

# Dynamic Modeling of New Technology Succession: Projecting the Impact of Macro Events and Micro Behaviors on Software Market Cycles

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## 1.0 Research Abstract

The subject of technology succession and new technology adoption in a generalized sense has been addressed by numerous authors for over one hundred years. During the last decades of the 20th century, researchers have applied techniques of chaos and complexity theory to describe technology succession rates and model market shifts. Technology adoption and market dynamics are influenced by both macro-level events at the global and regional level, and micro-level behaviors of buyers and interactions within and between corporations. Models which accommodate macro-level events as well as micro-level actions are needed to gain insight to future market outcomes.

In the case of the ICT industry, macro-level factors affecting technology adoption and subsequently forecasts of enterprise software spend include global events and shocks, economic factors, and global regulatory trends. Micro-level elements involve individual agent actions and interactions, such as the behaviors of buyers and suppliers in reaction to each other, and to macro events. Vertical industry shifts, regional issues, and the actions of other key actors such as venture capitalists and industry giants also impact adoption trends and subsequently software market fluctuations. Projecting technology adoption and software market composition and growth requires evaluating a special set of technology characteristics, buyer behaviors, and supplier issues and responses which make this effort particularly challenging.

The Windrum and Birchenhall model of technological succession in the presence of network externalities<sup>1</sup> provides a starting point for modeling technological succession based on firm innovation driven by consumer preferences. The objective of the research is to use systems dynamic modeling to reproduce the model, then further evaluate it to determine:

- Its applicability to illustrate technology adoption in a scenario involving multiple suppliers (competing technologies) and buyers (adopters)
- Appropriate modifications to key elements which refine the model's usefulness in both a theoretical and commercial environment
- How the model can be generalized, then adapted, to reflect other macro events and micro-level agent responses in the software technology markets

Further testing of the model shows that certain buyer and supplier characteristics and parameters used in the original design require modification in order to adequately reflect actual technology adoption cycles and market trends. Initial enhancements result in a generalized base framework which can then be extrapolated to reflect the impact of economic shocks and market shifts induced by supplier actions.

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<sup>1</sup> Windrum, Paul & Chris Birchenhall, "Technological diffusion, welfare and growth: technological succession in the presence of network externalities". Maastricht: Maastricht Economic Research Institute on Innovation and Technology, MERIT Infonomics Research Memorandum Series, 2002.

Continued testing indicates observable trends driven by price/design ratios and impacted by both externalities and agent behaviors.

## 1.2 Background and Literature Review

A number of models were developed in the 1980's specifically focused on the issue of technology adoption and market shifts which result from the actions of buyers and suppliers and by exploring various market trends. Farrell and Saloner<sup>2</sup> address the benefits of standardization, and the direct network externalities that can result from compatibility between suppliers. They explore the impact of excess inertia on technology switching from old to new standards in the context of both incomplete and complete information, and test the "bandwagon effect": early adopters switch first, precipitating the effect, and others follow, including those who opposed the change initially. Exercising the model shows that the advantage goes to first movers who commit early and set the standard, though there is a risk initial costs due to incompatibility with the majority of the industry.<sup>3</sup> It also finds that a buyer's decision will depend upon its predecessor's decision, resulting in three possible scenarios where all or none switch, or where there is a bias for switching to secondary movers.

David discusses the defacto adoption of the QWERTY keyboard arrangement where a potentially inferior technology is locked in due to a path dependent sequence of economic changes.<sup>4</sup> Here, new technology adoption is governed more by a series of distributed, historical events and chance occurrences rather than calculated, strategic business decisions on the part of the firm. David describes a series of events contributing to three primary conditions insuring QWERTY's dominance over the Dvorak Simplified Keyboard: technical interrelatedness, economies of scale, and quasi-irreversibility of investment, which made displacement by a proven superior technology impossible.<sup>5</sup> The process is likened to the "Polya urn scheme", where increasing adoption of the technology choice occurs continually, eventually resulting in technological unity, which eventually eliminates evolution of new standards.

Katz and Shapiro address the effect of sponsorship on technology adoption, market shifts, and consumer choice.<sup>6</sup> In the context of software markets, sponsorship occurs when suppliers have proprietary technologies which they are willing to discount initially in order to gain market share and buyer mindset, recouping costs over time through highly profitable maintenance and services pricing. Consumer choice can be influenced by the number of other consumers selecting compatible technologies, and the value of the good for the consumer increases with higher adoption rates or increasing network externalities.<sup>7</sup> The authors test the model with conditions of two technologies, and two periods represented by two groups of consumers, for various conditions of technology sponsorship: none, one, or both. No sponsorship results in the adoption of technologies with current period superiority, but sponsorship of one technology will dominate regardless of features due to attractiveness in price. In the case of uniform sponsorship, standardization occurs which can result in sub-optimal technology selection such as the QWERTY scenario previously described.

Mamer and McArdle explore the topic in the context of two decision uncertainties: technical uncertainty, which can be mitigated by research incurring specific costs, and strategic uncertainty, which pertains to competitor's actions and cannot be eliminated through investigation.<sup>8</sup> Unlike other models evaluated, this focuses less on market or buyer adoption of competing technologies and more specifically on the strategic implications of firms deciding to embrace innovation. The model tests a single firm eliminating uncertainty through research when evaluating new technology investment, then introduces a competing firm also facing innovation decisions. When the second firm enters, both are gathering decision

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<sup>2</sup> Farrell, Joseph, and Garth Saloner, "Standardization, Compatibility, and Innovation". M.I.T. Working Paper #345, April, 1984.

<sup>3</sup> Ibid., p. 24.

<sup>4</sup> David, Paul A. "Clio and the Economics of QWERTY". *Economic History*, Vol. 75 No.2, pp. 332-337, May, 1985.

<sup>5</sup> Ibid., p. 334. David refers to these elements as the foundation of "QWERTY-nomics".

<sup>6</sup> Katz, Michael L., and Carl Shapiro, "Technology Adoption in the Presence of Network Externalities". *The University of Chicago: Journal of Political Economy*, 1986, vol. 94, no. 4, pp. 822-841.

<sup>7</sup> Ibid.; Farrell and Saloner, op.cit., p.1.

<sup>8</sup> Mamer, John W. and Kevin F. McArdle, "Uncertainty, Competition, and the Adoption of New Technology". *Management Science*, Vol. 33, No. 2, February 1987, pp. 161 – 177.

information independently of the other, but when one stops and decides to move forward two opposite outcomes can result. Gains derived from firm one's new technology can be decreased by firm two by competing in substitute goods; or both can benefit from the innovation by competing in complementary markets.<sup>9</sup> Technical evaluation costs and unclear competitive returns can then outweigh potential gains and hamper increasing adoption of innovation.

Arthur takes the position that insignificant events may by chance advantage one technology over another when two or more increasing-return technologies compete for market share.<sup>10</sup> Using a two-agent two-technology model, demand and supply are kept stable in order to examine the effects of historical events affecting agent choice of technology. The model is tested in different cases of constant, diminishing, and increasing returns to determine whether fluctuations in the order of choices introduced by these events makes a difference in market adoption of technology.<sup>11</sup> The returns to choosing one technology over another depend upon the number of previous adopters at the time of selection. The process is evaluated against the properties of predictability, flexibility, ergodicity, and path-efficiency. When testing with homogeneous agents choice order does not matter, so that the first technology chosen is selected again and again, producing comparable results to David's QWERTY example where an inferior technology can be locked in producing an inflexible market. Under constant returns, each agent selects the same technology, resulting in an equal probability that either will be adopted and a shared market will evolve. Under increasing returns agents will switch to a new technology if the number of adopters exceeds the current installed base, eventually overtaking the existing market.

Shy focuses on the demand-side factors of consumer preferences for new technology adoption in relation to network size supporting each generation of technologies.<sup>12</sup> Supporting factors include technology growth rate, consumer population size, and the relative degree of backward compatibility of the new technology. The model uses overlapping generations of consumers to simulate the presence of an installed base and a potential for new consumers to adopt the emerging technology. Findings indicate that new technologies are adopted more frequently when quality and network size are treated as substitutes. Adoption rates are a factor of perceived utility based on a combination of network size and sophistication of the technology. The absence of backward compatibility restricts adoption if network size and technological advance are considered complementary, but may encourage it if consumers view them as substitutable.

Modis approaches the concept of technology adoption within the context of the product life cycle and the seasonal shifts that occur during the lifecycle of a product and an enterprise.<sup>13</sup> Product sales cycles of start-up, rapid growth, maturation, and decline compare to the natural evolution of technological and business evolution as follows:

- Winter – products are establishing a presence in the market
- Spring - product innovation, learning and investment occur
- Summer – enterprises become successful, centralized and conservative
- Fall – process innovation is the primary driver
- Winter 2 – products begin to exit the marketplace and their replacements emerge

Modis finds that S-shaped curves chart the evolution of technology adoption over time and across the seasons of a firm. These curves overlap as new generations of emerging technologies overtake incumbents, and cross each other in reverse curves as substitution and market share transfer occurs.<sup>14</sup> Life cycles are observed to shorten as product saturation increases, and can be predicted by tracking the length of life cycles over time within product families. Modis credibly illustrates the model using numerous examples from both recent industry trends and historical examples.

At the macro level, Gartner research identifies three broad stages of 7 – 10 year technology life cycles within the last decades that track the major economic cycles of the period. Each decade shows

<sup>9</sup> Ibid., p. 169.

<sup>10</sup> Arthur, W. Brian, "Competing Technologies, Increasing Returns, and Lock-in by Historical Events". *The Economic Journal*, 99, (March 1989), pp. 116-131.

<sup>11</sup> Ibid., p. 118.

<sup>12</sup> Shy, Oz, "Technology revolutions in the presence of network externalities". *International Journal of Industrial Organization*, 14 (1996), 785-800.

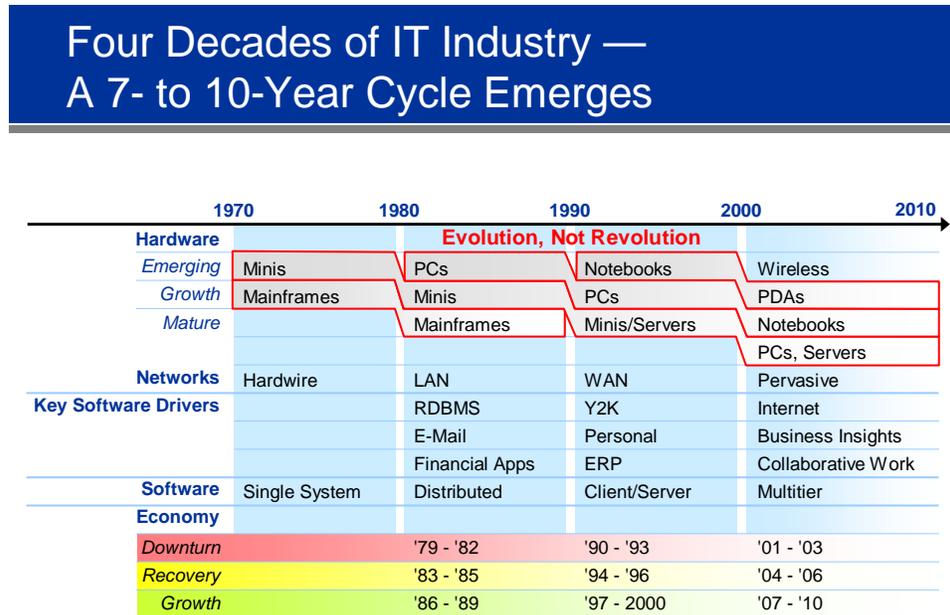
<sup>13</sup> Modis, Theodore, *Conquering Uncertainty*. New York: McGraw-Hill, 1988.

<sup>14</sup> Ibid., p.20.

overlapping cycles of maturity, growth, and emergence of a technology mega trend or major style of computing for hardware, networks, and software:<sup>15</sup>

**Figure 1: It Industry Technology Life Cycles**

Source: Gartner, October, 2005



### Gartner

Within the industry life cycle are generational product life cycles which evolve through stages of emergence, growth, maturity, consolidation, and decline.<sup>16</sup> Technology adopters (buyers) must examine technology choices within the context of various criteria, including vertical industry specializations, various geography concerns, and intra-industry relationships between suppliers, buyers, and service providers. Research at the micro level indicates that buyers can be characterized within three categories regardless of vertical industry or geographic region, consisting of the following estimated market composition<sup>17</sup>:

- Type A: aggressive, leader, features focused – 15%
- Type B: mainstream, adaptive, benefits-focused – 56%
- Type C: late adopter, follower, cost-focused – 29%

These categories and their allocations have been proven consistent over time. However, the actions of each adopter type need to be evaluated within the context of product life cycles to gain a true understanding of buyer technology adoption shifts. This specific issue will be addressed at future stages in the model being developed.

<sup>15</sup> Correia, Joanne, and Mertz, Sharon, "CRM Market Trends". Gartner, Inc.: Gartner Customer Relationship Management Summit, San Diego, October, 2005.

<sup>16</sup> Longwood, Jim, Tom Austin and Betsy Burton, "Understand the Challenges and Opportunities of the Market Life Cycle". Gartner, Inc., ID Number G00127583, February 16, 2006.

<sup>17</sup> Kirwin, Bill, Joseph Feiman, Diane Morello and Phillip Redman, "Enterprise Personality Profile: How Did We Get There?". Gartner, Inc., ID Number: COM-22-3093, March 16, 2004.

### 1.3 The Windrum and Birchenhall Model

Windrum and Birchenhall use agent-based modeling to develop a model of technological successions where heterogeneous populations of adaptive buyers and suppliers evolve over time.<sup>18</sup> The model simulates groups of buyers entering and exiting the market who base their technology choices on combinations of specific factors such as production costs, price, and performance quality. Buyers elect to adopt the new technology over the incumbent at a point in time if the value of the existing technology from a feature and investment standpoint (i.e. benefits are greater than the return of investing the money elsewhere) is less than the design advantage and financial returns that can be gained from adopting the new solution. Suppliers react by adjusting capacity, production levels and design features in reaction to consumer preferences, and set price by calculating mark-up over cost. Firms base their decisions on sales revenues, levels of capacity, and a combination of profit and monetary wealth which drives capacity and production decisions. Future design enhancement decisions are predicated on the ability of the firm to increase business benefit to the target market segment. Technological shocks are also introduced which alter the composition of the market. The shock introduces new technology features provided by new entrants, which are then consumed by a new set of buyers who subsequently enjoy the new technology at a lower unit cost.<sup>19</sup> Findings indicate that new technology adoption ultimately depends upon consumer preferences, primarily in advantages resulting from new or enhanced design features and decreased production costs over time.

This model was selected as a basis for further evaluation and testing due to its ability to address various conditions for technological succession within the context of multiple agent variables reflecting the behavior of buyers and suppliers. What follows is a description of how the model was simulated, tested, then modified to determine the impact of selected macro- and micro-level events within software markets. Conclusions and areas for future exploration are given at the close of the paper.

#### 1.3.1 Introduction to the Dynamic Systems Model

The model was initially developed using many of the default variables outlined by Windrum and Birchenhall to simulate agent behaviors within the enterprise software market.<sup>20</sup> The revised model consists of two groups of primary agents: buyers, or purchasers of enterprise software, and suppliers, or software vendors. Other market-moving agents exist within the industry who act as forces for technology adoption and market growth, such as venture capitalists, key industry personalities, and analyst firms: for simplicity they are not included in the initial model. This model focuses on enterprise application software technology adoption, and does not encompass individual consumer buying patterns or behaviors at this time.

#### 1.3.2 Buyer Attributes and Behaviors

Enterprise software buyer behavior is, in part, dependent on whether the specific decision maker is a line of business executive, CIO, CFO, or a procurement agent acting on the behalf of the company to obtain the most favorable price for the solution requested. Buyer actions are influenced by a variety of selections such as software features/functionality (Design), price and/or required capital investment, delivery model, and perception of vendor viability. Behaviors and interactions between and within the market supply and demand side are also influenced by a set of ongoing macro-level conditions, and are disturbed by intermittent economic and geopolitical shocks. Regulatory and compliance issues often redirect buyer budget allocation, subsequently altering supplier design center decisions which result in reallocation of research and development resources. Vertical industry design requirements and related technology adoption are often driven by external events such as privatization in emerging economies,<sup>21</sup>

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<sup>18</sup> Windrum and Birchenhall, op.cit.

<sup>19</sup> Ibid., pp. 14-15.

<sup>20</sup> For a list of the Windrum-Birchenhall variables see Windrum-Birchenhall, op.cit., Table 1, p.22.

<sup>21</sup> Technologies and applications which are required to enable privatization of basic infrastructure, such as utilities and telecomm, show early adoption in transition economies.

legal requirements, social demands, and economic conditions affecting business strategy and technology spend.

Regional or country-specific regulations and macro-level events also contribute to changes in buyer selection and adoption rates. When shocks are severe, such as significant macro-economic, geopolitical, or force majeure disruptions, observed behavior and subsequent consumption patterns indicate an environment of fear, creating decision paralysis resulting in temporary market stall.<sup>22</sup> Budget redirection often results due to increased costs in specific areas, illustrated by a shift in spending to vertical industries such as the boom in construction following the Katrina hurricane disaster in 2005.<sup>23</sup> Significant shocks produce long-term shifts, exhibited by businesses shedding non-core activities and investing in core competencies, or stockpiling cash for acquisitions or as a hedge against anticipated follow-on events. These behaviors all tend to produce a temporary atrophy in new technology adoption apart from those which guard against immediate potential risk. Among these are new security and monitoring technologies such as retinal scans, embedded chips, or advanced scanning devices at border crossings for trailer or container shipment content inspection.

Merger and acquisition activity has also been shown to influence buyer decisions which shift market shares among technology providers.<sup>24</sup> Among major market players, observed behaviors indicate an upsurge in spending for acquisition target technologies directly following acquisition announcement, followed by a decline as the sales pipeline is depleted and buyers adopt a “wait-and-see” attitude while the new entity rationalizes their product line strategy.<sup>25</sup> Larger firms often broaden their technology or application platform by acquiring niche players, forcing a decision by the installed based to either continue using the technology or move to another’s suppliers solution. Decisions to adopt another technology in these cases are frequently based on perceived long-term vendor viability rather than new technology design. This interaction among agents produces a high level of volatility, shifting the market and technology adoption patterns, and will be addressed in a future iteration of the model.

### 1.3.3 Characteristics of Suppliers

Suppliers of enterprise application software are characterized by various business models, company size, and target markets, ranging from small privately held niche vendors to multi-billion dollar application suite providers. Supplier behavior and investment decisions are influenced by a wide range of factors, including:

- Stakeholder and shareholder expectations
- Buyer consumption demands for product features, pricing, and delivery models
- Competitive pressures
- Significant technology shifts requiring major architectural changes to the basic design center
- Absence or presence of shocks
- Consumer preferences which influence enterprise IT spend

Business and go-to-market strategies are crafted around these elements and influence longer term objectives for company growth, as well as specific market penetration decisions such as technology sponsorship or channel development. Availability of venture capital significantly impacts the opportunity for innovation organizations to bring new technologies to the market, while acquisition activity can also drive adoption rates by offering widespread exposure to previously unknown developments by smaller research-based firms. New technologies in enterprise application software frequently undergo waves of adoption based on the maturity of regional markets, lead by western economies (primarily the U.S. followed by Western Europe) and followed by the transition and emerging economies of Central and Eastern Europe, Asia-Pacific, and Latin America. Market maturity, resource considerations, and imperfect

<sup>22</sup> Hahn, William, et.al., “ERIE Analysis Shows the Impact on Innovation”. Gartner, Inc., ID Number G00137848, March 15, 2006.

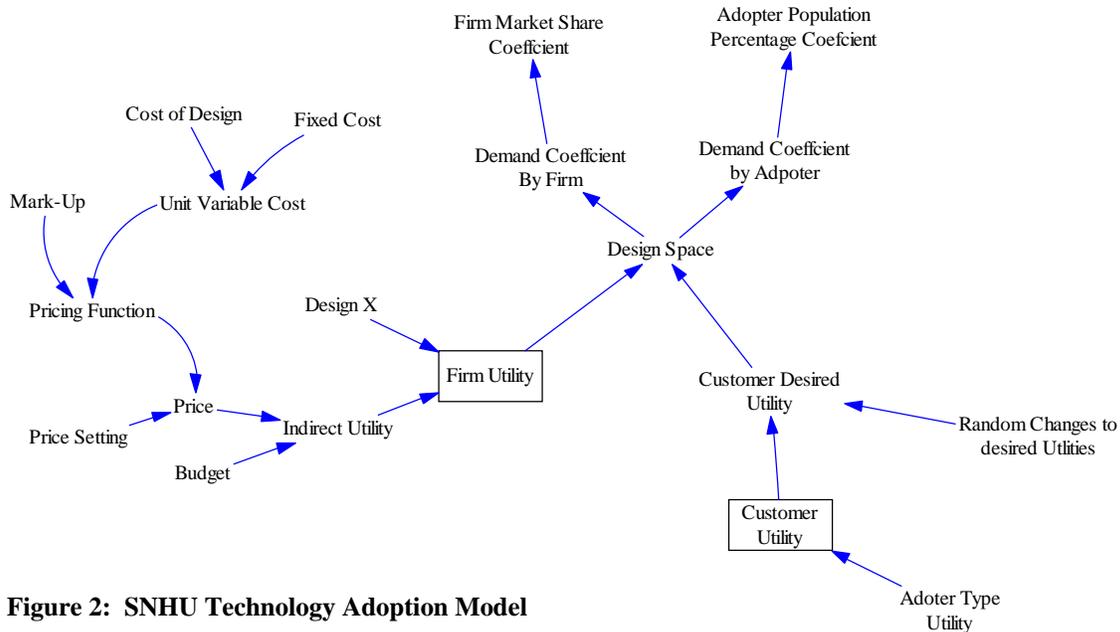
<sup>23</sup> Economic forecasts reflected the impact of the hurricane and rebuilding on the U.S. economy. See Global Insight, U.S. Executive Summary documents, fall 2005, <http://www.globalinsight.com>.

<sup>24</sup> Eschinger, Chad, and Colleen Graham, “New Oracle Earnings Show first Glimpse of PeopleSoft Impact”. Gartner, Inc., ID Number: G00126949, March 29, 2005.

<sup>25</sup> Ibid.; Modis, op.cit.

knowledge of new market opportunities therefore impact supplier decisions on new product introduction, hence controlling availability of new technologies and affecting buyer choice. Suppliers can also manipulate technology adoption and buyer behavior by introducing licensing schemes which make solution alternatives attractive, using either term or subscription licenses which reduce cost and risks associated with long-term commitments. From this perspective contractual instruments can act as drivers of technology adoption within the enterprise software markets.

### 1.4 A Systems Dynamic Model of Technology Succession



**Figure 2: SNHU Technology Adoption Model**

A systems dynamic modeling tool<sup>26</sup> was chosen for model development over Windrum-Birchenhall’s original series of batch programming runs with randomized variable values. A significant advantage of this tool is the ability to model changes to specific variables or relationships and view their impact immediately. This provides the ability to observe changes in real time and determine the impact of relationships between agent variables as defined by values and ratios. The model allows for shifts in product design, costs, pricing, and consumer budget to simulate market fluctuations and assess impacts on patterns of adoption. At the core of the model is the design space, representing the interaction point between buyers and suppliers. Characteristics of the design space, along with subsequently modeled firm and adopter coefficients, provide an environment for firms and the market to adjust to changes based on both firm offerings and adopter utilities.

#### 1.4.1 Other Variations from the Windrum-Birchenhall Model

The Windrum and Birchenhall concept of “utility” was adjusted for the enterprise application software market to more accurately reflect overall market characteristics. The model assumes that the consumer will not purchase the technology if the value of investing the budget elsewhere (Indirect utility) exceeds the direct utility derived from consuming the product with a certain set of functional characteristics.<sup>27</sup> Many software applications in the 21<sup>st</sup> century are germane to conducting business at

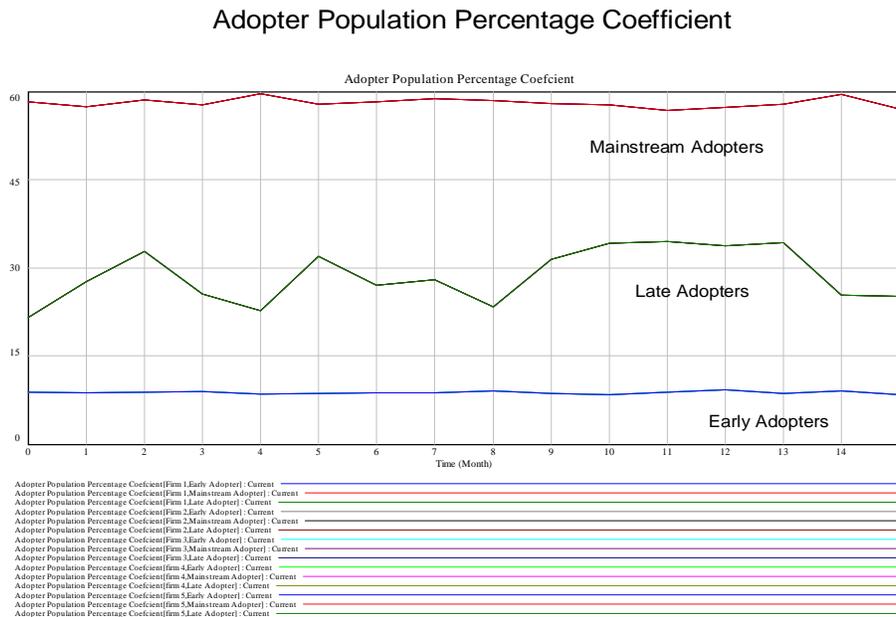
<sup>26</sup> Vensim® (Ventana® Simulation Environment, copyright 1988-2002, Ventana Systems, Inc.) was used to construct the model.

<sup>27</sup> Windrum and Birchenhall, op.cit.

nearly any level: for certain applications, software expenditures are then assumed to be allocated as a basic business requirement and are not available for alternative, asset-returning investments. Furthermore, enterprises adopting late in the product lifecycle risk serious competitive disadvantage from cumbersome manual process or face potentially fatal business disruption caused by inability to recover from failures of mature or unsupported technologies. Utility in this case then becomes synonymous with quantifiable, but not necessarily alternative investment-related business benefit. Suppliers are also increasingly capable of reducing “choice” of new technology adoption, forcing the buyers decision to adopt new technology platforms by eliminating support for older technologies in their “sunset” phase.

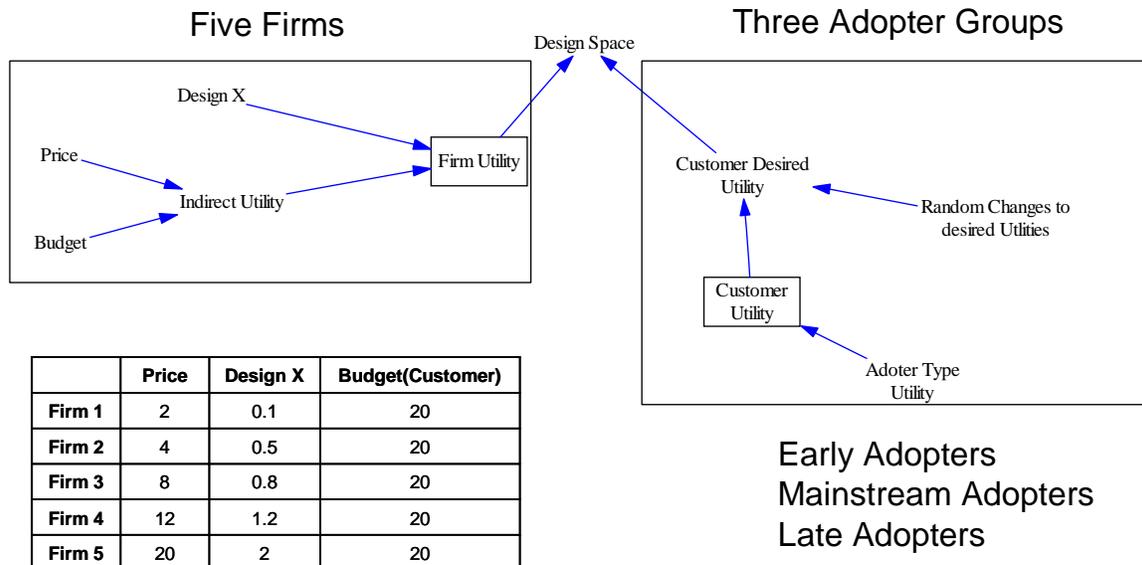
To simplify modeling of inherent business environment complexity, three key variables were initially selected to represent the core of the initial model for both technology supply and demand decisions: price, design, and customer budget. Price, a critical element for both buyers and suppliers, is determined by market forces and driven by consumer preferences for alternative designs and consumption models. Supplier inputs to price are driven by research and development expenditures, channel development costs, and marketing or promotional costs rather than the fixed asset considerations of physical plant and production capacity and costs assumed by Windrum and Birchenhall. Costs, affecting price, can be assumed to climb by incremental units as R&D staffs are expanded to develop new design features, or as channel penetration campaigns are executed. Firms applying sponsorship strategies to capture market share<sup>28</sup> can influence buyer decision by applying price incentives early in the adoption curve, then reap increasing returns as technologies mature and incremental maintenance contracts deliver a higher level of profitability.

The Gartner ABC model of buyer market composition was used to represent the three buyer groups. Ratios representing the size of each group were assigned using the variable Adopter Population Percentage Coefficient illustrated in Figure 3. The model does not assume an existing technology base, but rather simulates competition between five firms offering various price and design levels to customers with equal budgets. Price and Design variables were set for the five competing firms to illustrate various levels of price-feature combinations where increasing richness in functionality commands higher prices. Prices are manipulated through a Price Setting variable for each of the five firms. Customer budget was initially fixed at a common value in order to observe varying price and design interactions. Figure 4 illustrates the model graphically.



<sup>28</sup> Katz and Shapiro, op.cit.

**Figure 3: Adopter Population Percentage Coefficient**

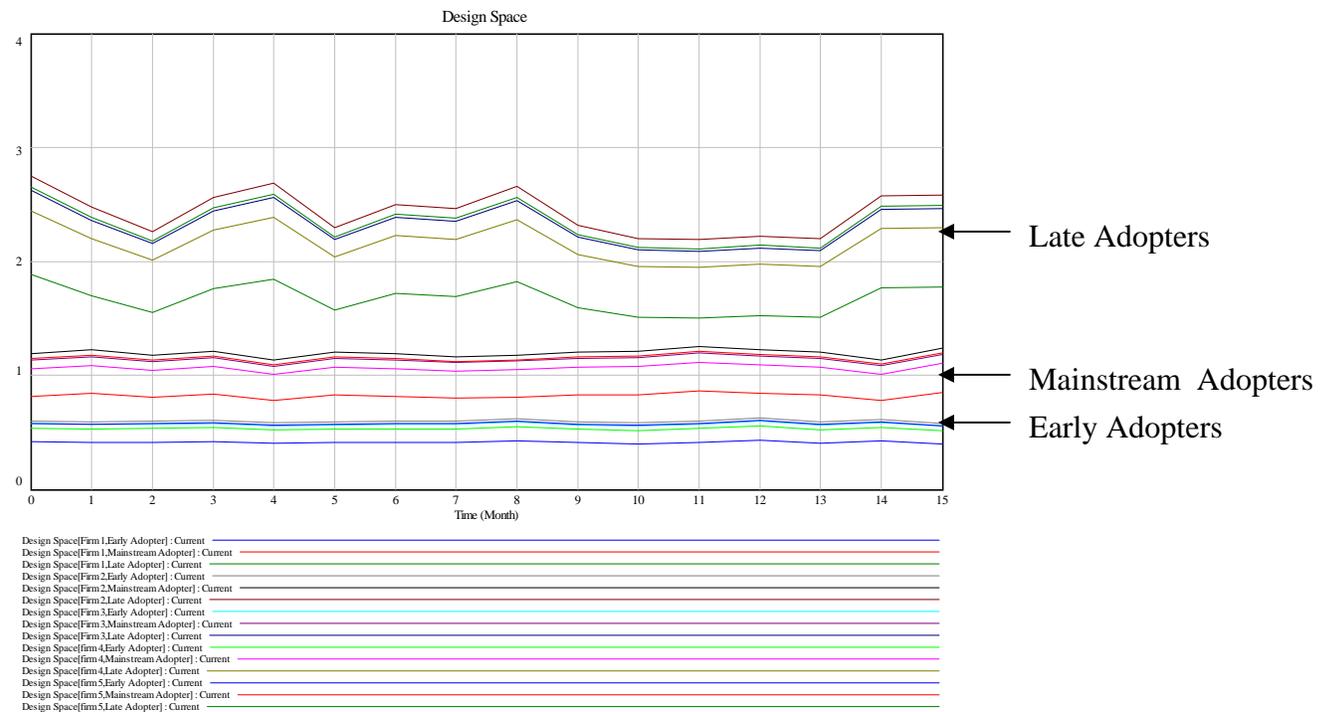
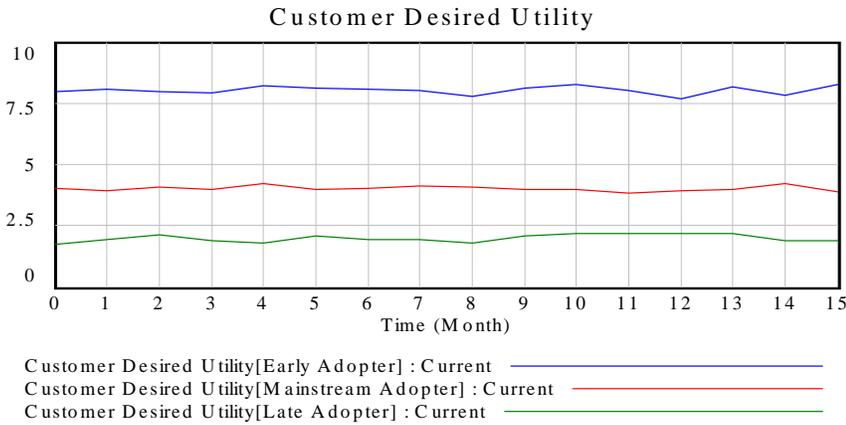


**Figure 4: Base Model**

### 1.4.2 Base Model Test Results

Output in Figure 6 shows the interaction of firm utility and customer desired utility illustrated by the firm/adopter pairs within the design space. Customer desired utility is higher for early adopters than late adopters as new technologies are considered of strategic importance rather than an operational utility (Figure 5). Not surprisingly, adopter types in each of the five firms aggregate together in groups on the graphs in three discernable bands. Late adopters show the greatest variation over time with more pronounced peaks and valleys. Behavior of early adopters is the most constant, which is not uncharacteristic of type A corporations where strategic direction is designed to consistently leverage new technologies for competitive advantage. Mainstream adopters, the largest segment of the buyer population, show only slightly greater modulation than the early adopters over time. Graphically depicted, firm 2 is positioned at the top of all adopter classes, firm 5 at the bottom, firms 1 and 3 in close competition, and firm 4 falls below firms 1 and 3. Positioning is due to the relationship of the price/design ratio vis-à-vis the fixed customer budget value.

**Figure 5: Customer Desired Utility**



**Figure 6: Design Space**

### 1.4.3 Demand Coefficient by Firm Introduced

Emanating from the design space, a demand coefficient by firm was introduced as an input to a firm market share coefficient. The demand coefficient is calculated as the summation of adopter and customer utilities for each respective firm. Figure 7 indicates that firms organize themselves consistent with the base model arrangement. Further testing on the market share coefficient will be conducted in the

future research.

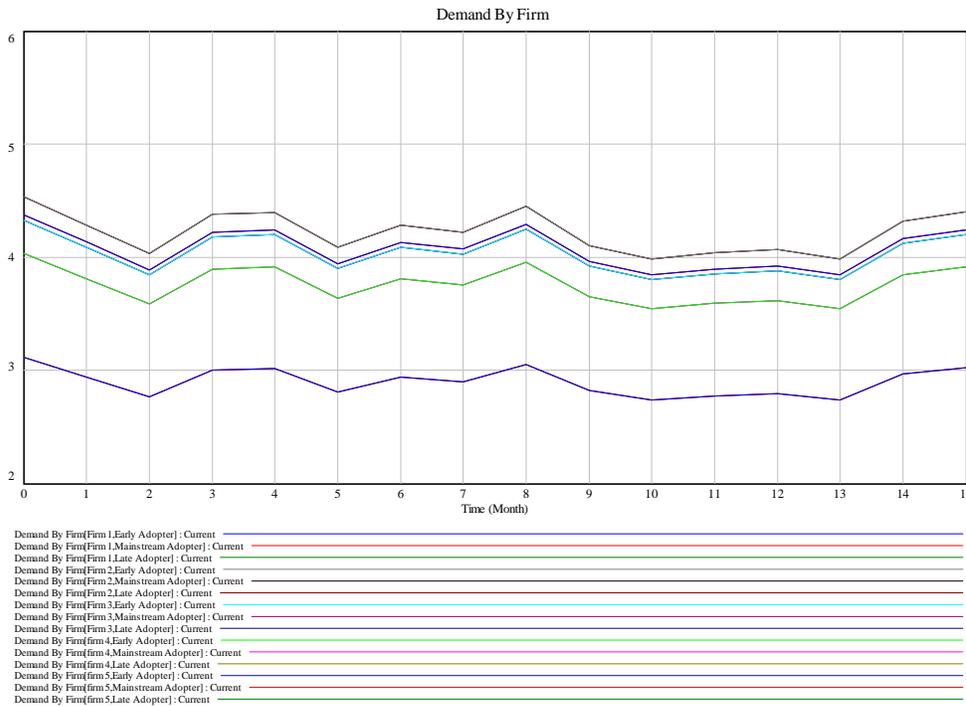
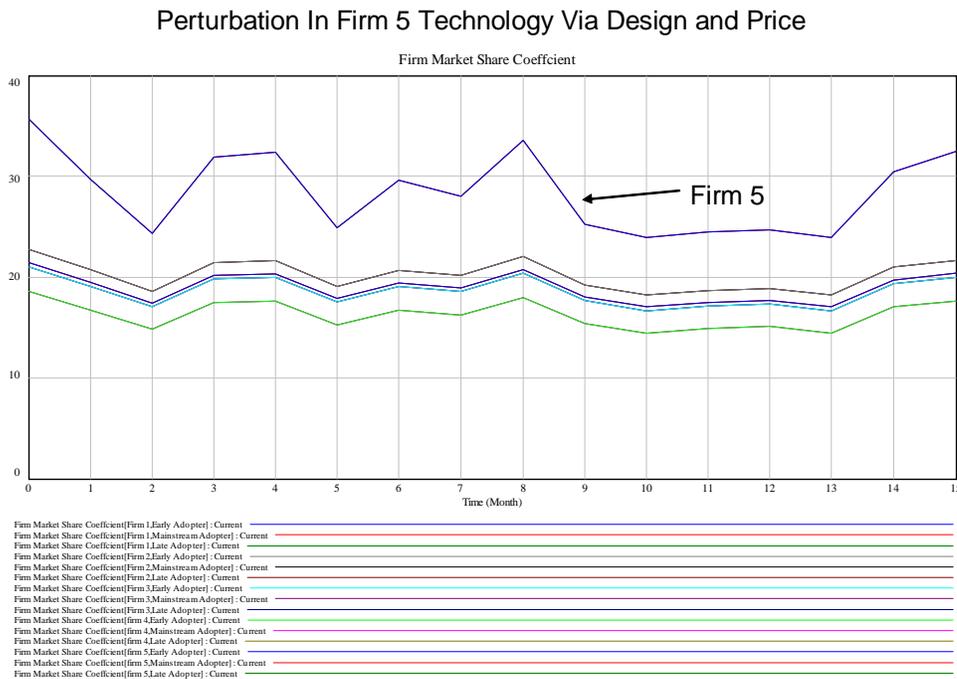


Figure 7: Demand Coefficient by Firm

### 1.4.4 Simulating a Macroeconomic Shock

Given the known baseline, a macroeconomic shock was simulated by reducing buyer consumption budgets equally across all firms. The firms with the most unfavorable price to design ratio either exit the model or become subject to reduced market performance. Firms that fall out of the model represent firms selling product below cost as a sponsorship strategy to gain mindshare and initial market position. Subsequently other budgets were reduced for only firms with unfavorable design to price ratios. The results show that these firms under an economic shock firms price themselves out of the market, simulating conditions of either process inefficiencies or uncontrolled development costs. A third scenario was tested for firms that have higher design functionality and associated prices to represent a business-critical vertical industry specialization immune to economic downturn. Budgets for those firms were increased and resulted in a market leader shift as shown in Figure 8. Results indicate that given differing economic conditions and varying functionality, the model is able to mimic macroeconomic effects and that results in

shift of market leaders depending on price and product design.



**Figure 8: Modeling a Market Shift**

## 1.5 Conclusions

Though still at the early stages of model development, a number of simulations were constructed and tested that exercised different features of the software to model various buyer adoption and supplier response conditions. Various base model tests indicated the importance of the design space as the primary interaction point, and additional coefficients increased our ability to adjust for alternative market scenarios. Tests manipulating the key variables of price, design and budget revealed model sensitivities and offered new insight on how the model could be used to simulate and project actual market behaviors. These first critical steps suggested new ways to increment and optimize the model for future extensions representing multiple technology succession markets and scenarios.

## 1.6 Areas for Future Research

The current model explored various impacts of price, design, and budget manipulation on technology adoption within enterprise software markets. Previous discussions indicate that numerous buyer and supplier behaviors and interactions within markets and regions can vary market structure and technology adoption. Macroeconomic factors also redirect budgets due to either uncertainty or business infrastructure necessity. Future models are anticipated which introduce the effect of macroeconomic indicators, model impacts of acquisition activity, and introduce variations in pricing, licensing, and deployment models which can shift buying decisions and impact new technology succession.

## References

- Arthur, W.B., *Increasing Returns and Path Dependency in the Economy*. Ann Arbor: University of Michigan Press, 1994.
- Arthur, W. Brian, "Complexity and the Economy". *Science*, 2 April 1999, **284**, 107-109.
- Arthur, W. Brian, "Competing Technologies, Increasing Returns, and Lock-in by Historical Events". *The Economic Journal*, **99**, (March 1989), pp. 116-131.
- Arthur, W. Brian & Wolfgang Polak, "The Evolution of Technology within a Simple Computer Model". Santa Fe: Santa Fe Institute, December 17, 2004.
- Bonabeau, Eric, "Don't Trust Your Gut". *Cambridge: Harvard Business Review*, May, 2003.
- , "Predicting the Unpredictable". *Cambridge: Harvard Business Review*, March, 2002.
- , "Agent-based modeling: methods and techniques for simulating human systems". *Proceedings of the National Academy of Sciences*, vol.99, suppl. 3, May 14, 2002.
- Correia, Joanne M., "Software Markets Reflect Growth Predictions, 2005". Gartner, Inc., ID Number G00136157, November 15, 2005.
- Correia, Joanne, and Mertz, Sharon, "CRM Market Trends". Gartner. Inc.: Gartner Customer Relationship Management Summit, San Diego, October, 2005.
- Dasari, Usha, Phillip V. Fellman, Jonathan vos Post and Roxana Wright, "Adaptation and Coevolution on an Emergent Global Competitive Landscape". Southern New Hampshire University, unpublished research paper,
- David, Paul A. "Clio and the Economics of QWERTY". *Economic History*, Vol. 75 No.2, pp. 332-337, May, 1985.
- Eschinger, Chad, and Colleen Graham, "New Oracle Earnings Show first Glimpse of PeopleSoft Impact". Gartner. Inc., ID Number: G00126949, March 29, 2005.
- Farrell, Joseph, and Garth Saloner, "Standardization, Compatibility, and Innovation". M.I.T. Working Paper #345, April, 1984.
- Feiman, Joseph, Bill Kirwin, Diane Morello, and Phillip Redman, "Enterprise Personality Profile: Dimensions and Descriptors". Gartner, Inc., ID Number: COM-22-3417, March 16, 2004.
- Hahn, William, Joanne M. Correia, George Shiffler III, Sharon A.Mertz, Charles Smulders, Roger Fulton, Colleen Graham, and Gerard F. Hallaren, "ERIE Analysis Shows the Impact on Innovation". Gartner, Inc., ID Number G00137848, March 15, 2006.
- Haines, Michael, "The Enterprise Personality Profile Builds Sales Insight". Gartner, Inc., ID Number: G00122510, September 2, 2004.
- Katz, Michael L., and Carl Shapiro, "Technology Adoption in the Presence of Network Externalities". *The University of Chicago: Journal of Political Economy*, 1986, vol. 94, no. 4, pp. 822-841.
- Kirwin, Bill, Joseph Feiman, Diane Morello and Phillip Redman, "Enterprise Personality Profile: How Did We Get There?". Gartner, Inc., ID Number: COM-22-3093, March 16, 2004.
- , "Enterprise Personality Profile: Applying the Lessons Learned". Gartner, Inc., ID Number COM-22-3233, March 16, 2004.
- Lissack, Michael R., "Chaos and Complexity – What does that have to do with management? A look at Practical Applications". U.K.: Henley Management College, 1996.
- Longwood, Jim, Tom Austin and Betsy Burton, "Understand the Challenges and Opportunities of the Market Life Cycle". Gartner, Inc., ID Number G00127583, February 16, 2006.
- Mamer, John W. and Kevin F. McCardle, "Uncertainty, Competition, and the Adoption of New Technology". *Management Science*, Vol. 33, No. 2, February 1987, pp. 161 – 177.
- Milling, Peter M., "Understanding and Managing Innovation Processes". *System Dynamics Review*, Vol. 18, No.1, Spring, 2002, pp. 73-86.
- Modis, Theodore, *Conquering Uncertainty*. New York: McGraw-Hill, 1988.
- Myerson, Roger B., "John Nash's Contribution to Economics". *Academic Press Inc., Games and Economic Behavior*, **14**, 287-295, 1996.
- Redman, Phillip, Joseph Feiman, Bill Kirwin and Diane Morello, "Enterprise Personality Profile: Know Thyself First". Gartner, Inc., ID Number: COM-22-3275, March 16, 2004.
- , "Use the Enterprise Personality Profile assessment to Determine Where Your Company is Weak". Gartner, Inc., ID Number: G00133198, November 16, 2005.
- Shy, Oz, "Technology revolutions in the presence of network externalities". *International Journal of Industrial Organization*, **14** (1996), 785-800.
- Waldrop, M. Mitchell, *Complexity: the Emerging Science at the Edge of Order and Chaos*. New York: Touchstone, 1992.
- Windrum, Paul, "Unlocking a lock-in: towards a model of technological succession". Maastricht: Maastricht Economic Research Institute on Innovation and Technology
- Windrum, Paul & Chris Birchenhall, "Technological diffusion, welfare and growth: technological succession in the presence of network externalities". Maastricht: Maastricht Economic Research Institute on Innovation and Technology, MERIT Infonomics Research Memorandum Series, 2002.