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**Innovation and Market Leadership in a
Technology Industry**

**POSTER
PRESENTATION**

OCTOBER 1, 2020

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UNIVERSITY**

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Abstract

According to the Abernathy-Utterback (A-U) model, firms focus on technological product innovation early in the product lifecycle and then shift to process innovation as markets mature. However, there is no consensus on the forms that non-technological innovation can take. In addition, the A-U model, does not include forms of non-technological innovation that are generally accepted by experts. In this study, a hybrid e-Delphi technique with an AHP decision model was used to evaluate the forms of innovation used to establish market leadership over the historical lifecycle of the U.S. personal computer industry. This research provides new insights that should aid innovators in choosing the right form of innovation depending on lifecycle stage.

Doctoral Dissertation

Problem

Firms tend to focus on product innovation early in the lifecycle and shift to process innovation as markets mature (Utterback (1994; Utterback & Abernathy, 1975). This body of research, which guides innovators and researchers, is generally referred to as the A-U model (Akiike, 2013). The absence of non-technological forms of innovation, in tools such as the A-U model, expose a **literature gap**.

The **general problem** is that there is no consensus on the forms that non-technological innovation can take.

The **specific problem** is that the A-U model does not include the forms of non-technological innovation that are generally accepted by experts (OECD, 2018). These new forms of innovation have been shown to produce returns that are larger, and more sustainable, than traditional product or process innovation.

Purpose

The purpose of this qualitative e-Delphi research study was to build consensus with an expert panel of innovators and researchers on the form(s) of innovation used to establish market leadership over the historical lifecycle of the U.S. personal computer (PC) industry.

Significance

The four forms of innovation relevant for evaluating market leaders are product, process, marketing, and organizational innovation. This provides additional insight that can be used by innovators based on the lifecycle stage.

Understanding innovation in the later stages of organizational development can be used as a baseline to extend the A-U model.

The assumption of a normal distribution for diffusion does not appear to hold true for sub-segments of the U.S. PC industry. Caution must be used when applying this model to other products and industries.

An analytical hierarchical process (AHP) decision model can be used with e-Delphi to speed (mathematical) consensus. The results produced are ratio scale which can be used for mathematical analysis and direct comparison.

Theory or Framework

Creative destruction (Schumpeter, 1934) is an activity that is central to economic growth.

Based on the **diffusion of innovations** theory (Rogers, 1962), innovations are brought to market and used first by innovators, then early adopters, late adopters, late majority, and finally laggards.

Utterback (1994), building on Utterback and Abernathy (1975), showed that firms focus on product innovation early in the lifecycle, and shift to process innovation as markets mature. This **A-U model** does not include forms of non-technological innovation generally accepted in theory and practice (OECD, 2018).

Relevant Scholarship

The spread of a product, process, or idea, innovation is referred to as diffusion in the marketing literature (Peres, Muller, & Mahajan, 2010).

Schumpeter (1934, 1939) further refined the idea by grouping technological change into a three-phase trilogy: invention, innovation, and diffusion.

Rogers (2003) and Rogers and Shoemaker (1971), outline a model for diffusion of innovations which has become widely established in the marketing literature (Wright & Charlett, 1995). Incremental innovations proceed along an existing S curve.

The A-U model, developed by Utterback and Abernathy (1975), and refined by others, is still a cornerstone of innovation theory today (Akiike, 2013).

The Organization for Economic Cooperation and Development (OECD), recognized only technological product or process innovation prior to 2005 (OECD, 1997), which is consistent with the A-U model. In 2005 the OECD updated their definition to recognize four types of innovation: product, process, marketing, and organizational innovation (OECD, 2005).

Incremental innovation proceeds along an existing S curve, disruptive innovation shifts and industry to a new S curve. Disruptive innovation tends to favor the disrupter, at the expense of incumbents (Christensen, 1997; Christensen & Overdorf, 2000; Christensen & Raynor, 2003).

OECD (2018) stated that there is no single recognized definition for business model innovation. This same conclusion has been reached by many other scholars (Massa, Tucci, & Afuah, 2017; Tikkanen, Lamberg, Parvinen, & Kallunki, 2005).

Research Question

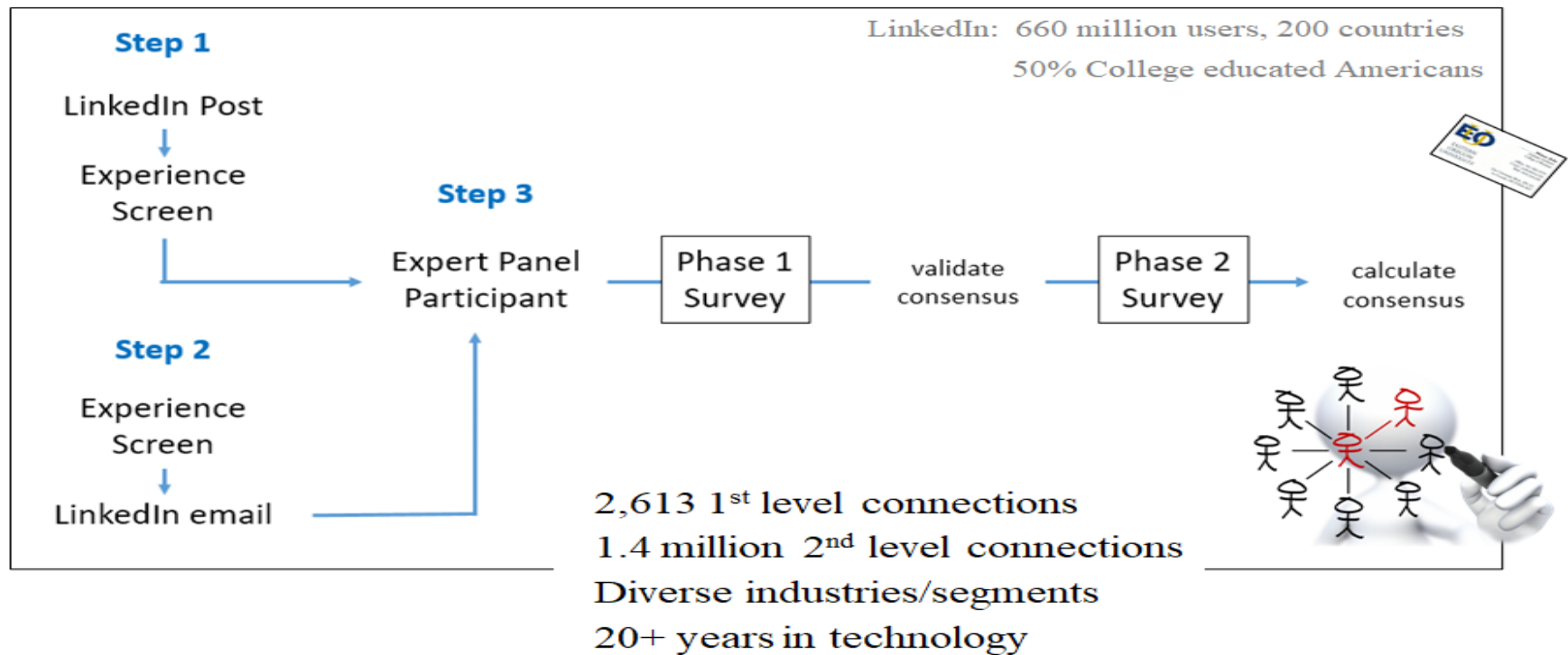
What is the consensus of an expert panel of innovators and researchers on the form(s) of innovation that were used by competitors to establish market leadership over the historical lifecycle of a technology industry?

Participants

The study included 30 verified experts in the PC industry. Experts were required to have 20+ years experience in the technology industry. The participants were recruited using social media (LinkedIn) and profiles were verified.

Sampling Process

Survey Process



Procedures

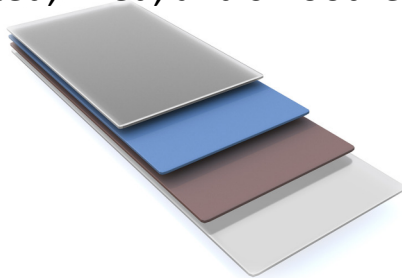
Data Collection: U.S. PC market share data

45 years data

Multiple data sources/sets

- 1980 – 1982 (Steffens, 1994)
- 1980 – 1998 (Narayandas & Rangan)
- 1975 – 1981 (Reimer, 2005)
- 1994 – 2008 (Rivken, 2010)
- 2009 – 2015 (IDC, 2016)
- 2013 – 2019 (Gartner Group, 2020a)
- 2013 – 2019 (Gartner Group, 2020b)

Cross-validated, filled, and smoothed



e-Delphi (expert) panel evaluation

Two rounds, calculate consensus after each round

- Round 1: establish consensus on forms of innovation
- Round 2: establish consensus on market leadership

Independent judgements

Round 1	Participants
question 1	30
question 2	27
Round 2	Participants
Altair	24
AST/Tandy	23
Apple 1	23
IBM	23
Commodore	19
Apple 2	20
Packard Bell	18
Compaq	19
Dell	19
HP	19
Lenovo	19

Analysis

e-Delphi responses were collected from each expert panel participant using a 1 – 9 Likert scale for each market share leader.

Analytical Hierarchical Process (AHP) decision model used to reach mathematical consensus (Saaty, 1980; Bunruamkaew, 2012).

AHP requires pairwise comparisons. Likert values are converted to pairwise using the transformation proposed by Kallas (2011).

$$a_{ij} = |\text{judgment}_{ik} - \text{judgment}_{jk}| + 1$$

Calculate the geometric mean of the results for each market share leader.

Construct matrix of pairwise comparison values

Construct a normalized matrix

Determine the priority vector and consistency index for each market share leader

4 forms of innovation

a_1 - product a_2 - process

a_3 - marketing a_4 - organizational

11 market share leaders

45 years of data

Apple						
1981 - 1982						
	Product	Process	Marketing	Organizational		
Geometric Mean	8.26	4.50	6.91	3.76		
Arithmetic Mean	8.35	5.22	7.39	4.65		
	$a_1 \rightarrow a_2$	$a_1 \rightarrow a_3$	$a_1 \rightarrow a_4$	$a_2 \rightarrow a_3$	$a_2 \rightarrow a_4$	$a_3 \rightarrow a_4$
	3.76	1.34	4.50	-2.42	0.74	3.16
	a_1	a_2	a_3	a_4		
a_1	1.00	4.76	2.34	5.50		
a_2	0.21	1.00	0.29	1.74		
a_3	0.43	3.42	1.00	4.16		
a_4	0.18	0.58	0.24	1.00		
sum	1.82	9.75	3.88	12.40		
	X_1	X_2	X_3	X_4	mean	consistency
X_1	0.55	0.49	0.60	0.44	0.52	4.07
X_2	0.12	0.10	0.08	0.14	0.11	4.04
X_3	0.23	0.35	0.26	0.34	0.29	4.06
X_4	0.10	0.06	0.06	0.08	0.07	4.05
	1.00	1.00	1.00	1.00	CI	0.02
					RI	0.90
					CR	0.02

Findings

Round 1: (forms of innovation) product, process, marketing, and organizational innovations were selected as the correct types of innovation to evaluate in Round 2.

Round 2: (methodology)

AHP reduced the number of e-Delphi rounds required to reach convergence.

AHP produced ratio scale results that can be proportionately compared.

Likert scale reduced the number of comparisons required for pairwise comparison.

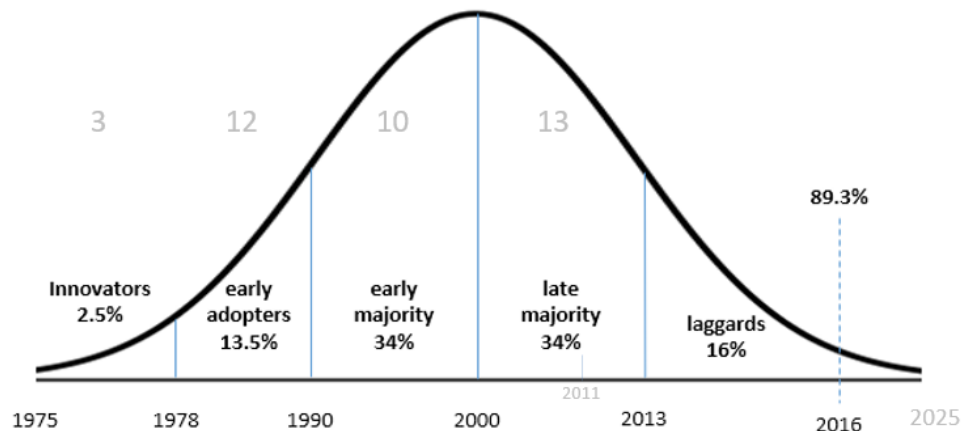
Pairwise requires $N(N-1)/2$ judgements and Likert only requires N judgements.

Likert scale eliminated risk of inconsistency in results

Round 2: (Diffusion of Innovations)

Diffusion follows a normal curve in overall market (consumer + business)

Diffusion curve is **not** normal for sub-segments (business & government)



Findings

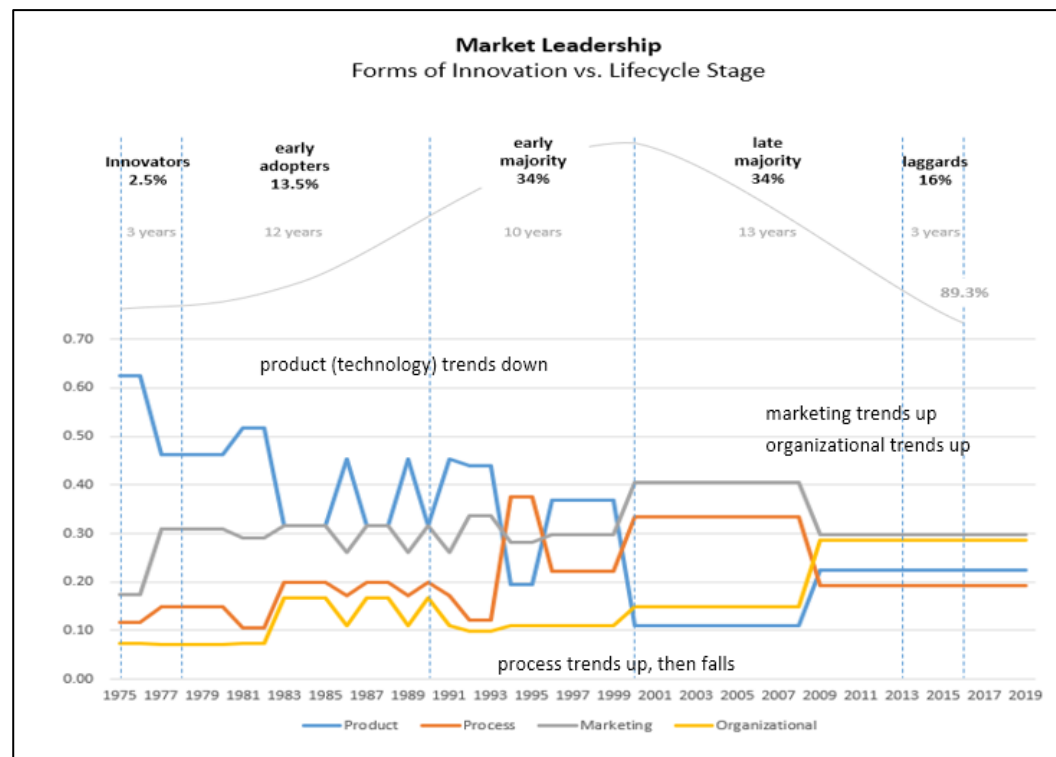
Round 2: (A-U Model)

Product innovation is the focal point early in the lifecycle. There is a Shift in focus to process innovation as the market matures. This **is** consistent with the A-U model.

Marketing innovation important early in the lifecycle and becomes **most** important over time.

Organizational innovation becomes more important towards the end of the lifecycle.

Creates a baseline for marketing innovation and organizational innovation in the A-U model.

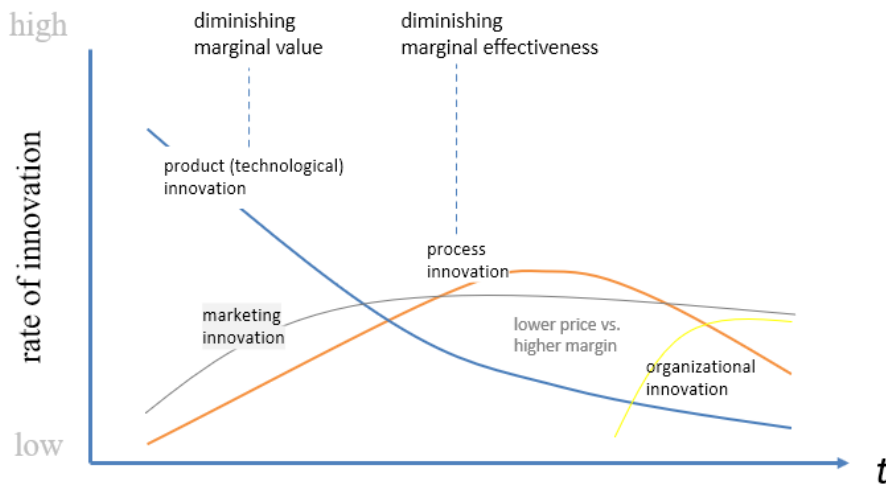


Interpretation

Innovation is best defined in terms of product, process, marketing, and organizational.

The form of innovation that enabled market leadership changed over time in the U.S. PC industry (1975 – 2019).

With testing in additional industries this could extend the A-U model to other generally accepted forms of innovation.



Expanded A-U Model

Innovation vs. market leadership

Limitations

This study only considered the choice of the form of innovation, and the stage of the lifecycle, and does not consider other qualitative elements.

The mathematical process used with AHP allows for rapid e-Delphi consensus, and ratio scale results, but may not allow for as many rounds of discussion.

This study focused on market share leaders. There may be other competitors who adopted the same strategy that did not become market share leaders (e.g. execution is important).

These results are specific to the U.S. PC industry. Additional research is required to extend these results to other industries.

Recommendations

Expand research to additional products and industries to validate the general case

Examine all competitors to identify what forms of innovation did not result in market leadership

Explore Rogers (1962, 2003) model within sub-segments and specific demographic attributes in complex markets

Standardize definition of Business Model Innovation and test against organizational innovation

Create tool to traverse social networks to measure demographic diversity and research project fit (target)

Expand testing of Likert-pairwise technique

Social Change Implications

Innovation responsible for 80% of U.S. economic growth since World War II (Atkinson, 2011)

Economic expansion creates jobs, reduces unemployment, and increases wages (Keynes, 1960)

Declining unemployment and increasing wages are associated with lower rates of property-related crime (Lin, 2008; Mustard, 2010; Raphael & Winter-Ebmer, 2001)

Lower unemployment improves physical health, mental health, and reduces the risk of stress related death (Bartley, 1994)

Income increases lead to larger amounts of charitable giving (Daniels, 2015; Havens, O'Herlihy, & Schervish, 2006)

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