Matching Supply with Demand: The Newsvendor Model

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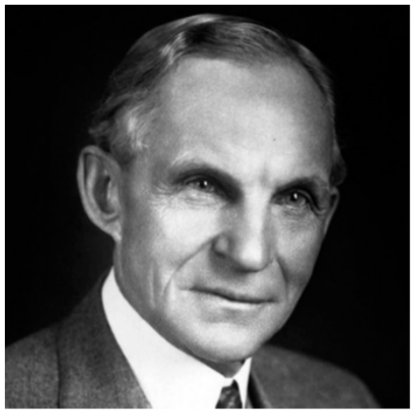
THE FORD MODEL T: STANDARDIZATION

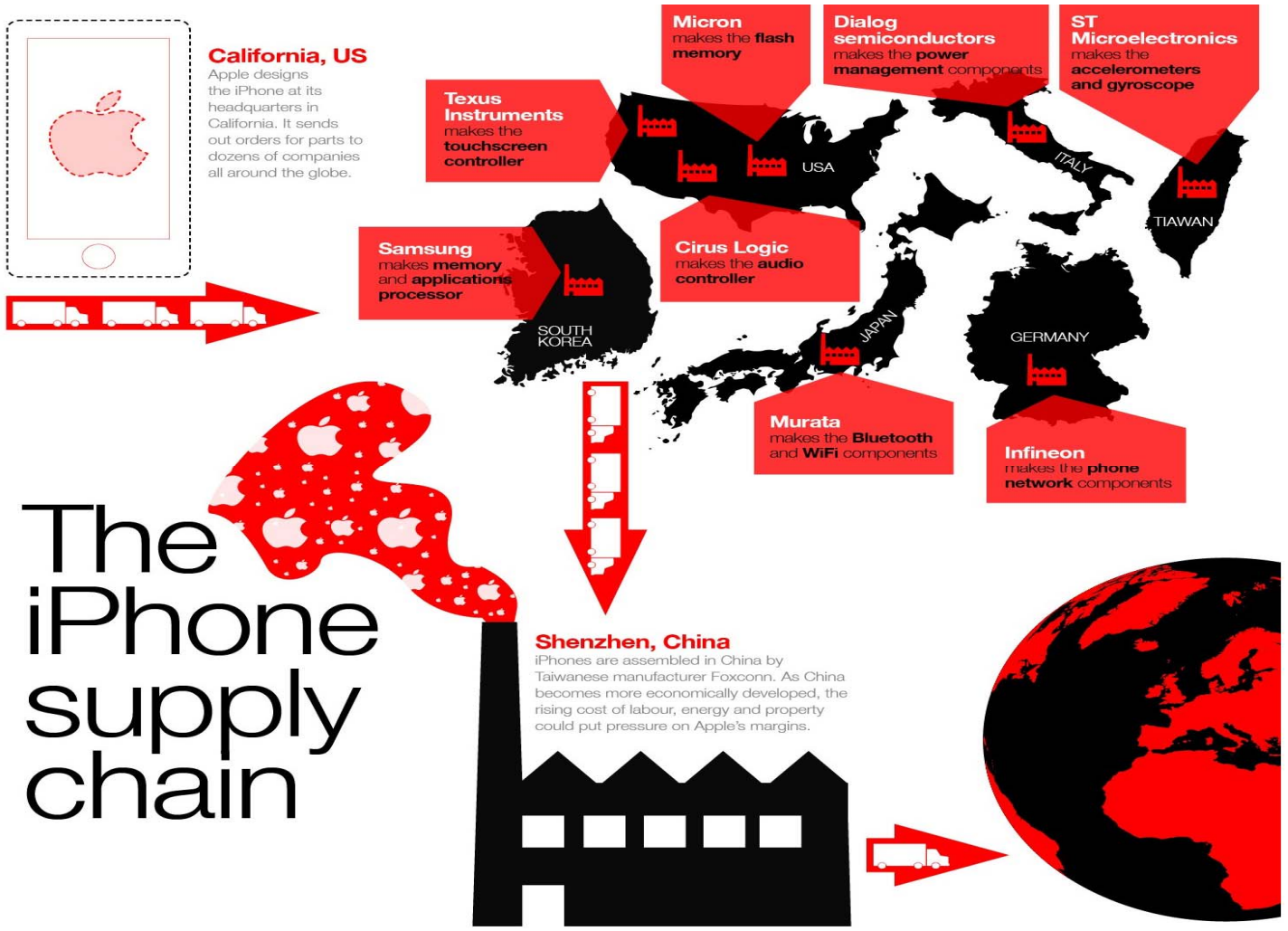


"Any customer can have a car painted in any color he wants as long as it is **black**"

Henry Ford (1909)

100 years ago business used to be an individual sport:
One product, produced by **one** company **locally**.
Had a very **long** life cycle (~15 years).

Apple iPhone Supply Chain



Today, business is a **global**, **team** sport!

RISK!

1) **Information risk:** Decisions made with poor information

2) **Alignment risk:** Decisions made with self-interest (as opposed to group's interest)

Managing Information and Alignment Risks is key to success

Managing Risk: The Newsvendor Model

THE NEWSVENDOR MODEL

The Newsvendor Model

Order newspapers overnight to sell tomorrow in the face of uncertain demand.

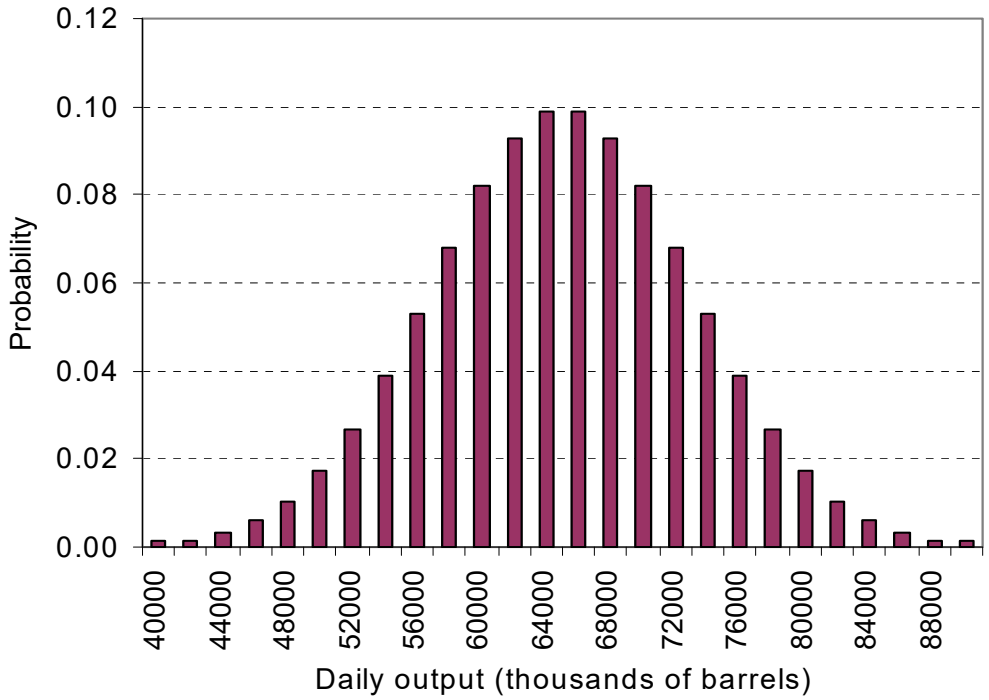
High demand

Low demand

Key features of model: **Place a bet** in the face of uncertainty, **no recall** to your decision, the product is **perishable**

Capacity Planning Example: Executive Committee at British Petroleum

- Processing facilities are needed for a new oil field.
- Maximum sustainable output from the oil-field ranges from 40,000 barrels per day to 90,000 barrels per day.
  - BP will know potential output only after production begins.
  - These capital investments are measured in billions of $.



How big should the processing facility be?

Alternative strategy: Build a relatively small facility with the (Real) option two years later to expand capacity.

Quantify the Uncertainty

- An *uncertain outcome* or a *random quantity* (also called stochastic variable) is a quantity that takes several possible values which are outcomes of a random experiment.

- Uncertain outcomes and quantities have a *likelihood* to happen
  - E.g. “It is 60% likely to rain today”.
    “I may be late to class”.

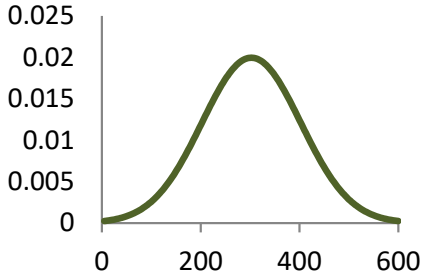
QUANTIFY THE UNCERTAINTY: FORECAST

WEATHER FORECASTS

Date	Conditions	Daytime High / Overnight Low (°F)	Precipitation
Tonight Sep 14	Showers Late	69°	60%
Thursday Sep 15	T-Storms	79°/67°	80%
Friday Sep 16	T-Storms / Wind	79°/66°	80%
Saturday Sep 17	Sunny	84°/66°	0%

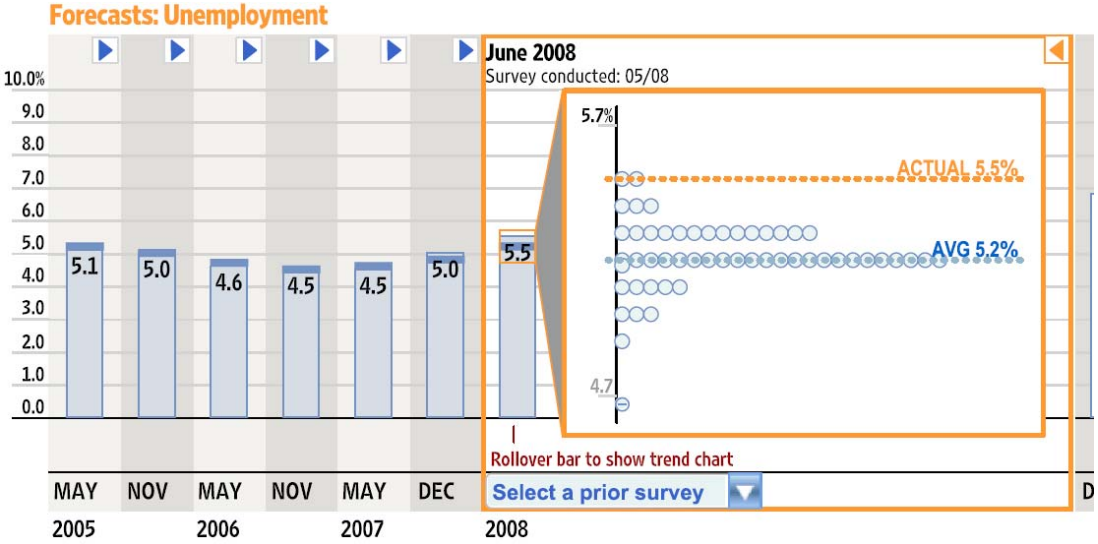
DEMAND FORECASTS

FROM MARKETING



FROM OPERATIONS

ECONOMIC FORECASTS



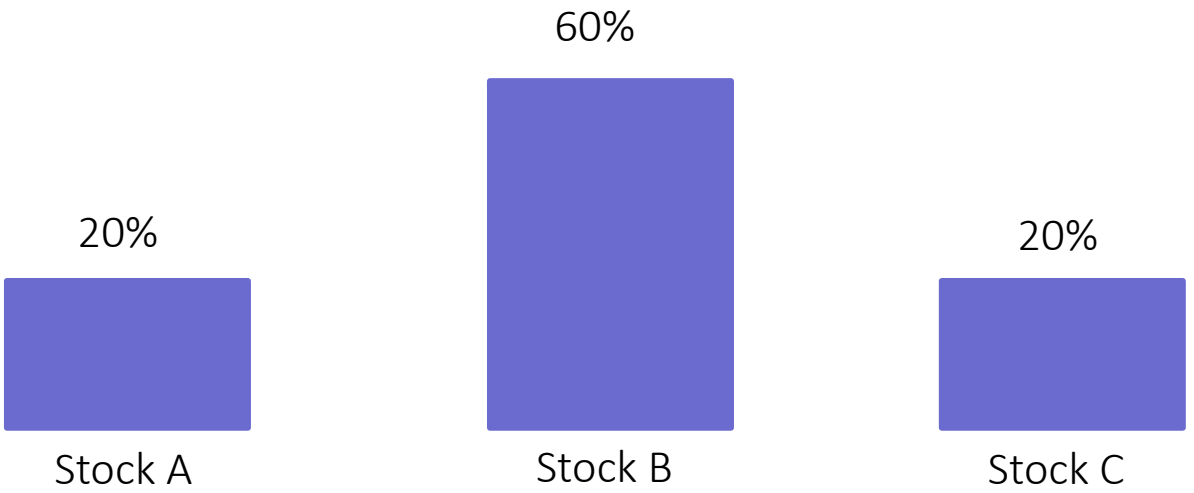
SOURCE: WSJ ECONOMIC FORECASTING SURVEY

- A forecast is a *distribution,* not a number!
- Forecasts have an accuracy associated with them
- Forecast accuracy cannot be judged by one outcome
- A distribution captures all these features

A forecast is a *distribution* of values, not a single number!

Dealing with Uncertainty

- Given a forecast, now which stock would you invest in?



Dealing with Uncertainty

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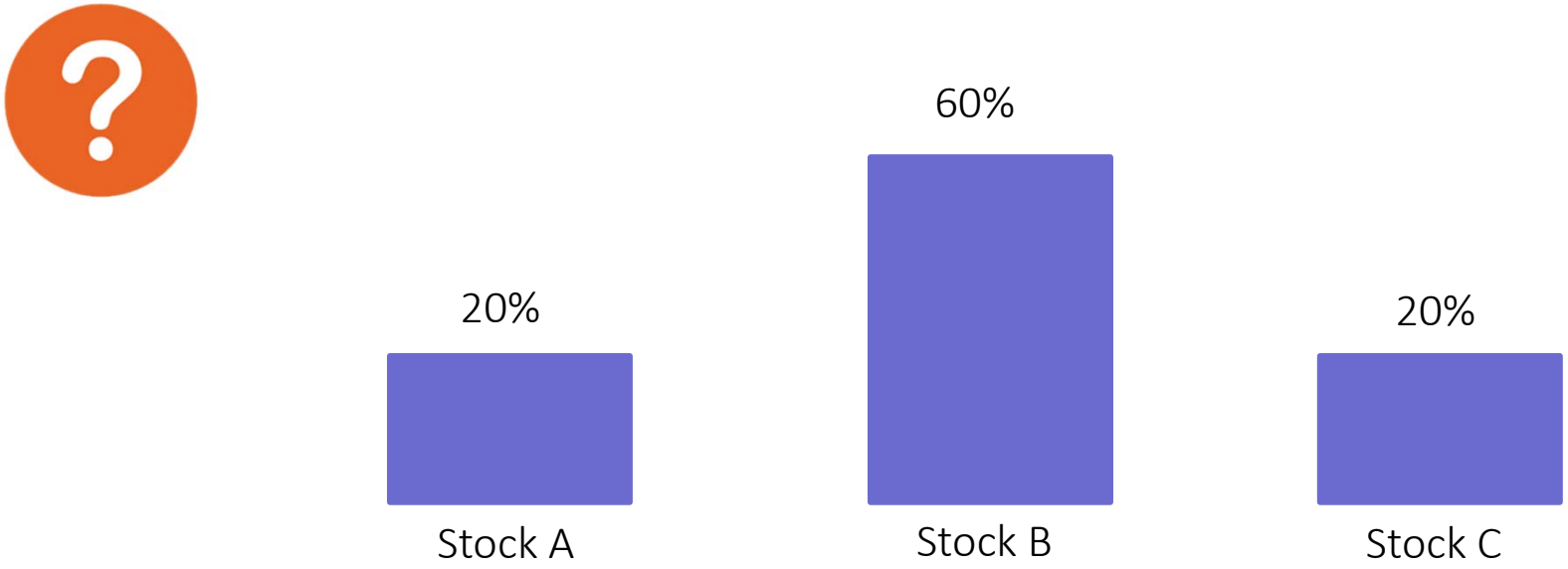

The human mind is particularly bad in understanding something uncertain: most people choose the *most likely* outcome. This could be wrong!

First Key Lesson for Today

"In the face of uncertainty you do *not* just choose what is most likely to happen"

Two Key Examples

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Doctor's decision: How much blood to carry when Justin is on a trip?

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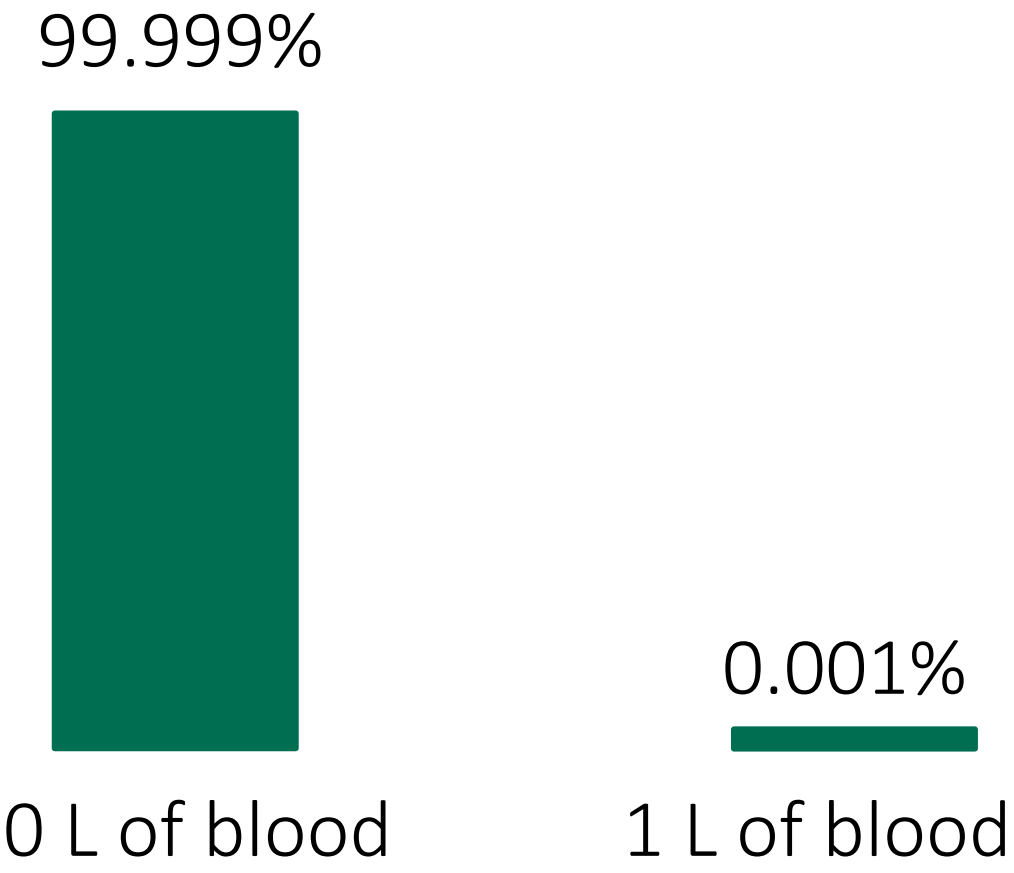
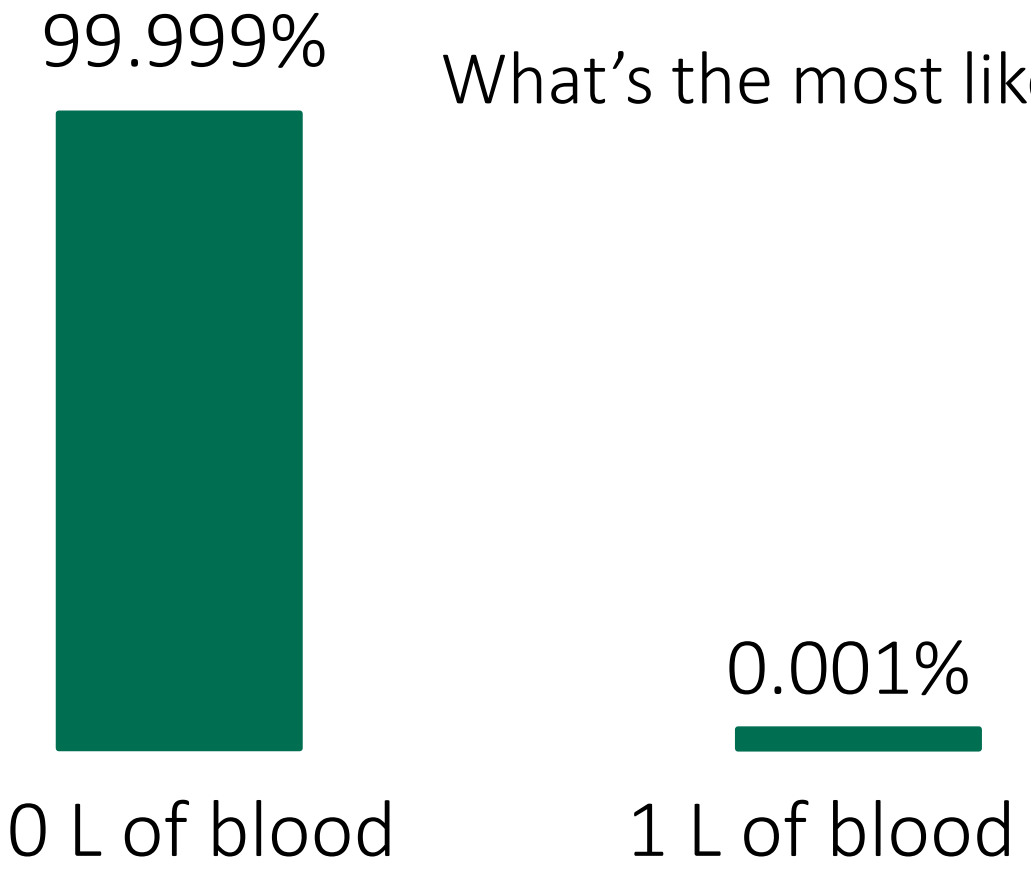


Two Key Examples

Doctor's decision: How much blood to carry when Justin is on a trip?

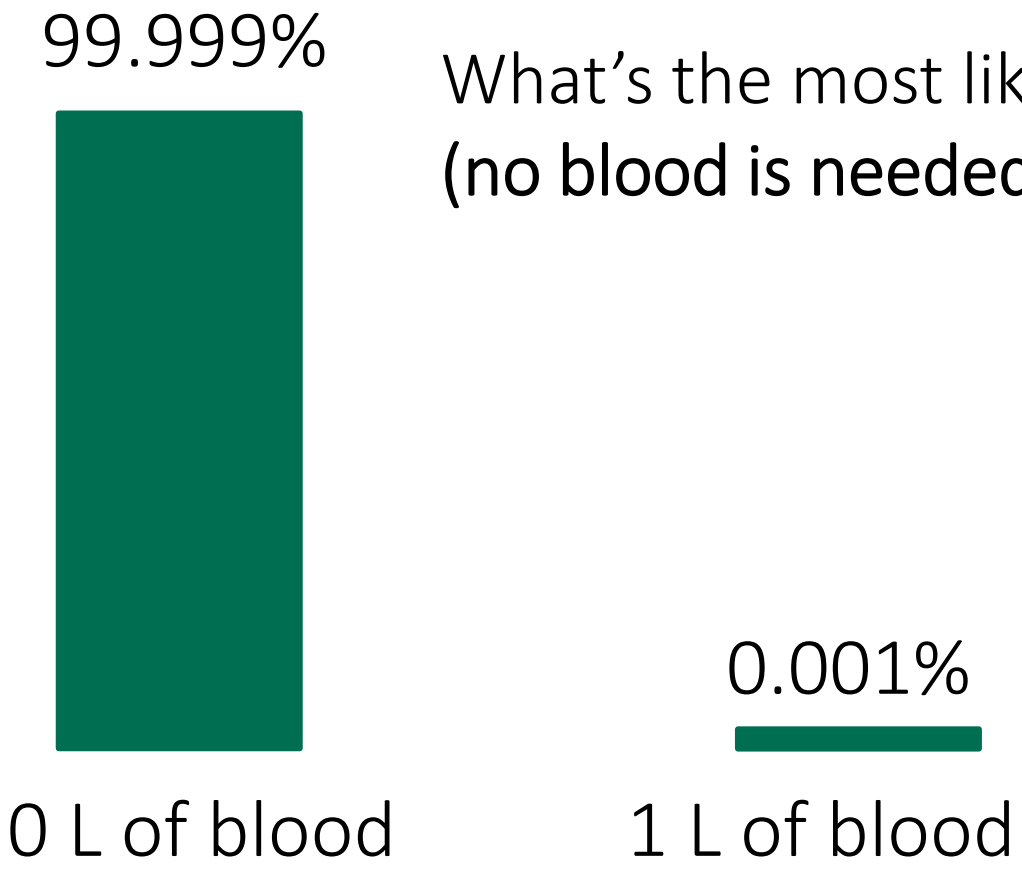
What's the most likely thing to happen?



Two Key Examples

Doctor's decision: How much blood to carry when Justin is on a trip?

What's the most likely thing to happen?
(no blood is needed)



Two Key Examples

Doctor's decision: How much blood to carry when Justin is on a trip?

99.999%

What's the most likely thing to happen?
(no blood is needed)

How much blood do you think they carry for Justin?

0 L of blood

0.001%

1 L of blood

Two Key Examples

Doctor's decision: How much blood to carry when Justin is on a trip?

99.999%

What's the most likely thing to happen? **(no blood is needed)**

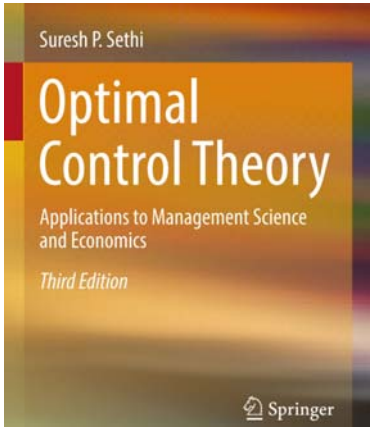
How much blood do you think they carry for Justin? **(10 L of blood)**

0 L of blood

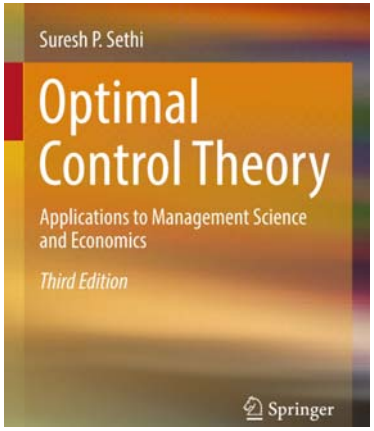
0.001%

1 L of blood

Two Key Examples

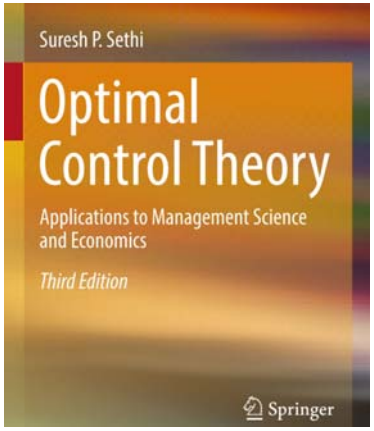


Two Key Examples



Bookstore's decision: How many such books to stock?

Two Key Examples



Bookstore's decision: How many such books to stock?

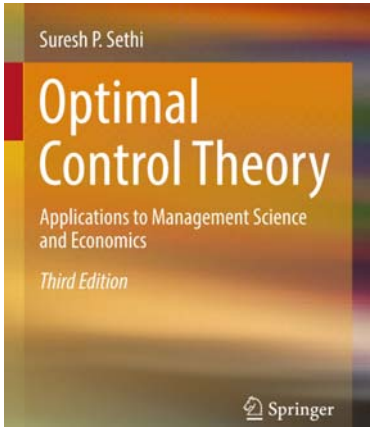
99.999%

No books

0.001%

1 book

Two Key Examples



Bookstore's decision: How many such books to stock?

99.999%

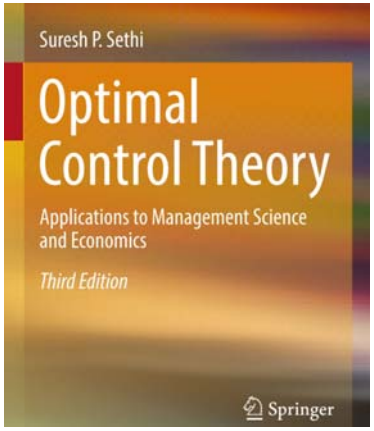
No books

What's the most likely thing to happen?

0.001%

1 book

Two Key Examples



Bookstore's decision: How many such books to stock?

99.999%

No books

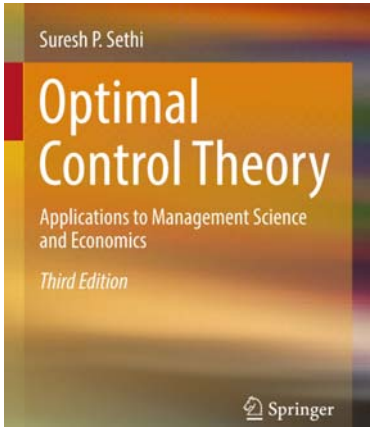
What's the most likely thing to happen?

(no such books are needed)

0.001%

1 book

Two Key Examples



Bookstore's decision: How many such books to stock?

99.999%

No books

What's the most likely thing to happen?

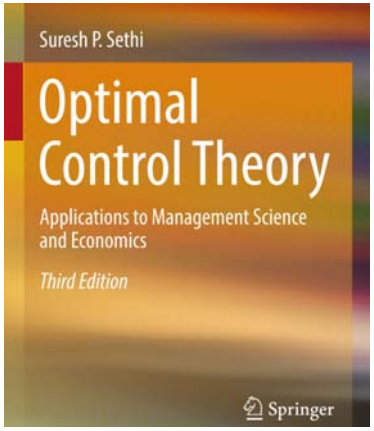
(no such books are needed)

How many to stock?

0.001%

1 book

Two Key Examples



Bookstore's decision: How many such books to stock?

99.999%

No books

What's the most likely thing to happen?

(no such books are needed)

How many to stock? **(none)**

0.001%

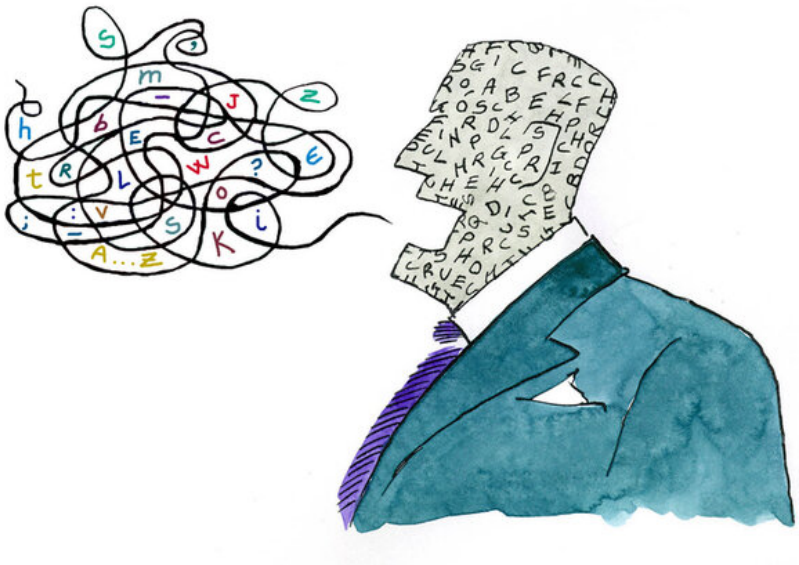
1 book

Second Key Lesson for Today

"In the face of uncertainty you **tilt your bet** away from the most likely value **in the direction where the consequences are less severe**"

You don't simply want to be correct "most often". You want to be "wrong in the right way most often" (where the consequences are least severe)!

The Role of Models in Science



WHAT IS A MODEL?

"Nothing is less real than realism. Details are confusing. It is only by selection, by elimination, by emphasis, that we get at the real meaning of things", Georgia O'Keeffe (1887-1986)

What is a model?

The Role of Models

"All models are wrong, but some are useful", George Box

"*A model is a lie that helps you see the truth*", H. Skipper

"Perfection is achieved, not when there is nothing more to add, but when there is nothing left to take away", Saint Exupery

"Art is like a man walking barefoot up a mountain on rocks for so long he can't feel his feet or the rocks. The purpose of art is to make the rocks rocky again. The technique of art is to make an object "unfamiliar," to make forms difficult, to increase the difficulty and length of perception because the process of perception is an aesthetic end in itself and must be prolonged. Art is a way of experiencing the artfulness of an object; the object itself is not important.", Victor Shklovsky

⟶[Replace "art" with "models/modeling"]

NEWSVENDOR MODEL: BEYOND NEWSPAPERS

Thinking Broadly about Alternate Applications of the Newsvendor Model

The main features of the newsvendor model are
1. An uncertain quantity (demand) and
2. A bet on that quantity (made before the exact value of the uncertain quantity is revealed).
3. There are consequences of getting this bet wrong.

This structure extends to many situations beyond the traditional Newsvendor Setup

An Uncertain Number	Ex-Ante Bet
Product demand	Stock level
# of guests at a party	Amount of food to order
Talk time demand	Cell-phone plan
Market size for new product	Capacity of production facility
Project complexity	Number of employees on project
Withdrawals at a hedge fund	Cash reserve/Short term investments

The optimal profit-maximizing bet balances the too-much and too-little costs

Other Examples

Applying the Newsvendor Model to these Examples

- Reasons to consider a different $C_u \neq r-c$
- Reasons to consider a different $C_o \neq c-s$
- Reasons to consider a different objective
- Who makes these decisions?
- Who estimates the costs?
- Organizational Culture

Key Lessons

- Most business problems are placing a bet in the face of uncertainty.
- In such cases, you tilt your bet in the direction where the consequences are less severe.
- Who is bearing these consequences? Align the incentives!

- The newsvendor model captures the intuition of placing bets in the face of uncertainty.
- Essentially, in making these decisions we must take into account the relative consequences of betting too high or too low. This tells us if we bet more or less than the mean. Further, how much more or less than the mean we go, depends on the uncertainty involved.
- Becoming better at betting on uncertainty is a life-changing experience.

NEXT

- Lecture 4.2: Value Chain Innovation
  - Read Ops Book Ch. 14
  - Case: Zara
  - Article: How Fast Fashion Works: Can It Work for You, Too? (HBR 2014)

Appendix

Method #1 : Demand Forecasting using Historical Data

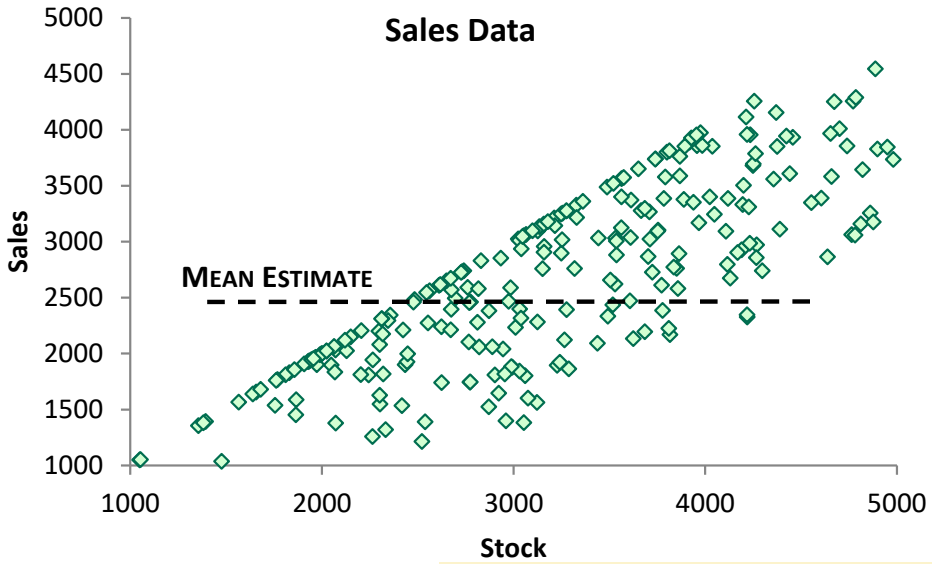
Self Study

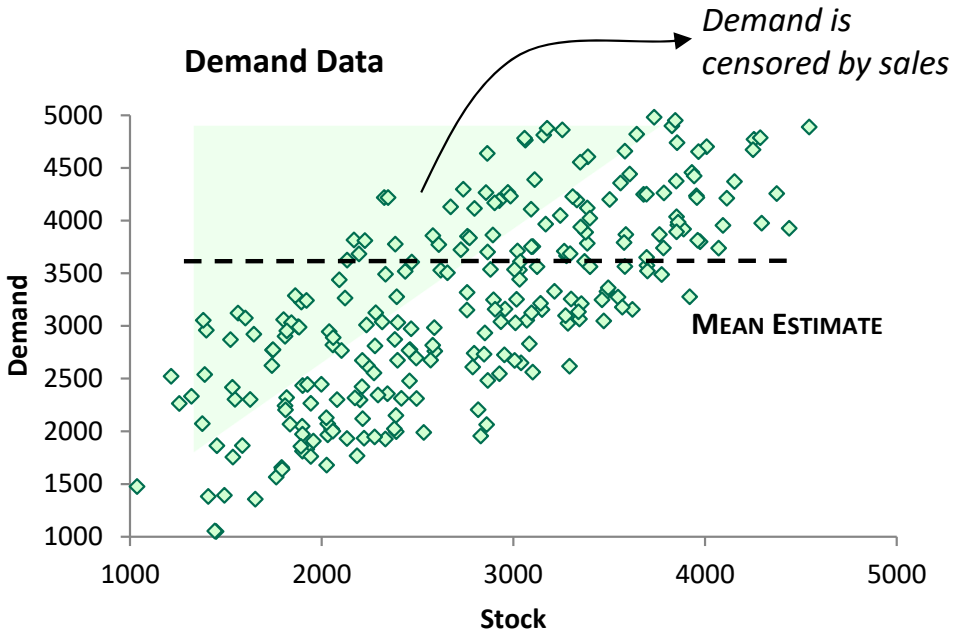
Procedure

- Collect historical demand data.
- Assume demand is distributed normally, compute mean and standard deviation.
- Include further explanatory variables, such as availability of other products, season, product stage, etc.
- Example: Wal-Mart uses extensive IT and real-time point of sales, RFID data to predict demand and stocking.

Pros/Cons

- Precise estimates are possible
- Assumes structural stability, ignores “inflexion points” in customer behaviour.
- Record Inaccuracy in point of sales data.
- Does not work for new products, or where historical data does not exist.
- Often sales are observed and not demand!





Sales are censored Demand.
Using Sales Data leads to Underestimation of Demand

Method # 2: The Quaker Method

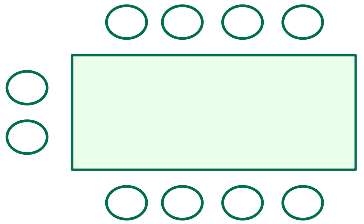
Self Study

Procedure

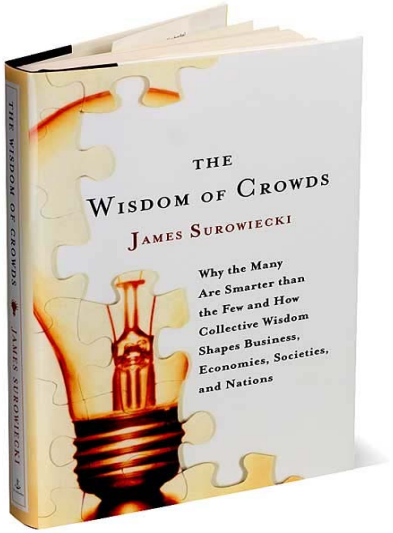
- Identify experts.
- Ask experts for forecasts, use mean forecast as mean and standard deviation of forecasts by different experts as standard deviation.
- Scale up standard deviation from experts to take into account size effects.
- Example: Retail buyers (consumer goods, fashion), Pharmaceuticals probability of success of new drugs

Pros/Cons

- Works for new products, incorporates human judgement.
- Organizational Issues: Politics around the table, anonymity.
- Does not take into account level of confidence/information of experts.
- Scale up factor of standard deviation is not easy to determine.



Method # 3: The Quaker Method on Steroids



Procedure

- Poll a large number of people, the crowd!
- Example: Dell.

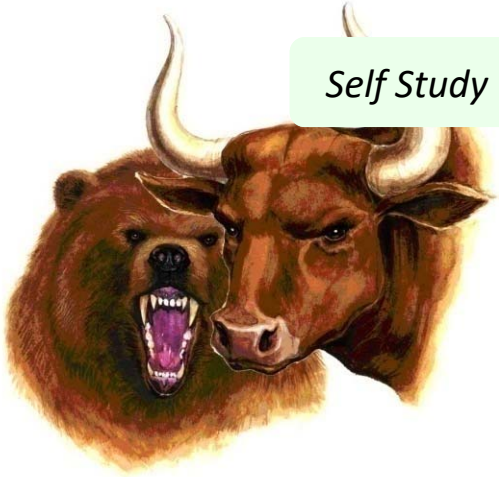
Pros/Cons

- Works well for new feature development,
- Infeasible in many corporate contexts
- Works only in cases where there is relevant distributed information

Prediction Markets Solve Some Issues with the Quaker Method

METHOD #3: PREDICTION MARKETS

Self Study



PROCEDURE

- Establish a trading platform where participants can buy and sell securities (using real or play money)
- The value of tradable securities is directly linked to events in the future.

- Example:
  - Holder of Security X is paid D$ if demand for product is D units, after demand is revealed.
  - This security can be bought and sold now.
  - The current price of the security captures the market's estimates of demand.

  - If you believe this is an underestimate, you would like to long (buy) this security, because its fundamental value is greater than what you have to pay to acquire it.
  - If you believe this is an overestimate, you would like to short (sell) this security, because its fundamental value is lower than what one has to pay to acquire it.
  - In equilibrium (no arbitrage), the price of a security should reveal the best estimate of demand.

- Fundamental Assumption: Efficient Markets create the right incentives for information revelation and aggregation
  - Information on Subjective Probabilities is distributed between many experts
  - Prices can be used to aggregate this information.
  - Markets create incentives for anonymous revelation.
  - Markets also create incentives for confidence weighting for information
    - The amount of money you will bet will depend on your confidence.

PREDICTION MARKETS AT BEST BUY

Self Study

THE WALL STREET JOURNAL.

Best Buy Taps 'Prediction Market'

Imaginary Stocks Let Workers Forecast Whether Retailer's Plans Will Meet Goals

By PHRED DVORAK

Article | Video | Interactive Graphics | Comments | MORE IN MANAGEMENT »

Predicting the Future

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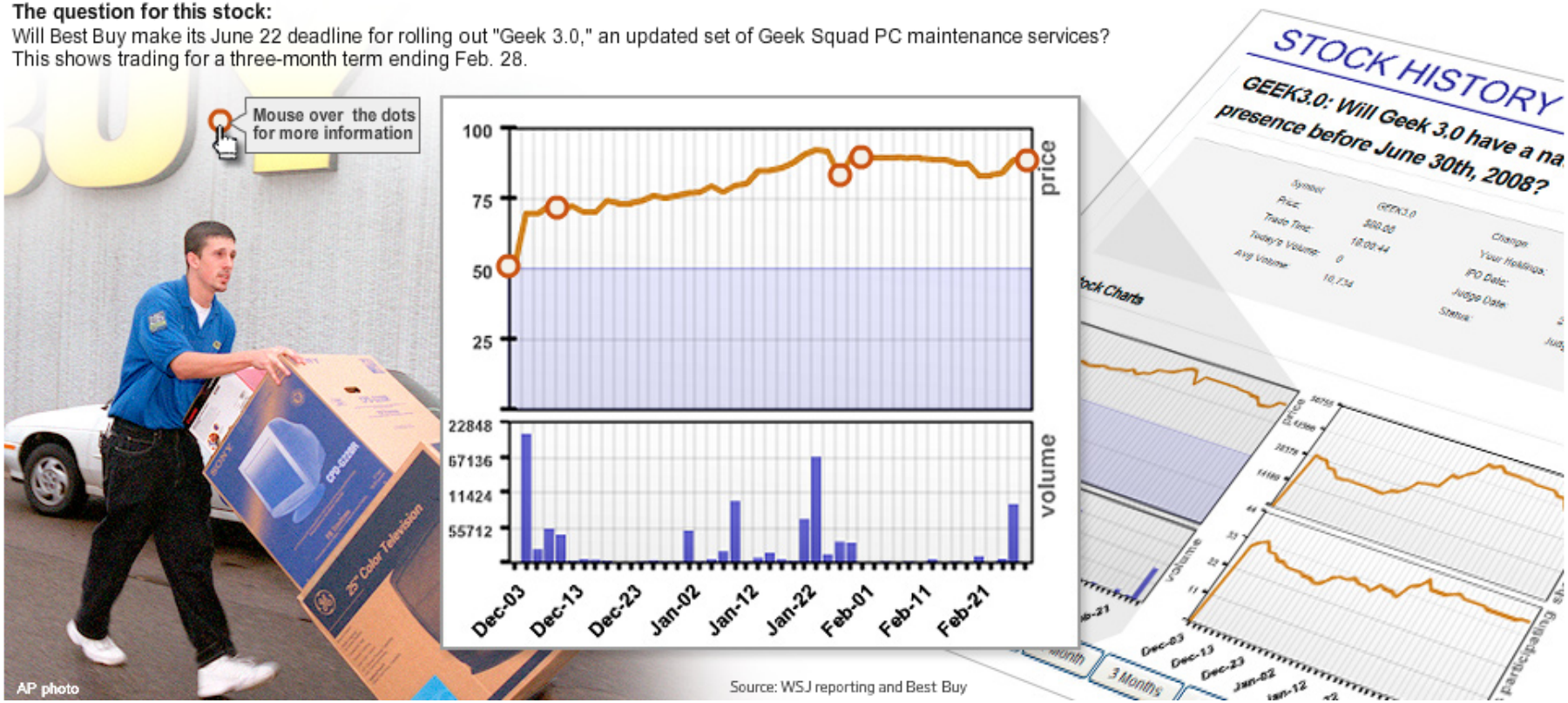
How to trade:
Best Buy employees get $1 million in fake money for a nine-month term. They buy and sell stocks, each of which poses a question like: Will this new product launch on time? Employees who've built up the biggest trading gains during the term get prizes.

The question for this stock:
Will Best Buy make its June 22 deadline for rolling out "Geek 3.0," an updated set of Geek Squad PC maintenance services? This shows trading for a three-month term ending Feb. 28.



SOURCE: WALL STREET JOURNAL, SEPTEMBER 16TH, 2008; " BEST BUY TAPS 'PREDICTION MARKET'"

Prediction Markets: Examples

Self Study

Public Markets

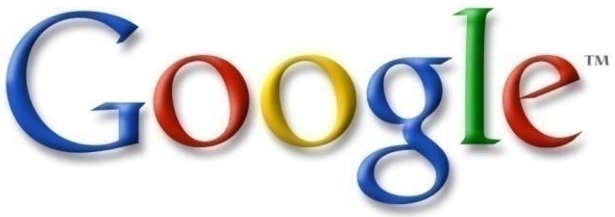
Hollywood Stock Exchange, HSX.com

NewsFutures.com

Iowa* Electronic *Markets

Software *Provider*

Corporate Markets



See also: Prediction markets: value among the crowd, Financial Times, 2013

Prediction Markets: Pros & Cons

Self Study

Pros

- Avoid political issues.
- Aggregate qualitative and quantitative information from multiple sources taking into account confidence levels.
- Can be used for products with no prior history of demand information.
- Provide precise estimates.
- Can be used also to provide distributions in real time and can be used to track impact of events over time.

Cons

- Market efficiency and strength of incentive effects.
- Liquidity Limitations: Markets must be liquid to work, require a lot of investors.
- Potential for manipulation
  - Programmer places a $100k bet on a project running behind schedule and then introduces a virus into the intranet
- Prediction markets are no crystal balls, only aggregate information
  - We can create a market forecasting when Riemann's Hypothesis will be proven; but what is the point?
- Prediction markets may be illegal, or against religious norms.