t, P_{ot} is the own price of software, RD_t is research and development (R&D) and K is a vector of other factors that shift the supply of software curve, such as research and development and multi-factor productivity. Equations 1 and 2 together form a system of equations representing the market for software. These two equations are estimated using two stage least squares.

4. Data

Data on sales of software were derived by combining real consumption and real investment expenditure on software. Current price measures of expenditure on software are available through the *Bureau of Economic Analysis National Income and Product Accounts* (NIPA) tables. These were deflated by the associated price indices for software also reported in the NIPA tables.

The own price P_0 is measured as a chain type price index of software, and is a result of hedonic price estimates. The price of computers is reported in the NIPA tables and is also a result of hedonic price estimates.[2] The hedonic estimates for P_0 are not as complete as those for computers (Hollanders and Meijers 2002 and Parker and Grimm 2000).

Advertising expenditure information was compiled from data supplied by McCann-Erickson Inc. and from Schonfeld and Associates Inc., as reported by the *Advertising Age*.

[2] This series is remarkable in its path. commencing at 22916 in 1964 and falling to 37.65 in 2000.

There is no price index specific to advertising expenditures. Hence, the GDP implicit price deflator was used. The real disposable income series was derived from the *2002 Economic Report to the President.*

Several variables were included as part of the Z vector. The influence of interest rates on the purchase of software can be captured by the 3-year bond rate. The bond rate is a proxy for the user cost of capital, which has been used in previous studies of consumer durables (see. for example. Barrett and Slovin 1988). The influence of debt can be explored by including a credit variable. This was calculated as real consumer credit and expressed as a ratio of real GDP. Data for the bond rate and credit variables were derived from the *2002 Economic Report to the President.* We considered also the influence of other prices, such as the price of durable goods, the price of non-durable goods and the price of structures (all derived from the NIPA tables). The *change* in the unemployment rate was also included in order to explore the impact of the general economic climate on sales of software. The unemployment data is available through the Bureau of Labor Statistics. For the sake of brevity, the results with these variables included are not reported, as these variables were not statistically significant. (These results are available from the authors.)

The supply equation includes R&D as a shifter. There is no historical series for R&D in the software industry. Instead we used two proxies: R&D expenditure in the electrical equipment manufacturing sector and R&D expenditures in the non-manufacturing industries. Data for these are reported in the *Industrial Research and Development Information System.* The inclusion of the former was never statistically significant. Hence, only the results with the non-manufacturing series are presented in this paper. This series can be interpreted as a general measure of innovation. A second problem is the absence of a specific R&D deflator, necessitating the use of the GDP implicit price deflator to derive a real R&D expenditure series. Multifactor productivity is an overall measure of the productivity of labor, capital, energy and raw materials inputs, and is an essential component of improvements in performance. Multifactor productivity data was derived from the U.S. Department of Labor, Bureau of Labor Statistics. This is a proxy for improvements in efficiency and productivity both within the software industry and beyond it, capturing spillover effects. In addition to this, we incorporated also unit labor costs for the durable goods sector. While this was correctly signed, it was not statistically significant and was hence removed subsequently from the equation.

The data is available from 1964 to 2000, limiting the use of lags to one period. The instrument list used for the two stage least squares estimation includes income, the price of computers, R&D, advertising, the unemployment rate, the 3 year bond rate, productivity growth and the credit ratio. Table 1 presents descriptive statistics of the key variables used (before taking logarithms).

Table 1: Means and Standard Deviations, 1964 – 2000

Variable	Mean	Standard Deviation
Real Software Sales	39.21	53.57
Software price	93.08	16.97
Computer price	3456.50	5432.09
Real Disposable Income	4157.81	1365.86
Real Advertising	1.20	0.62
Credit	0.014	0.001
Real R&D	118.31	135.42

5. Results

A number of models were estimated, incorporating different potential demand and supply shifters, including lags in the variables. We adopted a general-to-specific modeling strategy, including current and lagged values of all variables and sequentially eliminating any statistically insignificant variables. The preferred model is presented in Table 2 (the full set of results is available from the authors).[3]

[3] Eviews version 4.0 was used to estimate the demand and supply model.

Table 2: Parameter Estimates of U.S. Software Demand and Supply Elasticities, 1964-2000, log-log form

Variable	Demand for Software (2SLS)	Supply of Software (2SLS)
Constant	-22.54 (-4.46)***	-36.97 (-7.43)***
Software price	-0.91 (-7.39)***	2.17 (8.72)***
Computer price	-0.33 (-3.70)***	-
Real Income	2.29 (5.22)***	-
Real Advertising $_{t-1}$	0.81 (3.52)***	-
Credit	-1.13 (-4.71)***	-
Real R&D $_{t-1}$	-	0.46 (4.84)***
Multifactor Productivity	-	6.25 (5.31)***

Note: t-statistics in brackets and *** indicates statistically significant at the 1 percent level.

All the coefficients have the expected signs. The own price coefficient is negative, and a Wald test confirms that it is not statistically significantly different from -1.[4] The coefficient on the hedonic price of computers is also negative, confirming the complementary nature of software and computers. They are not perfect complements, because even though software is needed to operate a computer, there is a large degree of discretion about the types and variety of software that will be used with a computer. A 10 percent reduction in the price of computers increases demand for software by around 3 percent. Interestingly, the advertising elasticity of 0.81 is also not statistically significantly different from 1.[5] Real income has a positive coefficient, confirming that software is a normal good. It is clear also that software is income elastic. The credit variable has a negative sign, indicating that an increase in the credit ratio acts as a break of further spending on software. This is consistent with Lardaro's (1993) finding of a negative association between indebtedness and U.S. consumer demand for durable goods. In unreported regressions, the coefficient on the bondrate was found to be positive, which is consistent with the notion that rising interest rates may induce an intertemporal substitution of expenditures, bringing forth outlays on software. However, this variable was never statistically significant.

[4] Chi-square value is 0.51 with a prob-value of 0.48.
[5] Chi-square value is 0.66 with a prob-value of 0.42.

The supply equation reveals that supply of software is very responsive to price, with this supply elasticity exceeding one. The R&D elasticity is small but it is statistically significant. The largest supply elasticity is, however, the multifactor productivity. Software supply is very responsive to changes in productivity.

Over the 1964-2000 period, real sales of software have increased by an average of 14 percent per annum. In contrast, the (quality adjusted) price of software has increased slightly by an average of 1.5 percent per annum, while the (quality adjusted) price of computers has fallen by an average of 17 percent per annum. Disposable income over the same period grew by about 3 percent per annum, on average. This suggests that software demand grew by about 6 percent per annum as a result of the fall in the price of computers and roughly by another 7 percent per annum as a result of growth in real disposable income. We conclude that demand for software has been fueled by the falling price of computers and the steady expansion in real disposable income (roughly 13 percent of the 17 percent annual growth in software is attributed to these two variables). Over the same period, it appears that half the growth in software supply was fuelled by productivity improvements.

6. Conclusion

Software is an important part of a technological society. Little is known about the responsiveness of software to important economic variables. This paper offers the first analysis of the demand for software, using U.S. data for the period 1964 to 2000. The results confirm that computers and software are complements and indicate that software sales are influenced by credit conditions and advertising and are responsive highly to income.

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