Innovation and Market Leadership in a Technology Industry

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EOU Colloquium
November 12, 2020

What Do These Firms Have in Common?

1976

2004

1994

Tech Big 5

Alphabet

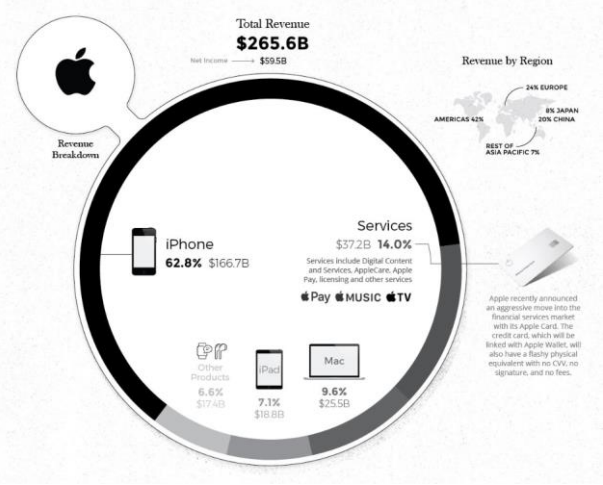
Google

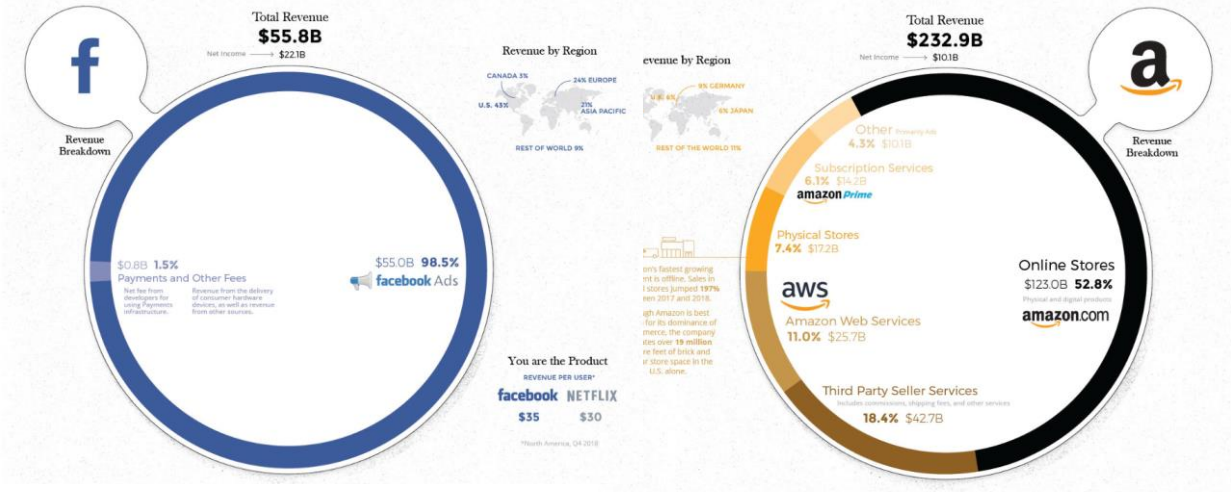
1998

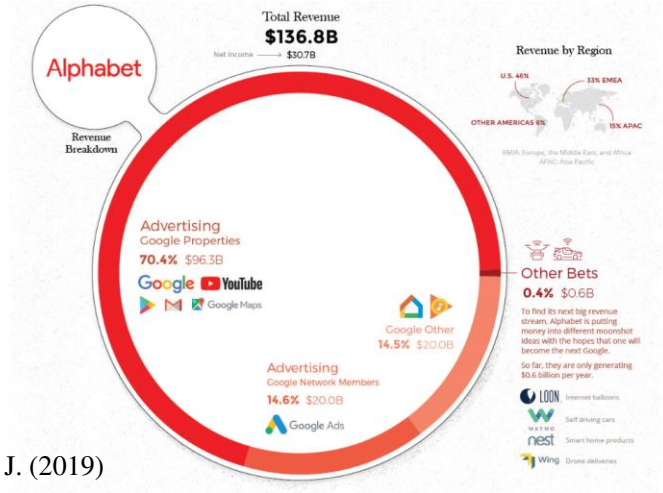
Microsoft

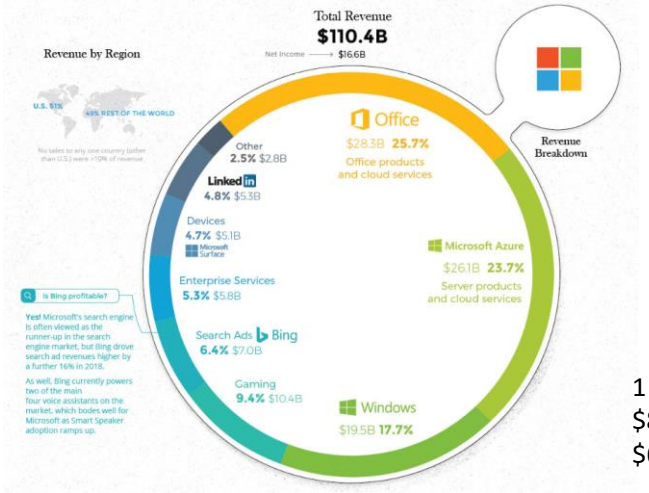
1975

Did NOT Exist Before 1975!









Desjardins, J. (2019)

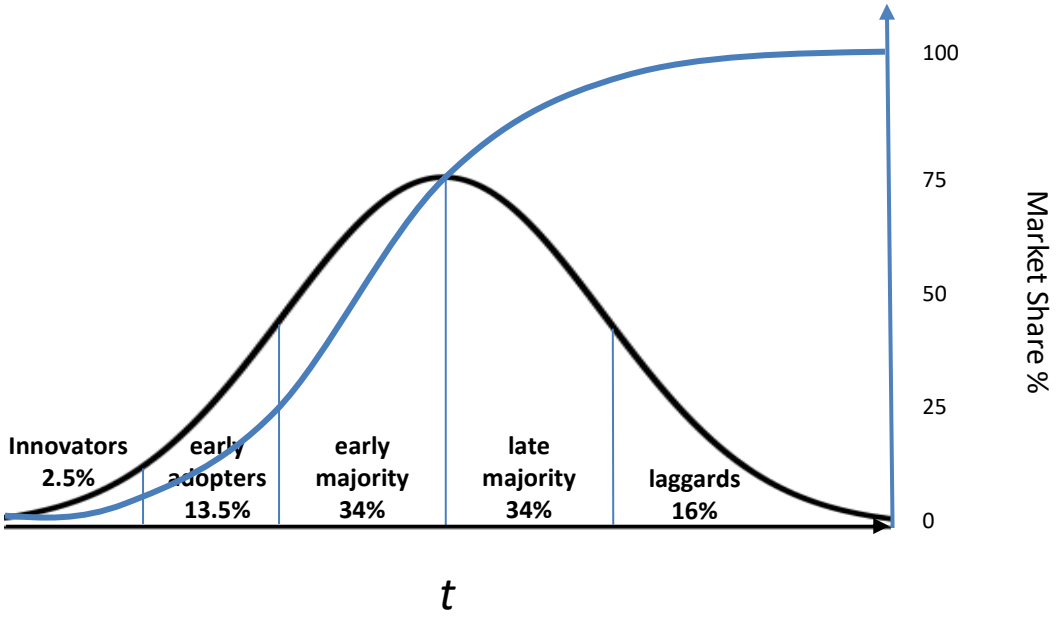
COMBINED

1 million+ employees
$802 billion revenue
$6.8 trillion market cap

Innovation Responsible for 80% of U.S. Economic Growth Since World War II (Atkinson, 2011)

Creative Destruction (Schumpeter, 1934)

Conceptual Foundation
Rogers Diffusion Theory



Rogers (1962, 2003)

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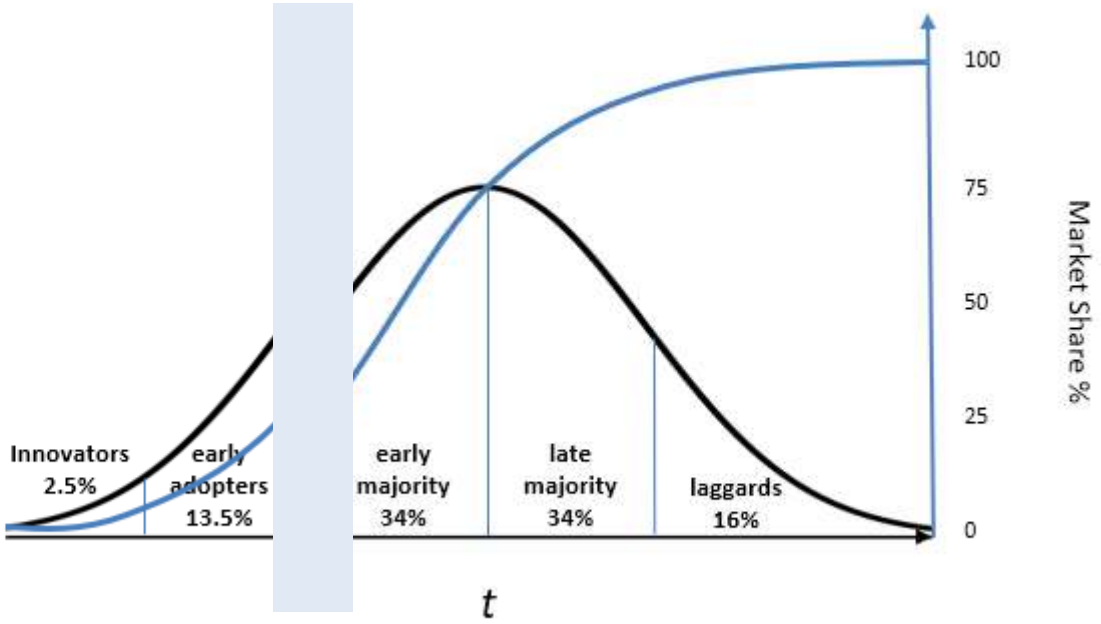
Conceptual Foundation
Crossing the Chasm

the Chasm



Moore (1991)

No Guarantee….

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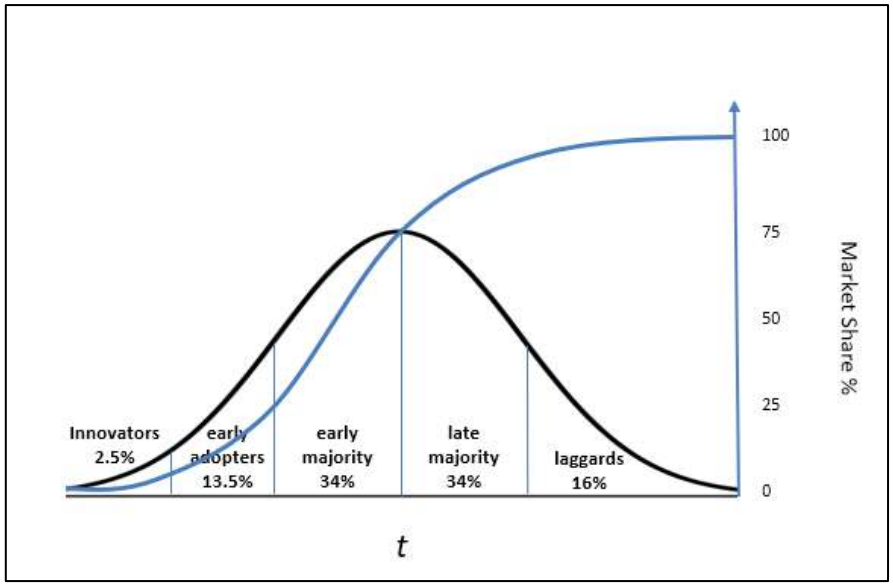
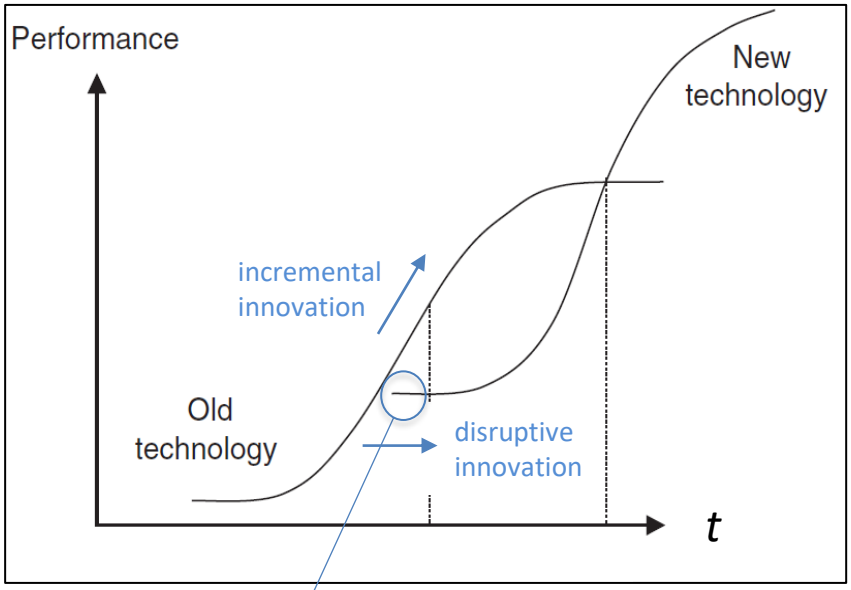
Conceptual Foundation

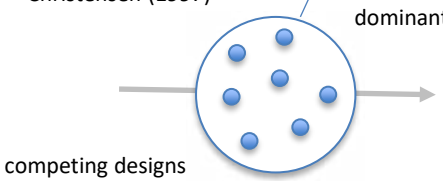
Incremental vs. Disruptive Innovation



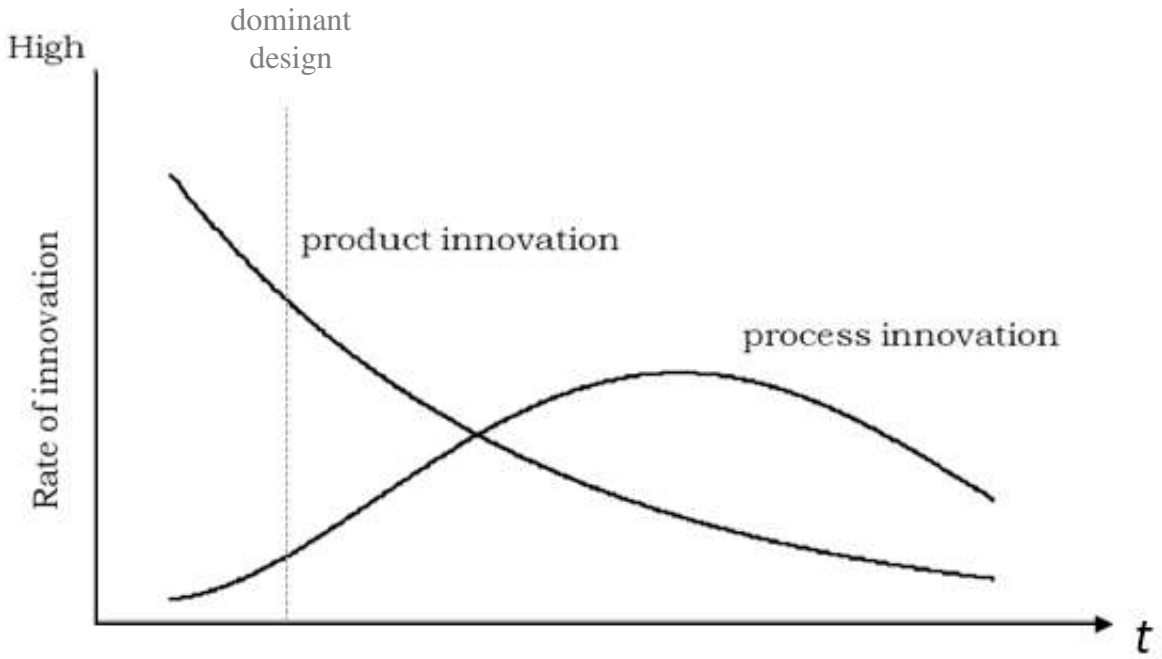
Rogers (1962, 2003)



Christensen (1997)



Conceptual Foundation
A-U Model



Abernathy & Utterback (1975)
Utterback (1994)

Forms of Innovation

product

process

marketing

organizational

business model

other frameworks…

Problem Statement

The general problem is that there does not appear to be consensus on the form(s) that non-technological innovation can take.

The specific problem is that the A-U model, which guides innovators and researchers (Teece, 1986; Akiike, 2013), does not include 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 four times larger, and far more sustainable, than traditional product/process innovation (Lindgart, Reeves, Stalk, & Deimler, 2009).

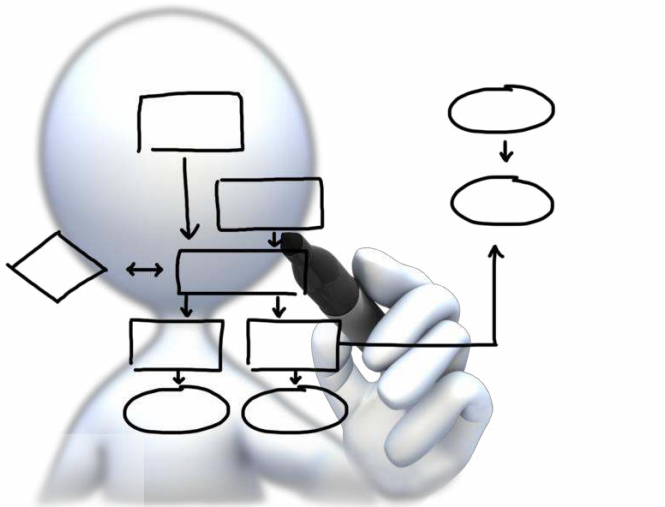
Research Question

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?

Research Process
Method & Design

Qualitative e-Delphi process, using an analytical hierarchical process (AHP) decision model, based on 45 years of historical industry results (1975 - 2020).

Build consensus on market share leaders, forms of innovation considered, and form used by each market share leader



Saaty (1980)
Linstone & Turoff (1975)
Dalkey & Helmer (1963)

Research Process
Expert Panel

Panel 20+ experts (Ludwig, 1997; Hsu & Sandford, 2007)

Experts in the technology industry with an understanding of the evolution of the PC industry

Purposeful selection based on response to an electronic LinkedIn invitation

LinkedIn profiles reviewed for industry experience

Expert Panel Recruiting

LinkedIn: 660 million users, 200 countries

50% College educated Americans

Step 1

LinkedIn Post

↓

Experience Screen

Step 2

Experience Screen

↓

LinkedIn email

Step 3

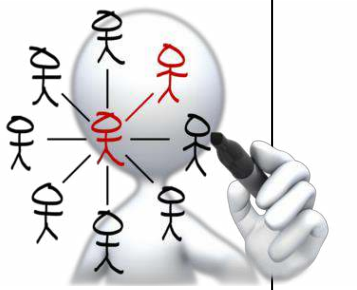
Expert Panel Participant

Phase 1 Survey

validate consensus

Phase 2 Survey

calculate consensus



2,613 1st level connections

1.4 million 2nd level connections

Diverse industries/segments

20+ years in technology

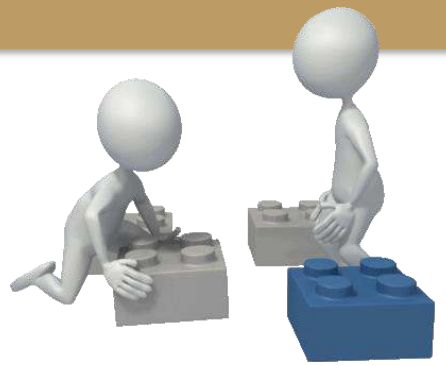
Tran (2020)

Zhang & Vucetic (2016)

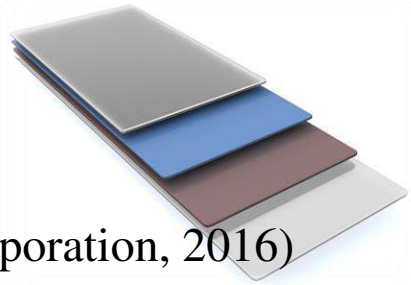
Huang, Tunkelang, & Karahalios (2014)

Unkelos-Shpigel, Sherman, & Hadar (2015)

Research Process
US PC Data Collection



- 45 years U.S. PC market share data
- Multiple data sources/sets
  - U.S. PC market share 1980 – 1982 (Steffens, 1994)
  - U.S. PC market share 1980 – 1998 (Narayandas & Rangan, 1996; Rivken, Porter, & Nabavi, 1999)
  - U.S. PC market share 1975 – 1981 (Reimer, 2005)
  - U.S PC market share 1994 – 2008 (Rivken, 2010)
  - U.S. PC market share 2009 – 2015 (International Data Corporation, 2016)
  - U.S. PC market share 2013 – 2010 (Gartner Group, 2020a)
  - Worldwide PC market share 2013 – 2020 (Gartner Group, 2020b)
- Cross-validated, filled, and smoothed



Research Process
Participation Rates

- 30 “verified” experts
- Two rounds
  - Phase 1: Forms of innovation
  - Phase 2: Market leaders
  - Calculate consensus
- Study target 20
  - Phase 1: 30 experts
  - Phase 2: 24 start => 19 end
  - Question fatigue vs. round fatigue
- Independent judgments

Phase 1	Participation
question 1	30
question 2	27
Phase 2	
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

Research Process
Phase 1 Responses

Forms of Innovation

Marketing

Organizational

Product

Process

Consistent with 3rd Edition Oslow Manual (OECD, 2005)

Research Process
Phase 2 Responses

PC Industry Market Share Leaders 1975 to 2019
U.S. units sold

1975 -76	**1977-80**	1981-82	1983-90	1986; 1989; 1991	1992-93	1994-95	1996-99	2000-08	2009-19	2013-19
Altair	**AST/Tandy**	Apple	IBM	Commodore	Apple	Packard Bell (NEC)	Compaq	Dell	HP	Lenovo*

*worldwide

Market share data. Numbers are based on results reported publicly by International Data Corporation (IDC), Gartner Group, and Ars Technica.

Please rate the importance of the form of innovation in establishing market leadership for **AST/Tandy in 1977**:

	not important								very important
a_1 Product innovation (changes in product produced)	○	○	○	○	○	○	○	○	○
a_2 Process innovation (changes in production process)	○	○	○	○	○	○	○	○	○
a_3 Marketing innovation (changes in marketing mix)	○	○	○	○	○	○	○	○	○
a_4 Organizational innovation (changes in structure / operation of organization)	○	○	○	○	○	○	○	○	○

What is your confidence level in these rankings?

	not confident								very confident
Confidence level	○	○	○	○	○	○	○	○	○

While a market leader, did the focus of innovation by this company change?

ordinal scale

Likert Scale 1..9

$a_{ij} = |judgment_{ik} - judgment_{jk}| + 1$

Saaty Scale 1..9 (pairwise)

pairwise

Research Process
Calculate Priority Matrix (AHP)

$$\begin{array}{c} \\ a_1 \\ a_2 \\ a_3 \\ a_4 \end{array} \begin{array}{c} \begin{array}{cccc} a_1 & a_2 & a_3 & a_4 \end{array} \\ \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & a_{34} \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} \end{array} \quad (1)$$

$$\begin{array}{c} \\ a_1 \\ a_2 \\ a_3 \\ a_4 \end{array} \begin{array}{c} \begin{array}{cccc} a_1 & a_2 & a_3 & a_4 \end{array} \\ \begin{bmatrix} 1 & a_{12} & a_{13} & a_{14} \\ 1/a_{12} & 1 & a_{23} & a_{24} \\ 1/a_{13} & 1/a_{23} & 1 & a_{34} \\ 1/a_{14} & 1/a_{24} & 1/a_{34} & 1 \end{bmatrix} \end{array} \quad (2)$$

a_1 to a_2, a_1 to a_3, a_1 to a_4
a_2 to a_3, a_2 to a_4
a_3 to a_4

pairwise

$$X_{ij} = \frac{a_{ij}}{\sum_{i=1..n} a_{ij}} \begin{bmatrix} X_{11} & X_{12} & X_{13} & X_{14} \\ X_{21} & X_{22} & X_{23} & X_{24} \\ X_{31} & X_{32} & X_{33} & X_{34} \\ X_{41} & X_{42} & X_{43} & X_{44} \end{bmatrix} \quad W_j = \frac{\sum_{j=1..n} X_{ij}}{n} \begin{bmatrix} W_1 \\ W_2 \\ W_3 \\ W_4 \end{bmatrix} \quad (3)$$

Consistency Index (4)

Saaty (1980)
Bunruamkaew (2012)

Research Process
Sample Matrix

Apple

1981 - 1982

	Product	Process	Marketing	Organizational
Geometric Mean	8.26	4.50	6.91	3.76
Arithmatic 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

4 forms innovation
11 market leaders
45 years

Research Process
Summary Results

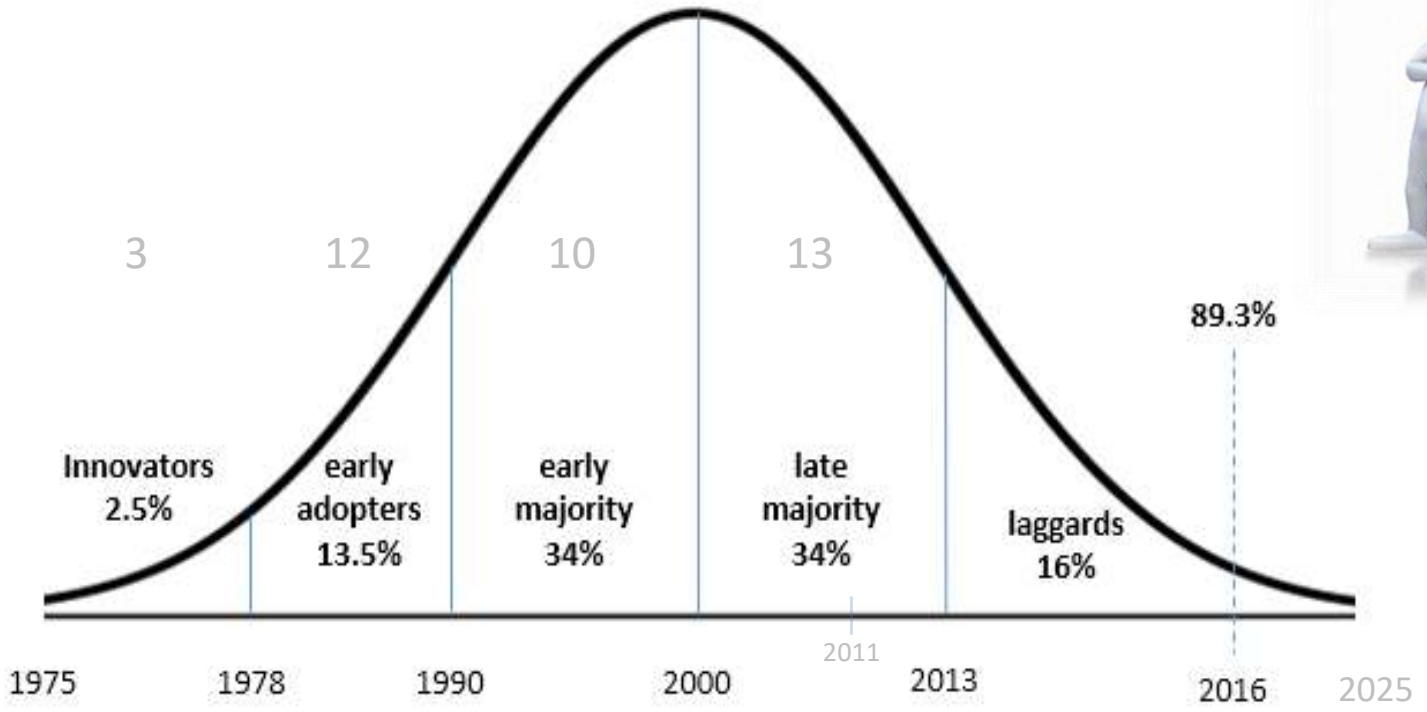
Geometric Mean	Period	Product	Process	Marketing	Organizational
Altair	1975 - 1976	7.60	3.15	3.90	2.25
AST/Tandy	1977 - 1980	6.78	4.45	5.99	2.68
Apple 1	1981 - 1982	8.26	4.50	6.91	3.76
IBM	1983 - 1988, 1990	6.15	5.53	6.15	5.29
Commodore	1986, 1989, 1991	6.18	4.49	5.17	3.69
Apple 2	1992 - 1993	7.57	5.00	7.08	4.63
Packard Bell	1994 - 1995	4.62	5.56	5.14	4.21
Compaq	1996 - 1999	6.39	5.65	6.09	4.39
Dell	2000 - 2008	5.59	7.59	7.90	6.12
HP	2009 - 2020	5.21	5.02	5.55	5.50
Lenovo	2013 - 2020	5.56	5.37	6.47	4.85

Pairwise Analysis	Period	Product	Process	Marketing	Organizational	CR
Altair	1975 - 1976	0.62	0.12	0.17	0.07	0.02
AST/Tandy	1977 - 1980	0.46	0.15	0.31	0.07	0.02
Apple 1	1981 - 1982	0.52	0.11	0.29	0.07	0.02
IBM	1983 - 1988, 1990	0.32	0.20	0.32	0.17	0.00
Commodore	1986, 1989, 1991	0.45	0.17	0.26	0.11	0.01
Apple 2	1992 - 1993	0.44	0.12	0.34	0.10	0.01
Packard Bell	1994 - 1995	0.19	0.37	0.28	0.15	0.00
Compaq	1996 - 1999	0.37	0.22	0.30	0.11	0.00
Dell	2000 - 2008	0.11	0.33	0.40	0.15	0.00
HP	2009 - 2020	0.22	0.19	0.30	0.29	0.00
Lenovo	2013 - 2020	0.23	0.20	0.42	0.14	0.00

ratio scale

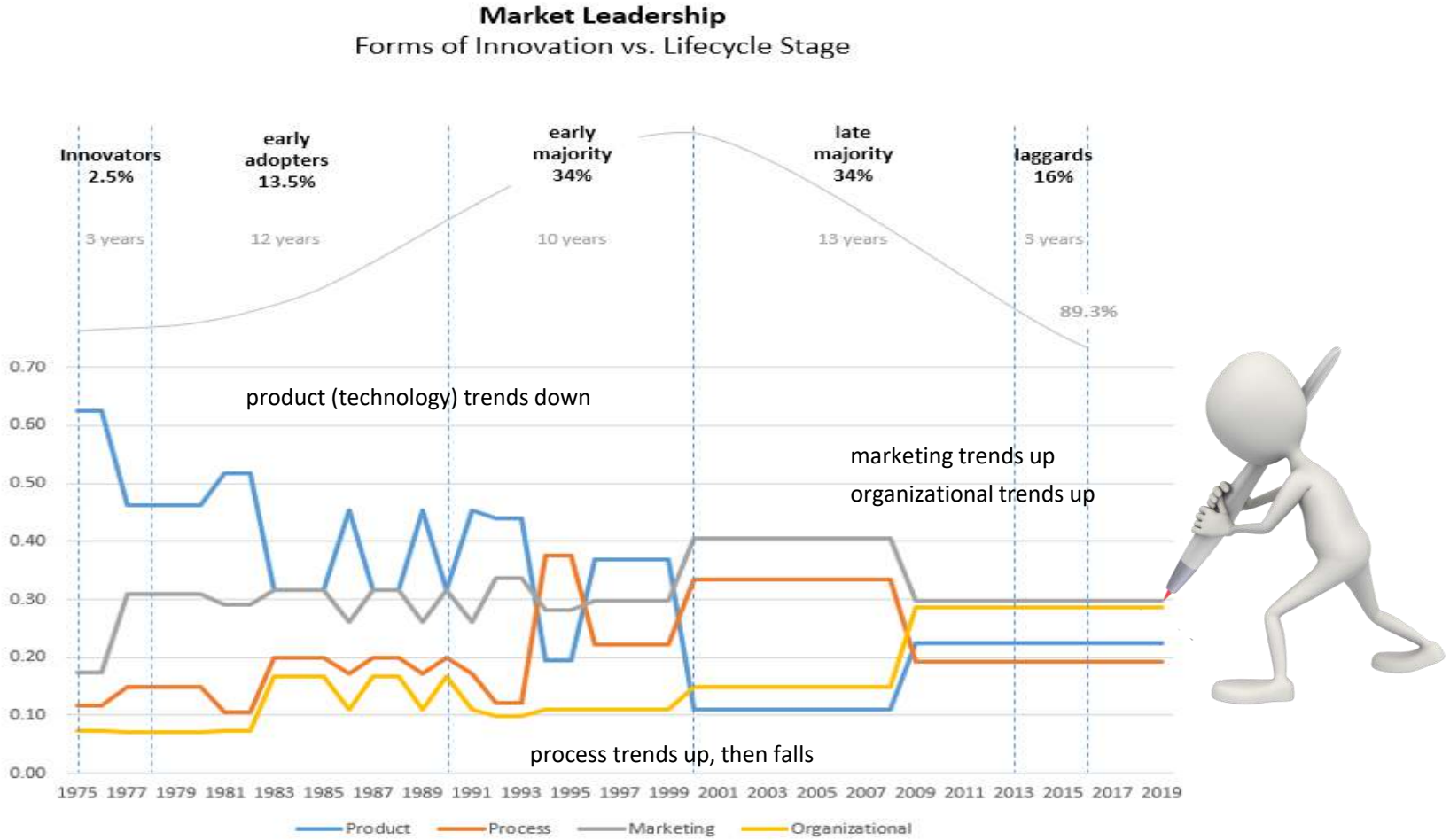
AIJ vs. AIP
Forman & Peniwati (1997)

Research Process
US PC Market Diffusion



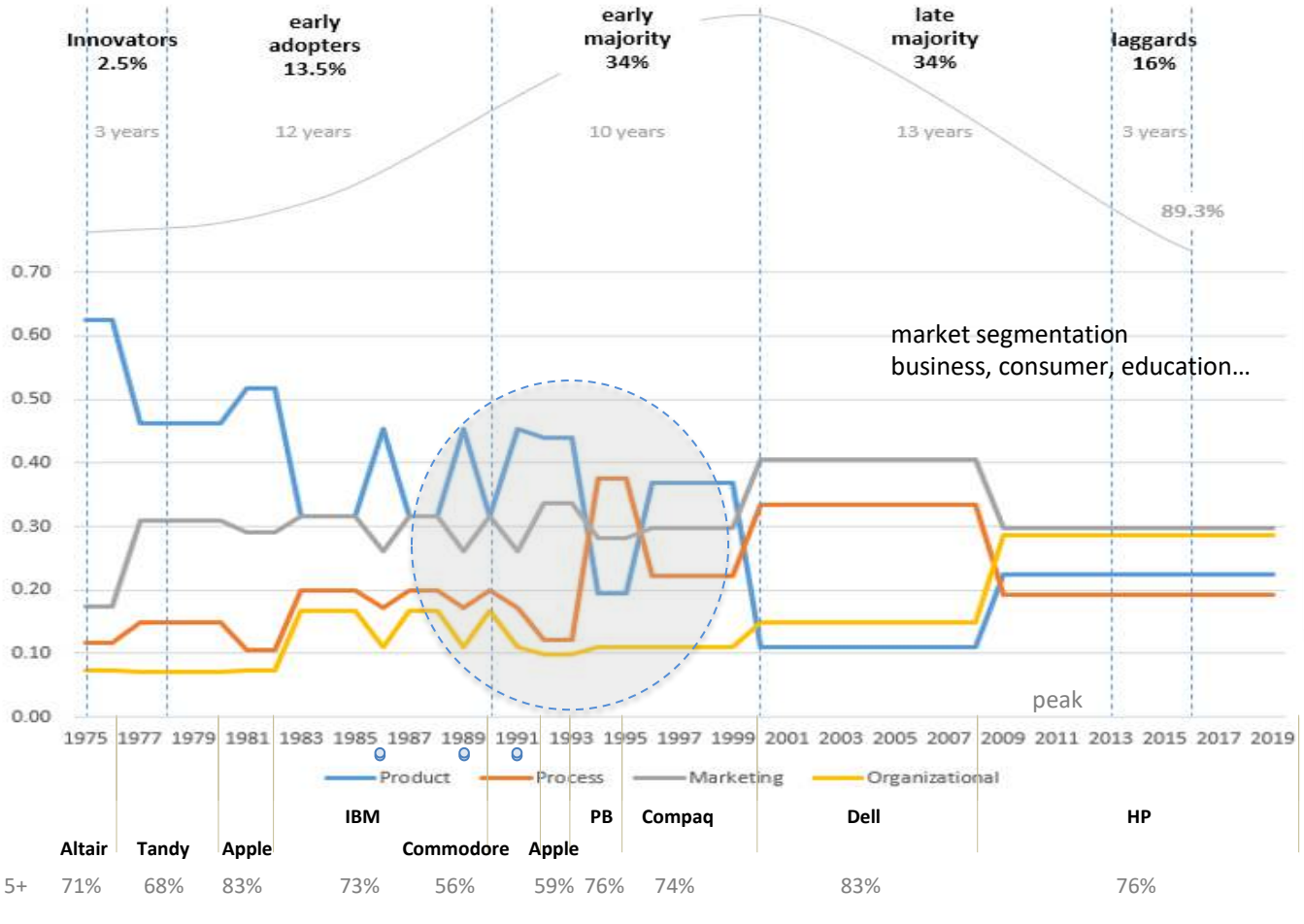
U.S. Census Bureau (2014, 2018)

Research Process
Results vs Lifecyle Stage



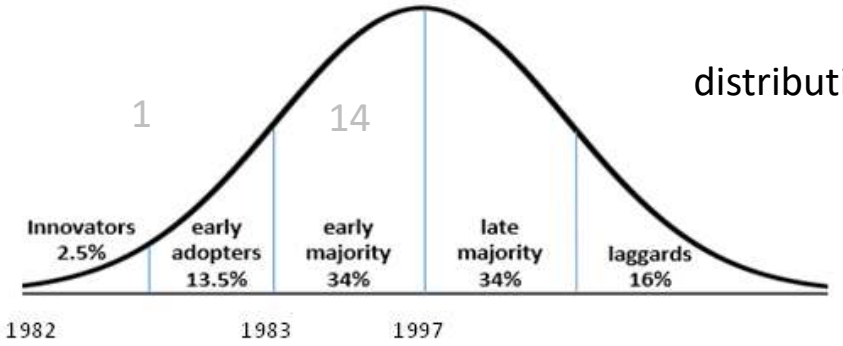
Research Process
Results vs Lifecyle Stage

Market Leadership
Forms of Innovation vs. Lifecycle Stage



ratio scale

Research Process
Business Market Diffusion



distribution is <u>not</u> normal

mid-point difference(s)

Year	1984	1989	1993	1997	2001	2003	mid-point
Total	24.4	37.3	46.6	50.6	53.5	55.5	1997
years	2	5	4	4	4	2	
growth rate	24%	11%	6%	2%	1%	2%	

Year	1984	1989	1993	1997	2001	2003	mid-point
Professional & technical	38.1	54.4	65.7	73.1	78.9	78.7	1988
Managers & administrators	42.5	61.8	73.7	78.7	80.4	80.8	1986
Sales	23.9	35.5	49.8	55.8	57.7	59.7	1993
Clerical	47.4	66.8	77.4	78.6	73.6	73.5	1985
Craftsmen	10.1	15.2	23.5	25.3	29.9	31.9	tbd
Operatives	5.8	9.6	15.7	18.6	19.5	21.5	tbd
Laborers	3.2	6.6	11.7	12.8	13.7	15.7	tbd
Service	6.0	9.8	15.1	16.8	23.3	27.5	tbd

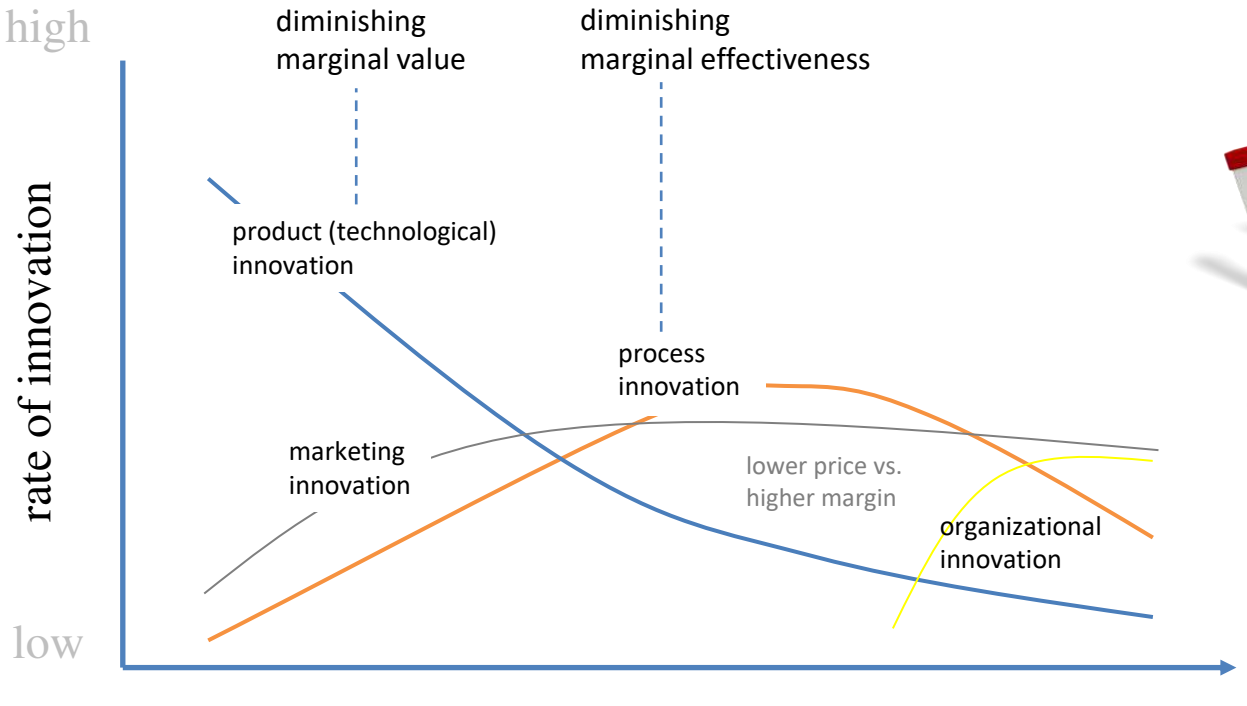
2025

Bureau of Labor Statistics (2005), Friedberg (2003), Hipple & Kosanovich (2003)

Research Findings

- Product, process, marketing, organizational innovation
- AHP decision model shows promise
  - Reduce e-Delphi rounds
  - Likert to pairwise
    - Reduce comparisons [N(N-1)/2 vs. N]
    - Eliminate inconsistency [a > b & b > c => a > c]
    - Zero value case [completely unimportant]
  - Ratio results
- Diffusion not “normal” in sub-segments
- Product -> process innovation early-mid cycle (A-U model)
- Marketing/organizational innovation mid-late stage

Research Findings
Expanded Model



Expanded A-U Model

Mantovani (2006)
Christensen (1997)
Utterback (1994)
Utterback & Abernathy (1975)

Innovation vs. market leadership

Recommendations

- Utterback & Abernathy (1975) based on 567 commercial innovations, 5 industries, 120 firms. Expand research to additional products and industries to validate.

- 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

Recommendations

- 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

Questions

More to come…

Special Thanks

Holly Chason

Robert Butler

John Thurber

Peter Maille

Gary Keller

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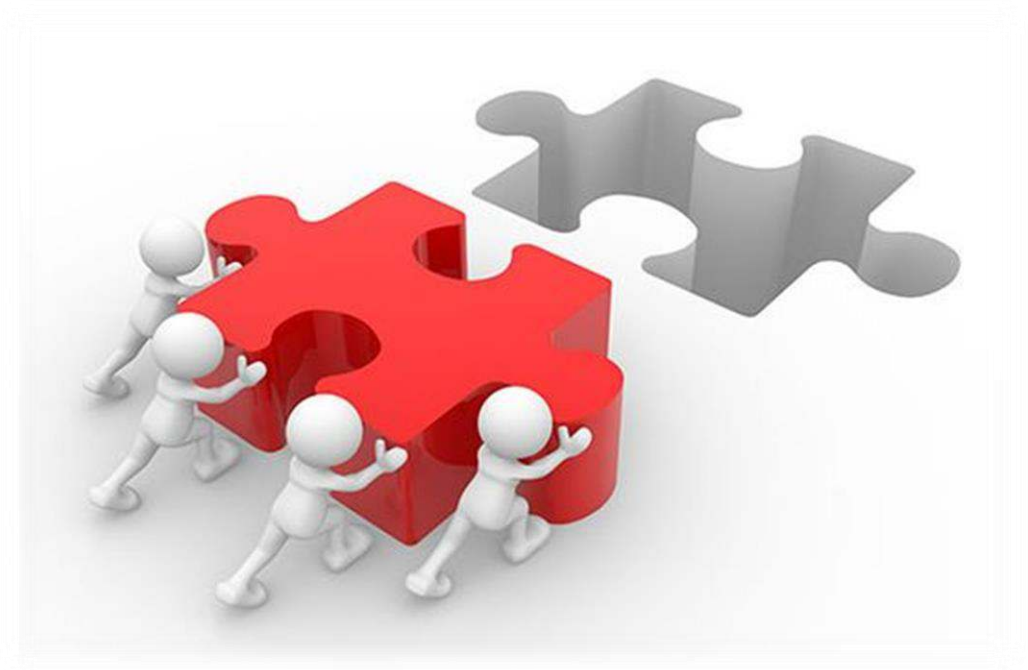
Backup



AHP Results

Altair

1975 - 1976

	Product	Process	Marketing	Organizational
Geometric Mean	7.60	3.15	3.90	2.25
Arithmatic Mean	7.83	3.79	4.88	3.17

$a_1 \rightarrow a_2$	$a_1 \rightarrow a_3$	$a_1 \rightarrow a_4$	$a_2 \rightarrow a_3$	$a_2 \rightarrow a_4$	$a_3 \rightarrow a_4$
4.45	3.71	5.36	-0.74	0.90	1.65

	a_1	a_2	a_3	a_4
a_1	1.00	5.45	4.71	6.36
a_2	0.18	1.00	0.57	1.90
a_3	0.21	1.74	1.00	2.65
a_4	0.16	0.53	0.38	1.00
sum	1.55	8.72	6.66	11.90

	X_1	X_2	X_3	X_4	mean	consistency
X_1	0.64	0.63	0.71	0.53	0.62	4.08
X_2	0.12	0.11	0.09	0.16	0.12	4.03
X_3	0.14	0.20	0.15	0.22	0.17	4.05
X_4	0.10	0.06	0.06	0.08	0.07	4.07
	1.00	1.00	1.00	1.00	CI	0.02
					RI	0.90
					CR	0.02

AST/Tandy

1977 - 1980

	Product	Process	Marketing	Organizational
Geometric Mean	6.78	4.45	5.99	2.68
Arithmatic Mean	6.96	4.83	6.26	3.43

$a_1 \rightarrow a_2$	$a_1 \rightarrow a_3$	$a_1 \rightarrow a_4$	$a_2 \rightarrow a_3$	$a_2 \rightarrow a_4$	$a_3 \rightarrow a_4$
2.34	0.80	4.11	-1.54	1.77	3.31

	a_1	a_2	a_3	a_4
a_1	1.00	3.34	1.80	5.11
a_2	0.30	1.00	0.39	2.77
a_3	0.56	2.54	1.00	4.31
a_4	0.20	0.36	0.23	1.00
sum	2.05	7.23	3.43	13.19

	X_1	X_2	X_3	X_4	mean	consistency
X_1	0.49	0.46	0.53	0.39	0.46	4.05
X_2	0.15	0.14	0.12	0.21	0.15	4.06
X_3	0.27	0.35	0.29	0.33	0.31	4.04
X_4	0.10	0.05	0.07	0.08	0.07	4.07
	1.00	1.00	1.00	1.00	CI	0.02
					RI	0.90
					CR	0.02

AHP Results

Apple

1981 - 1982

	Product	Process	Marketing	Organizational
Geometric Mean	8.26	4.50	6.91	3.76
Arithmatic 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

IBM

1983 - 1988, 1990

	Product	Process	Marketing	Organizational
Geometric Mean	6.15	5.53	6.15	5.29
Arithmatic Mean	6.57	6.04	6.57	5.96

$a_1 \rightarrow a_2$	$a_1 \rightarrow a_3$	$a_1 \rightarrow a_4$	$a_2 \rightarrow a_3$	$a_2 \rightarrow a_4$	$a_3 \rightarrow a_4$
0.62	0.00	0.87	-0.62	0.25	0.87

	a_1	a_2	a_3	a_4
a_1	1.00	1.62	1.00	1.87
a_2	0.62	1.00	0.62	1.25
a_3	1.00	1.62	1.00	1.87
a_4	0.54	0.80	0.54	1.00
sum	3.15	5.05	3.15	5.98

	X_1	X_2	X_3	X_4	mean	consistency
X_1	0.32	0.32	0.32	0.31	0.32	4.00
X_2	0.20	0.20	0.20	0.21	0.20	4.00
X_3	0.32	0.32	0.32	0.31	0.32	4.00
X_4	0.17	0.16	0.17	0.17	0.17	4.00
	1.00	1.00	1.00	1.00	CI	0.00
					RI	0.90
					CR	0.00

AHP Results

Commodore

1986, 1989, 1991

	Product	Process	Marketing	Organizational
Geometric Mean	6.18	4.49	5.17	3.69
Arithmatic Mean	6.47	4.89	5.68	4.37

$a_1 \to a_2$	$a_1 \to a_3$	$a_1 \to a_4$	$a_2 \to a_3$	$a_2 \to a_4$	$a_3 \to a_4$
1.70	1.01	2.50	-0.69	0.80	1.48

	a_1	a_2	a_3	a_4
a_1	1.00	2.70	2.01	3.50
a_2	0.37	1.00	0.59	1.80
a_3	0.50	1.69	1.00	2.48
a_4	0.29	0.56	0.40	1.00
sum	2.15	5.94	4.01	8.78

	X_1	X_2	X_3	X_4	mean	consistency
X_1	0.46	0.45	0.50	0.40	0.45	4.03
X_2	0.17	0.17	0.15	0.20	0.17	4.01
X_3	0.23	0.28	0.25	0.28	0.26	4.02
X_4	0.13	0.09	0.10	0.11	0.11	4.02
	1.00	1.00	1.00	1.00	CI	0.01
					RI	0.90
					CR	0.01

Apple

1992 - 1993

	Product	Process	Marketing	Organizational
Geometric Mean	7.57	5.00	7.08	4.63
Arithmatic Mean	7.85	5.60	7.40	5.20

$a_1 \to a_2$	$a_1 \to a_3$	$a_1 \to a_4$	$a_2 \to a_3$	$a_2 \to a_4$	$a_3 \to a_4$
2.57	0.49	2.94	-2.09	0.36	2.45

	a_1	a_2	a_3	a_4
a_1	1.00	3.57	1.49	3.94
a_2	0.28	1.00	0.32	1.36
a_3	0.67	3.09	1.00	3.45
a_4	0.25	0.73	0.29	1.00
sum	2.21	8.39	3.10	9.75

	X_1	X_2	X_3	X_4	mean	consistency
X_1	0.45	0.43	0.48	0.40	0.44	4.02
X_2	0.13	0.12	0.10	0.14	0.12	4.01
X_3	0.30	0.37	0.32	0.35	0.34	4.01
X_4	0.12	0.09	0.09	0.10	0.10	4.01
	1.00	1.00	1.00	1.00	CI	0.00
					RI	0.90
					CR	0.01

AHP Results

Packard Bell

1994 - 1995

	Product	Process	Marketing	Organizational
Geometric Mean	4.62	5.56	5.14	4.21
Arithmatic Mean	5.17	6.17	5.72	4.78

$a_1 \rightarrow a_2$	$a_1 \rightarrow a_3$	$a_1 \rightarrow a_4$	$a_2 \rightarrow a_3$	$a_2 \rightarrow a_4$	$a_3 \rightarrow a_4$
-0.94	-0.52	0.41	0.42	1.35	0.93

	a_1	a_2	a_3	a_4
a_1	1.00	0.51	0.66	1.41
a_2	1.94	1.00	1.42	2.35
a_3	1.52	0.70	1.00	1.93
a_4	0.71	0.43	0.52	1.00
sum	5.18	2.64	3.60	6.68

	X_1	X_2	X_3	X_4	mean	consistency
X_1	0.19	0.19	0.18	0.21	0.19	4.00
X_2	0.38	0.38	0.40	0.35	0.37	4.01
X_3	0.29	0.27	0.28	0.29	0.28	4.00
X_4	0.14	0.16	0.14	0.15	0.15	4.01
	1.00	1.00	1.00	1.00	CI	0.00
					RI	0.90
					CR	0.00

Compaq

1996 - 1999

	Product	Process	Marketing	Organizational
Geometric Mean	6.39	5.65	6.09	4.39
Arithmatic Mean	6.63	6.00	6.63	4.84

$a_1 \rightarrow a_2$	$a_1 \rightarrow a_3$	$a_1 \rightarrow a_4$	$a_2 \rightarrow a_3$	$a_2 \rightarrow a_4$	$a_3 \rightarrow a_4$
0.74	0.30	2.01	-0.44	1.26	1.70

	a_1	a_2	a_3	a_4
a_1	1.00	1.74	1.30	3.01
a_2	0.57	1.00	0.70	2.26
a_3	0.77	1.44	1.00	2.70
a_4	0.33	0.44	0.37	1.00
sum	2.67	4.62	3.37	8.97

	X_1	X_2	X_3	X_4	mean	consistency
X_1	0.37	0.38	0.39	0.34	0.37	4.01
X_2	0.21	0.22	0.21	0.25	0.22	4.01
X_3	0.29	0.31	0.30	0.30	0.30	4.00
X_4	0.12	0.10	0.11	0.11	0.11	4.01
	1.00	1.00	1.00	1.00	CI	0.00
					RI	0.90
					CR	0.00

AHP Results

Packard Bell

1994 - 1995

	Product	Process	Marketing	Organizational
Geometric Mean	4.62	5.56	5.14	4.21
Arithmatic Mean	5.17	6.17	5.72	4.78

$a_1 \rightarrow a_2$	$a_1 \rightarrow a_3$	$a_1 \rightarrow a_4$	$a_2 \rightarrow a_3$	$a_2 \rightarrow a_4$	$a_3 \rightarrow a_4$
-0.94	-0.52	0.41	0.42	1.35	0.93

	a_1	a_2	a_3	a_4
a_1	1.00	0.51	0.66	1.41
a_2	1.94	1.00	1.42	2.35
a_3	1.52	0.70	1.00	1.93
a_4	0.71	0.43	0.52	1.00
sum	5.18	2.64	3.60	6.68

	X_1	X_2	X_3	X_4	mean	consistency
X_1	0.19	0.19	0.18	0.21	0.19	4.00
X_2	0.38	0.38	0.40	0.35	0.37	4.01
X_3	0.29	0.27	0.28	0.29	0.28	4.00
X_4	0.14	0.16	0.14	0.15	0.15	4.01
	1.00	1.00	1.00	1.00	CI	0.00
					RI	0.90
					CR	0.00

Compaq

1996 - 1999

	Product	Process	Marketing	Organizational
Geometric Mean	6.39	5.65	6.09	4.39
Arithmatic Mean	6.63	6.00	6.63	4.84

$a_1 \rightarrow a_2$	$a_1 \rightarrow a_3$	$a_1 \rightarrow a_4$	$a_2 \rightarrow a_3$	$a_2 \rightarrow a_4$	$a_3 \rightarrow a_4$
0.74	0.30	2.01	-0.44	1.26	1.70

	a_1	a_2	a_3	a_4
a_1	1.00	1.74	1.30	3.01
a_2	0.57	1.00	0.70	2.26
a_3	0.77	1.44	1.00	2.70
a_4	0.33	0.44	0.37	1.00
sum	2.67	4.62	3.37	8.97

	X_1	X_2	X_3	X_4	mean	consistency
X_1	0.37	0.38	0.39	0.34	0.37	4.01
X_2	0.21	0.22	0.21	0.25	0.22	4.01
X_3	0.29	0.31	0.30	0.30	0.30	4.00
X_4	0.12	0.10	0.11	0.11	0.11	4.01
	1.00	1.00	1.00	1.00	CI	0.00
					RI	0.90
					CR	0.00

AHP Results

Dell

2000 - 2008

	Product	Process	Marketing	Organizational
Geometric Mean	5.59	7.59	7.90	6.12
Arithmatic Mean	6.11	7.79	8.11	6.47

$a_1 \rightarrow a_2$	$a_1 \rightarrow a_3$	$a_1 \rightarrow a_4$	$a_2 \rightarrow a_3$	$a_2 \rightarrow a_4$	$a_3 \rightarrow a_4$
-1.99	-2.31	-0.53	-0.31	1.47	1.78

	a_1	a_2	a_3	a_4
a_1	1.00	0.33	0.30	0.65
a_2	2.99	1.00	0.76	2.47
a_3	3.31	1.31	1.00	2.78
a_4	1.53	0.41	0.36	1.00
sum	8.83	3.05	2.42	6.90

	X_1	X_2	X_3	X_4	mean	consistency
X_1	0.11	0.11	0.12	0.09	0.11	4.01
X_2	0.34	0.33	0.31	0.36	0.33	4.01
X_3	0.37	0.43	0.41	0.40	0.40	4.01
X_4	0.17	0.13	0.15	0.14	0.15	4.01
	1.00	1.00	1.00	1.00	CI	0.00
					RI	0.90
					CR	0.00

HP

2009 - 2019

	Product	Process	Marketing	Organizational
Geometric Mean	5.21	5.02	5.55	5.50
Arithmatic Mean	5.79	5.47	6.05	6.05

$a_1 \rightarrow a_2$	$a_1 \rightarrow a_3$	$a_1 \rightarrow a_4$	$a_2 \rightarrow a_3$	$a_2 \rightarrow a_4$	$a_3 \rightarrow a_4$
0.19	-0.34	-0.29	-0.53	-0.48	0.05

	a_1	a_2	a_3	a_4
a_1	1.00	1.19	0.75	0.78
a_2	0.84	1.00	0.65	0.67
a_3	1.34	1.53	1.00	1.05
a_4	1.29	1.48	0.95	1.00
sum	4.47	5.21	3.35	3.50

	X_1	X_2	X_3	X_4	mean	consistency
X_1	0.22	0.23	0.22	0.22	0.22	4.00
X_2	0.19	0.19	0.19	0.19	0.19	4.00
X_3	0.30	0.29	0.30	0.30	0.30	4.00
X_4	0.29	0.28	0.28	0.29	0.29	4.00
	1.00	1.00	1.00	1.00	CI	0.00
					RI	0.90
					CR	0.00

AHP Results

Dell

2000 - 2008

	Product	Process	Marketing	Organizational
Geometric Mean	5.59	7.59	7.90	6.12
Arithmatic Mean	6.11	7.79	8.11	6.47

$a_1 \rightarrow a_2$	$a_1 \rightarrow a_3$	$a_1 \rightarrow a_4$	$a_2 \rightarrow a_3$	$a_2 \rightarrow a_4$	$a_3 \rightarrow a_4$
-1.99	-2.31	-0.53	-0.31	1.47	1.78

	a_1	a_2	a_3	a_4
a_1	1.00	0.33	0.30	0.65
a_2	2.99	1.00	0.76	2.47
a_3	3.31	1.31	1.00	2.78
a_4	1.53	0.41	0.36	1.00
sum	8.83	3.05	2.42	6.90

	X_1	X_2	X_3	X_4	mean	consistency
X_1	0.11	0.11	0.12	0.09	0.11	4.01
X_2	0.34	0.33	0.31	0.36	0.33	4.01
X_3	0.37	0.43	0.41	0.40	0.40	4.01
X_4	0.17	0.13	0.15	0.14	0.15	4.01
	1.00	1.00	1.00	1.00	CI	0.00
					RI	0.90
					CR	0.00

HP

2009 - 2019

	Product	Process	Marketing	Organizational
Geometric Mean	5.21	5.02	5.55	5.50
Arithmatic Mean	5.79	5.47	6.05	6.05

$a_1 \rightarrow a_2$	$a_1 \rightarrow a_3$	$a_1 \rightarrow a_4$	$a_2 \rightarrow a_3$	$a_2 \rightarrow a_4$	$a_3 \rightarrow a_4$
0.19	-0.34	-0.29	-0.53	-0.48	0.05

	a_1	a_2	a_3	a_4
a_1	1.00	1.19	0.75	0.78
a_2	0.84	1.00	0.65	0.67
a_3	1.34	1.53	1.00	1.05
a_4	1.29	1.48	0.95	1.00
sum	4.47	5.21	3.35	3.50

	X_1	X_2	X_3	X_4	mean	consistency
X_1	0.22	0.23	0.22	0.22	0.22	4.00
X_2	0.19	0.19	0.19	0.19	0.19	4.00
X_3	0.30	0.29	0.30	0.30	0.30	4.00
X_4	0.29	0.28	0.28	0.29	0.29	4.00
	1.00	1.00	1.00	1.00	CI	0.00
					RI	0.90
					CR	0.00

AHP Results

Lenovo

	Product	Process	Marketing	Organizational
Geometric Mean	5.56	5.37	6.47	4.85
Arithmatic Mean	5.95	6.05	6.79	5.26

$a_1 \to a_2$	$a_1 \to a_3$	$a_1 \to a_4$	$a_2 \to a_3$	$a_2 \to a_4$	$a_3 \to a_4$
0.19	-0.91	0.70	-1.10	0.51	1.62

	a_1	a_2	a_3	a_4
a_1	1.00	1.19	0.52	1.70
a_2	0.84	1.00	0.48	1.51
a_3	1.91	2.10	1.00	2.62
a_4	0.59	0.66	0.38	1.00
sum	4.34	4.96	2.38	6.83

	X_1	X_2	X_3	X_4	mean	consistency
X_1	0.23	0.24	0.22	0.25	0.23	4.00
X_2	0.19	0.20	0.20	0.22	0.20	4.00
X_3	0.44	0.42	0.42	0.38	0.42	4.01
X_4	0.14	0.13	0.16	0.15	0.14	4.01
	1.00	1.00	1.00	1.00	CI	0.00
					RI	0.90
					CR	0.00

Research Sources
Digital Resources

TreeSize Free

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Select Directory | Stop Scan | Refresh | Size | Allocated Space | File Count | Percent | Automatic Units | GB | MB | KB | Expand | Start TreeSize Free as Administrator

Scan | Mode | Unit | Expand | Tools

Name	Size	Allocated	Files	Folders	% of Parent ...	Last Modified
1.3 GB C:\Users\Wilson\Dropbox\Walden\PhD dissertation\Literatu...	**1.3 GB**	**1.3 GB**	**1,091**	**50**	**100.0 %**	**10/17/2020**
582.0 MB research methods	**581.2 MB**	**582.0 MB**	**451**	**14**	**45.1 %**	**9/14/2020**
422.0 MB AHP	**421.7 MB**	**422.0 MB**	**154**	**3**	**72.5 %**	**8/6/2020**
55.2 MB Delphi	55.1 MB	55.2 MB	60	0	9.5 %	8/6/2020
37.7 MB AHP - scale	37.6 MB	37.7 MB	25	0	6.5 %	9/14/2020
24.4 MB Delphi + AHP	24.4 MB	24.4 MB	15	0	4.2 %	8/6/2020
11.2 MB LinkedIn	11.0 MB	11.2 MB	133	1	1.9 %	4/14/2020
8.3 MB Internet recruiting	8.2 MB	8.3 MB	30	1	1.4 %	9/24/2019
7.6 MB [13 Files]	7.6 MB	7.6 MB	13	0	1.3 %	7/19/2019
6.2 MB Case Study	6.2 MB	6.2 MB	11	0	1.1 %	2/29/2020
5.4 MB Mixed method	5.4 MB	5.4 MB	5	0	0.9 %	7/29/2019
3.8 MB Grounded Theory	3.8 MB	3.8 MB	5	0	0.7 %	9/9/2019
422.5 MB Innovation	**421.8 MB**	**422.5 MB**	**396**	**21**	**32.7 %**	**10/17/2020**
106.7 MB PC industry analysis	106.6 MB	106.7 MB	60	3	8.3 %	4/24/2020
76.5 MB new - review	76.4 MB	76.5 MB	78	0	5.9 %	8/4/2019
40.4 MB [14 Files]	40.4 MB	40.4 MB	14	0	3.1 %	7/7/2020
16.7 MB product lifecycle	16.7 MB	16.7 MB	49	1	1.3 %	2/2/2020
12.4 MB holding	12.4 MB	12.4 MB	4	0	1.0 %	7/29/2019
11.4 MB entrepreneurship	11.4 MB	11.4 MB	2	0	0.9 %	7/1/2020
10.9 MB project significance	10.9 MB	10.9 MB	11	0	0.8 %	8/3/2019
8.3 MB business cases	8.3 MB	8.3 MB	21	0	0.6 %	2/20/2020
2.4 MB dot com crash - internet	2.4 MB	2.4 MB	4	0	0.2 %	9/11/2019
920.0 KB sales training	917.0 KB	920.0 KB	1	0	0.1 %	7/28/2019

+ traditional print publications…

Diffusion Curves

Year	1984	1985	1986	1987	1988	1989	1993	1997	2000	2001	2002	2003	2007	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
									25									13							
Households	8.2%	9.6%	10.9%	12.3%	13.6%	15.0%	22.9%	36.6%	51.0%	56.3%		61.8%	69.7%	74.1%	75.6%	76.8%	78.9%	83.8%	85.1%	86.8%	89.3%				
																				86.8%	88.5%	90.2%	91.9%	93.6%	95.3%
US Workers								16																	
Overall	24.4%	27.0%	29.6%	32.1%	34.7%	37.3%	46.6%	50.6%	52.5%	53.5%	54.5%	55.5%													
										53.5%	54.5%	55.5%	56.5%	57.5%	58.5%	59.5%	60.5%	61.5%	62.5%	63.5%	64.5%	65.5%	66.5%	67.5%	68.5%
						8																			
Professional & technical	38.1%	41.4%	44.6%	47.9%	51.1%	54.4%	65.7%	73.1%	77.0%	78.9%		78.7%													
			5																						
Managers & administrators	42.5%	46.4%	50.2%	54.1%	57.9%	61.8%	73.7%	78.7%	79.8%	80.4%	80.6%	80.8%													
		4								80.4%	80.6%	80.7%	80.9%	81.0%	81.2%	81.4%	81.5%	81.7%	81.9%	82.0%	82.2%	82.4%	82.5%	82.7%	82.8%
Clerical	47.4%	51.3%	55.2%	59.0%	62.9%	66.8%	77.4%	78.6%	75.3%	73.6%		73.5%													
Craftsmen	10.1%	11.1%	12.1%	13.2%	14.2%	15.2%	23.5%	25.3%	28.4%	29.9%	30.9%	31.9%													
											30.9%	31.9%	32.9%	33.9%	34.9%	35.9%	36.9%	37.9%	38.9%	39.9%	40.9%	41.9%	42.9%	43.9%	44.9%
Laborers	3.2%	3.9%	4.6%	5.2%	5.9%	6.6%	11.7%	12.8%	13.4%	13.7%	14.7%	15.7%													
											14.7%	15.7%	16.7%	17.7%	18.7%	19.7%	20.7%	21.7%	22.7%	23.7%	24.7%	25.7%	26.7%	27.7%	28.7%

PC Market Share Data

U.S. PC Market Share
1975 - 2019

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Acer	-	-	-	-	-	-	-	-	-	-	-	-	-
Altair	100.0%	13.0%	6.1%	3.3%	-	-	-	-	-	-	-	-	-
Apple	-	-	0.4%	9.1%	21.0%	29.3%	41.0%	28.5%	20.0%	19.0%	18.0%	16.0%	14.0%
AST/Tandy	-	-	60.8%	49.6%	48.1%	37.6%	22.5%	10.1%	5.0%	4.0%	3.0%	2.5%	2.0%
Commodore	-	-	2.4%	9.9%	15.5%	15.8%	10.6%	3.6%	21.6%	32.4%	32.8%	33.2%	20.5%
Compaq	-	-	-	-	-	-	-	-	1.1%	2.5%	4.0%	5.8%	7.5%
Dell	-	-	-	-	-	-	-	-	-	0.0%	0.0%	0.3%	0.6%
Gateway	-	-	-	-	-	-	-	-	-	-	-	-	-
HP	-	-	-	-	-	0.7%	6.1%	4.6%	-	-	-	-	-
IBM/Lenovo	-	-	-	-	-	-	5.0%	22.2%	42.0%	39.5%	37.0%	32.5%	28.0%
Microsoft	-	-	-	-	-	-	-	-	-	-	-	-	-
Osborne	-	-	-	-	-	-	1.4%	8.2%	0.5%	-	-	-	-
Packard Bell (NEC)	-	-	-	-	-	-	-	-	-	-	-	-	-
Toshiba	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	0.0%	87.0%	30.4%	28.1%	15.5%	16.7%	13.4%	22.9%	9.8%	2.6%	5.2%	9.8%	27.4%

U.S. PC Market Share
1975 - 2019

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Acer	-	-	-	-	-	-	-	-	4.5%	3.8%	3.0%	2.7%	2.3%
Altair	-	-	-	-	-	-	-	-	-	-	-	-	-
Apple	12.4%	10.7%	10.9%	13.8%	13.2%	13.4%	11.5%	10.6%	6.4%	4.1%	4.6%	3.2%	3.8%
AST/Tandy	1.9%	1.7%	1.8%	2.7%	2.8%	4.0%	3.5%	2.3%	2.4%	-	-	-	-
Commodore	17.5%	18.5%	13.6%	15.9%	9.6%	2.3%	0.3%	0.2%	-	-	-	-	-
Compaq	6.0%	4.4%	4.5%	4.1%	5.7%	9.4%	11.7%	10.8%	12.9%	16.0%	16.7%	16.2%	15.7%
Dell	0.9%	0.9%	1.0%	1.6%	3.7%	4.8%	4.2%	4.9%	6.8%	9.3%	13.2%	15.9%	18.5%
Gateway	-	0.2%	1.0%	2.5%	3.6%	4.3%	5.1%	5.1%	6.1%	7.1%	8.4%	8.6%	8.7%
HP	-	-	-	-	-	-	2.4%	3.8%	5.3%	6.6%	7.8%	6.4%	11.1%
IBM/Lenovo	22.5%	16.9%	16.1%	14.1%	11.7%	13.0%	8.7%	7.9%	8.3%	8.7%	8.2%	6.4%	5.4%
Microsoft	-	-	-	-	-	-	-	-	-	-	-	-	-
Osborne	-	-	-	-	-	-	-	-	-	-	-	-	-
Packard Bell (NEC)	-	3.3%	3.9%	4.7%	5.3%	6.4%	14.3%	14.4%	11.4%	8.8%	6.2%	5.2%	4.3%
Toshiba	-	-	-	-	-	-	-	-	-	-	1.4%	1.9%	2.3%
Other	39.0%	43.4%	47.2%	40.6%	44.4%	42.4%	38.3%	40.0%	35.9%	35.7%	30.5%	33.6%	27.9%

PC Market Share Data

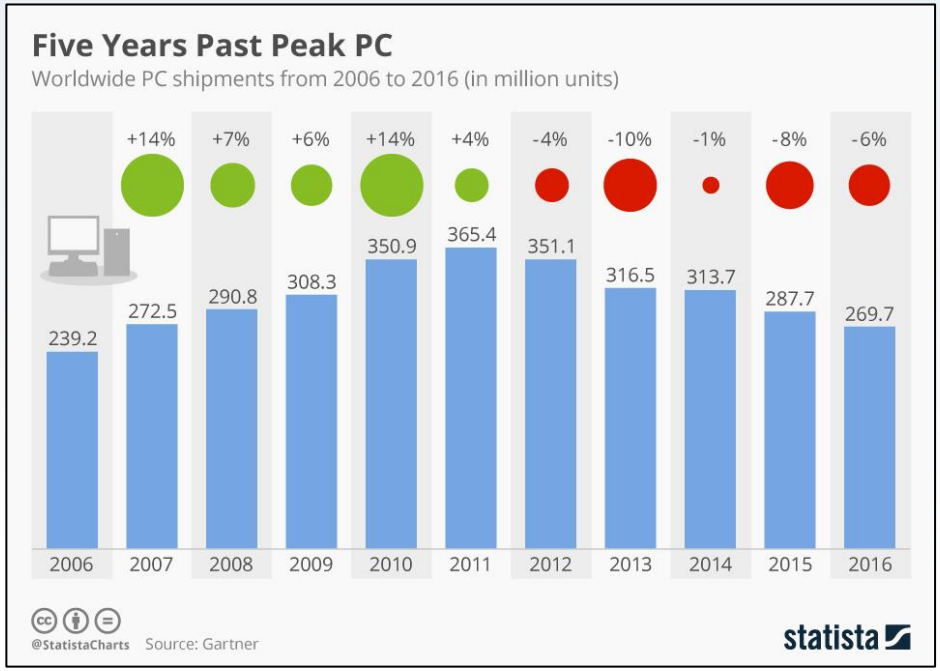
U.S. PC Market Share
1975 - 2019

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Acer	2.3%	1.9%	1.5%	1.1%	0.7%	1.4%	2.4%	6.0%	9.3%	12.1%	10.4%
Altair	-	-	-	-	-	-	-	-	-	-	-
Apple	3.8%	3.8%	3.7%	3.7%	3.6%	4.4%	5.2%	6.5%	7.9%	9.0%	10.5%
AST/Tandy	-	-	-	-	-	-	-	-	-	-	-
Commodore	-	-	-	-	-	-	-	-	-	-	-
Compaq	15.7%	-	-	-	-	-	-	-	-	-	-
Dell	18.5%	23.5%	28.5%	31.7%	34.9%	35.7%	32.8%	29.1%	29.4%	25.5%	23.4%
Gateway	8.7%	7.4%	6.0%	5.6%	5.1%	6.1%	-	-	-	-	-
HP	11.1%	18.4%	17.0%	18.8%	20.6%	20.4%	22.4%	24.8%	24.7%	25.0%	24.8%
IBM/Lenovo	5.4%	5.5%	5.6%	4.9%	4.3%	3.6%	4.2%	4.4%	4.1%	-	-
Microsoft	-	-	-	-	-	-	-	-	-	-	-
Osborne	-	-	-	-	-	-	-	-	-	-	-
Packard Bell (NEC)	4.3%	3.8%	-	-	-	-	-	-	-	-	-
Toshiba	2.3%	2.8%	2.8%	2.9%	3.1%	3.3%	3.8%	4.0%	4.6%	8.1%	8.8%
Other	27.9%	33.0%	34.9%	31.4%	27.7%	25.1%	29.2%	25.2%	20.0%	20.3%	22.1%

U.S. PC Market Share
1975 - 2019

	2011	2012	2013	2014	2015	2016	2017	2018	2019
Acer	8%	0%	0%	0%	1%	1%	2%	3%	2%
Altair	-	-	-	-	-	-	-	-	-
Apple	11%	11%	11%	12%	13%	12%	13%	13%	13%
AST/Tandy	-	-	-	-	-	-	-	-	-
Commodore	-	-	-	-	-	-	-	-	-
Compaq	-	-	-	-	-	-	-	-	-
Dell	22%	21%	22%	24%	24%	25%	26%	27%	28%
Gateway	-	-	-	-	-	-	-	-	-
HP	26%	27%	25%	27%	28%	28%	31%	31%	30%
IBM/Lenovo	7%	8%	10%	11%	12%	14%	13%	15%	15%
Microsoft	-	-	-	-	-	-	2%	4%	4%
Osborne	-	-	-	-	-	-	-	-	-
Packard Bell (NEC)	-	-	-	-	-	-	-	-	-
Toshiba	9%	7%	7%	6%	5%	0%	-	-	-
Other	17%	26%	24%	20%	18%	19%	14%	8%	8%

Recent Sales Results (Global)



Richter (2017)

Kannan (2020)