

# Innovation: Business Metrics

**Rajesh Chandy**

Carlson School of Management  
University of Minnesota

With

Jaideep Prabhu (Imperial College London)

Alina Sorescu (Texas A&M University)

Gerard Tellis (USC)

Advancing Measures of Innovation:  
Knowledge Flows, Business Metrics, and Measurement Strategies

# Overview

- Innovation
  1. What is it?
  2. Who does it?
  3. How is it done?
  4. Who gains from it?

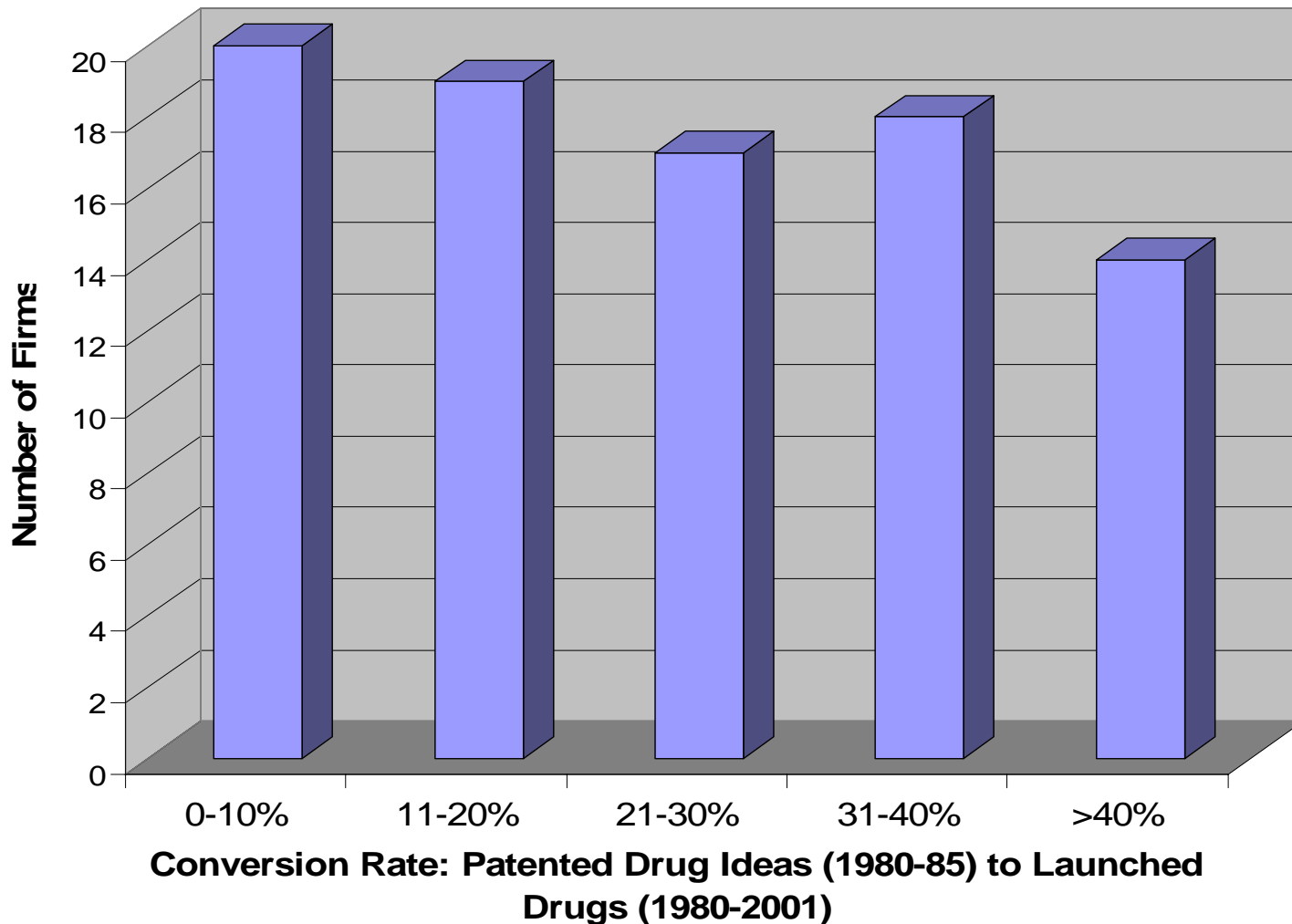
# The \$802 million pill



# Conversion: From Invention to Innovation

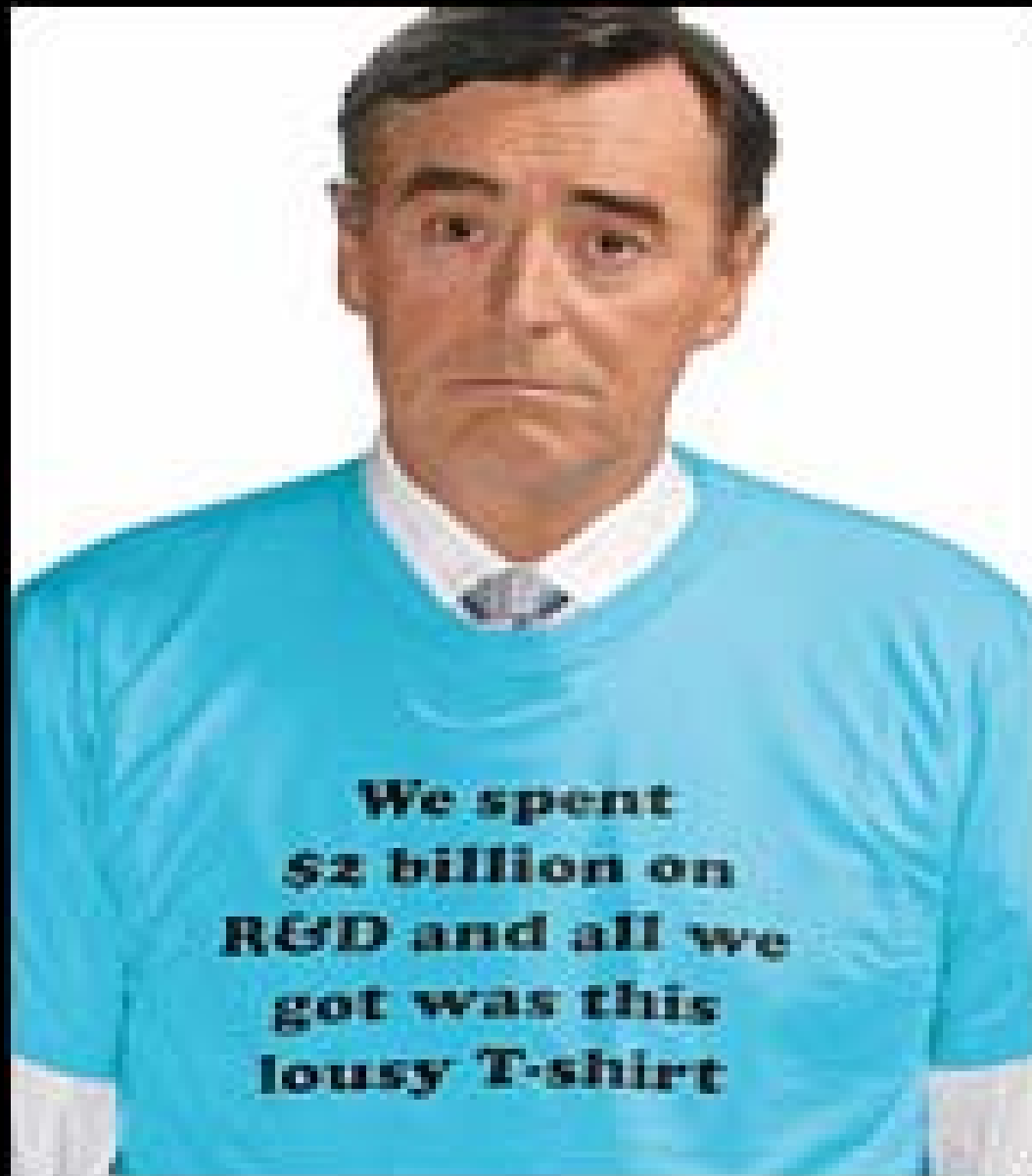
- Only one in five promising drug ideas make it to launch
- Costs of pharma innovation include the cost of failed drug ideas
- But the rate of failure varies substantially across firms

# From Invention to Innovation: Conversion Ability in Pharmaceuticals

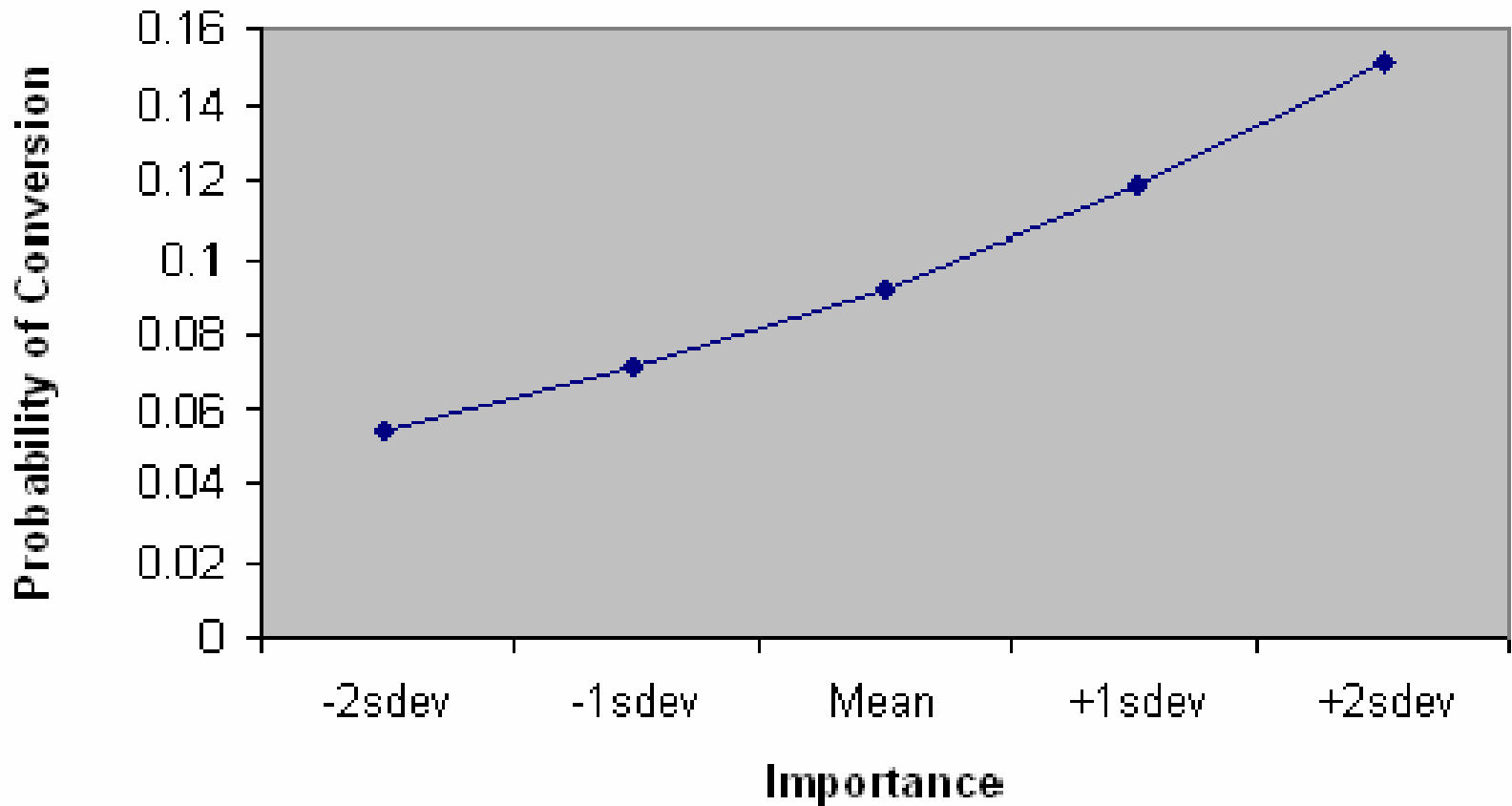


Source: Chandy, Hopstaken, Narasimhan, and Prabhu (2006)

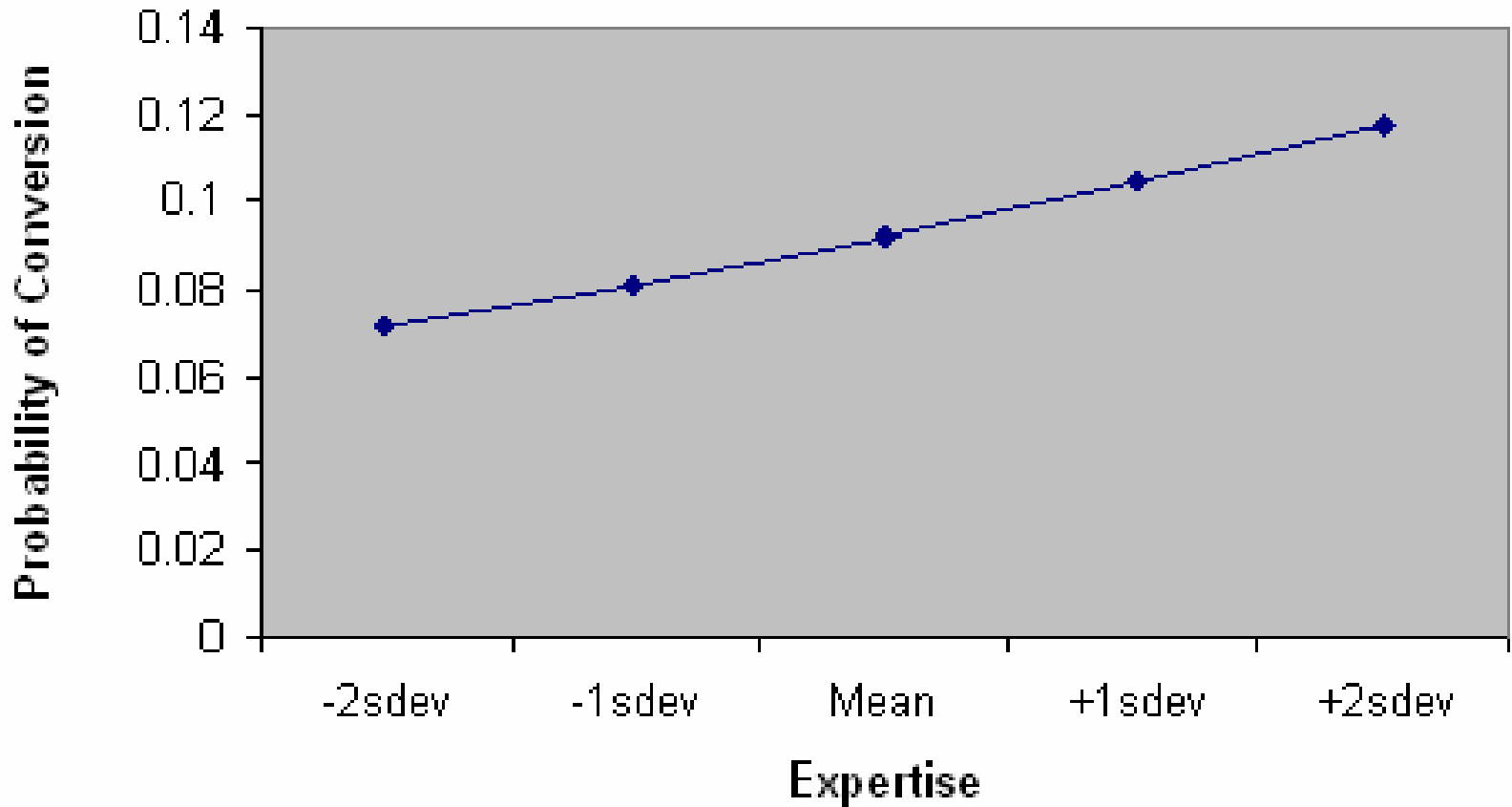
# Not all firms gain from innovation



# Importance is Important

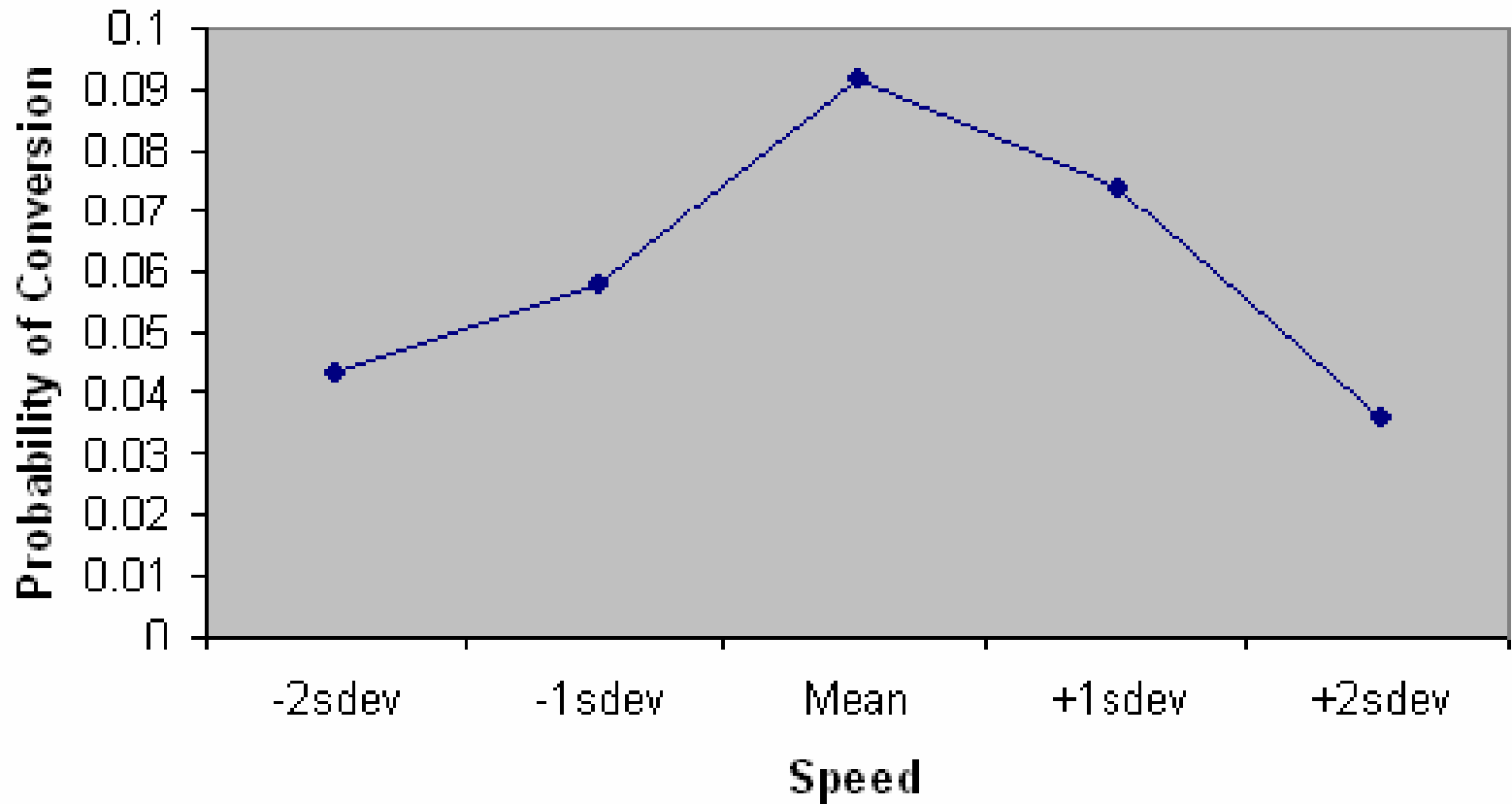


# Experience Counts

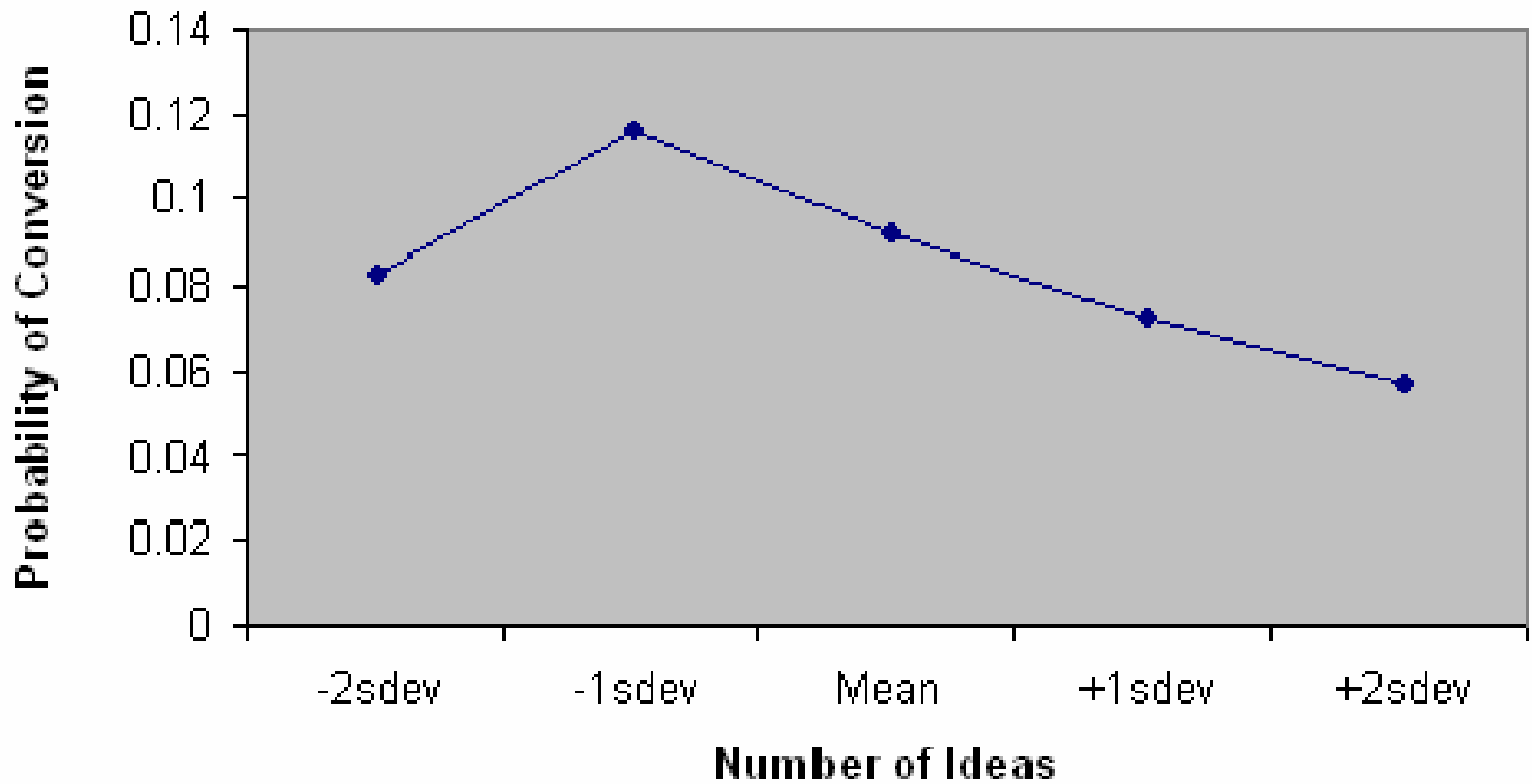




# Speed Can Kill



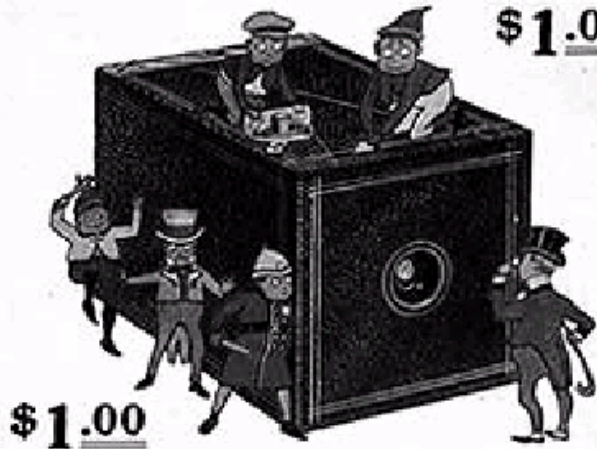
# More Can Mean Less



# Kodak Brownie

Any school-boy or girl can make good pictures with one of the Eastman Kodak Co.'s **Brownie Cameras**

**\$1.00**



Brownies load in daylight with film cartridges for 8 exposures, have fine meniscus lenses, the Eastman Rotary Shutters for snap shots or time exposures and make pictures 2½ x 2½ inches.

Brownie Camera, for 2½ x 2½ pictures, . . . . .	\$1.00
Tripartite Film Cartridge, 8 exposures, 2½ x 2½, . . . . .	.15
Paper-Film Cartridge, 8 exposures, 2½ x 2½, . . . . .	.10
Brownie Developing and Retarding Outfit, . . . . .	.75
Brownie Removable Finder, . . . . .	.25

*Take a Brownie Home for Christmas.*

Brownie, circulars and Kodak catalogues free on the basis of 10¢ mail.

**EASTMAN KODAK CO.**

Rochester, New York.

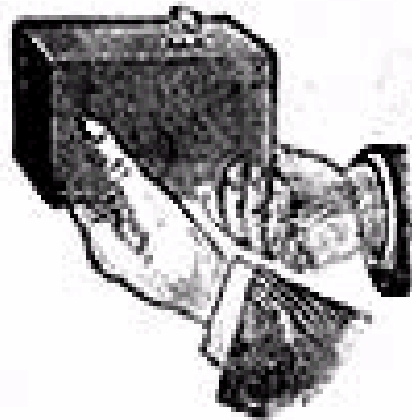




GEORGE EASTMAN, AS AN AMATEUR, DIGGED UP HIS FIRST PORTABLE PHOTOGRAPHIC OUTFIT WHILE WORKING IN A BANK IN ROCHESTER, N.Y.

# Kodak Camera

SPORTING GOODS 46



## New Kodak Cameras.

*"You press the button, we do the rest."*

(OR YOU CAN DO IT YOURSELF.)

Seven New Styles and Sizes

ALL LOADED WITH

Transparent Films.

For Sale by all Photo, Stock Dealers.

Send for Catalogue.

THE EASTMAN COMPANY, Rochester, N. Y.

# A Typology of Innovations

		<i>Customer Need Fulfillment</i>	
		Low	High
<i>Newness of Technology</i>	Low	Incremental innovation	Market breakthrough
	High	Technological breakthrough	<b>Radical innovation</b>

*Source: Chandy and Tellis (1998)*

# Sony Mavica







# Who is more likely to introduce radical product innovations: Incumbents or Outsiders?

- *Proportion of radical product innovations from incumbents vs. outsiders*

**a.** 90% incumbents

10% outsiders

**b.** 75% incumbents

25% outsiders

**c.** 50% incumbents

50% outsiders

**d.** 25% incumbents

75% outsiders

**e.** 10% incumbents

90% outsiders

# Old Question, New Twist

- Schumpeter: New entrants versus dominant incumbents
- The Incumbent's Curse
  - Radical innovations often seem to come from small entrepreneurs
  - Incumbents seem to stall, ignore or fight radical innovations

## *The Economist*, March 9, 2006

- Radical innovation is the “only kind lone entrepreneurs can do”
- William Baumol: Entrepreneurs are the “only ones who want to do it”
- Fred Scherer: The incandescent lamp, alternating current and jet engine were all introduced not by “regimented R&D of established corporations but scrappy new firms”

# Researcher Quotes: “Incumbents...”

- “underinvest” in radical product innovation, and are “incompetent” at it (Henderson 1993, p. 248)
- are prone to “technological inertia” (Ghemawat 1991, p. 161)
- are unable to cope with even “seemingly minor” changes in product configuration (Henderson and Clark 1990, p. 9)
  - e.g., portable fans, disk drives

# Disadvantages of Dominant Firms

- Incentives
  - Fear of cannibalizing specialized investments
  - Entrepreneurial employees are less able to capture benefits from new ideas
- Inertia
  - Set routines and procedures

# Dominant Firm Quotes...

- “Who the hell wants to hear actors talk?”
  - Harry M. Warner, Warner Brothers, 1927
  
- “Television won’t be able to hold on to any market it captures after the first six months. People will soon get tired of staring at a plywood box every night.”
  - Darryl Zanuck, head of 20th Century Fox, 1946

# Have Researchers Looked in the Wrong Places?

- Highly specialized products
  - Photolithographic aligners
  - Medical diagnostic imagers
  - Private branch exchanges
- Ad hoc, convenience samples

# Have Researchers Looked in the Wrong Way?

## Advantages of Dominant Firms: Resources

- Technological resources
- Marketing expertise
- Market power
- Credibility, customer franchise
- Financial



# Chandy & Tellis (2000): Partial List of Innovations

Air conditioner	AM radio	Laser disc player
Analog answering machine	Analog quartz watch	Magnetic tape player (R-To-R)
Autofocus color CR camera	B&W celluloid roll camera	Mechanical color TV
Ball point pen	Camcorder	Mechanical refrigerator
Cassette tape player	CD player	Mechanical vacuum cleaner
Cellular phone	Color celluloid roll camera	Mini-disc player
Desktop computer	Digital answering machine	Phone set with cord
Digital camera	Digital quartz watch	Portable computer
Digital video disc player	Disposable shaver	Single-player video game
Dot-matrix printer	Dry Ink (electrostatic) copier	VCR
Electric blanket	Electric blender	Laser printer
Electric can opener	Electric clothes washer	Mechanical B&W TV
Electric dishwasher	Electric fan	Mechanical dishwasher
Electric garbage disposer	Electric percolator	Mechanical typewriter
Electric shaver	Electric toaster	Microwave oven
Electric typewriter	Electrochemical fax	Palm computer
Electronic black & white TV	Electronic color TV	Phonograph
Electronic desktop calculator	Electronic pocket calculator	Safety shaver-disposable blades
Electronic watch	Fluorescent lamp	Photoelectric scanning fax
FM Radio	High definition television	Voice mail
Incandescent vacuum lamp	Instant camera	
Internal combustion automobile	Laptop computer	

# Definitions

- *Radical product innovator*: Firm that first commercializes a radical product innovation
- *Incumbent*: A firm that manufactured and sold at least one product belonging to the preceding product generation
- *Firm size*: If number of employees in the firm:  
< 100 = small; 100-2500 = medium; >2500 = large

# Results

# *Results: Incumbency of Radical Innovators*

**Non-Incumbent**

53%

**Incumbent**

47%

# *Size of Radical Innovators*

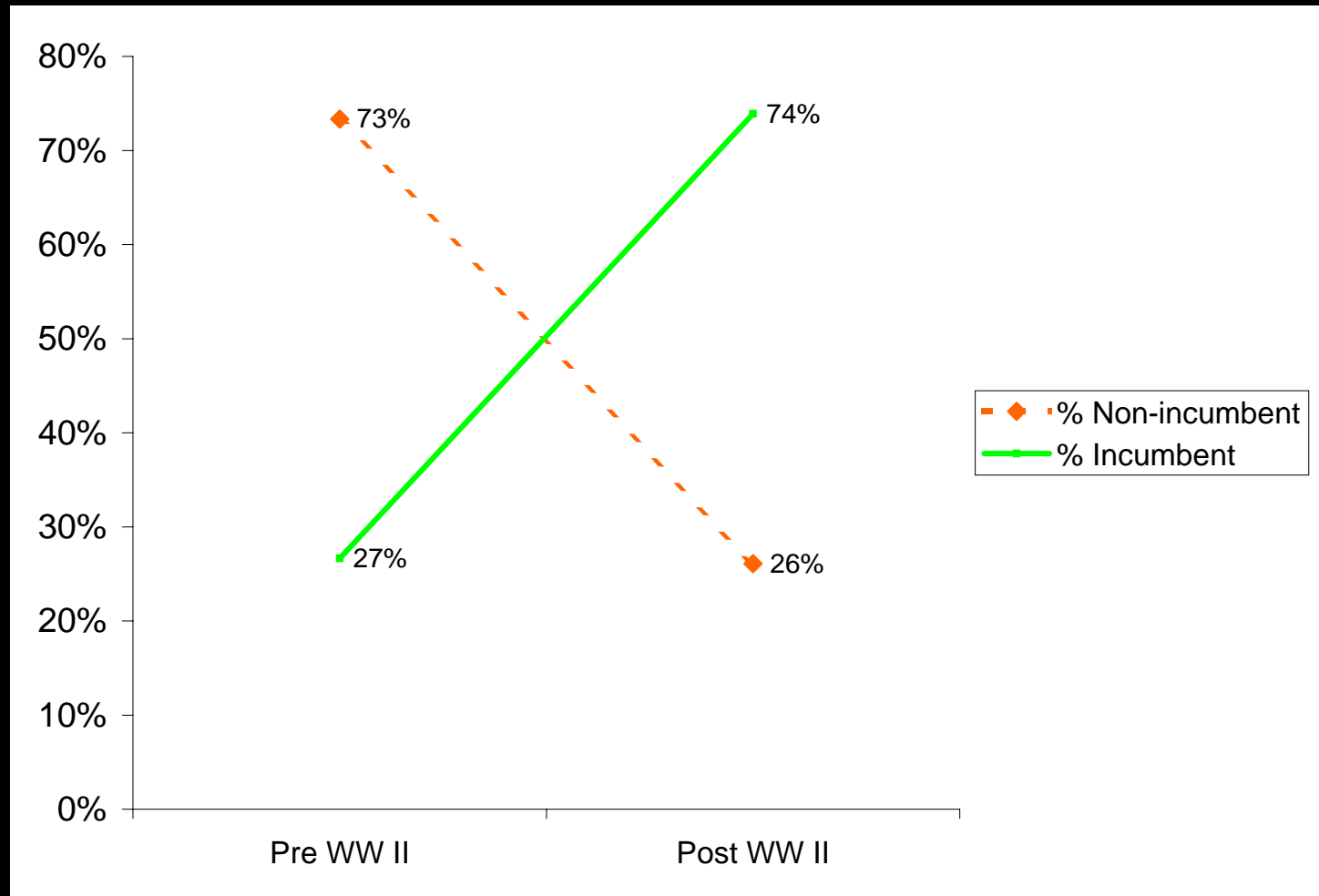
**Small & Medium**

58%

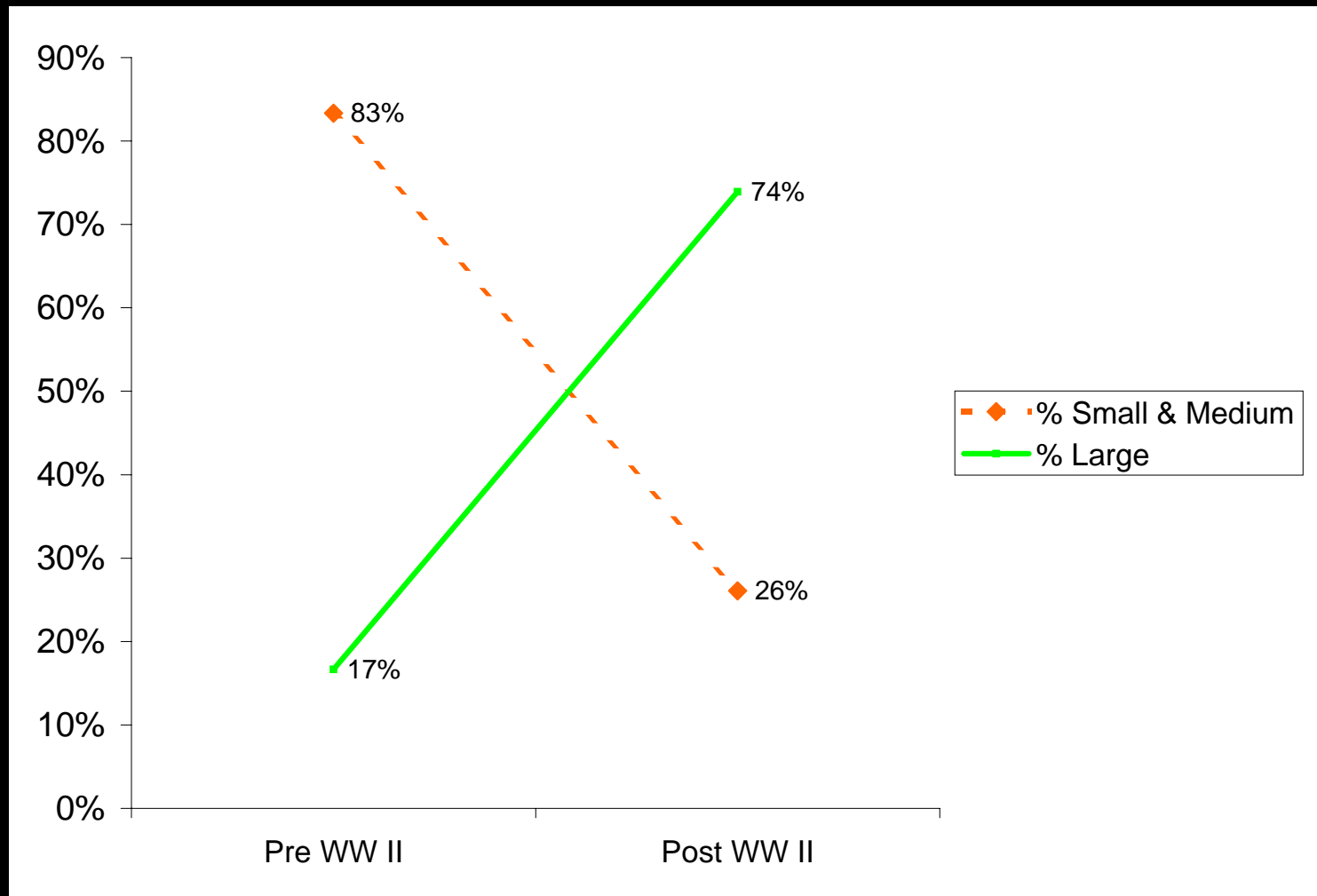
**Large**

42%

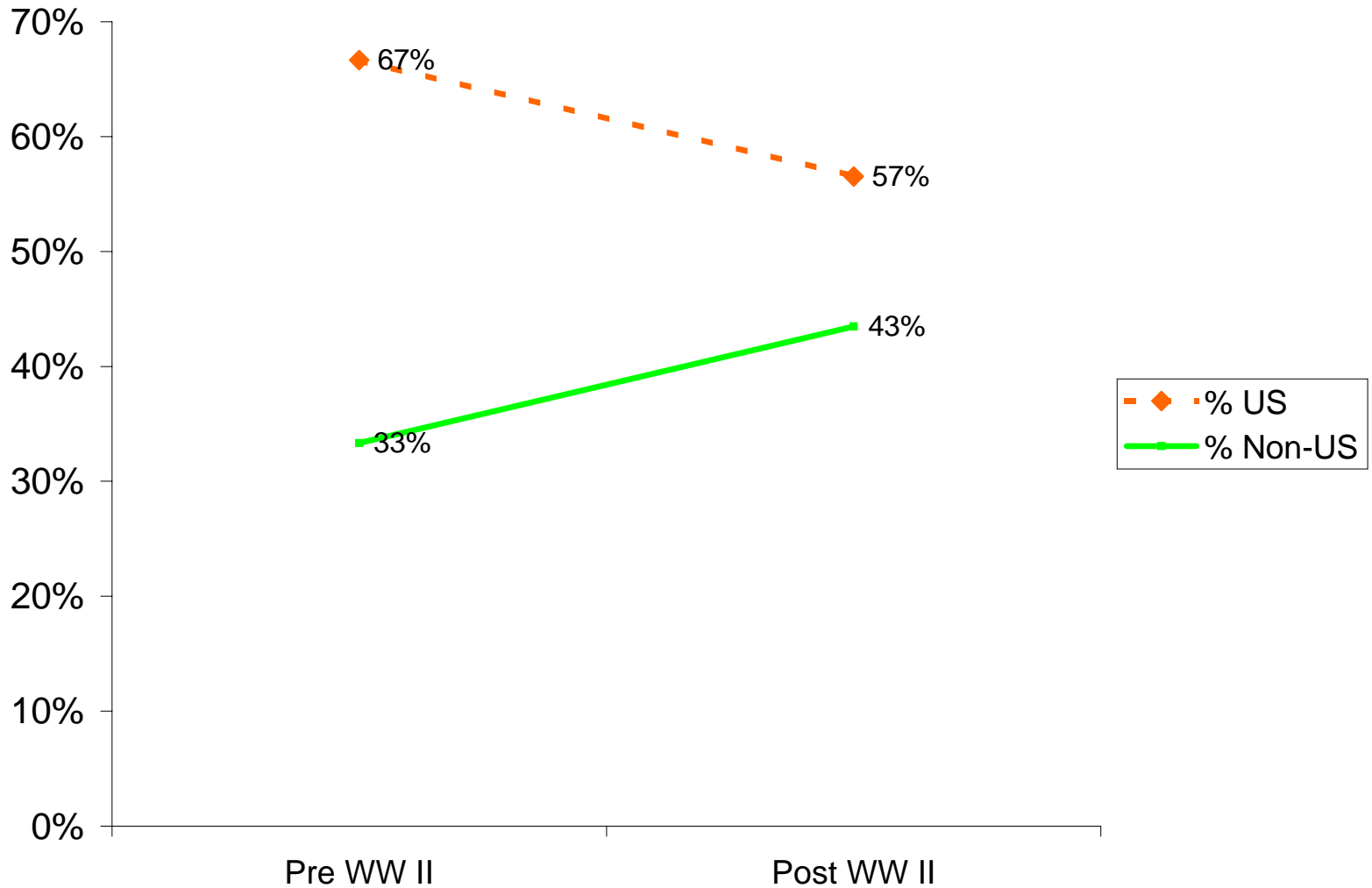
# Trends: Incumbents vs. new entrants



# Large vs. Small Firms



# US vs. Non-US





# Pharmaceutical Innovation

## Food and Drug Administration (FDA) Definitions

<b>Chemical type</b>	<i>New molecular entity (NME)</i>	An active ingredient that has never been marketed before.
	<i>Update</i>	A new formulation, new dosage of existing components or, a commercialized drug that has a new usage.
<b>Therapeutic potential</b>	<i>Priority review drug</i>	A drug that represents a significant therapeutic advance over available therapy.
	<i>Standard review drug</i>	A drug that has therapeutic qualities similar to those of an already marketed drug.

# Data Overview: US Pharma Industry

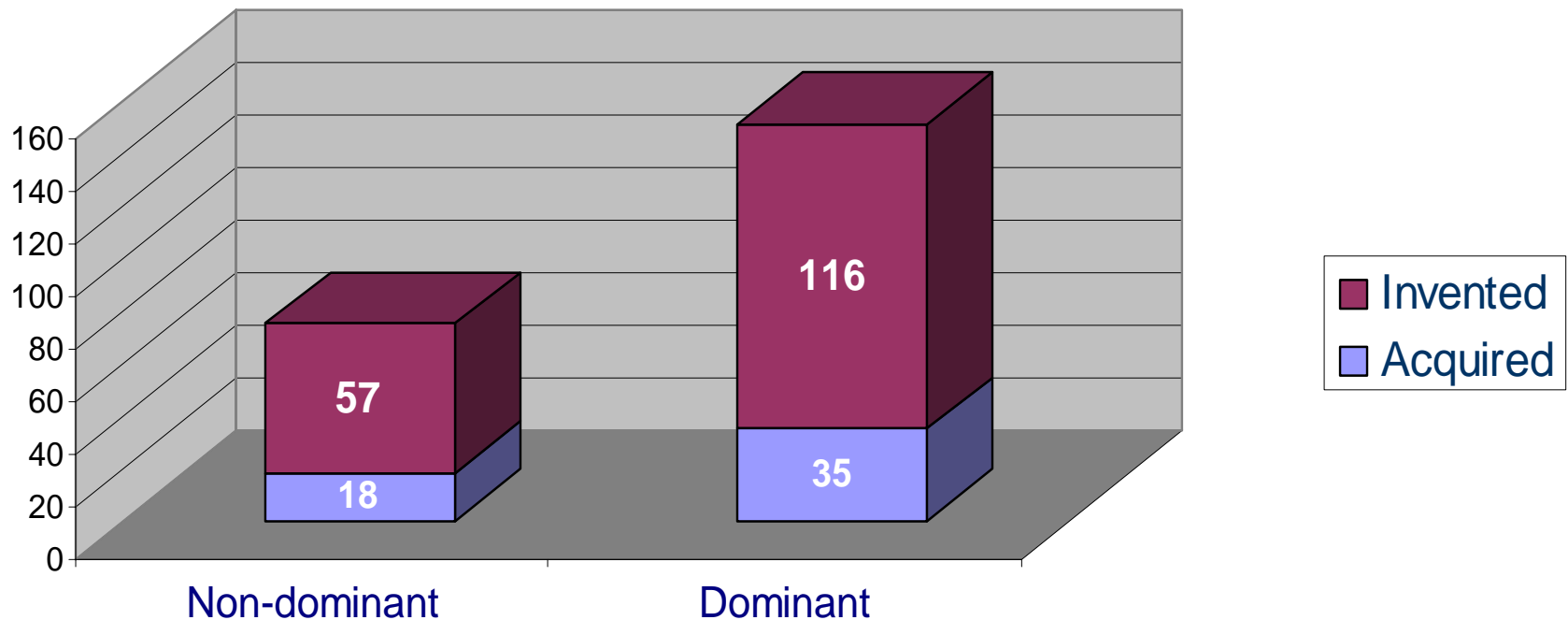
- Census of innovations from 1991 to 2000: 380 breakthrough products.
- Used in the study: 255 breakthroughs from 66 firms.

	Market Breakthroughs 40
Techn. Breakthroughs 135	Radical Innovations 80

- 209 innovations were introduced by their inventors; 46 were licensed/bought during trials.

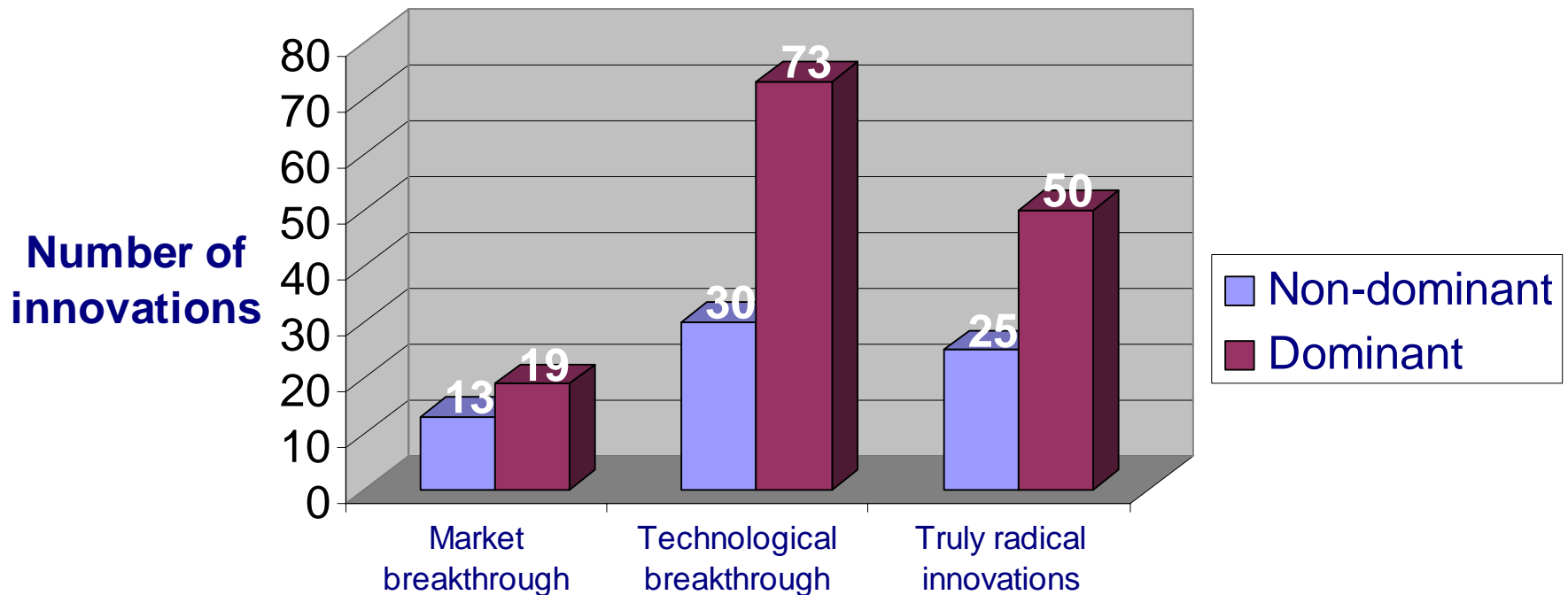
# Innovation in Global Pharma: 1991-2000

Number of breakthroughs introduced by dominant and non-dominant firms



# Dominance and Types of Breakthroughs

**Types of innovations introduced by dominant and non-dominant firms**

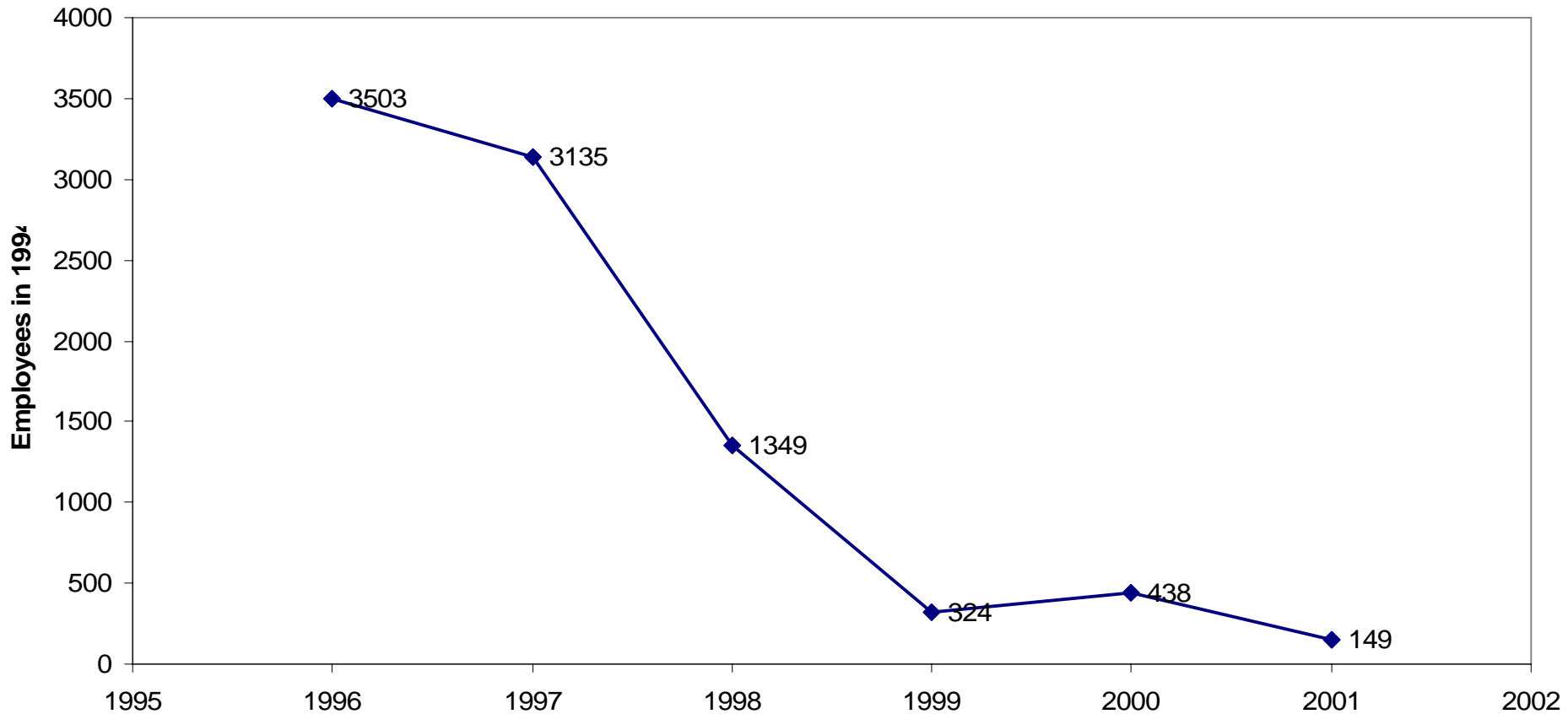


# Innovation in Global Pharma

Most innovative pharma firms (1991-2000):

<i>Company</i>	<i>Breakthroughs</i>	<i>Truly radical Innovations</i>	<i>Total Innovations</i>
GlaxoSmithKline	19	8	382
Roche	15	7	147
Bristol-Myers Squibb	15	4	320
SmithKline (pre- Glaxo merger)	12	4	177
Abbot Laboratories	11	2	284
Merck	11	7	489
Johnson&Johnson	10	2	136
Aventis Pharma	9	4	83
Hoechst	9	3	79
Novartis	9	0	163
Wyeth	9	2	144
Pfizer	9	1	118
Parke-Davis	9	4	93
AstraZeneca PLC	8	0	117
Eli Lilly	6	2	231

# Average Size of Transactional Internet Banking Entrants by Year



Larger firms also more likely to do development in-house

# Incremental Innovation: Banking

Incremental Innovation	Dominant Firms	Non-dominant Firms	Significance Level
M-Banking (Mobile or PDA)	12.45%	6.95%	$p < 0.05$
Online Broker Service	24.91%	10.42%	$p < 0.001$
Online Tax Filing	40.75%	17.76%	$p < 0.001$
Java Applets	56.60%	25.10%	$p < 0.001$
Online Business Banking	61.89%	36.29%	$p < 0.001$

# Little Research Across Nations On:

- Innovation outputs
  - Most studies focus on inputs: R&D, employees, patents
- Non-OECD countries
- Financial impact of innovation
  - Do innovations affect firms' market value?
  - Does payoff vary by nations?
- Drivers of innovation
  - Internal culture of firm or external culture of country?



# Innovation in Firms Across Nations

## Tellis, Chandy, & Prabhu (2006)

<i>Country</i>	<i>Firms Sampled</i>
<b>TOTAL</b>	<b>4074</b>
<b>Australia</b>	<b>128</b>
<b>Canada</b>	<b>154</b>
<b>USA</b>	<b>848</b>
<b>UK</b>	<b>383</b>
<b>Germany</b>	<b>315</b>
<b>Switzerland</b>	<b>80</b>
<b>Netherlands</b>	<b>62</b>
<b>Sweden</b>	<b>113</b>
<b>France</b>	<b>242</b>
<b>Italy</b>	<b>99</b>
<b>Japan</b>	<b>409</b>
<b>Korea</b>	<b>333</b>
<b>China</b>	<b>183</b>
<b>Singapore</b>	<b>176</b>
<b>Hong Kong</b>	<b>167</b>
<b>Taiwan</b>	<b>243</b>
<b>India</b>	<b>139</b>

# Procedure

- Pre-tested questionnaire in four (English-speaking) countries
- Translated original questionnaire into 8 languages
- Translated, back-translated, and re-translated
- Obtained firms' names from data bases
- Called firms to identify VP of innovation
- Mailed survey
- Sent reminder 10 to 14 days later
- ***Integrated survey data with firm level, industry level, country level archival data***

# Survey data checks

- Non-response bias
- Respondent experience, knowledge
- Patent cross-check
- Multi-item scales
- Positively & negatively valenced items
  - Yea-saying, nay-saying, mid-point, demand bias

# Preliminary results

- Macro (country-level) variables do not explain much variance in firm-level innovation
- R&D investment, firm culture are key drivers of radical innovation

# What Do We Mean by Firm Culture?

- Three attitudinal traits
  - Tolerance for risk
  - Future market focus
  - Willing to cannibalize
- Two structural traits
  - Product champions
  - Incentives for enterprise

# Returns to Innovation

“Innovate or die? Sorry, that misses the point. There’s actually an innovation glut. The real shortage is profits.”

*(Fortune 2000)*

“If you have a smokestack, if you make something, if you have revenues, and God forbid, if you produce something, then you’re considered doomed to fail.”

**Carl Gustin Jr.**, Kodak Sr. VP and Chief Marketing Officer, describing response to Kodak’s digital imaging efforts, July 2000

# Why do some firms gain more from innovation?

- Shareholder wealth
- Return on Investment
- Market share
- Survival

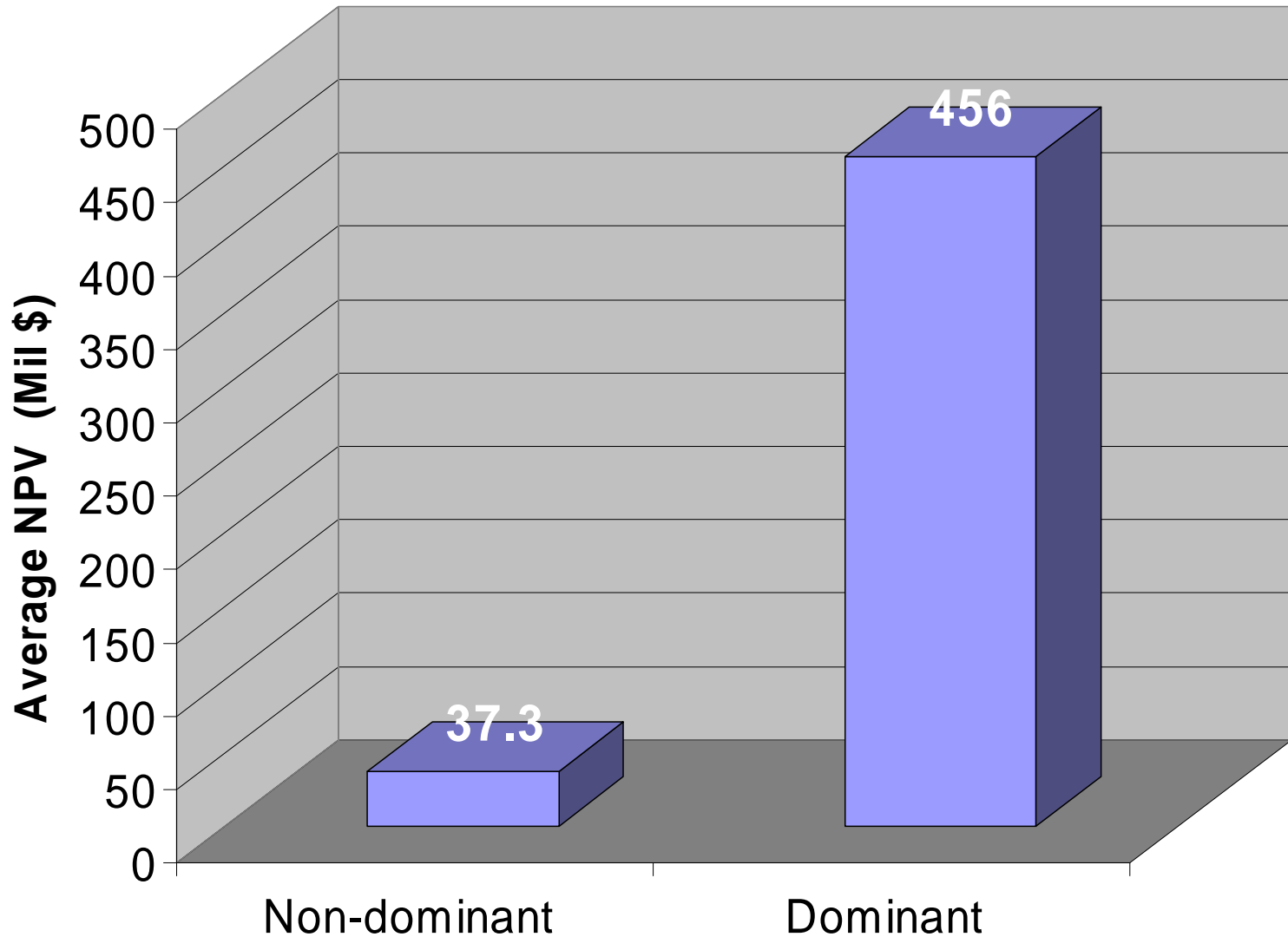
# Stock-Market Response to Innovation

Top 10 most valuable drugs (1991-2000): Sorescu, Chandy, and Prabhu 2003

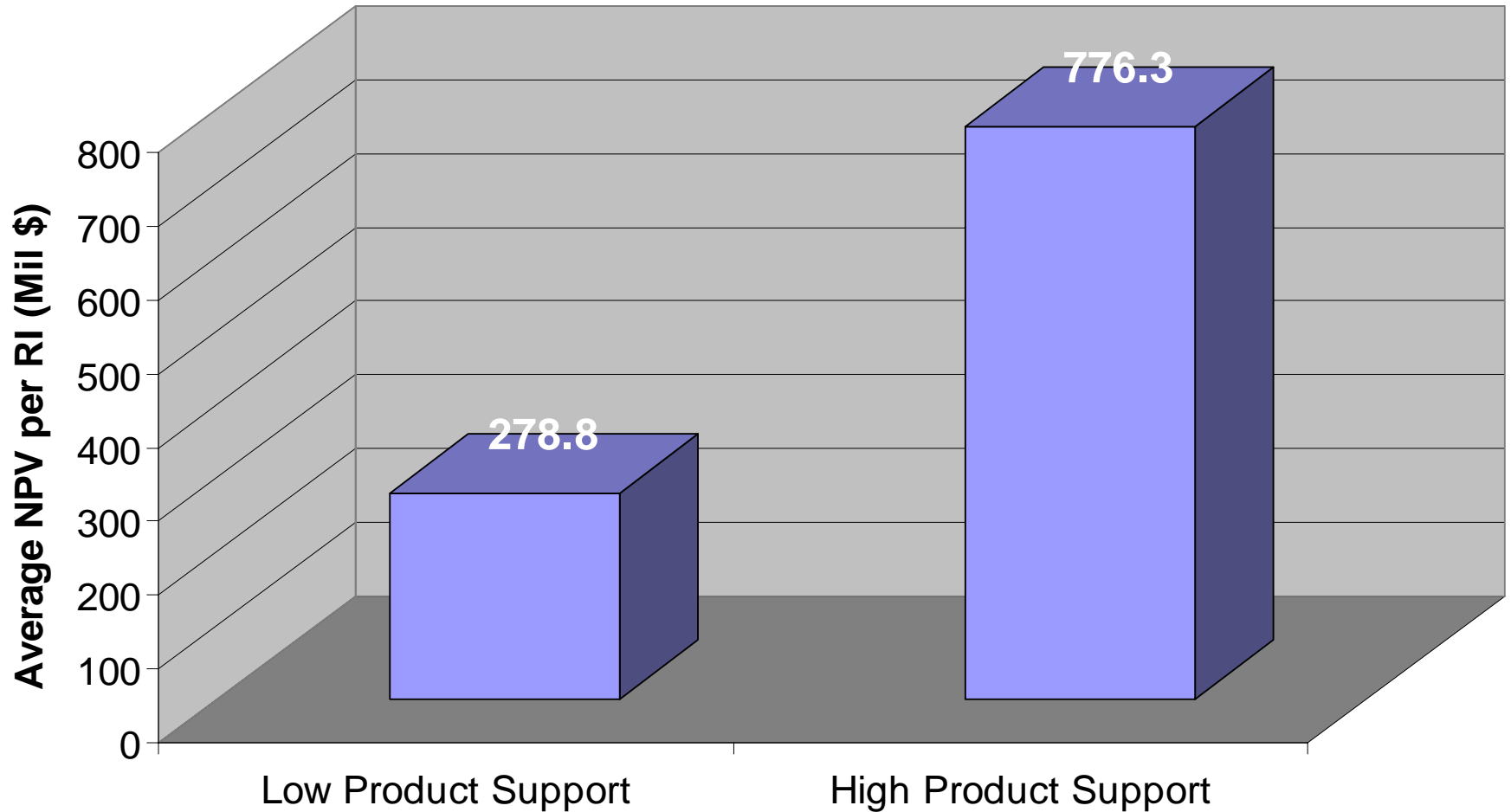
<i>Drug Name</i>	<i>Drug Class</i>	<i>Company</i>	<i>Approval Date</i>	<i>Innovation Type</i>	<i>Licensed</i>	<i>NPV (in \$ mil.)</i>
<i>Singulair</i>	Respiratory; Pulmonary Asthma/Anti-Asthmatic	Merck	20-Feb-98	Tech breakthrough	No	6981.7
<i>Tikosyn (Dofetilide)</i>	Cardiovascular; Arrhythmia/Anti- Arrhythmic	Pfizer	10-Jan-99	Tech breakthrough	No	6313.5
<i>Viagra</i>	Gynecological; Genito-Urinary Impotence	Pfizer	27-Mar-98	Radical Innovation	No	6189.9
<i>Rapamune</i>	Immunology/Autoimmune Disease	Wyeth	15-Sep-99	Radical Innovation	No	5745.0
<i>Mylotarg</i>	Cancer; Blood Cancer; Leukemia	Wyeth	17-May-00	Radical Innovation	No	5552.9
<i>Glucovance</i>	Metabolic Disorders; Diabetes; Diabetic Complications	Bristol-Myers Squibb	31-Jul-00	Tech breakthrough	Yes	5428.8
<i>Rebetron</i>	Infectious Diseases & Viral Diseases; Antiviral Hepatitis	Schering-Plough	3-Jun-98	Market Breakthrough	Yes	4910.0
<i>Aggrastat</i>	Cardiovascular	Merck	14-May-98	Radical Innovation	No	4807.4
<i>Relenza</i>	Infectious Diseases & Viral Diseases; Antiviral Influenza	GlaxoSmithKline	27-Jul-99	Radical Innovation	Yes	4112.7
<i>Temodar</i>	Cancer, Brain Cancer	Schering-Plough	11-Aug-99	Radical Innovation	Yes	3281.4



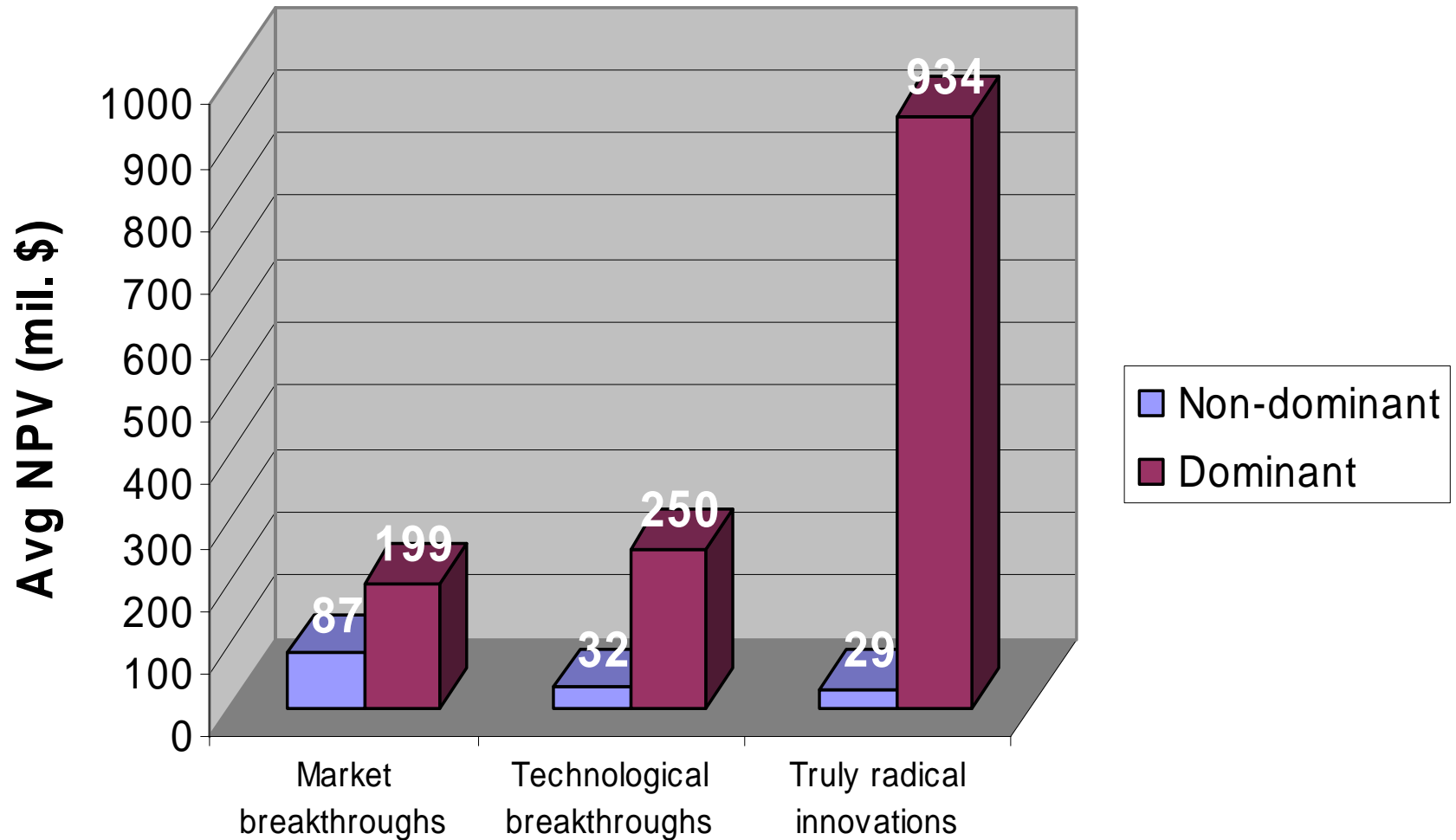
# Who gains more?



# Effect of Product Support for Dominant Firms



# Stock Market Response to Innovation



# Measures and data sources

Conceptual variable	Measured variable	Data source
Type of innovation	<p><b>Market breakthrough:</b> Priority review</p> <p><b>Technological breakthrough:</b> NME</p> <p><b>Radical innovation:</b> Priority review + NME</p>	<ul style="list-style-type: none"> <li>• NDA Pipeline</li> <li>• FDA Pink Sheets</li> </ul>
Dominance	$f(\text{Sales, Assets, Profits})$	<ul style="list-style-type: none"> <li>• COMPUSTAT, DataStream, FIS</li> </ul>
Value of radical innovations	Net present value	<ul style="list-style-type: none"> <li>• CRSP</li> <li>• DataStream</li> </ul>
Product support	<p>Marketing support: (SF, AD)/ # products</p> <p>Tech. support: (R&amp;D, PATS)/ # products</p>	<ul style="list-style-type: none"> <li>• Verispan Inc.</li> <li>• NDA Pipeline</li> <li>• USPTO Database</li> </ul>
Product scope	Entropy x # products in product portfolio	<ul style="list-style-type: none"> <li>• National Drug Code Directory</li> </ul>
Control variables:	<p>Cost of capital</p> <p>Licensed or invented</p> <p>Country of origin</p>	<ul style="list-style-type: none"> <li>• LB Fixed Income Res. Program</li> <li>• DataStream etc.</li> <li>• FDA Pink Sheets</li> <li>• DataStream</li> </ul>

# Metrics needed..

- Outputs
  - Investment → Invention → Innovation → Exploitation
- Levels
  - Micro and Macro
  - Within and Across Industries
  - OECD and Emerging

“This data collection effort is phenomenally laborious. And frankly, the... [incentives] are not there in the profession for developing these sorts of data sets that are absolutely essential. In Europe...it is largely the governments who have advanced the effort and they are into this in association with academics and so on.... That is missing, for the most part, in the United States. One possible contribution...is to...work more closely with...the public authorities to collect the kind of data that is being talked about today.”

– (Wesley Cohen, in Kortum 2004).

# Summary

- Innovation
  - What is it?
    - Not what we typically measure
  - Who does it?
    - Not whom we typically assume
  - How is it done?
    - Not how we implicitly believe
  - Who gains most from it?
    - Not who we often think

# A Wish List

- Greater funding for innovation metrics
- Access to micro-level data
- Integration across nations, industries, databases