A Dynamic IT Adoption Model for the SOHO Market: PC Generational Decisions with Technological Expectations

Namwoon KIM
Hong Kong Polytechnic University

Jin K. HAN
Singapore Management University, jkhan@smu.edu.sg

Rajendra K. SRIVASTAVA
Singapore Management University, rajs@smu.edu.sg

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Namwoon Kim • Jin K. Han • Rajendra K. Srivastava
Department of Business Studies, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong
School of Business, Singapore Management University, Singapore
McCombs School of Business, The University of Texas at Austin, Austin, Texas 78712
bunam@polyu.edu.hk • jkhan@smu.edu.sg • rajendra.srivastava@bus.utexas.edu

The *small-office/home-office* (SOHO) professionals comprise the fastest growing segment in the labor force today. Typically being a one-person business based at home, SOHO owners mostly rely on office information technology to single handedly run their entire operation. Despite the segment's ostensibly growing dependence and influence on the information technology (IT) industry, still very little is known about the dynamics between SOHO and IT products. With the purpose of addressing this void, we investigate the SOHO professionals' adoption patterns of multigenerational IT products. Accordingly, we develop and empirically estimate an individual SOHO-level *initial-* and *repeat-purchase* logit model that captures the procurement patterns for successive generations of technological products, namely the PC category. Specifically, we find that SOHO professionals' procurement choices are influenced by a number of salient dimensions (i.e., income, performance, price, interpurchase time, network externalities). Furthermore, some SOHO owners are found to have a preference for a future (expected) generation (over a currently available one), which is explained via their business dispositions (i.e., technology orientation, result orientation, search orientation) toward accepting technological incertitude.
(*Technological Expectations; Information Technology; Network Externalities; Logit Modeling*)

> The most striking change in Third Wave civilization will probably be the shift of work from both office and factory back into the home. If as few as 10 to 20 percent of the work force … make this historic transfer over the next 20 to 30 years, our entire economy, our cities, our ecology, our family structure, our values, and even our politics would be altered almost beyond recognition. Alvin Toffler (1981, p. 223)

1. Introduction

The concept of the "work place" or "office" has undergone a significant change over the past decade as an ever-growing segment of the work force has chosen the home as a primary work locale. This segment, generally referred to as SOHO (*small-office, home-office*), is defined by the industry as home-based businesses with fewer than five employees (Clark 1994). With the majority of the SOHO ventures being one-person operations, the rapid growth of this segment has been largely made possible through landmark developments in information technology (IT) and information systems (IS) (i.e., personal computers (PCs), facsimile machines, copiers, printers, telephony, Internet), which have allowed for single-handed business operations to be entirely feasible (Bernstein 1995, Davidson 1991).

There remains a continued pressure on SOHO businesses to invest in newer generations of IT products,

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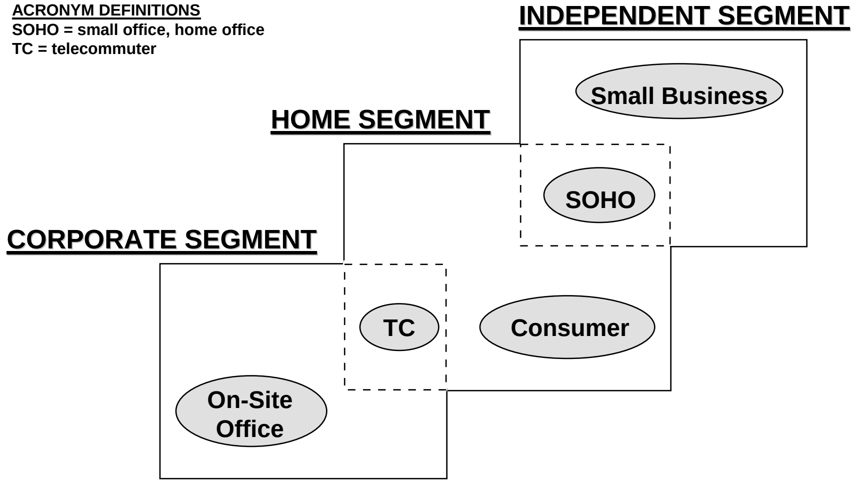
as the following statistic shows: 86% (vs. 68%) of SOHO professionals report improvements in efficiency and productivity as the result of investing in *state-of-the-art* vs. *less-than-up-to-date* office technology (Sutcliffe 1996). Despite most SOHO businesses being nontechnology related, SOHO entrepreneurs perennially face the problem of balancing the cost and benefits of upgrading to the latest IT products in pursuit of continuance and growth of their businesses (Trowbridge 1994). Reportedly at "10 million strong and still growing," the SOHO segment ostensibly represents an influential force that can shape the future direction of the IT industry (Golaski 1995).

A better understanding of the SOHO segment can succor both IT and IS providers and scholars to proactively plan and develop appropriate strategies for this swelling segment. The current state of research on SOHOs, however, remains scant and relatively lacking in insights for the following reasons. Specifically, until recently, the SOHO segment was perceived as *not quite* significant enough to warrant serious attention. Moreover, when SOHOs were considered, the segment was generalized (i.e., inaccurately) in the same context as telecommuters (TCs), small businesses (SBs), or the nonbusiness consumer market (see Figure 1) (Bissell 1994). Consequently, knowledge accumulated on SOHOs remains not only sparse but also lacking in relevance. A detailed and accurate study of the segment is warranted.

The significance of identifying SOHOs as separate from TCs, SBs, or consumers is meaningful on both conceptual and strategic grounds. First, although there are some commonalities between SOHOs and the other three identified segments, a critical distinction between them lies in the way decisions are made. As an independent entrepreneur typically with zero to four employees, the SOHO owner makes all decisions regarding the entire business operation, including choices about IT procurement (Saffo 1994). Accordingly, IT product choices tend to be largely subject to the dispositions of a single SOHO professional vs. a buying center employed by TCs or SBs (Christensen 1988). Moreover, unlike the consumer segment that considers IT foremost as a "lifestyle enhancer," SOHO professionals make IT purchase decisions primarily based on the needs of their business operations (Edwards 1994). In short, SOHOs are a segment uniquely embodying an autonomous home-based business culture that is coupled with fast-growing clout and IT reliance.

The purpose of this paper is to take an exploratory look at this rapidly emerging segment and its relation to IT (specifically the use of PCs). After all, Davidson (1991) credits PCs as the single most important tool responsible for the SOHO phenomenon. To this end, we consider the evolution of the SOHO segment by ascertaining the segment's initial PC purchase and upgrade decisions. Specifically, we model SOHO

Figure 1 Identification of the SOHO Segment



professionals' procurement choices among the successive PC generations (inclusive of future generation) to be influenced by a number of salient dimensions (e.g., income, performance, price, interpurchase time, network externalities). Furthermore, we allow SOHO owners the flexibility of opting for a future (expected) generation (over a currently available one), which is explained via their business dispositions (e.g., technology orientation, result orientation, search orientation) toward accepting technological incertitude.

The rest of the paper is organized as follows. First, we review the relevant literature on the SOHO segment and on its IT usage. Second, we discuss the model specification that is followed by a description of the data used for empirical analysis. Subsequently, the general model is estimated. Finally, we discuss some implications of the findings and suggest directions for future research.

2. Background

2.1. Roots of SOHOs

The rise of the SOHO movement was first predicted by Alvin Toffler in 1969 in his seminal work *Future Shock*. The phenomenon itself, however, did not effectively materialize until the mid-1980s because the forces that drove its development were not in place before this time. The reasons for the rise of the SOHO structure are typically attributed to three factors: (1) structural changes in the labor force, (2) growth of the service sector, and, most importantly, (3) the advent of IT (Christensen 1988).

Structural Changes in the Labor Force. A large percentage of the baby boom generation in the United States made an early exit from corporate ranks due to layoffs, dead-end careers, or other pressures. According to the Conference Boards Statistics (Goldstein 1990), each year l2 million middle managers systematically leave the corporate positions, and the most popular option is to start home-based ventures as their next careers. Adding to the SOHO pool are an increasing number of women and minorities aspiring to achieve success outside of limiting corporate settings. Furthermore, with the divorce rates reaching record figures, single-working parents are entering home-based businesses to accommodate the care of their children. Finally, as life expectancy climbs to age 85, more and more senior citizens can be seen creating home-based businesses, which comprises almost 15% of the SOHO segment. Inadvertent conditions in various sectors have had a contributing effect on the rise of SOHO popularity.

Growth of the Service Sector. The 1980s witnessed a disproportionate growth in the service (vs. industrial) sector of the economy. As a number of service jobs can be performed independent of time and location constraints, while industrial jobs typically cannot, the SOHO sector absorbed the bulk of the service sector's spurt, especially the white collar home-based jobs (Christensen 1988).

Information Technology Advancements. If the previous two factors are considered as having played supporting roles in fueling the SOHO phenomenon, advancements in IT certainly have assumed the leading impetus for the SOHO trend. That is, the extant literature resoundingly points to the PC as the single most important IT product that has actually catalyzed the SOHO movement (i.e., Christensen 1988, Davidson 1991, Karamjit 1996, Romei 1990, Tazelaar 1986, Winfield 1996), and the reason for this is rather evident as Davidson (1991, p. 19) explains.

> With an investment of as little as $1,500 and a few hundred dollars of off-the-shelf software, a home-based business owner can single handedly manage such tasks as keeping books, preparing mass mailings, and developing business plans. Ten years ago, additional staff would have been required.

The deep-rooted connection between PCs and SOHOs is also manifested in the parallel evolutionary paths of the two, and this partnership is expected to proceed further as their paths unfold in the years ahead (Engle 1997). Nevertheless, the dynamics of this relationship have yet to be explored. A study of the adoption behavior in the context of successive PC generations may perhaps offer some insight into these dynamics. In the following discussion, we address key influences in SOHOs' IT procurement decisions.

2.2. SOHOs and IT Decisions

Along with SOHOs' growing reliance on IT comes the pressure to keep up with the latest advancements in office technology. For instance, the results of a large-scale SOHO survey, sponsored by Xerox, reveal that *state-of-the-art* (vs. *less-than-up-to-date*) office technology yields superior results in efficiency and productivity, specifically in the areas of "customer service and support, developing and marketing new products and services, and an enhanced ability to manage cash flow" (Sutcliffe 1996, p. 10). The study further reports that a majority of SOHO professionals who have invested in state-of-the-art technology have improved their competitiveness by "accomplishing what large companies do, presenting a professional image, and acquiring new customers." Although the nature of most SOHO businesses is nontechnical, advanced technology ostensibly assumes a vital role in the SOHO segment.

Performance vs. Price. In a normative sense, there is little doubt about the benefits (e.g., efficiency, productivity, and competitiveness) that technological advancements may bring to SOHO professionals. In reality, however, procurement decisions are generally subject to a number of other consideration factors, with *price* being typically the most prominent. For example, surveys have repeatedly identified *performance* and *price* as two of the most important attributes in SOHOs' PC purchase decisions (i.e., *Home Office Computing Survey 1990*). Moreover, studies have shown that the manner in which performance and price are generally considered is in the form of a *tradeoff* or a *ratio* between the two dimensions (Hitt and Brynjolfsson 1994, Gordon 1990, Phister 1979). In other words, prospective buyers in technological product categories compare alternatives among different PC generations via their assessments of performance / price ratios.

In the context of PC generation upgrade decisions, we expect SOHO professionals to apply the same performance and price ratio principle in considering different PC generational options. However, unlike the initial purchase situations, we predict SOHO professionals to use their last purchased generation as the standard for evaluating all possible candidates for an upgrade. For example, an owner of a PC 386 machine is likely to use this machine as a reference point when evaluating performance and prices of other PC generations available in the market. This underlying rationale can be ascribed to the reference-point theory, which posits that *the most recent purchase* is a reference point for subsequent purchases in the product category (Kahneman and Tversky 1979, Kameda and Davis 1990). Hence, in line with this reasoning, we hypothesize that

Hypothesis 1a. *SOHO's evaluation of a given PC generation is conditional upon the relative performance/price ratios between the given and the most recently purchased PC generations.*

In addition to the availability of successive generations in the marketplace, an inherent facet of high-technology products is the periodic introduction of new generations. As a result, buyers have become accustomed to the trends of improving performance and declining prices in technological product categories (Balcer and Lippman 1984, Bridges et al. 1995). This, in turn, has conditioned "consumers to develop expectations that may influence their purchase decisions" (Bridges et al. 1995, p. 65). Accordingly, with the likelihood of an expectation for a future generation having already been formed, SOHO professionals are likely to engage in assessments of performance and price differentials between a future (expected) generation and the last purchased generation. Consequently, we expect the following in their procurement considerations.

Hypothesis 1b. *SOHO's evaluation of a future (expected) PC generation is conditional upon the relative performance/price ratios between the expected and the most recently purchased PC generations.*

Network Externalities. For SOHO professionals, every IT procurement decision represents "a work opportunity tied to a purchase" (Ehinger 1994). As such, issues surrounding network externalities have been considered by some to be more important than *price* in PC purchases for home-based business usage (e.g., Majkiewicz 1989, Reifsnyder 1988). First, communication (i.e., file exchange, cowork on programs) with other PC users is easier on the same generation PCs. That is, sending and sharing computer files and programs are dependent on software compatibility, and most software operations are dependent on the PC generation. For example, Windows and Excel perform optimally on the PC 386-compatible machine or more advanced generations. Therefore, the utility of a generation is enhanced by the proportion of adopters who use it. Secondly, psychological utility may increase due to the lower perceived risk associated with products that have a broader acceptance. The increase in each individual's utility due to network externalities (e.g., compatibility with other users, lower perceived risk associated with leading formats or standards) associated with the growth in the installed base (i.e., the number of users) has been widely recognized (Brynjolfsson and Kemerer 1996, Katz and Shapiro 1985 and 1986, Thum 1994, Esser and Leruth 1988, Shurmer 1993).

Due to the effects of technological substitution (i.e., a simultaneous occurrence of a new generation's market expansion and an older generation's impending obsolescence) (Norton and Bass 1987), which are inherent to the high-technology product categories, we expect the effect of the cumulative generation adoption to follow a nonlinear form. Specifically, the cumulative adoption of a generation is posited to enhance the utility (for any of the two reasons mentioned) in the early part of the generation's life cycle. However, as technological obsolescence sets in toward the latter part of the life cycle, the user will start to experience degradation in the valence effect. To this effect, we hypothesize that

Hypothesis 2a. *SOHO's evaluation of a given PC generation is influenced by the generation's network externalities, which follow a concave pattern.*

In contrast, the effects of network externalities, coupled with technological substitution, should work in the exact opposite direction when evaluating the appeal of waiting for a future (expected) PC generation. First, as the market expansion of the latest available PC generation starts to unfold—while its network externalities enhance the appeal for selecting this generation—the utility of waiting for the future (expected) generation should de facto diminish. Moreover, as the latest available generation's obsolescence starts to set-in after some time, the impact of network externalities is expected to reverse directions. Therefore, we propose

Hypothesis 2b. *SOHO's evaluation of a future (expected) PC generation is influenced by the latest available generation's network externalities, which follow a convex pattern.*

Interpurchase Time. In essence, the problem of generational upgrade falls into the broader class of repeat-purchase situations for durables, which means that purchase decisions may not be totally independent of interpurchase-time considerations. Specifically, in repeat category-purchase situations for durables, it has been shown that the longer the time since the last purchase, the higher the likelihood of a purchase occurring again (Pedrick and Zufryden 1994). The rationale is that prolonged interpurchase times typically signify that the buyer has gone without a utility-enhancing product for an extended period; not surprisingly, lengthy interpurchase times have often been linked to inefficiency, inconvenience, or loss of opportunity (Sinha and Chandrashekaran 1992). Accordingly, we expect SOHO professionals to be rather sensitive to extended interpurchase times due to their disproportionate reliance on high technology. The longer they wait to upgrade, the higher their likelihood in lagging behind in efficiency, productivity, and / or competitiveness (Sutcliffe 1996). In line with this reasoning, we expect prolonged interpurchase times to increase (vs. decrease) the utility associated with the option of selecting an available generation vs. waiting for a future (expected) generation.

Hypothesis 3a. *SOHO's evaluation of a given PC generation is positively affected by the length of the interpurchase time.*

Hypothesis 3b. *SOHO's evaluation of a future (expected) PC generation is negatively affected by the length of the interpurchase time.*

Business Disposition Toward Incertitude. Any procurement decision—whether it be an initial purchase or an upgrade—involving a future (expected) generation unequivocally carries a level of risk and uncertainty from a prospective buyer's standpoint (Bakos and Kemerer 1992). Particularly for SOHO professionals, the enormity of addressing such incertitude takes on a critical significance when the entire business operation is dependent upon the impending purchase. In past studies, individuals' overall dispositions toward risk and uncertainty have been shown to influence their attitudes toward purchase options (Kahn and Sarin 1988, Mauer and Ott 1995, Stem et al. 1977) i.e., a general risk-averse vs. risk-seeking attitude reveals different preferences for choosing a future (expected) generation. Moreover, the general disposition toward incertitude has also been captured via an individual's information search behavior aimed at resolving the incertitude (Cash 1984, Gemunden 1985, Moeller and Pesonen 1981) i.e., the extent of information search reflects the disposition toward incertitude.

The utility of a SOHO professional choosing the future (expected) generation, therefore, may also hinge upon his or her idiosyncratic business disposition toward the incertitude involved. To this end, we examine the extent to which each SOHO business considers risk and uncertainty associated with new technology (technology orientation) and the information search process (search orientation) involved to be an intrinsic component to the business, or just simply an unnecessary distress (result orientation). The technology orientation, which signifies entrepreneurs' propensity to implement the latest available technology in their businesses, is likely to lessen the utility of presently doing without current state-of-the-art technology in anticipation of the future generation. As the result, orientation focuses on the end outcome per se (vs. the means of task completion), the urgency aspect is not likely to favor the option of waiting for the future PC generation. Finally, the search orientation, which captures SOHO owners' extensiveness in the information search process, is consistent with postponing the current purchase incident in favor of future (expected) generations. Therefore, we posit that

Hypothesis 4a. *SOHO's evaluation of a future (expected) PC generation is negatively affected by the individual's technology orientation.*

Hypothesis 4b. *SOHO's evaluation of a future (expected) PC generation is negatively affected by the individual's result orientation.*

Hypothesis 4c. *SOHO's evaluation of a future (expected) PC generation is positively affected by the individual's search orientation.*

The business disposition construct (*technology orientation, result orientation*, and *search orientation*) is further elaborated in §4.1. In the following section, we present an individual SOHO owner-level delineation of the PC procurement decision process.

3. The Proposed Model

A PC-generation choice model, covering the initial purchase and the timing of subsequent PC upgrades is developed for the SOHO segment. Following the individual utility maximization principle, we formulate a multinomial logit model that is conditioned on the SOHO owner's past PC purchase event. A description of the model estimation procedure is provided, which is followed by model validation and benchmark comparisons.

3.1. Model Development

We assume that there are K number of PC generations available in the market at time t, where K_t is the most advanced generation available at time t; $(K+1)_t$ represents the future (expected) PC generation that is not yet available at time t. Hence, a SOHO owner n may choose to purchase any one of the available K generations, or they may choose to postpone the PC purchase in expectation of the future (expected) generation $(K+1)_t$. Moreover, the utility of a SOHO owner n in choosing any one of the available or expected generations is posited to be conditional upon the entrepreneur's *most recent* PC purchase at time t'. For example, an owner of a PC 386 is likely to use this computer as a reference point when evaluating performance and prices of other PC generations available in the market. If an option is deemed appropriate, the purchase takes place. Otherwise, the SOHO owner will wait for the future (expected) generation. Also, by denoting the previous nonownership status in the PC category as the 0th generation, the initial PC purchase incident is treated as a special case of conditional purchase (hence, *the most recent PC purchase* belongs to one of the following PC generations: $0, 1, 2, \dots, K_{t'}$, where *generation* 0 represents the prior nonownership status in the PC category).

Regardless of the PC generation last purchased, however, SOHO owners face the inevitable dilemma of technological obsolescence with the passage of time. As a result, despite having purchased PC at time t', we assume that SOHO owners invariably evaluate all current options on hand at a given time t. Accordingly, altogether $K+1$ options are considered at time t, which entail: (1) K options from the available generation set $\{1, 2, \ldots, K_t\}$ plus (2) an option of waiting for the expected future generation $(K+1)_t$. Although the evaluations of all $K+1$ options are simultaneous, the two types of options (available vs. expected generations) typically vary in their utility considerations. Specifically, salient factors (e.g., performance, price, income, interpurchase time) tend to dominate utility assessments among available alternatives (i.e., generation set $\{1, 2, \ldots, K_t\}$), whereas latent factors (e.g., expectations, idiosyncratic IT dispositions), in addition to the salient ones, tend to exert influence on future expectations (Broniarczyk and Alba 1994). To this end, we present two utility assessment specifications: (1) for choosing an available PC generation and (2) the other opting for a future PC generation.

3.2. Utility for Choosing an Available PC Generation

$$U_{jtn|it'} = (b_{0jtn} - b_{0itn}) + a_{11}NE_{jt} + a_{12}NE_{jt}^2 + a_2 T_{tn}^* + \varepsilon_{jtn|it'} \quad (1)$$

where $U_{jtn|it'}$ = utility for purchasing generation j at time t given the most recent purchase was generation i at time t' for a SOHO professional n,

$$b_{0jtn} = \frac{b_j}{PRICE_{jt}/INCOME_{nt}},$$

$$b_{0itn} = \frac{b_i}{PRICE_{it}/INCOME_{nt}},$$

b_j = performance of generation j, b_i = performance of generation i, $PRICE_{jt}$ = price of generation j at time t, $PRICE_{it}$ = price of generation i at time t, $INCOME_{tn}$ = annual household income for SOHO professional n, NE_{jt} = cumulative number of adoptions of generation j till time t, T_{tn}^* = the time since the most recent purchase for individual SOHO professional n at time t, a_{11}, a_{12}, and a_2 = coefficients, and $\varepsilon_{jtn|it'}$ = Gumbel-distributed disturbance term, i.i.d., for $j = 1$ to K_t, $i = 0$ to K_t, $t = 1$ to T, and $n = 1$ to N.

The effects of performance and price are in the form of a ratio (performance / price) that indicates the relative performance value among the different PC generations—a well-accepted measure used in longitudinal studies on technological product markets, especially the computer industry (Hitt and Brynjolfsson 1994, Gordon 1990, Phister 1979). A key advantage to this ratio formulation is that, despite a generation's performance being time-invariant, the performance value itself is allowed to change as prices typically drop over time.

Furthermore, the performance and price ratio is adjusted for income for the following reasons. As SOHO professionals are spread over a wide range of income distributions, the impact of relative performance value comparisons among PC generations will vary from one entrepreneur to another. In other words, once adjusted for income, newer generations will appear to be carrying relatively more performance value, because higher levels of income have a tendency to mitigate the effects of price (Horsky 1990). This income effect is consistent with studies showing higher income as positively inducing higher repeat purchase probabilities in the durables category (Bayus 1991). Hence, by adjusting the performance value with income, we not only refrain from overstating the role of price, but we also accommodate some of the SOHO segment's heterogeneity.

3.3. Utility for the Future (Expected) PC Generation

$$U_{(K+1)_t tn|it'} = (b_{0Etn} - b_{0itn}) + a_{31}NE_{Et} + a_{32}NE_{Et}^2 + a_4 T_{tn}^* + a_{BDI}BDI_n + \varepsilon_{(K+1)_t tn|it'} \quad (2)$$

where $U_{(K+1)_t tn|it'}$ = utility for selecting future (expected) generation at time t given the most recent purchase was generation i at time t' for a SOHO professional n, b_{0Etn} = income-adjusted expected performance / price ratio of future (expected) generation at time t, NE_{Et} = cumulative number of adoptions of the *latest available generation*[1] at time t, T_{tn}^* = the

[1] While a market growth of the latest available generation enhances the generation's own network externalities, it will reduce the utility

time since the last purchase for individual SOHO professional n at time t, BDI_n = Business Disposition toward Incertitude for individual SOHO professional n, a_{31}, a_{32}, a_4, and a_{BDI} = coefficients, $\varepsilon_{(K+1)_t tn|it'}$ = Gumbel-distributed disturbance term, i.i.d. for $i = 0$ to K_t,[2] $t = 1$ to T, and $n = 1$ to N.

As the future (expected) generation represents a currently unrealizable option, salient factors alone may not fully account for the utility associated with expected forthcoming technology (Broniarczyk and Alba 1994). Therefore, we attempt to probe the latent factors that may provide an added insight to the process. To this end, we incorporate individual SOHO professional's business dispositions toward technology and search process for an exploratory purpose. A detailed discussion on these business disposition variables is provided in §4.1.

3.4. Estimation of the Disaggregate Multinomial Logit

Given the utility formulations of the available and the expected generational options, we use the multinomial logit framework to model the individual-level SOHO (disaggregate) generational decision. Consistent with the logit framework, the error terms of the generational options are assumed to be independent and identically follow the Gumbel distribution. In the multinomial logit formulation, the probability that a SOHO owner n selects generation j at occasion t is expressed as

$$P_{jtn|it'} = \frac{e^{U_{jtn|it'}}}{\sum_{k=1}^{(K+1)_t} e^{U_{ktn|it'}}}. \tag{3}$$

The maximum likelihood estimation (MLE) method is used for determining the model parameters. The model estimation problem reduces to the likelihood function in Equation (4), which is maximized with respect to the performance parameters for the generations (b_js) and the coefficients for the remaining variables: Network Externalities, Interpurchase Time, and Business Disposition toward Incertitude

$$L = \prod_{n=1}^{N} \prod_{t=1}^{T} \prod_{j=1}^{(K+1)_t} P_{jtn|it'}^{Q_{jtn}} \tag{4}$$

where N = total sample size of SOHO owners, T = whole time periods in the model, $(K+1)_t$ = number of options at time t (*including the future (expected) generation option*), $Q_{jtn} = 1$ if SOHO owner n purchases the generation j at time t, or $= 0$ if not, and $P_{jtn|it'}$ is the same as in Equation (3).

Maximizing the likelihood function in Equation (4) requires a more flexible procedure than typical logit models, because the number of available options (generations) changes over time. To provide this flexibility, we use the Nonlinear Least Squares (NLIN) procedure in SAS. That is, NLIN is used to specify a negative likelihood function as the loss function, which we then minimize to get the maximum likelihood estimates. More specifically, we use the Marquardt numerical optimization procedure (Judge et al. 1985) that yields stable estimates when potentially strong correlations exist among the independent variables.

3.5. Data Description

Because the development of the SOHO segment has mirrored the evolutionary path of the PC, it is worthwhile to examine the proposed model starting with the year 1980, when the PC boom began (Opiela 1996). The choice of data for model estimation covers a 13-year period, from 1980 to 1992, and there were 4 generations of IBM-compatible PCs (PSC 86/88, PC 286, PC 386, and PC 486) and 3 generations of Apple computers (Apple series, Macintosh, and Macintosh II series) developed during this period. To collect data, we developed a questionnaire and sent it to 370 randomly-selected SOHO business owners listed for an association of U.S. SOHOs. A total of 141 responses were returned, resulting in a response rate

for a future (expected) generation at the same time. Conversely, the decline in sales of the latest available generation caused by its technological obsolescence will reduce the generation's network externalities, but increase the utility for the future (expected) generation. Again, this logic is based on the reference-point theory that posits the most recent purchase to be a reference point for the subsequent future purchase (Kahneman and Tversky 1979, Kameda and Davis 1990). See our discussion leading to Hypotheses 1b, 2a, and 2b in §2.2 for further details.

[2] The performance / price ratio for a consumer's "nonownership" status (i.e., a null most recent purchase) is represented as b_{00tn} in Equations (1) and (2), which is equal to b_0, because there is no price adjustment for nonownership. This is the case when the SOHO professional has not yet bought any generation and the purchase at this time is the initial purchase.

of 38.1%. The respondents were comprised of more male SOHO entrepreneurs (65.2%) than female counterparts (34.8%) with an overall average age of 41. Moreover, 79.4% were married and had a relatively high-level education (an average of 14.4 years). To check for nonresponse bias, we first compared the information on the number of employees. The number of total employees (excluding the owner) did not differ significantly at $p < 0.05$ level amongst the respondents (2.08) vs. nonrespondents (2.19). Second, we compared the early respondents vs. late respondents as Armstrong and Overton (1977) noted that the latter group is similar to the nonrespondents from a sampling representativeness point of view. Again, we did not find significant differences in the demographics across the two groups (early vs. late respondents), alleviating much of the concern on nonresponse bias. Upon elimination of respondents with missing data, we ended up with 129 usable responses for model estimation. A panel-type dataset was generated by combining the PC purchase history and disposition data for each of the 129 SOHO entrepreneurs, covering 13 years and 8 PC generations (inclusive of the future (expected) generation).

4. Estimation Results of the Proposed Model

4.1. Measurement of the Disposition Construct

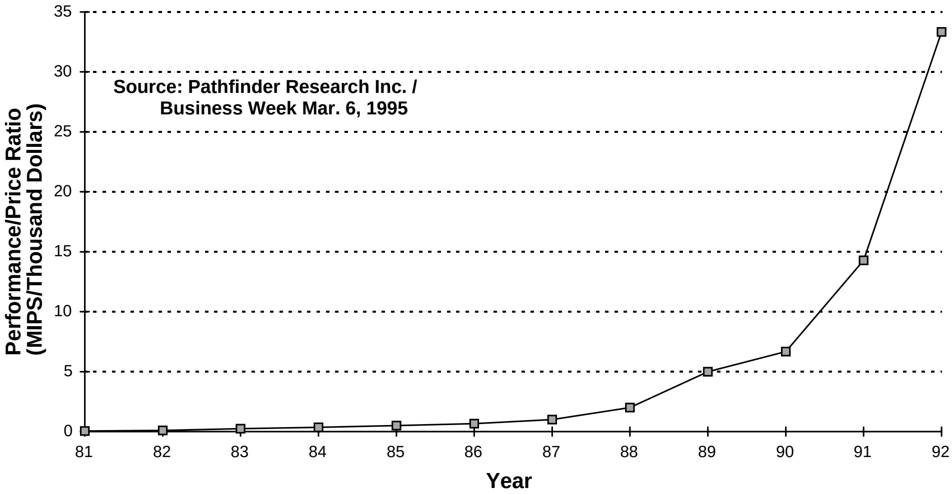
To incorporate the impact of the three business disposition variables discussed in §§2.2 and 3.3 into our model, we adopted measures from the relevant existing literature and modified them for the SOHO professional's business context. To measure the *technology orientation* dimension, we adopted three items developed by Gatignon and Xuereb (1997) and Kanter (1988). For *result orientation*, we employed seven items from Button et al. (1996), Noe and Wilk (1993), and Sujan et al. (1994) and modified them for the current study. Finally, we measured *search orientation* using five items from Beatty and Smith (1987) and Goldman and Johansson (1978) in the context of the SOHO consumer's technological product market. All 15 items were answered with a 5-point, Likert-type scale ranging from "Strongly Disagree" to "Strongly Agree." After performing a factor analysis, we ended up with three items for each factor that provide reasonably high loading (>0.5). Following Narver and Slater's (1990) reliability test procedure, we obtained the item-to-total correlation and Cronbach's alpha value for each factor of the business dispositions. The measurement reliability is presented in Table 1.

As we show in Table 1, the Cronbach's alpha coefficients of the three business disposition factors—technology orientation (TO_n) (0.817), result orientation (RO_n) (0.721), and search orientation (SO_n) (0.755)—surpass the 0.70 threshold recommended by Nunnally (1978) for the test of scale reliability. These

Table 1 Reliability Analysis of Business Dispositions Toward Incertitude

Business Disposition Component	Item-to-Total Correlation	Cronbach's Alpha
Technology Orientation (TO_n)		0.817
I am one of the first to purchase new technologies/products for my business.	0.805	
Having the latest equipment is important for my business performance.	0.861	
I need technologically advanced equipment to be competitive in my industry.	0.812	
Result Orientation (RO_n)		0.721
Learning new ways of running business operations does not excite me.	0.693	
It is enough for my business that something gets the job done. I do not care how or why it works.	0.766	
The task efficiency may be enhanced by learning new ways of doing things. (reverse coding)	0.528	
Search Orientation (SO_n)		0.754
I visit retail stores to examine and compare different options.	0.763	
I read articles, magazines, and newspapers to learn more about IT products.	0.709	
I do not buy an IT product until I feel absolutely confident about my decision.	0.744	

Figure 2 PC Market Performance / Price Ratio



three factors were interpreted as capturing the three dimensions of the SOHOs' dispositions toward future IT generation discussed in the previous sections. Furthermore, these factors, evidently representing a multifaceted disposition construct, are included in the utility specification for the future generational option in place of the single disposition variable (BDI_n) in Equation (2), providing Equation (2′) as follows

$$U_{(K+1)_t tn|it'} = (b_{0Etn} - b_{0itn}) + a_{31} NE_{Et} + a_{32} NE_{Et}^2 + a_4 T^*_{tn} + a_5 TO_n + a_6 RO_n + a_7 SO_n + \varepsilon_{(K+1)_t tn|it'} \quad (2')$$

where TO_n, RO_n, and SO_n respectively represent the Technology Orientation, Result Orientation, and Search Orientation of individual SOHO professional n. Definitions of the other variables remain the same as in Equation (2).

4.2. Expected Performance / Price Ratio of Future Generations

The income-adjusted expected performance / price ratio is obtained by adjusting the *expected market* performance / price ratio with each SOHO owner's income per annum. This expected market performance / price is gathered from industry data, and the unit of measurement is in millions of instructions per second (MIPS) per dollar. For purposes of the model estimation, we use the subsequent year's market performance / price ratio as the expected value for the future PC generation (see Figure 2).

4.3. Model Estimation Based on the Data

The model estimation program is written in SAS using the Nonlinear Least Squares (NLIN) procedure. The estimation results of the model are presented in Table 2, under the heading "Model Specification—Proposed."

A priori, we set the initial value for the performance parameter of the first generation PC (PC 86/88), b_1, which is fixed arbitrarily at 5 so that performance parameters for other generations are estimated as relative values, which allows for more stable estimation results for the case of unconstrained b_1. Overall, we observe the parameter estimates of the proposed model to be in line with our expectations. In regard to the PC performance parameter estimates, we expected the values to be in a descending order according to generations—from latest to earliest. In other words, we hypothesized $b_4 \geq b_3 \geq b_2 \geq b_1$ in the IBM-compatible market and $b_7 \geq b_6 \geq b_5$ in the Apple personal computer market. The results in Table 2 support our predictions regarding the magnitude of the performance parameters (except for b_2 that is statistically insignificant).

Table 2 Parameter Estimates for the Proposed and Comparative Models

Parameter	Definition	Proposed	Nested 1	Nested 2	Nonnested
		Model Specification			
	Performance for				
b_1	PC 86/88	5.000	5.000	5.000	5.000
b_2	PC 286	1.080	4.6917*	9.373*	20.000
b_3	PC 386	11.329*	16.244*	15.243*	40.000*
b_4	PC 486	48.420*	41.775*	35.762*	46.137*
b_5	Apple Series	5.010*	5.013*	7.536*	20.000*
b_6	Macintosh Series	5.316*	7.585*	15.140*	40.000*
b_7	Macintosh II Series	15.001*	21.675*	22.060*	45.054*
b_0	Nonownership	−0.021			
	Coefficient for				
	Available Generations				
a_{11}	Network Externalities (NE_{jt})	0.001	0.001		
a_{12}	Network Externalities (NE_{jt}^2)	−0.005*	−0.005*		
a_2	Interpurchase Time (T_{tn}^*)	0.089*	0.014		
	Expected Generation				
a_{31}	Network Externalities (NE_{Et})	−0.001	−0.001		
a_{32}	Network Externalities (NE_{Et}^2)	0.026*	0.002		
a_4	Interpurchase Time (T_{tn}^*)	−0.126*	−0.153*		
a_5	Technology Orientation (TO_n)	−0.989*	−2.136*		
a_6	Result Orientation (RO_n)	−0.044	−0.145*		
a_7	Search Orientation (SO_n)	0.604*	0.778*		
	Nonnested				
b_8	Waiting				48.653
a	$PRICE_{jt}$				−0.028
r	Expected $Price_t$ (Max $PRICE_{jt}$ at t)				1.179
	Log Likelihood (LL)	−1,237.417	−1,471.773	−1,816.519	−2,706.934
	Number of Parameters	16	15	6	9
	Bayesian Information Criterion	1,276.296	1,508.222	1,831.098	
	$U^2 = 1 - LL(Proposed)/LL(Comparative)$		0.159	0.319	
	Akaike Criterion	−1,253.417			−2,715.934
	Schwarz Criterion	−1,313.451			−2,749.703
	Posterior Probabilities (BCVL)	1.00			0.00

*Indicates that parameter was significant at $p < 0.05$.

In Hypothesis 2a, we posited an inverted-U relationship between network externalities and the utility for an available generational option. Consistent with our expectations, a_{12}, the coefficient for the quadratic term of generational network externalities (NE_{jt}^2), is estimated to be negative and is statistically significant (although the linear term (NE_{jt}) appeared to be insignificant). Nonetheless, as the quadratic term determines the concavity of the proposed technological substitution effect, its significant and negative outcome empirically confirms the inverted-U relationship between the network externalities and the utility of a specific generation.[3] To the opposite effect, Hypothesis 2b posited that the network externalities of the latest available generation will have a convex pattern of influence on the utility of the future (expected) generation. As expected, a_{32} (the

[3] For estimation purposes, a discrete time analog is used, whereby NE_{jt} is measured by the cumulative number of adoptions of generation j until time $t-1$.

coefficient for the quadratic term NE^2_{Et}) is estimated to be positive and robust, and less importantly, a_{31} (the coefficient for the linear term NE_{Et}) is insignificant.

Hypotheses 3a and 3b predicted that the longer the interpurchase time, the more obsolete the technological product currently in possession becomes; hence, the appeal is likely to be greater for upgrading *now* vs. *sometime later*. The significant positive parameter, a_2, for the available generations and the robust negative parameter estimate for the expected future generation, a_4, both support the conjectures concerning pressures against waiting for a future product.

As the future generation option represents an expectation of forthcoming technology, we hypothesized that the SOHOs' dispositions toward incertitude would factor into its utility considerations (Hypotheses 4a–4c). The results indicate two of the three disposition dimensions as being significant: negatively for technology orientation, a_5, and positively for search orientation, a_7, supporting Hypotheses 4a and 4c. The estimate for result orientation, a_6, turns out to be insignificant but the direction of impact is negative as in Hypothesis 4b. In sum, the estimation results generally support the model construct and are consistent with our previous discussion in §3. For the test of Hypotheses 1a and 1b and the general goodness of the model fit, we next compare the proposed model with three other formulations.

5. Validation of the Model

In this section, we validate the model performance by comparing the proposed model with three other model formulations based on various model-fit criteria. The proposed model has included the effects of SOHOs' purchase history, SOHO segment heterogeneity, and the dynamic generation-specific performance and price ratios. In contrast, Nested Model 1 does not account for purchase history, thereby providing a test for Hypotheses 1a and 1b; Nested Model 2 does not incorporate the SOHO segment heterogeneity; whereas, the Nonnested Model captures none of the three effects from the proposed model.

5.1. Development of Two Nested and One Nonnested Models

To validate the model performance, we compare the proposed model with two nested models and one nonnested model. These three models contain fewer predictor variables and/or simplistic specifications for the utility functions. Nested Model 1 is similar to the proposed model with the exception being that SOHO professionals' purchase histories are not taken into account. Such a formulation will provide a benchmark to assess the role of the most recent purchase in the subsequent purchase incident

$$U_{jtn} = b_{0jtn} + a_{11}NE_{jt} + a_{12}NE^2_{jt} + a_2 T^*_{tn} + \varepsilon^*_{jtn}, \quad (5)$$

$$U_{(K+1)_t tn} = b_{0Etn} + a_{31}NE_{Et} + a_{32}NE^2_{Et} + a_4 T^*_{tn} + a_{BDI}BDI_n + \varepsilon^*_{(K+1)_t tn} \quad (6)$$

where U_{jtn} = utility for purchasing generation j at time t for a SOHO professional n, $U_{(K+1)_t tn}$ = utility for selecting future (expected) generation at time t for a SOHO professional n, and all other variables are the same as those in Equation (1) in §3.2, for $j = 1$ to K_t, $t = 1$ to T, and $n = 1$ to N, and ε^*_{jtn} for $j = 1$ to $(K+1)_t$ = Gumbel-distributed disturbance term, i.i.d.

Estimation results for Nested Model 1 are provided in Table 2, under the heading "Model Specification—Nested Model 1." Like Nested Model 1, Nested Model 2 also has the same type of utility formulation as the proposed model, except that Nested Model 2 supports fewer variables. In particular, Nested Model 2 does not incorporate any individual SOHO-level heterogeneity. The utility function for Nested Model 2 is given in Equations (7) and (8)

$$U_{jtn} = b_{0jt} + \varepsilon^{**}_{jtn} \quad (7)$$

for $j = 1$ to K_t, $t = 1$ to T, and $n = 1$ to N, and

$$U_{(K+1)_t tn} = b_{0Et} + \varepsilon^{**}_{(K+1)tn} \quad (8)$$

for $t = 1$ to T and $n = 1$ to N, where $b_{0jt} = b_j / PRICE_{jt}$, b_{0Et} = expected performance/price ratio not adjusted to individual SOHO owner's income, ε^{**}_{jtn} for $j = 1$ to $(K+1)_t$ = Gumbel-distributed disturbance term, i.i.d., and b_j and $PRICE_{jt}$ have the same meaning as in Equation (1) in §3.2.

In Nested Model 2 (Equations (7) and (8)), the price / performance ratio (b_{0jt}) for available generations and the expected performance / price ratio (b_{0Et}) are not adjusted with each SOHO's income level. In addition, Nested Mode 2 does not incorporate each SOHO's business disposition variables. As a result, Nested Model 2 explains dynamic generation-specific performance and price ratios, but it does not consider SOHO segment heterogeneity. Consequently, the comparison of the two models probes the contribution of the SOHO's heterogeneity in predicting choices. Estimation results for this model are provided in Table 2, under the heading "Model Specification—Nested Model 2."

The Nonnested Model, while a direct derivation of the proposed model, takes on a more typical linear utility specification for the jth option as

$$U_{jtn} = b_j + a\,PRICE_{jt} + \varepsilon^{***}_{jtn} \tag{9}$$

and for the future (expected) generation option as

$$U_{(K+1)_t tn} = b_{(K+1)} + ar\,\mathrm{Max}(PRICE_{jt}) + \varepsilon^{***}_{(K+1)_t tn} \tag{10}$$

for $j = 1$ to K_t, $t = 1$ to T and $n = 1$ to N, where ε^{***}_{jtn} for $j = 1$ to $(K+1)_t$ = Gumbel-distributed disturbance term, i.i.d., a = coefficient for the price effect, and r = multiplier of the maximum price at time t.

Here, b_j (performance parameter for generation $j = 1$ to K_t) and $PRICE_{jt}$ take on the same meaning as in Equation (1) in §3.2. But unlike the proposed model, the Nonnested Model has b_{k+1}, the performance parameter for the future (expected) generation option. In the utility function for the future (expected) generation (Equation (10)), its expected average price is captured by a certain multiple (r) of the maximum price of the available generations at the present time t, Max($PRICE_{jt}$). As evident in Equations (9) and (10), the Nonnested Model has fixed performance parameters across time and the SOHO segment, and also includes $PRICE_{jt}$ and Max($PRICE_{jt}$), as covariates for the utility function. This is a typical linear utility formulation in the existing choice modeling literature (McFadden 1974, Ben-Akiva and Lerman 1985). Consequently, the Nonnested Model does not capture the purchase history, the SOHO segment heterogeneity, on the dynamic generation-specific performance and price ratios, whereas the proposed model captures all three. Estimation results for this model are also provided in Table 2.

5.2. Comparison of the Proposed Model with the Nested and Nonnested Models

The performance of the proposed model is compared with that of Nested Models 1 and 2, and the Nonnested Model based on the well-established model comparison criteria. The results are summarized at the bottom of Table 2.

Comparison with the Nested Models. First, we calculate the log likelihood for each of the three models (proposed, Nested 1, and Nested 2) and then perform the log likelihood ratio test (or chi-squared test of model significance) (Judge et al. 1985). Here, the ratios $\lambda_{N1} = 2$ (log likelihood of the proposed model − log likelihood of Nested Model 1); and $\lambda_{N2} = 2$ (log likelihood of the proposed model − log likelihood of Nested Model 2) are chi-square distributed, and the chi-square values 468.712 (λ_{N1}) and 1,158.204 (λ_{N2}) are statistically significant at the level $p < 0.01$. The significant log likelihood ratio test λ_{N1} provides a strong support for Hypotheses 1a and 1b, thereby indicating the merit in incorporating the most recent PC purchase as the point of reference in evaluating other alternatives. From the log likelihood ratio test λ_{N2}, we observe that it is worthwhile to add parameters for consumer heterogeneity.

Next, we provide the U^2 statistic (Guadagni and Little 1983, Hauser 1978, McFadden 1974), which is calculated by 1-(log likelihood of the proposed model / log likelihood of benchmark model). This U^2 statistic shows the incremental amount of uncertainty explained by one model over the other. As per Guadagni and Little's (1983) discussion, our U^2 values in Table 2 for the proposed model over the Nested Models (0.159 over Nested Model 1 and 0.319 over Nested Model 2) represent substantial improvements in explanatory power.

We also include the Bayesian Information Criterion (BIC) that measures the advantage of including consumer heterogeneity in the logit model (Chan and Mountain 1988). This is calculated by the negative log likelihood $+0.5k\ \ln(N)$, where k is the number of parameters and N is the sample size. BIC shows whether there is a significant improvement in the model fit after accounting for the increased number of parameters, and the model improvement is represented by a reduction of BIC value for the proposed model over the two Nested Models. In Table 2, we notice that the reductions of BIC values for the proposed model establish large improvement in model performance from those of the benchmark models: Nested Model 1 ($1{,}508.222-1{,}276.296=231.926$) and Nested Model 2 ($1{,}831.098-1{,}271.463=559.662$).

Comparison with the Nonnested Model. We also compare our proposed model with the Nonnested Model in Equations (9) and (10). Based on a model's predictive ability and parsimony, the existing literature suggests three criteria for comparing Nonnested Models: Akaike Criterion, Schwarz Criterion, and the Bayesian Cross-Validated Likelihood (BCVL) Method (Fornell and Rust 1989, Parker and Gatignon 1994, Rust and Schmittlein 1985).

The Akaike Criterion is widely used because of its simplicity when applied to Nonnested Model comparison (Akaike 1974, Rust and Schmittlein 1985). Built on an information theoretic assumption, this criterion suggests to select the model with a larger A value where $A=\log(\text{maximum likelihood})-(\text{number of estimated parameters})$. From Table 2, we note that our proposed model ($A=-1{,}253.417$) is preferred to the Nonnested Model ($A=-2{,}715.934$) using this criterion. Like the Akaike condition, the Schwarz Criterion also penalizes models having large numbers of parameters in the formula: $B=\log(\text{maximum likelihood})-0.5\log(\text{number of independent observations})\times(\text{number of estimated parameters})$ where the model with a larger B value is preferred (Schwarz 1978, Stone 1979). The proposed model with $B=-1{,}313.451$ performs better than the Nonnested Model ($B=-2{,}749.703$) according to the Schwarz Criterion.

Finally, the BCVL method developed by Rust and Schmittlein (1985) calculates posterior probabilities for each of the competing models based on the split-sample cross-validation theory (for a full review of this method, see Fornell and Rust 1989). Practically, the BCVL method provides the following formulation for the posterior probabilities of the competing models

$$P(S_j \mid D) \cong \left\{\sum_{i=1}^{M}\left[\exp\left\{\left((\chi_j^2-\chi_i^2)/2\right)+(q_j-q_i)+\log P(S_i)-\log P(S_j)\right\}\right]\right\}^{-1}$$

(Fornell and Rust 1989),

where model S_j ($j=1,\ldots,M$) with data D and the number of estimated parameters q_j has prior probability $P(S_j)$ with $\sum_{i=1}^{M}P(S_j)=1$ and $(\chi_j^2-\chi_i^2)/2$ may be substituted for by the difference in Akaike values (A_i-A_j). According to the BCVL criterion, the model with a higher posterior probability is preferred to the other competing models. For our model comparison, we follow the equal prior assumption suggested by Rust and Schmittlein (1985) and get approximate posterior probabilities of 1.00 for our proposed model and 0.00 for the Nonnested Model as shown in Table 2.[4] This result also favors the proposed model over the competing Nonnested Model.

5.3. Model Estimation Based on the Two Submarkets: IBM Compatibles and Apple Computers

As IBM compatibles and Apple computers establish their own customer groups, it is worthwhile to separately analyze these two submarkets. This additional analysis will also demonstrate the robustness of our model based on different datasets.[5] In the current data, 43% of SOHO professionals purchase IBM compatibles, 40% adopt Apple computers, and the remaining 17% switch between IBM compatibles and Apple computers from 1980 to 1992. After eliminating the switchers, we estimated our model twice based on the purchase data of IBM compatibles and Apple computers, respectively. The model estimation results of these two submarkets are provided in Table 3.

[4] The posterior probabilities converging to 1.00 or 0.00 are not unusual. Rust and Schmittlein (1985) also provided similar results when comparing forecasting models using data on medical innovations.

[5] We thank the anonymous reviewer who suggested that we include this model estimation for the two submarkets.

Table 3 Parameter Estimates for the Two Submarkets: IBM Compatibles and Apple Computers

Parameter	Definition	IBM Compatibles Submarket	Apple Computers Submarket
	Performance for		
b_1	PC 86/88	5.000	
b_2	PC 286	7.452	
b_3	PC 386	24.104*	
b_4	PC 486	38.190*	
b_5	Apple Series		5.122
b_6	Macintosh Series		11.588*
b_7	Macintosh II Series		23.655*
b_0	Nonownership	−0.150	−0.060
	Coefficient for		
	Available Generations		
a_{11}	Network Externalities (NE_{jt})	0.004	0.001
a_{12}	Network Externalities (NE^2_{jt})	−0.001*	−0.009*
a_2	Interpurchase Time (T^*_{tn})	0.325*	0.174
	Expected Generation		
a_{31}	Network Externalities (NE_{Et})	−0.000	−0.003
a_{32}	Network Externalities (NE^2_{Et})	0.028*	0.027*
a_4	Interpurchase Time (T^*_{tn})	−0.100*	−0.101*
a_5	Technology Orientation (TO_n)	−0.577*	−0.511*
a_6	Result Orientation (RO_n)	−0.302*	−0.001
a_7	Search Orientation (SO_n)	0.444	0.295*

*Indicates that parameter was significant at $p < 0.05$.

Comparing the parameter estimates based on the whole market in Table 2 (under the heading "Proposed") and those based on two submarkets in Table 3, we find no significant difference between them, which shows that our model is robust when using different submarket data. For the IBM compatibles submarket in Table 3, the performance parameters (b_js) are in the order that is consistent with our expectations ($b_4 \geq b_3 \geq b_2 \geq b_1$) and the coefficients of Network Externalities ($NE_{jt}, NE^2_{jt}, NE_{Et}, NE^2_{Et}$), Interpurchase Time ($T^*_{tn}$), and Business Dispositions (TO_n, RO_n, SO_n) are in the same direction as they are in Table 2. Similarly, the estimation results from the Apple computers market data in Table 3 are also in line with those we obtained from the whole market data in Table 2. Although the magnitudes of parameter estimates are different between the whole and the submarkets, the direction and significance level of the parameters are consistent. This result also adds to the validity of our model.

6. Discussion

With the general objective of capturing the dynamics between SOHO and the multigeneration PC category, our proposed model was put to the test on SOHO-based, panel-type data. In the process, we uncovered some empirical findings worth noting.

As indicated by the comparisons of model performance (§5.2), SOHO professionals generally appear to follow the protocol of using the most recently purchased PC as the reference in evaluating alternative generations. This result further generalizes Kahneman and Tversky's (1979) work on reference points in the multigenerational product repeat-purchase context. Moreover, our results lend credence to and generalize the boundaries of the supposition that consumers consider tradeoffs between *performance* and *prices* when comparing alternatives in high-tech categories—whether it be within one generation or across generations, or even in the context of a future (expected) generation.

By allowing separate utility formulations for available generations and the future (expected) generation, we were able to find evidence of SOHO professionals engaging in technological substitution practices in the PC category. Moreover, we find that the substitution pattern does not necessarily occur in the order of consecutive generations. In other words, SOHO owners can choose from any one of the available generations, or they have the option of a postponing the purchase in favor of a future (expected) generation.

Second, via the separate formulations of the two options, we were able to observe the juxtaposition of the effects of the same variables, namely *interpurchase time* and *network externalities*, on the different options. Specifically, prolonged interpurchase times tend to raise the probability of a purchase incident occurring in the present while lowering the appeal of waiting for a future (expected) generation. Also, in line with the technological substitution hypothesis, an available generation's network externalities were shown to exert impact following a concave pattern on that generation's utility, while network externalities of the current generation appear to affect the utility of a future (expected) generation following the inverse pattern (convex form).

Lastly, our findings bring attention to the capricious element inherent to the purchase decisions in high-tech product categories. As mentioned previously, high-tech multigenerational products are subject to technological substitutions and future generational expectations (i.e., on performance and price) typically abound for the prospective buyers. However, since expectations necessarily accompany some level of incertitude, the procurement decision becomes difficult to delineate without the knowledge of the decision maker's general disposition toward dealing with incertitude. In the context of IT procurement among SOHOs, our findings suggest the exigency in ascertaining the prospective buyer's technology and search orientations to obtain a more comprehensive picture of the procurement process.

7. Conclusion and Limitations

In this paper, we attempted to highlight the importance of the fastest growing segment in the labor force, SOHO, for its growing reliance and influence on the IT industry. Although IT represents a "critical component in the SOHO business strategies" (Sutcliffe 1996), still little is known about the dynamics between SOHO and IT products, particularly in the extant scholarly literature. With an initial aim of filling this void, we set out to investigate the SOHO professionals' adoption patterns of multigenerational IT products. Accordingly, we developed and empirically estimated an individual SOHO-level *initial-* and *repeat-purchase* logit model that captures the procurement patterns for successive generations of technological products, namely the PC category.

Our model formulation allowed us to investigate not only the SOHO owners' technological substitution pattern per se, but also the underlying processes driving their substitution decisions. Such investigations have been made possible largely because of the panel-type data used in the study. The proposed model uses easily obtainable data on PC purchase times, models, and SOHO business dispositions. As demonstrated, such information can be readily gathered via surveys. Based on these data, we were able to generate a panel-type purchase history for each SOHO professional and each PC generational option for every time period. Traditionally, panel-type purchase history data have not been used in technological or durable product markets, primarily due to unavailability of ready-made data in such form. Therefore, through our application, we have tried to illustrate both the feasibility and the motivation for using panel-type data in studying technological and durable category purchases.

Altogether, the salient and latent explanatory variables of the proposed model appear to accommodate the underlying SOHO professional's PC procurement decisions quite reasonably. We forward the following for the model's performance: (1) the variables have been compiled based on their relevance to the SOHO segment and (2) the formulation allows for SOHO segment heterogeneity and dynamism—as evidenced in comparisons with the Nested and Nonnested Models.

First, our robust findings for the proposed model strengthen our position that SOHOs indeed warrant separate attention from the other segments in the labor force. For instance, sitting at an intersection of *office*, *independence*, and *home*, SOHO professionals exhibit characteristics that are more *official* relative to regular consumers in their decision making. However, they also seem to incorporate more *individual attitudes* than their corporate counterparts in purchase decisions. Second, as the SOHO segment is comprised of a diverse set of professionals with a high potential for growth, our results reaffirm the need to accommodate the heterogeneity and dynamism for a better understanding of the SOHO segment as a whole. In this context, insights about individual SOHO owners have important implications on issues such as product development and database marketing, especially because the model captures changing SOHO owner preferences for each PC generation. Such analyses are essential in generational strategy decisions in multigeneration technological product markets for IT and IS providers.

The proposed approach / model, however, is not without limitations. First, the proposed model estimates the parameters without stratifying the segment to capitalize on the information content represented by individual SOHO heterogeneity. While the proposed model provides a reasonable tradeoff between theoretical soundness and practical implementability, stratified-level models are inherently more tractable and estimable.

Second, in our model formulation, old generation PCs continuously appear in the choice set even after some of them are no longer available or frequently purchased in the market.[6] As secondary markets are not well developed for personal computers, it is suspected that our model might provide biased choice probabilities for those old generations. However, we also note that the cumulative sales of each generation in the network externalities terms (NE_{jt} and NE_{jt}^2) in Equation (1) capture the effects of the lack of availability of old generations. Specifically, a concave pattern of network externalities represented by a negative value of a_{12} in Table 2 ensures a minimal market impact of old generations on their choice probabilities at their declining stage of the product life cycle. Nevertheless, our model may not totally be free from this estimation bias issue as long as it assumes a fixed number of choice alternatives like other standard logit models in the existing literature. Future research efforts incorporating a time-dependent indicator representing the number of choice alternatives for a certain time period could provide a better solution to this problem.

Finally, although our model incorporates SOHO owners' heterogeneity by including the impact of individual interpurchase time, income, and business disposition variables, it still does not offer perfect individual heterogeneity. This is because we estimate the performance / price ratio of the generations to be the same across individual SOHO owners. However, our model is motivated again by a balance between theoretical soundness (the need to capture perfect individual heterogeneity) and practicality. These limitations provide motivation for, and can be mitigated by, future research.

[6] The reviewer's suggestion to discuss this issue is gratefully acknowledged.

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