Technology,
Government, Business, and Universities:
The Innovation Ecosystem

SIMPOSIO: Desarollo Local y Regional a Través de la Cienca, Tecnología e Innovación, con la Minería, Como para el Crecimiento Integral de la Región de Atacama

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Abstract

Technology, Government, Business, and Universities: The Innovation Ecosystem

The purpose of this presentation is to present an overview of the roles of the government, business enterprises, and universities in the promotion and creation of innovation. Our approach is to present key concepts, principles, methods, tools and use illustrative examples from research and executive practice. We begin by defining "innovation". We argue that innovation is both a process and an output. From a process perspective, innovation is an emergent property of a complex social-technical system composed of government, business enterprises, and universities. The behavior of this system is the result of policies engineered by the government. We illustrate this point with examples of various macro economies, e.g. Chile. Using these examples we illustrate effective government policies. Next we discuss innovation as an output from business enterprises. We focus on enterprise level methods and tools for innovation. They are: business model transformation, business process reengineering, inventive problem solving, analysis of customer requirements, technology roadmapping, and knowledge management. Consistent with our practice, we illustrate the use of these methods and tools in detail. Next, we touch on the role of universities. For universities to promote innovation, we identify six research paths, three research strategies, and two goals. We cite a few examples from MIT. We present a key role of universities: to create interpretation spaces for researchers, government, and business where new innovative knowledge and ideas can be explored and generated in an environment of strong mutual trust. Innovation is impossible without decisive executives who are committed to action. Therefore, we present a detailed discussion of a new prescriptive approach that take a fresh look at decision-making for executives and policy makers. Finally, we distill from all of the above a set of principles that help unlock innovation. Finally we distill from all of the above a set of principles that help to unlock innovation.

What is Innovation?

An idea or practice, or material artifact perceived to be relevant by the unit of adoption.[1]

output and interactions

Blades of a pair of scissors; one is the recognition of an economic and market need and the other involves technical knowledge.[2]

inputs and their interactions

... application of ideas that are new to the firm, whether embodied in products, processes, services, or in work organisation, management or marketing systems.[3]

input and processes

Innovation is a product of the interaction between necessity and chance, order and disorder, continuity and discontinuity.[4]

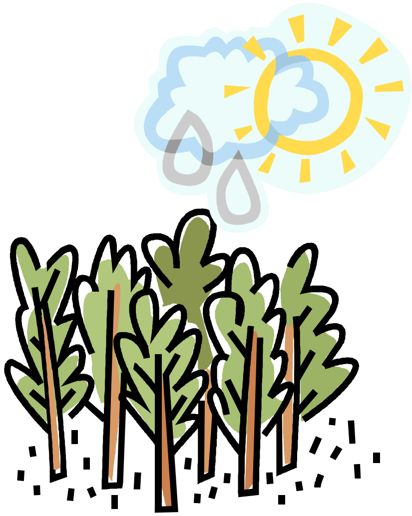
emergent from environment

The effort to create purposeful, focused change in an enterprise's economic and social potential.[5]

social economic output

1. G. Zaltman, R. Duncan, and J. Holbeck. 1973. Innovations and Organizations.
2. J. Schmookler. 1996. Invention and Economic Growth.
3. M. Gibbons, C. Limoges, et al. 1994. The New Production of Knowledge. Stockholm, SAGE.
4. I. Nonaka. 1990. Redundnat, Overlapping Organization: A Japanese Approach to Managing the Innovation Process.
5. P.R. Drucker. 1985. The Discipline of Innovation.

The ecosystem of innovation



Innovation emerges from an ecosystem comprised of government, industry, universities, and other enterprises.

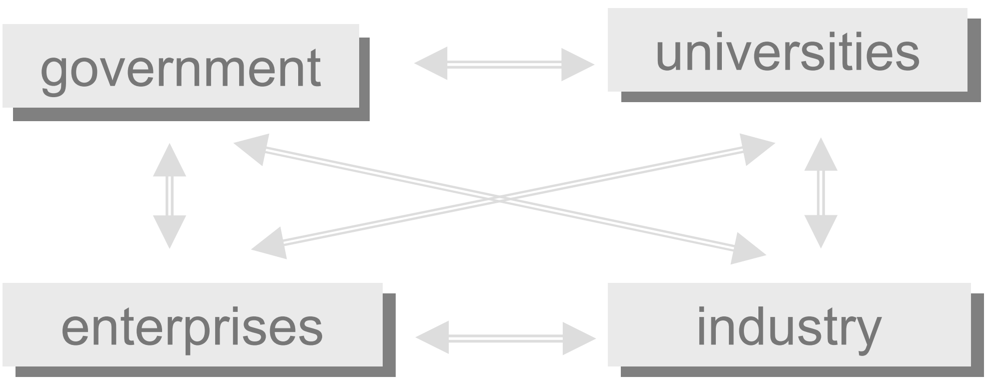
The subsytem interactions within the ecosystem promote or inhibit innovative outputs.

The structure and behavior of this system is the result of government policy.

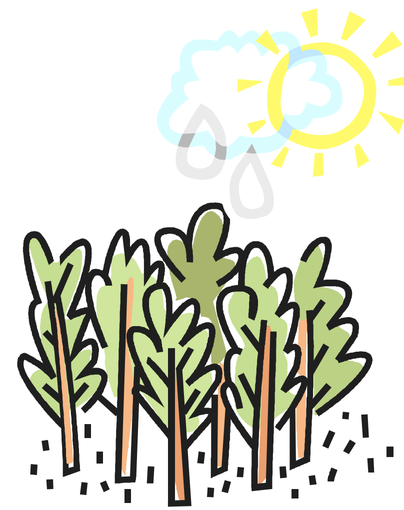
There are principles, methods, and tools to stimulate innovation. Knowledge and learning are the key that fuel the intensity of innovation within the system.

Agenda

- Innovation policy
- Interpretation spaces



- Business model transformation
- Process reengineering
- Inventive problem solving
- Knowledge management
- Technology management
- Decision analysis



Unlocking innovation

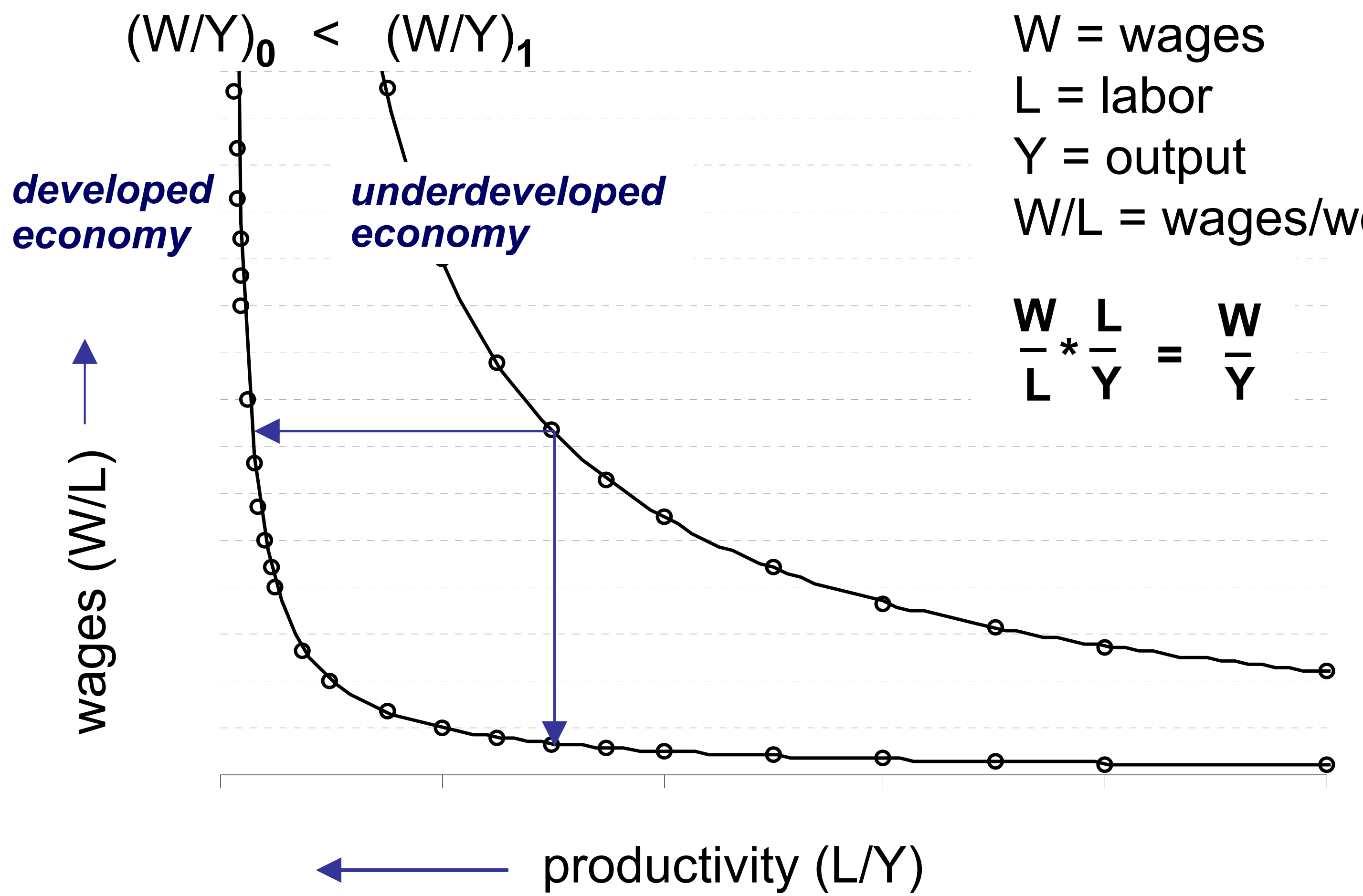
Lessons from national innovation strategies

Catching up… skills and technologies can be imported quickly and more cheaply than those available to the early innovators.

- However, the later the industrialization, the *greater* and *more different* the economic interventions its government must create.
- It must create unorthodox, and novel economic models.
- Novel → there is a *new* and *different control mechanism*, i.e. set of institutions that imposes a discipline on economic behavior based on the principle of reciprocity.
- In classical economics the invisible hand of the market, supply demand equilibrium, is the reciprocal control mechanism.
- In the catch-up regime, the *visible hand of government* through new institutions, intermediate assets, and insistence on market performance establishes the reciprocal the control mechanism.

source: A. H. Amsden. 2001. The Rise of the Rest. Oxford University Press.

The theory



W = wages
L = labor
Y = output
W/L = wages/worker

$$\frac{W}{L} * \frac{L}{Y} = \frac{W}{Y}$$

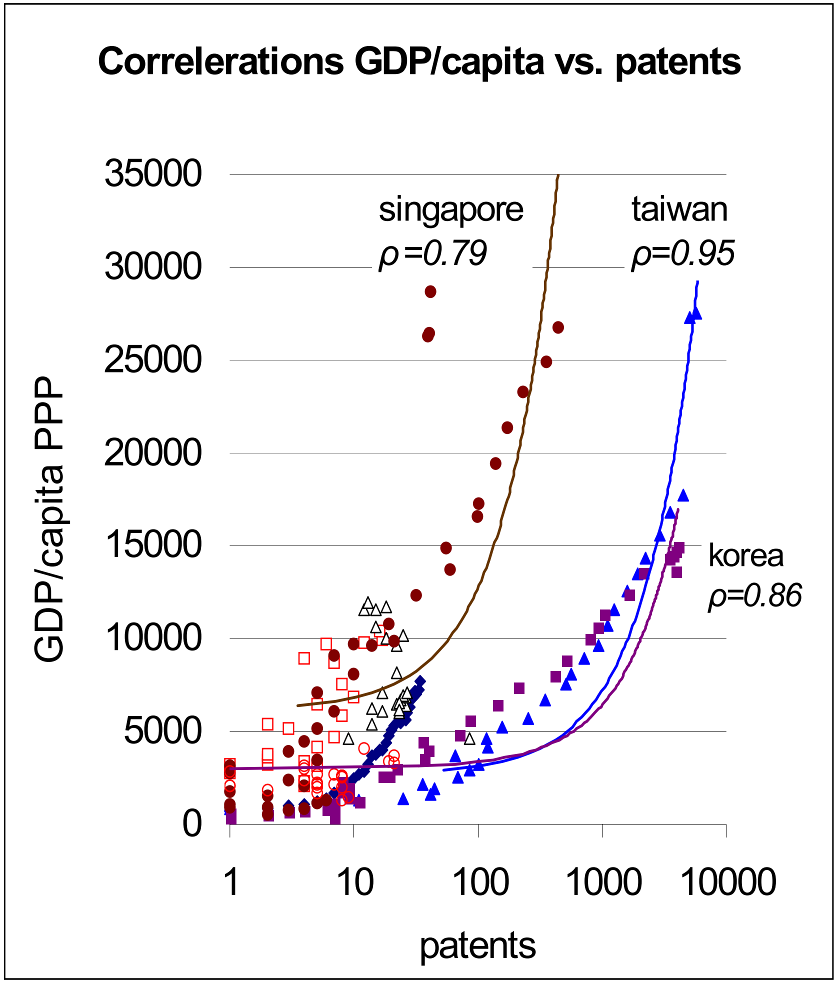
Source:A.H. Amsden. 2001. The Rise of the "The Rest"

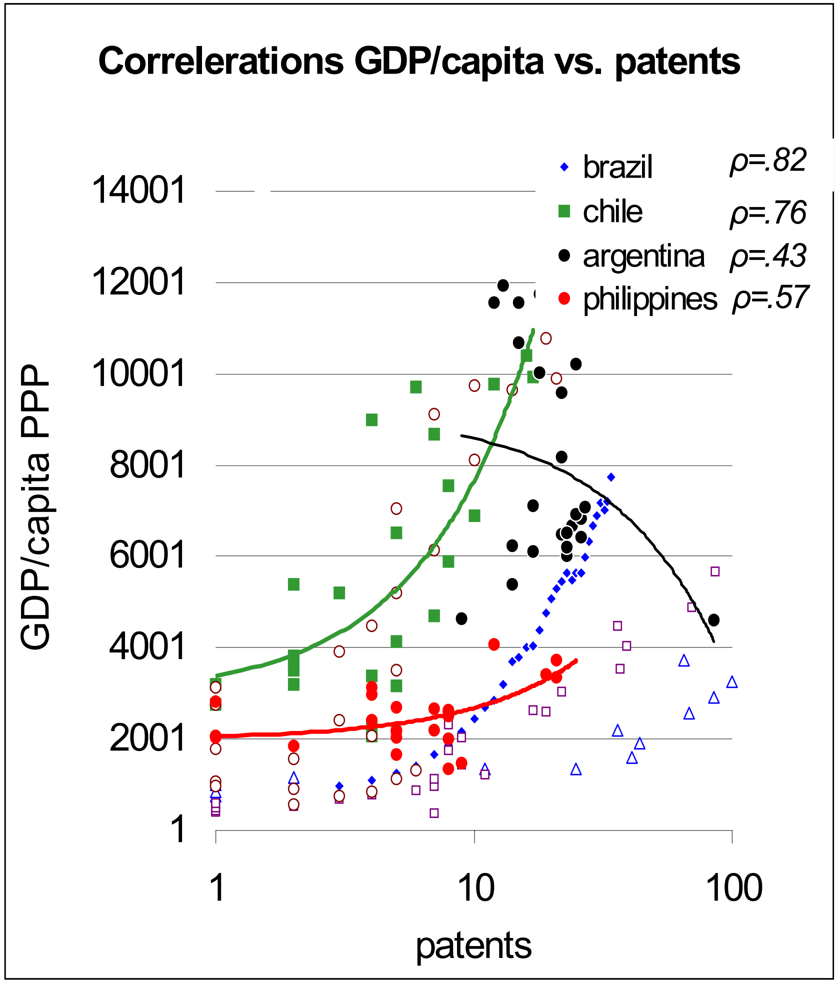
Catching up and falling behind

1960 GDP PPP position	Ratio: GDP PPP relative to top position				
	1960	**1970**	**1980**	**1990**	**2000**
Argentina	1.00	1.00	1.00	1.00	1.00
Chile	0.52	0.56	0.99	0.65	0.95
Brazil	0.32	0.56	0.60	0.60	0.52
Singapore	0.29	0.40	0.53	0.42	0.41
Philippines	0.28	0.31	0.52	0.37	0.36
South Korea	0.20	0.28	0.43	0.36	0.27
Taiwan	0.18	0.27	0.30	0.17	0.14

World bank, Tang analysis

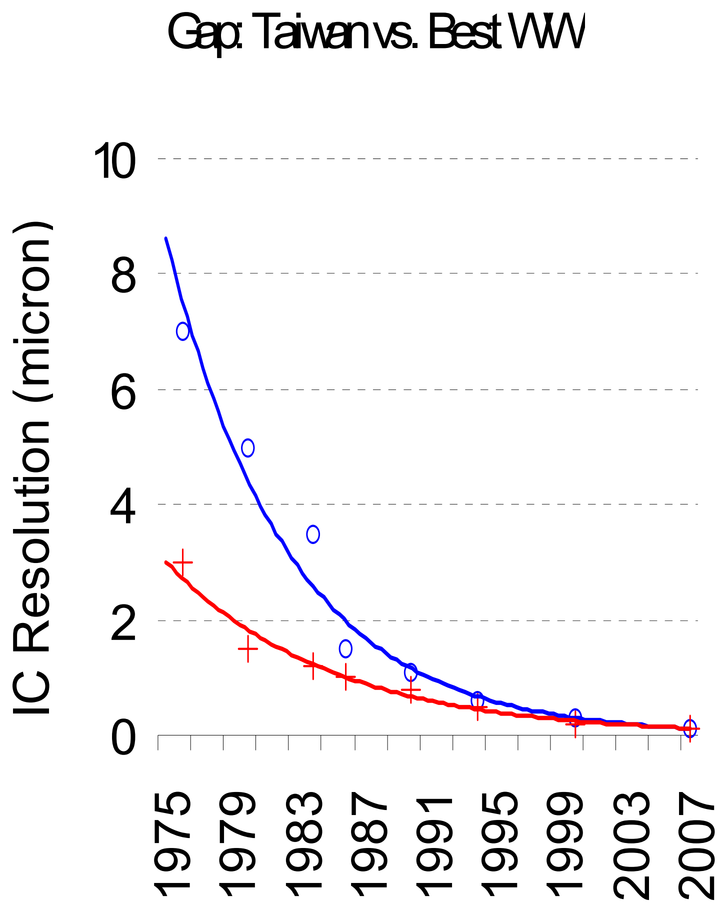
Strong correlations: GDP and patents 1963-2000





source: World Bank data, Tang and Osorio-Urzua analysis

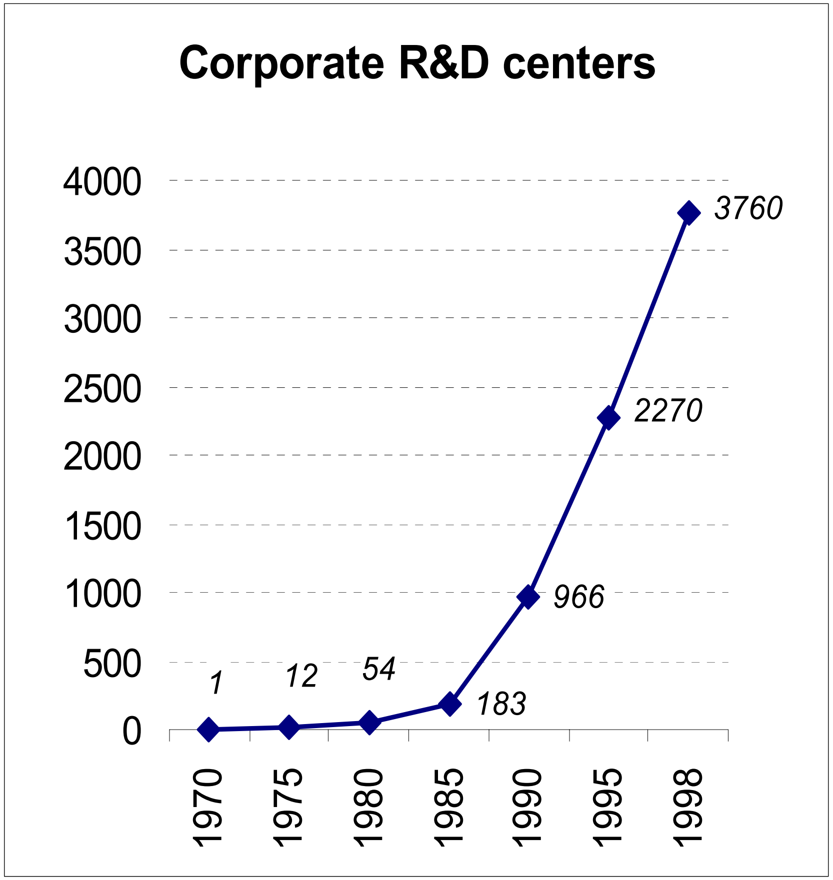
Creation of a silicon valley

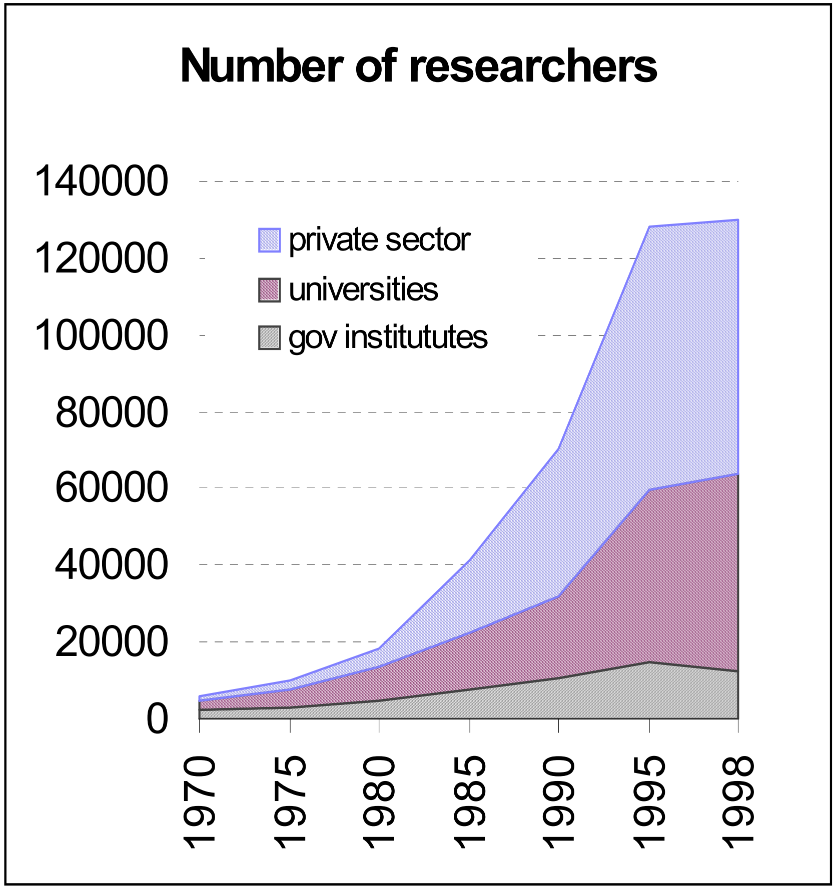


WW Market share	
IC foundry*	>70%
IC design*	>15%
IC OEM/ODM*	50-80%
Notebook PC+	55%
Motherboard+	65%
Monitor+	65%
LCD#	52%
GPS (16M units)	50%

sources: J.A Mathews. 1997. A Silicon Valley of the East: Creating Taiwan's Semiconductor Industry
• www.oecd.org/dataoecd/45/17/31239069.pdf for year 2004.
+ ibid. for year 2000.
#www.businessweek.com/globalbiz/content/jun2006/gb20060613_689104.htm - 57k - for year 2006.

Korea's national investment





source: W.W. Keller and R.J. Samuels.2003. Crisis and Innovation in Asian Technology.

Catching up and Falling Behind

Top Ten High-Tech Exporters 1986
$B 1997 USD

1	United States	**$65**
2	Japan	**$53**
3	Germany	**$31**
4	United Kingdom	**$24**
5	France	**$14**
6	Netherlands	**$ 9**
7	Italy	**$ 8**
8	Switzerland	**$ 8**
9	**Taiwan**	**$ 7**
10	**South Korea**	**$ 7**

Top Ten High-Tech Exporters 2005
$B 1997 USD

1	**China**	**$406**
2	United States	**$284**
3	Japan	**$212**
4	Germany	**$183**
5	**South Korea**	**$167**
6	**Hong Kong**	**$157**
7	**Taiwan**	**$145**
8	**Singapore**	**$126**
9	**Malaysia**	**$ 99**
10	United Kingdom	**$ 95**

Late developing countries

Source: Issues in Science and Technology. Spring 2007.

Lessons from business transformation

Be alert for signals of change.
Rethink your *business model* and assumptions.
Avoid repeating an aging or failing formula.

- Understand the *whole system* of which your company is only an element.
- Manage the system boundaries, the external participants, and the interactions.

- Consider the *value network*, your role and those of other participants.
- Know precisely where and how you are positioned.
- Anchor on a strong capability and create a defendable *control point.*

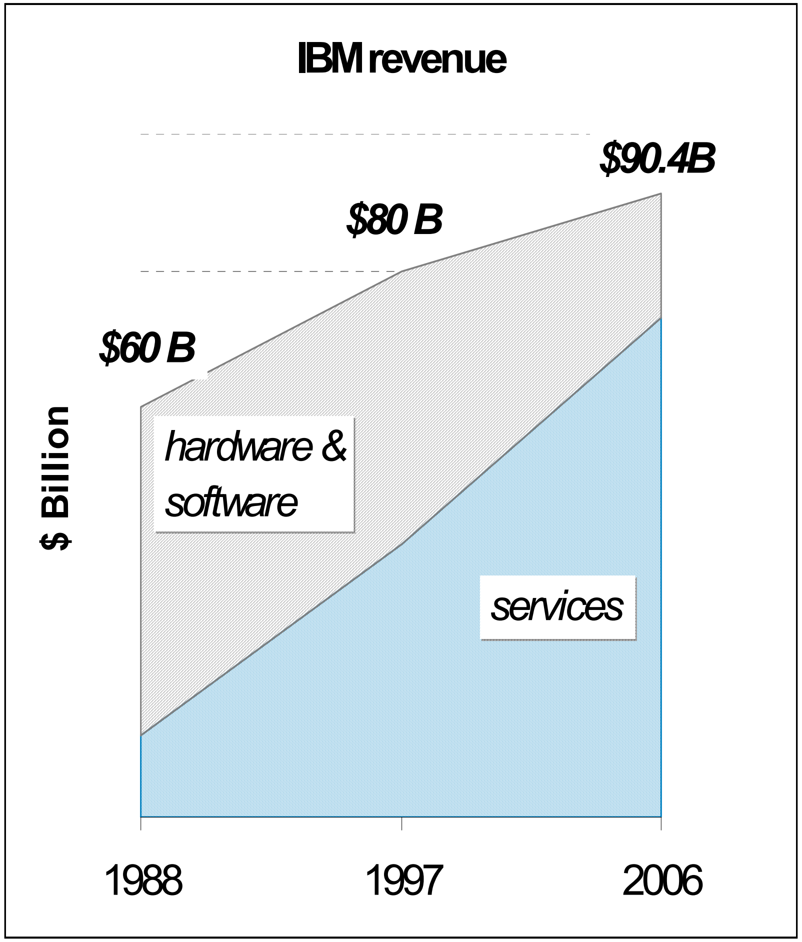
- Cost is important, but your ability to *generate economic returns* to your customer is even more important.
- No company grows by just saving money.

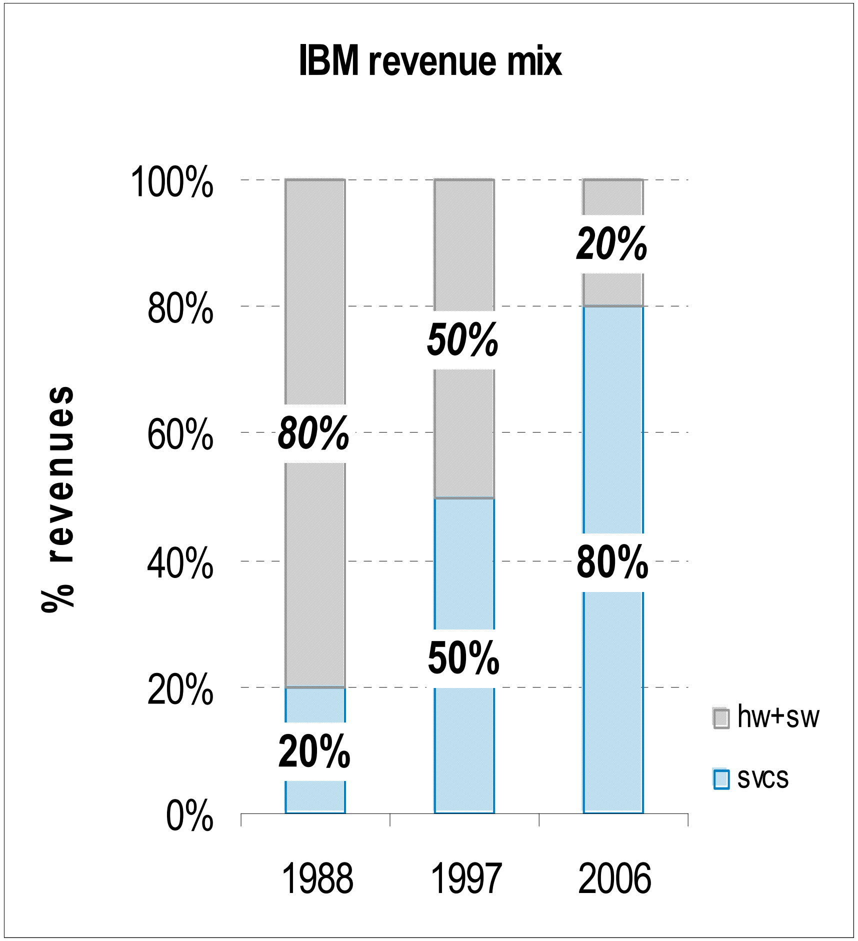
Shift to Services is universal

	employment in agriculture %		employment in industry %		**employment in services** %	
	1996	2006	1996	2006	1996	2006
WORLD	**41.9**	**36.1**	**21.1**	**21.9**	**37.0**	**42.0**
Developed economies & EU	6.2	4.2	28.5	24.7	65.3	71.2
SE Europe (non-EU)	27.2	20.3	28.7	25.8	44.1	53.8
East Asia	48.5	40.9	24.3	25.6	27.2	33.5
SE Asia & Pacific	51.0	45.4	16.5	18.6	32.5	36.0
South Asia	59.7	49.4	15.2	21.0	25.1	29.6
Latin America & Caribbean	23.1	19.6	20.7	20.8	56.1	59.6
North Africa	36.5	34.4	19.8	20.0	43.7	45.6
Sub-Saharan Africa	74.4	65.9	7.5	10.0	18.1	24.1
Middle East	21.2	18.1	25.2	26.6	53.7	56.3

source: ILO Global employment trends model. 2006 preliminary estimates.

IBM revenues shift to services





source: IBM annual reports

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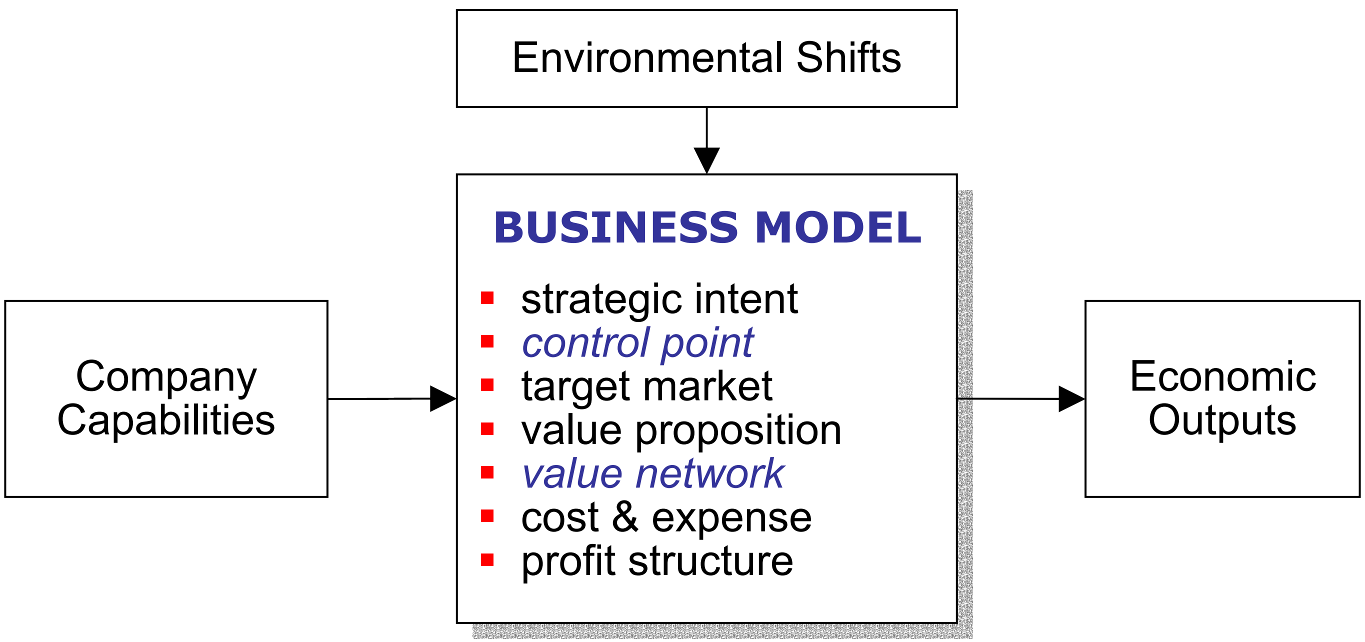
What is a business model?

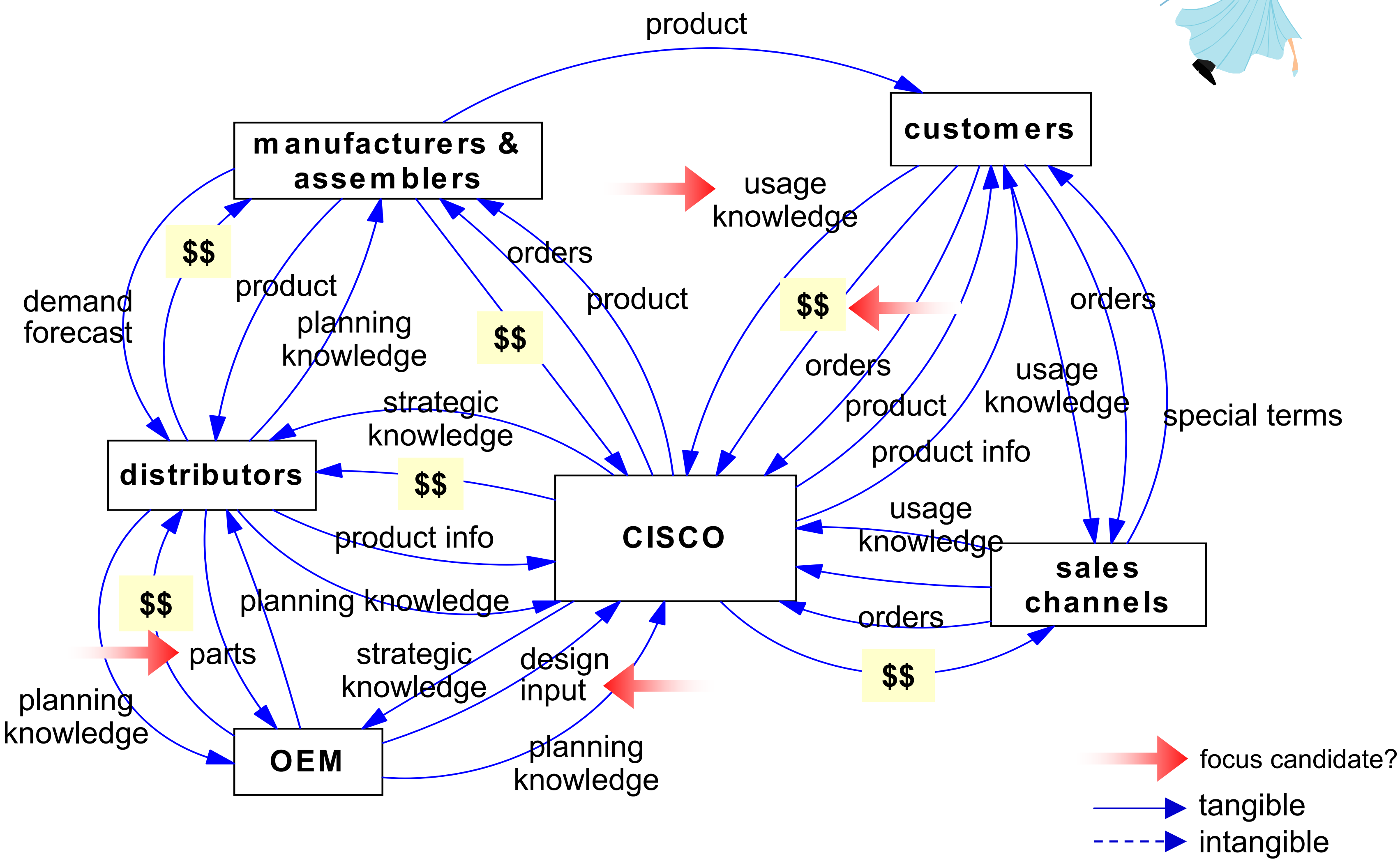
A business model describes how a firm:

1. Creates an asset that customers will buy
2. Captures profits
3. Architects the organization for customer value, profit, and control
4. Leverages internal and external resources
5. Fulfills the firm’s value proposition



sources: Definition is an adaptation from T.W. Malone et al. 2006. Do Some business models perform better than others? MIT Sloan WorkingPaper 4615-06 and SSRN Electronic Paper Collection: http://ssrn.com/abstract=920667
Figure is adapted from H. Chesbrough and R.S. Rosenbloom. 2000. The role of the business model in capturing value from innovation: Evidence From Xerox Technology Spin-offs co.
Tang and Osorio analysis.

Build the network; pick a focus and partners



source: S. van Middendorp. 2005. Value Network Analysis, Strategic Planning Faces the Music. Creative Commons Attribution 2.5 License.

Why a business model? Build a strategic control point

control power		media industry	software industry	manufacturing industry
high	10	content quality talent lock-in	free, strong standard switching costs	price performance switching costs
	9	distribution channels	value network	distribution channels value network
	8	version, archives, interpretation	version, install base, compatibility	customer relationship quality, service
	7	copyright	patent, copyright	patent, copyright
	6	brand	brand, upgrades	brand, refresh cycles
	5	first to market	first to market	first to market
	4	fast follower	fast follower	fast follower
	3	highly advertised	free trial release highly advertised	highly advertised
	2	hyped/sensational	price advantage	price advantage
none	1	commodity	commodity	commodity

Lessons from business process reengineering

- Understand the *business model* and the *value network* of which the business process is a part.
- *Review key assumptions* about the business process and how it generates value to the customer.

- Rethink the rules of engagement within the value network.
- *Allies and competitors are situational, they are not institutional*.
- Consistently adversarial relationships are not always optimal. Perpetual alliances don't even exist within a company.

- *Manage the business boundaries*, do not erase them.
- *Technology is a tool*, an instrument, to achieve a goal. It should not be the goal itself.

New model of interaction: cooperation

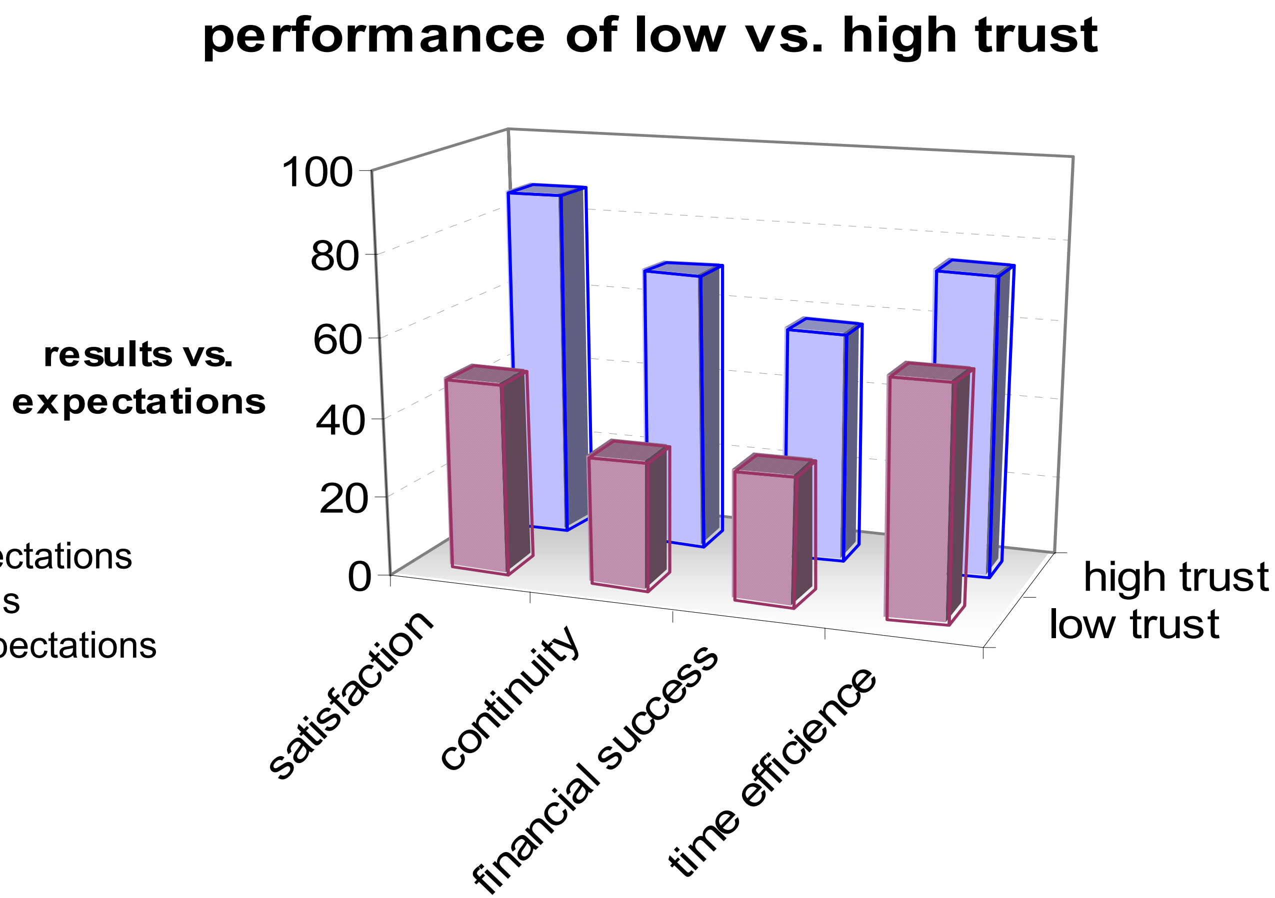
		Party 1	
		c1	c2
Party 2	r1	0,0	200,600
	r2	600,200	0,0

- 3 Nash equilibria. 2 pure strategies, one mixed strategy.
- NE, (600,200), (200,600), and (75,225).
- They are indifferent at p=.375. Coordination failure probability 0.625.

Pre-play communications	Proportion of hits
No communications	**.48**
One-way communications. (one round)	.95
Two-way communications (one round)	.55
Two-communications (three rounds)	**.63**

source: Cooper, et al. 1989. Communication in etc. Rand Journal of Economics 20: 568-87. Romp.1997. Game Theory. Oxford U. Press.

Trust improves outcomes



0=way below expectations
5=met expectations
10=way above expectations

source: L. Bstieler. 2006. Trust Formation in Collaborative New Development. JPIM.

TRIZ summary

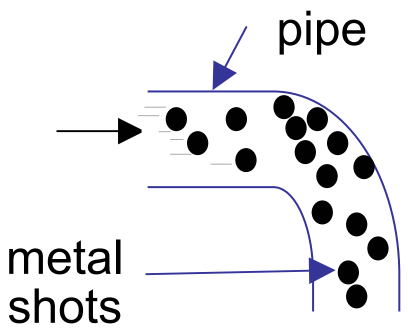
TRIZ is an example of a systematic approach to *review assumptions* about the system.
Conflicts are opportunities to innovate.

- Approach begins by identifying the conflicts in the design problem.
- Conflict is then framed as engineering parameters.
  TRIZ identifies 39 engineering parameters.
- Using the engineering parameters, find the design principles that resolve the conflict.
  TRIZ identifies 40 engineering design principles.
- Using the design principles, develop creative solutions.

TRIZ is now being extended to other disciplines, such as manufacturing and finance.*

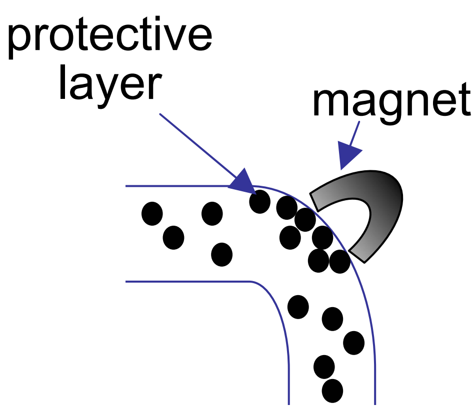
* For manufacturing contact Rohan A. Shirwaiker at ras1031@psu.edu, for finance contact Stephen Dourson at editor@triz-journal.com

TRIZ example



Pipe transports metal shots

- *Problem:* Metal shots cause wear down of the corner of the pipe.
- *Conflict:* Coat the corner to avoid wear, but this is temporary, and it is costly.



Conflict resolution

- *Principle #28.* Replacement of Mechanical Pattern. Use of magnetic fields to interact with the object.
- *Solution:* The magnet attracts the shots against the wall of the pipe. Other shots collide against them and are forced off the wall. Newly arriving shots fill the wall.

source: K.N. Otto, K. Wood. 2001. Product Design. Prentice Hall

TRIZ conflict resolution table

		Characteristics that get worse								
		1	2	3	...	...	...	37	38	39
Characteristics to improve	1		-	15,8 29, 34	...			28,29 26,32	26,35 18,19	35,3 24,37
	2	-		-	...	...		25,28 17,15	2,26 35	1,28 15,35
	3	15,8 29, 34	-		...	...	...	35,1 26,24	17,24 26,16	30,14 7,26
	4	-	35,28 40,29	-	...	...	...	26	-	10,26 34,2
	...	...	...	...	...	...	...	...	...	...
	...	...	...	...	...	...	...	...	...	...
	38	26,28 18,35	35,28 35,10	14,13 17,28	...	...	...	34,27 25		5,12 35,26
	39	35,26 24,37	27,28 15,3	18,4 28,38	...	...	...	35,18 27,2	5,12 35,26	

design principles

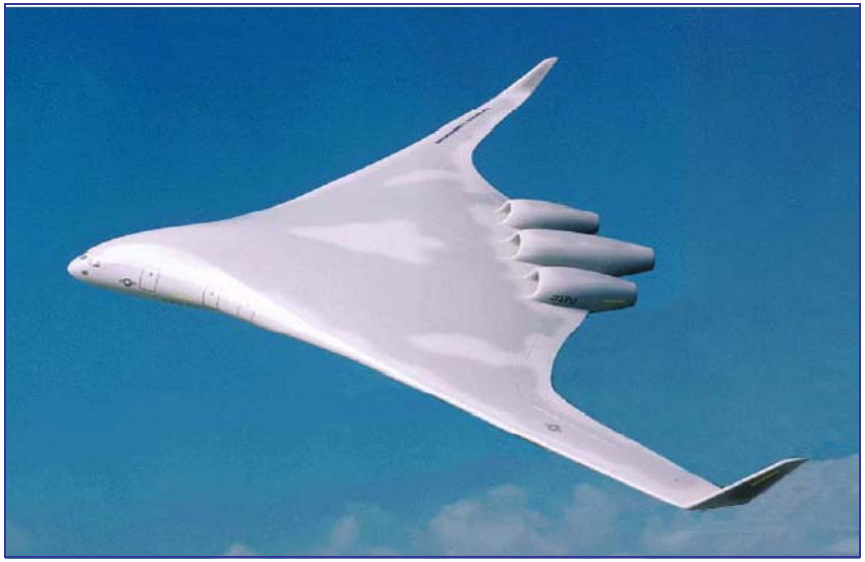
1. *weight of moving object*
2. *weight of stationary object*
3. *length of moving object*
4. *length of stationary object*
5. *area of moving object*
6. *area of stationary object*
7. *volume of mobile object*
8. *volume of stationary object*
9. *speed*
10. *force*

....

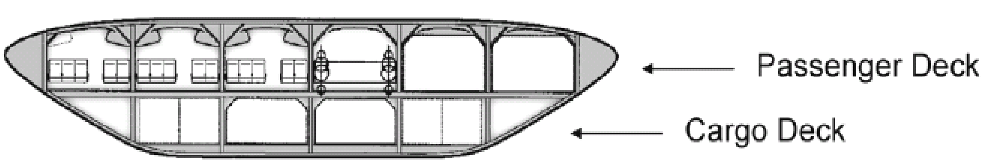
36. *complexity of design object*
37. *difficult to control or measure*
38. *level of automation*
39. *productivity*

source: K.N. Otto, K. Wood. 2001. Product Design. Prentice Hall

TRIZ examples



	21. power
7. Volume of Moving object	35, 6 13, 18



Design Principle #6. Principle of universality.
Let the object perform several different functions.
Blend the fusilage and wing into one unit.

Maximum Takeoff Weight	-18%
Total Sea-Level Static Thrust	-19%
Fuel Burn per Seat	-32%

source: www.aoe.vt.edu/research/groups/bwb/papers/TheBWB**Aircraft**.pdf

Lessons from knowledge management

Knowledge is tacit and explicit.

- A generative cycle produces deeper and more useful knowledge. This cycle depends on both technical and social mechanisms.

Knowledge is sticky.

- This property makes the acquisition of knowledge costly. It influences the locus and mechanisms for knowledge transfer.
- Usage (learning by doing) is a key mechanism by which deeper and new knowledge is acquired or developed.
- Usage knowledge gives power to those that have it.

There is impedance in knowledge transfer.

- Sacrifices are required to overcome this impedance, as well as, to maintain a high impedance to protect intellectual assets.

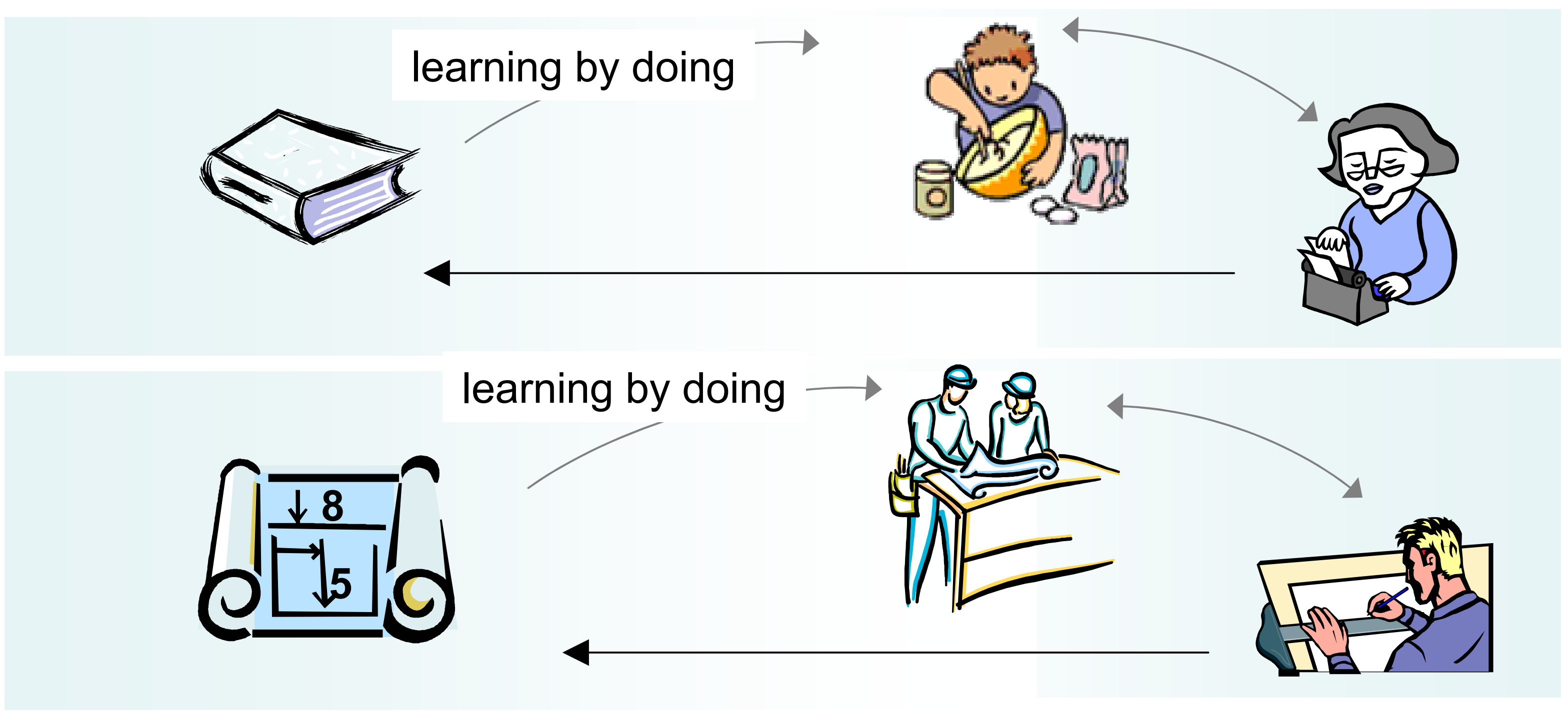
Two kinds of knowledge

Explicit knowledge

Expressible in manuals, data, formulae, theories, specifications, …

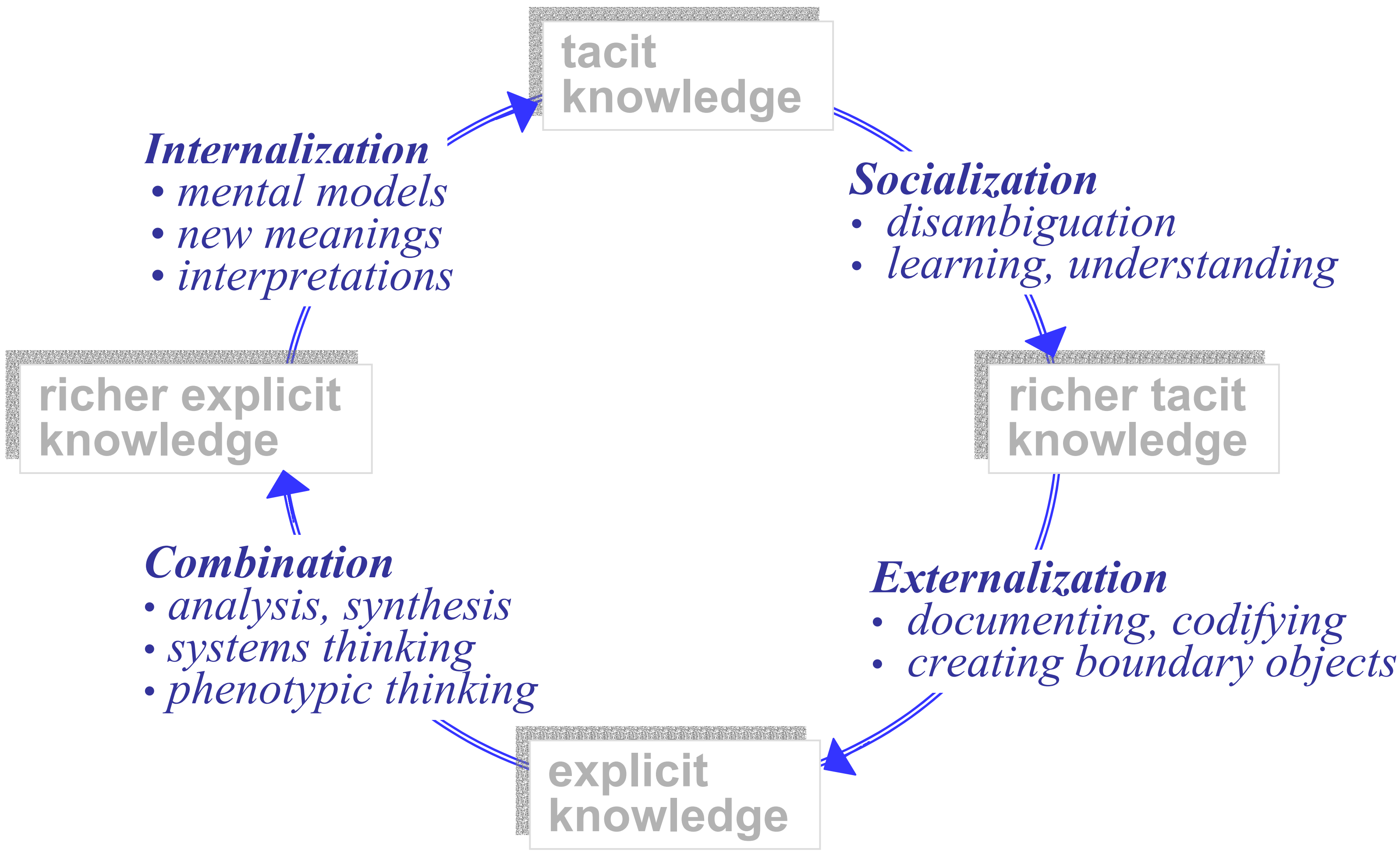
Tacit knowledge

Experience, insight, judgment, know-how, highly personal, …



sources: I. Nonaka, N. Konno. 1998. The Concept of "Ba": Building a Foundation for Knowledge Creation
M. Polanyi. 1966. The Tacit Dimension.

Dynamics of organizational learning



source: I. Nonaka, N. Kono. 1998. The Concept of "Ba": Building a Foundation for Knowledge Creation, , Tang and Osorio analysis.

Learning sticky knowledge from **lead users**

Users create the majority of the innovations.

	Innovation Developed by				
	user	manufacturer	supplier	other	N
Scientific instruments	77%	23%	0%	0%	111
Semiconductor processes	67	21	0	0	49
Pultrusion process	90	10	0	0	10
Tractor-shovel related	6	94	0	0	11
Engineering plastics	10	90	0	0	5
Plastics additives	8	92	0	0	16
Industrial gas-using	42	17	33	8	12
Thermoplastics-using	43	14	36	7	14

Lead users

- first to face the needs that will be general in the market.
- first positioned first to reap the benefits of having a solution.

source: E. von Hippel.1988. The Sources of Innovation

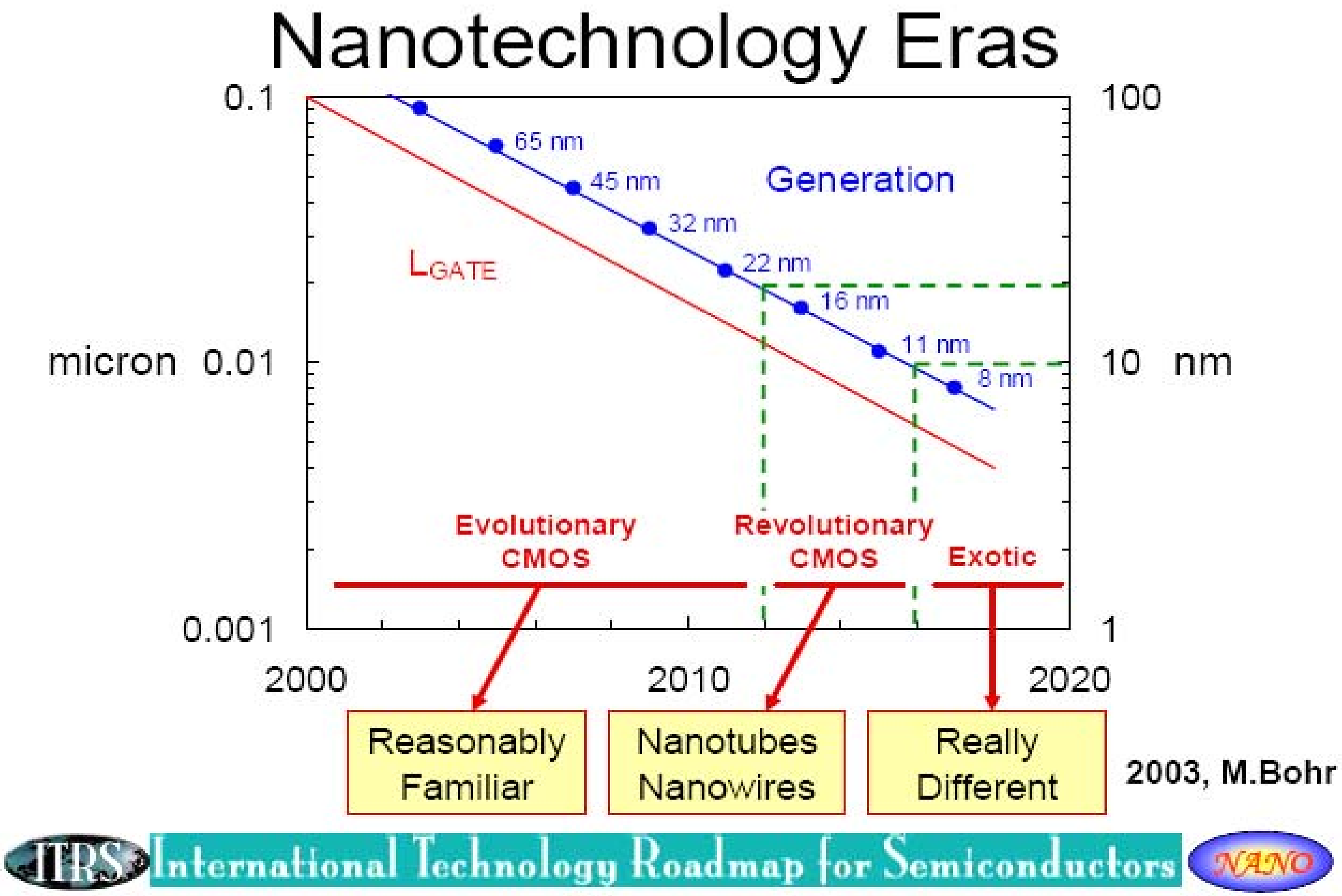
Lessons from technology management

Trajectory of technology is largely predictable.
Its economic trajectory is also largely predictable.

- Mapping these trajectories in parallel we can specify a long range stream of products for a firm.
- Similarly, we can specify a long range plan for the development of technology capabilities for an industry to benefit industry stakeholders.
- These plans we call roadmaps.

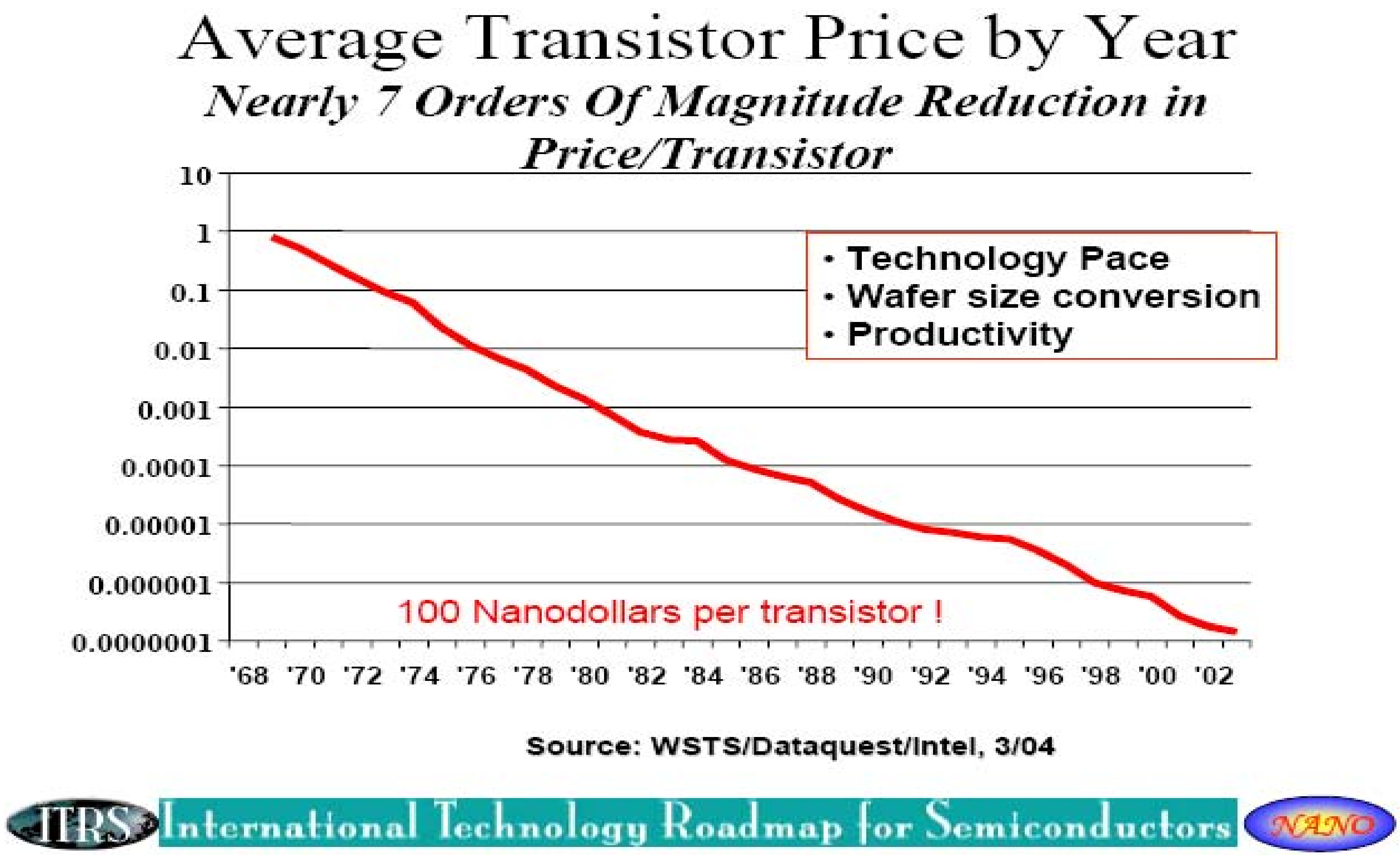
- There is a progression of technology maturity and readiness, which can be described and used to evaluate a company's readiness.
- Similarly there is a progression for manufacturing readiness, which can be described and used to prepare a firm to manufacture products with a new technology.

Technology is predictable



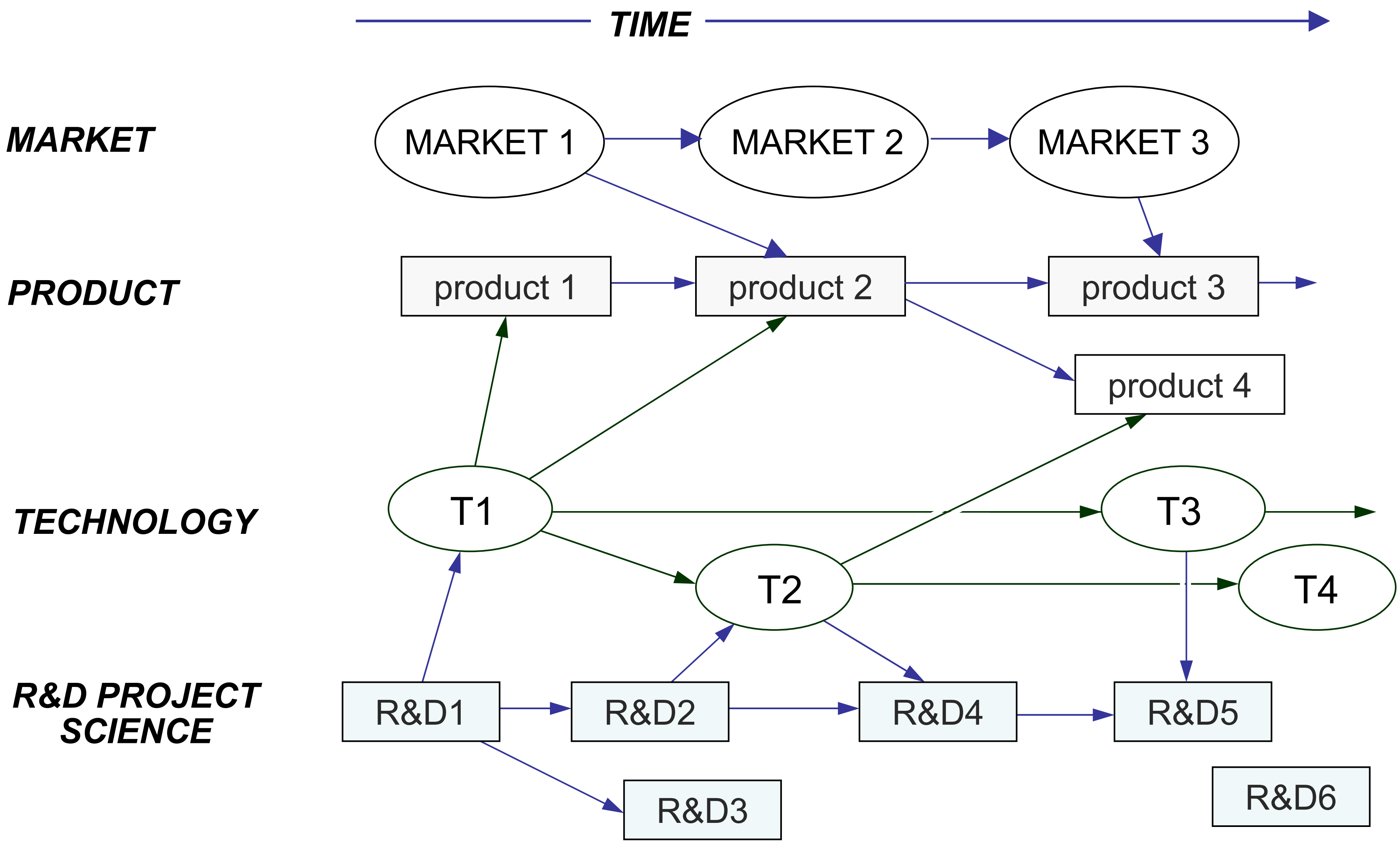
source: P.A. Gargini. ITRS presentation

Economics is also predictable



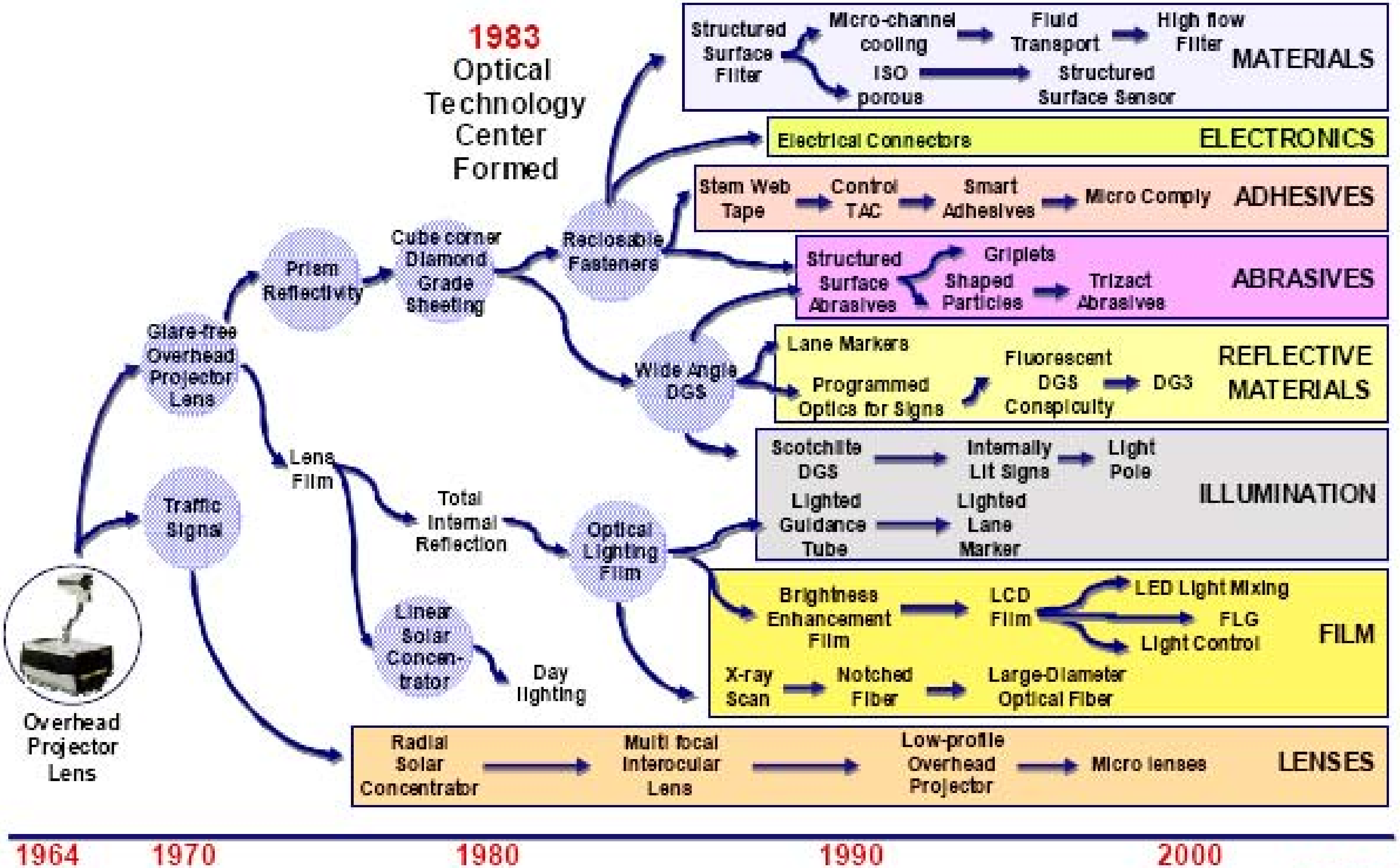
source: P.A. Gargini. ITRS presentation

Schema for a Technology Roadmap

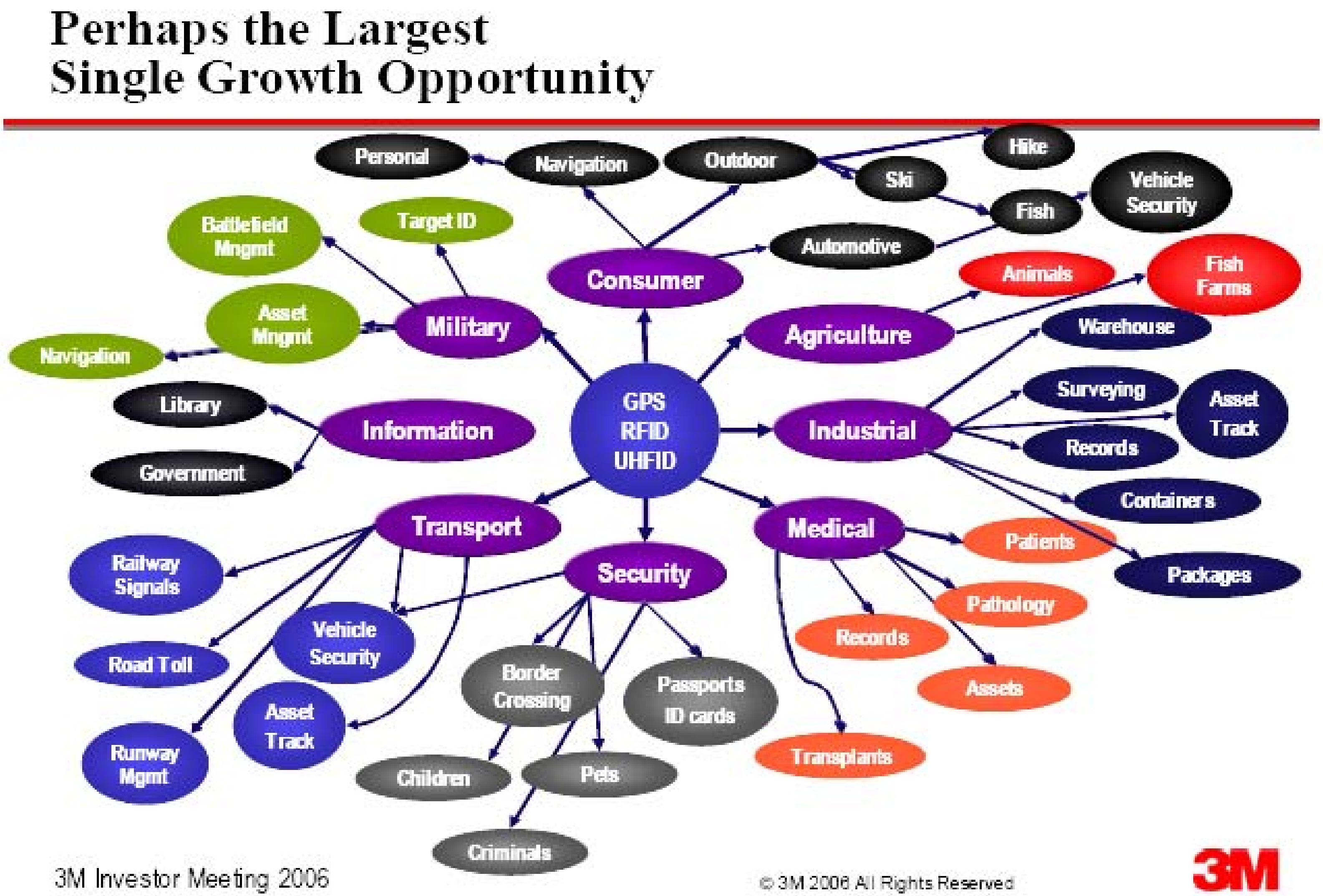


source: R.N. Kostoff, R.R. Schaller. 2001. Science and Technology Roadmaps. IEEE

Product And Technology Migration At 3M; Microreplication Technology



From technology to products



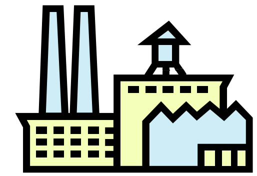
Manufacturing Readiness Levels

Technology Readiness Levels	Manufacturing Readiness Levels
1 Basic principles observed	
2 Concept formulated	
3 Proof-of-concept	**3** Manufacturing concepts identified
4 Breadboard in the laboratory	**4** Manufacturing processes identified
5 Component in relevant environment	**5** Manufacturing processes developed Cost goals and drivers identified
6 Prototype in relevant environment	**6** Key manufacturing processes demonstrated. Unit cost identified.
7 Prototype in operational environment	**7** Prototype manufacturing system done. Unit cost acceptable.
8 System qualified operationally	**8** Manufacturing processes stable. Unit cost on track to target goals.
9 Proven by customer operations	**9** Manufacturing processes proven. Unit cost and quality on target.
	10 Lean manufacturing. Key waste drivers eliminated.

source: US Department of Defence. 2006. Defence Acquisition Guidebook.

Industry roadmap

1. Vision Statement
2. Industry Overview
   Industry contributions to the economy
   Industry position world wide
   Industry position nationally
3. Challenges
   Technology Challenges
   Business challenges
   Policy challenges
4. Meeting the Challenges
5. Technology Recommendations
6. Business Recommendations
7. Policy Recommendations



Recommendation X+2

es

Recommendation X+1

es

Recommendation X

- Current state
- Needs and challenges
- New capabilities
  How to get there
- Improvements
  How to get there

sources: adapted from http://www.chemicalvision2020.org/pdfs/chem_vision.pdf, Tang & Osorio analysis

The U.S. Chemical Industry (excerpts)

Vision

- Responsible for breakthroughs in R&D that enhance the quality of life worldwide.
- Set the world standard for excellence in manufacturing operations that protect worker health, safety, and the environment.

Industry position

- 1995 value shipped $367.5 B worldwide.
- Employs 1 million people in the US.

Meeting the challenges

- Improve operations with a focus on supply chain management.
- Leadership in balancing environmental and economic factors.
- Leverage investments in technology with government and academe.

Example of a technology recommendation - **Chemical measurement**

Current State: major progress, but weak deployment into production.

Needs/challenges: nanotrace analysis capability, theoretical models to guide and optimize chemical analysis, experiment remotely by engineers and scientists.

New capabilities: non-specialists will be able to use research grade instruments.

Improvements: analysis cycle time will be reduced by 10X.

How to get there: cooperative research between industry, instrumentation companies, universities, and federal labs to advance the state of the art. Establish interoperability of instruments.

source: http://www.chemicalvision2020.org/pdfs/chem_vision.pdf

Lessons about the role of universities

Innovation evolves through a **dynamic interaction** of science, applied science, technology, economics, and product development.

Universities can dramatically improve these interactions.

- This development is not linear. It is bidirectional.
- By noting this fact, university research has contributed greatly to science, technology, new products, and economic growth.

- A key role of universities is also to create sheltered interpretation spaces where diverse economic actors can interact in a way they cannot on their own.
- These interpretation spaces improve the interactions across domains and enable the creation of new knowledge.

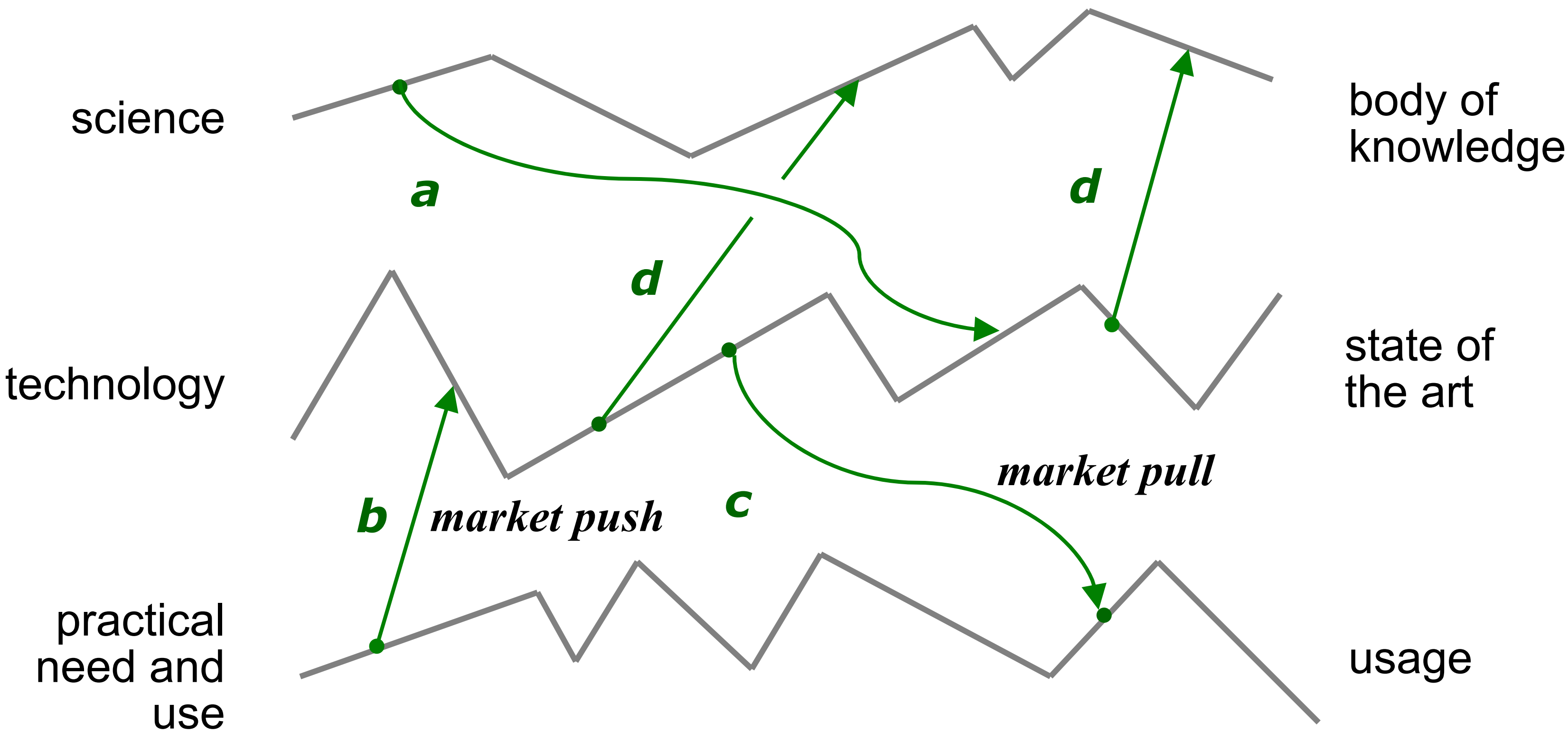
Interpretation is key to knowledge creation and economic performance.

University research contributions

	completely dependent			largely dependent		
	1975-1985	1986-1994	total	1975-1985	1986-1994	total
Products						
Drugs / medical	27%	31%	58%	17%	13%	30%
Info. Technology	11	19	30	17	14	31
Chemical	4	9	13	4	11	15
Electrical	6	5	11	3	3	6
Instruments	16	22	38	5	3	8
Machinery	n/a	8	n/a	n/a	8	n/a
Metals	13	8	21	9	4	13
Processes						
Drugs / medical	29%	11%	40%	8%	6%	14%
Info. Technology	11	16	27	16	11	27
Chemical	2	8	10	4	11	15
Electrical	3	3	6	4	3	7
Instruments	2	20	22	1	4	5
Machinery	n/a	5	n/a	n/a	3	n/a
Metals	12	15	27	9	11	20

source: E. M. Mansfield. 1998. Academic research and industrial innovation: An update of empirical findings. Research Policy 26; 773-776

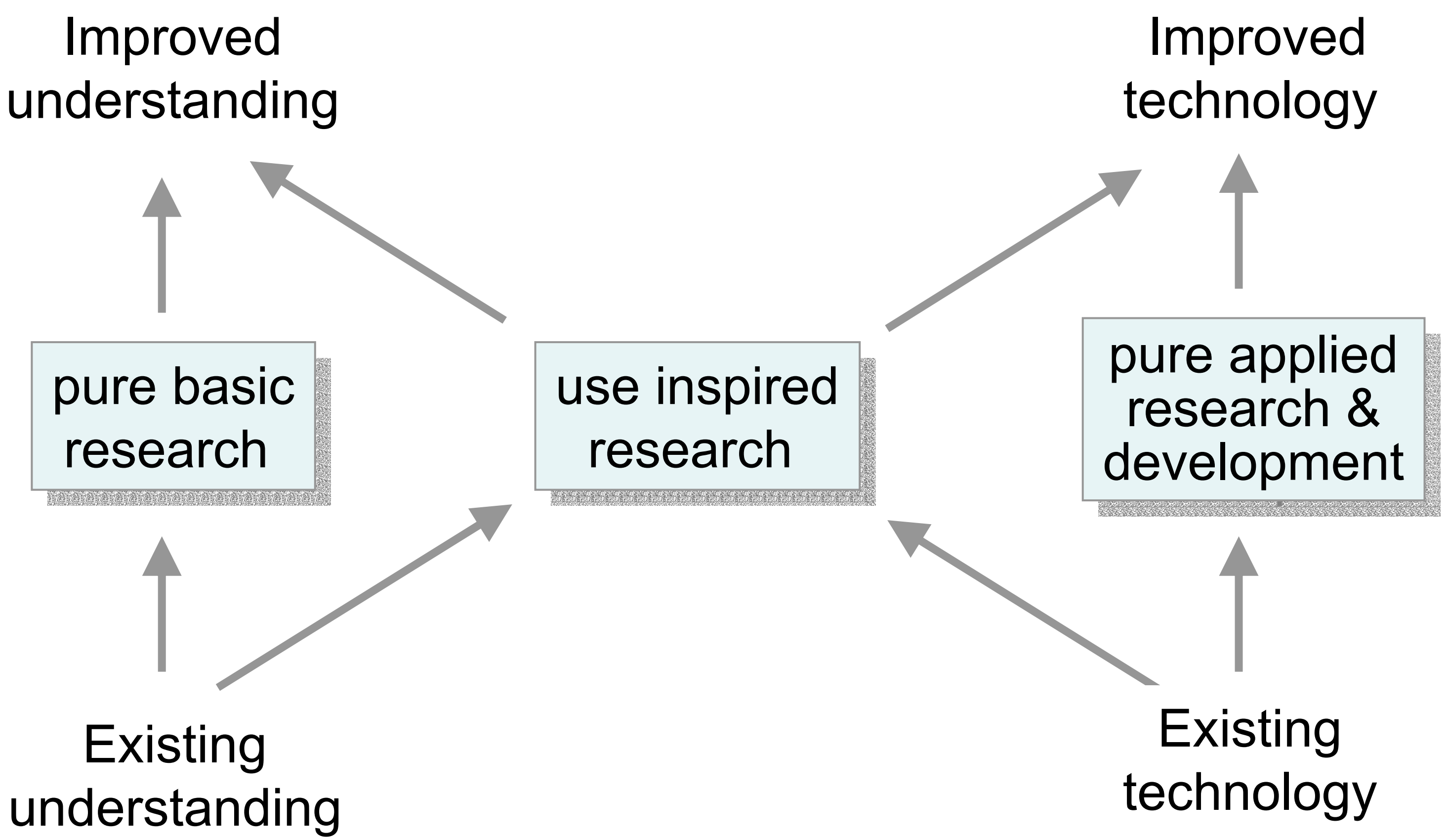
Bidirectional flow of Science and Technology



a normal process, science → technology.
b recognize need for an artifact or scientific understanding
c normal process of adoption of technology for a use
d need for understanding physical phenomena

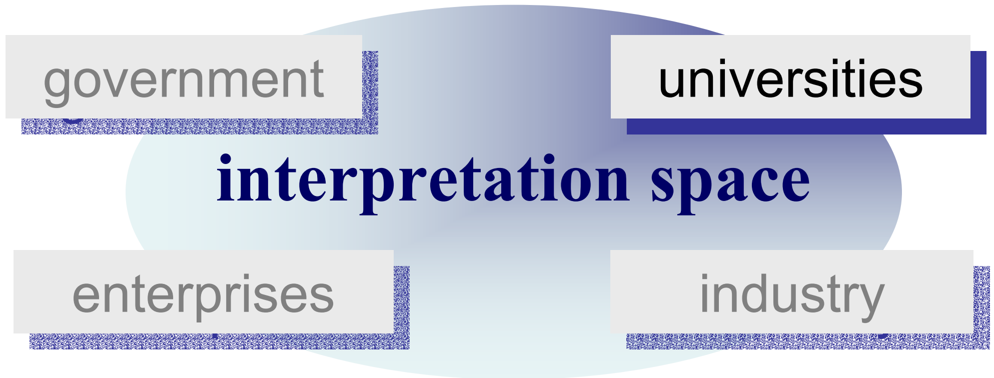
source: adapted from T.J. Allen. 1984. Managing the Flow of Technology.

6 research paths, 3 strategies, 2 goals



source: D.E. Stokes.1997. Pasteur's Quadran: Basic Science and Technological Innovation. Brookings. t

Universities: provide interpretation space



Interpretation. **The activity out of which something *innovative* emerges – a new insight, a new idea, or a new approach to solving a problem.* Interpretation is about finding new meanings.**

Interpretive spaces do *not* grow naturally in market economies. Boundaries are institutionally inflexible. There is impedance across domains. There is not sufficient trust.

- There is no innovation without new interpretation or new meanings.
- Interpretation space, in an environment of trust, can sustain a diversity of economic actors who would be unable to do so on their own.
- Interpretation is key to economic performance.

* Lester R.K. and M.J. Piore. 2004. Innovation: The Missing Dimension.

Lessons from decision analysis

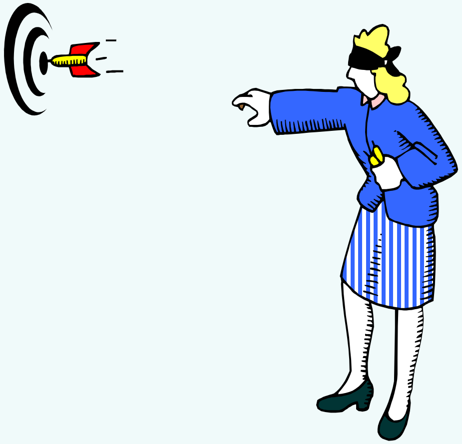
Executive decisions result from *mental models* continuously developed, tested, and refined through years of experience.

Therefore, we conceptualize decisions simply as a function of variables executives *can control* and variables executives *cannot control*.

- We can determine the statistical significance of each of the variables.
- We can determine the % contribution of each of the controllable variables to the outcome.
- We can *ex ante* analyze the quality of the forecast data and take action to improve it.

We can explore the *entire solution space* under *any* uncertainty condition. Therefore, we can answer a wide range of hypothetical questions.

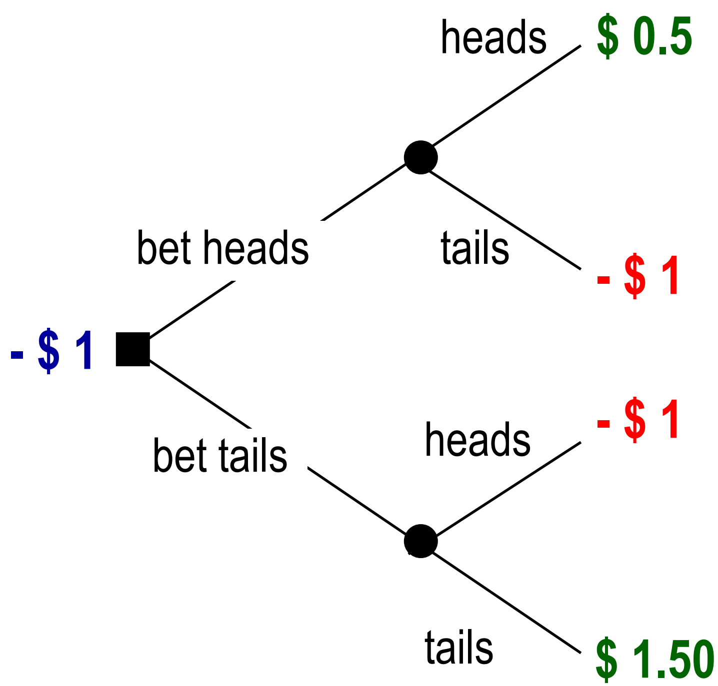
Which is the better decision?



good outcome = good decision?

Good decisions = good outcomes ?

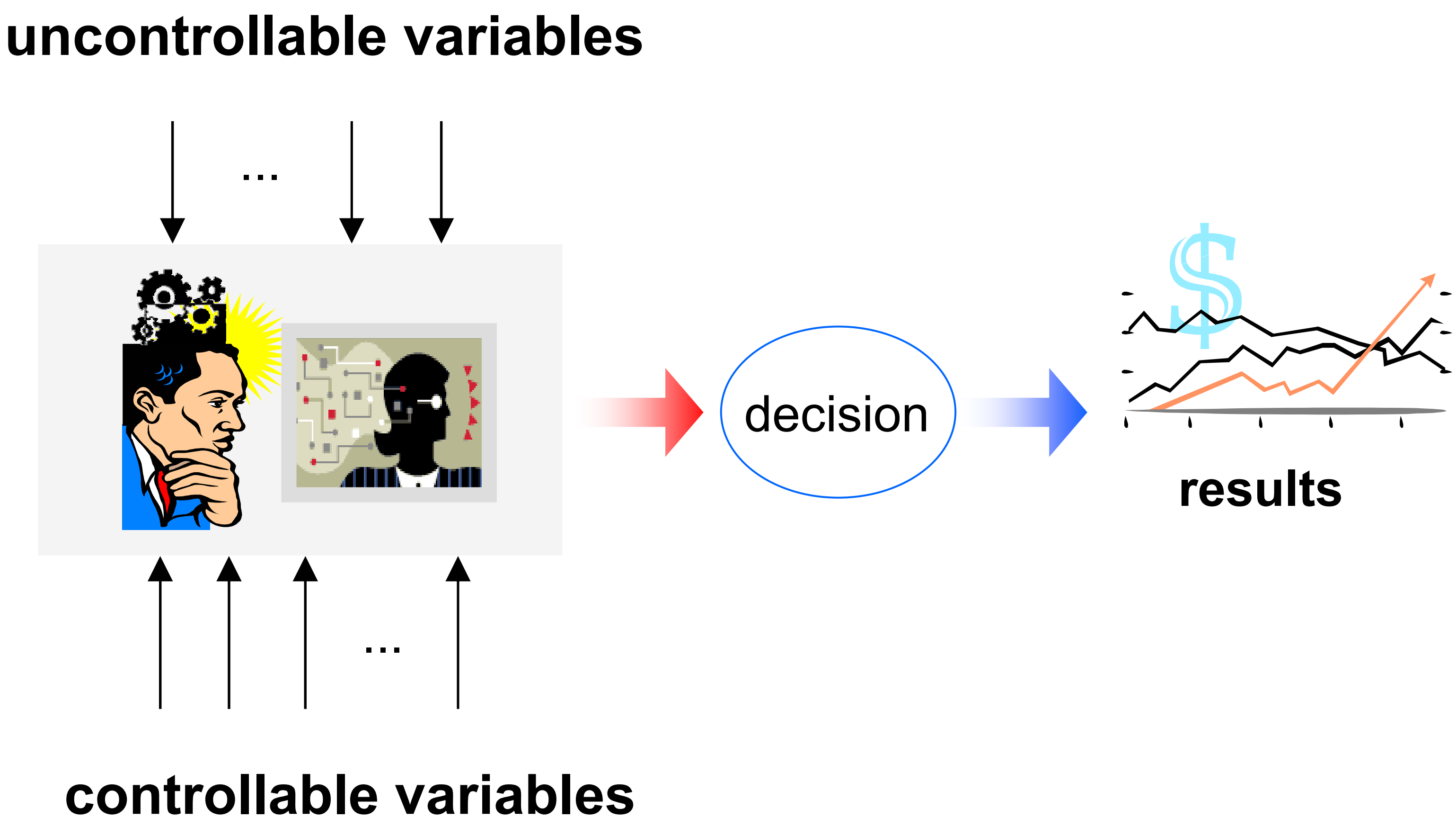
- bet $1.00 on unbiased coin toss
- $1.50 if call heads and get heads
- $2.50 if call tails and get tails
- otherwise, nothing



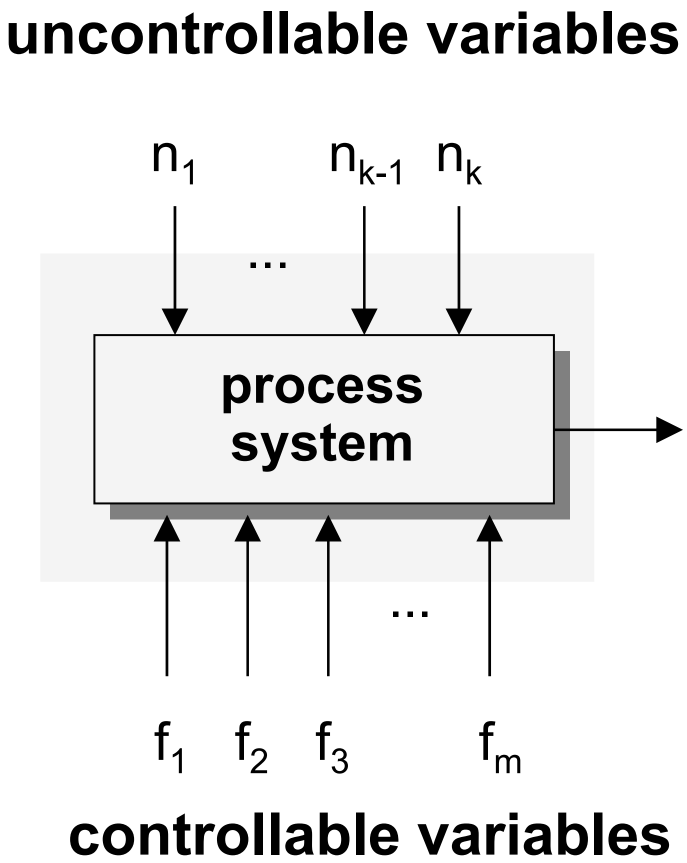
	outcome: heads	outcome: tails
decision: heads	good outcome bad decision	bad outcome bad decision
decision: tails	bad outcome good decision	good outcome good decision

source: Hazelrigg, 2001

We consider decisions as a mental process



We will develop a model for this mental process



$$Y = \varphi\,(f_1, f_2, \ldots, f_m, n_1, n_2, \ldots, n_K)$$

With statistical analysis
we address the combinatorial
explosion problem.

There is support for the choice of variables

ANOVA
WORST environment t=18
Includes supplemental treatments

Source	DF	Seq SS	Adj SS	Adj MS	F	P
SG&A	1	30.366	54.974	54.974	164.66	0.000
COGS	1	676.518	92.328	92.328	276.55	0.000
capacity	1	27.992	14.933	14.933	44.73	0.000
portfolio	2	109.505	8.605	4.302	12.89	0.000
sales	1	44.122	33.583	33.583	100.59	0.000
financing	2	6.361	20.558	10.279	30.79	0.000
COGS*capacity	1	3.212	2.488	2.488	7.45	**0.008**
portfolio*sales	2	3.887	3.887	1.944	5.82	**0.005**
Error	67	22.368	22.368	0.334		
Total	78	934.330				

S = 0.577800   R-Sq = 97.61%   R-Sq(adj) = 97.21%

sawes 1979, Hoffman, Slovic and Rorer 1986, Bar Yam 2003

Robust alternatives

Variations of Strategy vs. BAU		derived profit, standard deviation		
		current	worst	best
(2,2,2,1,2,1)	BAU	$ -5.54 M, 1.29	$ -9.40 M, 1.06	$ -2.89 M, 1.59
(3,2.5,2,2,1½,1½)	realistic	$ -1.13 M, 1.00	$ -4.46 M, 1.11	$ 1.59 M, 0.44
(3,2.5,2,2,1½,3)	realistic ⊕ [China plan divestiture]	$ 0.05 M, 1.24	$ -3.20 M, 0.83	$ 2.38 M, 0.74

		Profit $ M	Standard deviation
(2,2,2,1,2,1)	BAU (current environment)	-$ 5.54 M	1.29
(2,2,2,1,2,1)	BAU (current & worst environments)	-$ 7.44 M	2.34
(3,3,1,2,2,3)	robust alternative (current & worst environments)	-$ 0.29 M	1.86

A better way

Data quality	***can be improved***
Range of alternatives considered	***entire solution space***
Importance of decision variables	***can be determined***
Uncontrollable variables	***can be considered***
Impact of uncontrollable variables	***can be determined***
Predictive power	***higher***

Unlocking Innovation

	Policy of mutual reciprocity	Business transformation	Process reengineering	TRIZ	Technology roadmapping	Knowledge management	DOE Decision Analysis	University for interpretation
Challenge the assumptions	☑	☑	☑	☑	☑	☑	☑	☑
Think systems, system of systems	☑	☑	☑	☑	☑	☑	☑	☑
Integrate diverse disciplines	☑	☑	☑	☑	☑	☑	☑	☑
Manage the boundaries & network	☑	☑	☑	☑	☑	☑	☑	☑
Explore the solution space	☑	☑	☑	☑	☑	☑	☑	☑
Develop new combinations	☑	☑	☑	☑	☑	☑	☑	☑
Experiment		☑	☑	☑	☑	☑	☑	☑

Questions ?