Forecasting ATE sales at Teradyne, Inc.

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Agenda

- Teradyne's business

- Problem statement

- Process comparison and analysis
  - Teradyne's forecasting process
  - System Dynamics process

- Conclusions and insights

- Next steps

Teradyne

- Manufactures and sells equipment that automatically tests semiconductors
  - Used in wafer sort operations and
  - Final testing after packaging
- Major customers include Intel, Motorola, Texas Instruments, Analog Devices, TSMC

**Semiconductor Capex**
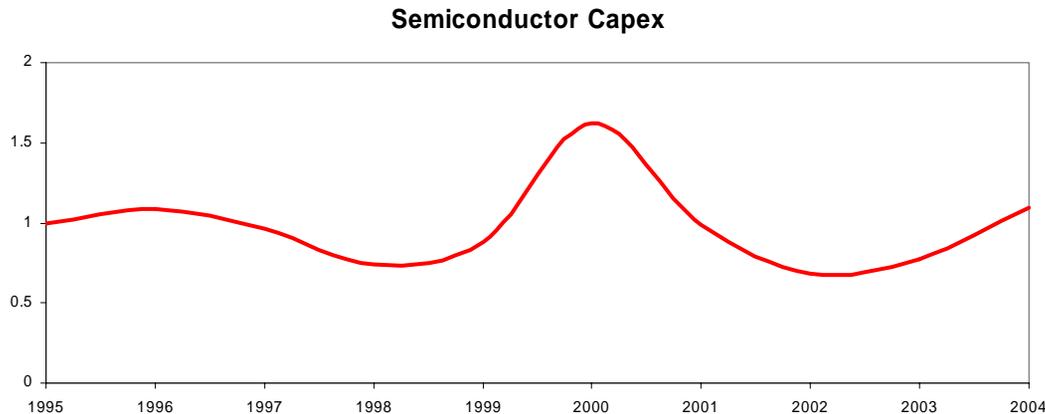
Problem Statement

- Teradyne sees dramatic cyclicality in its orders and struggles to efficiently adjust production to meet demand.

Teradyne's forecasting process

- Size of ATE market correlated with total semiconductor market size
- Historically, Constant buy rate
  - ATE market = 2.5% * semi market
  - Size of semiconductor market based on external forecasts
- Recent data departs from historical trends
- Sales team provides input for market share estimates and short term forecasting based on customer input

Reference Mode Breakdown

- Growth in market size

- Oscillation in market size

- Increasing amplitude of oscillation in market size
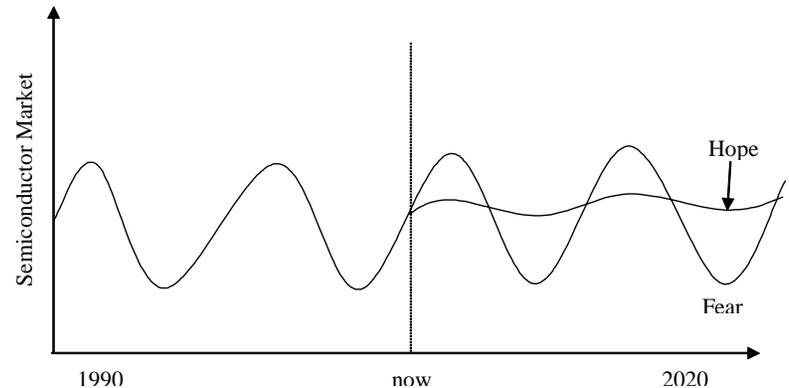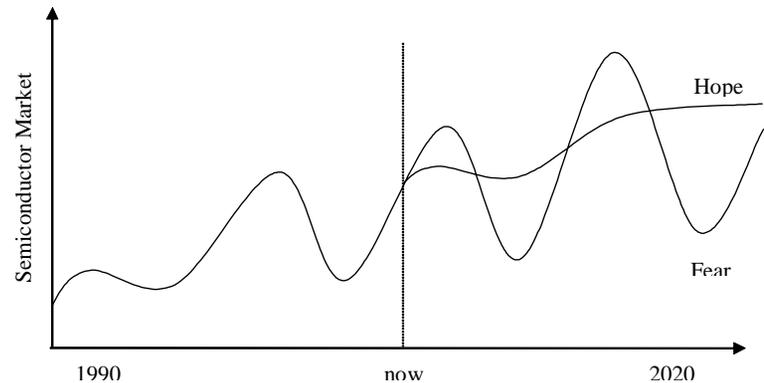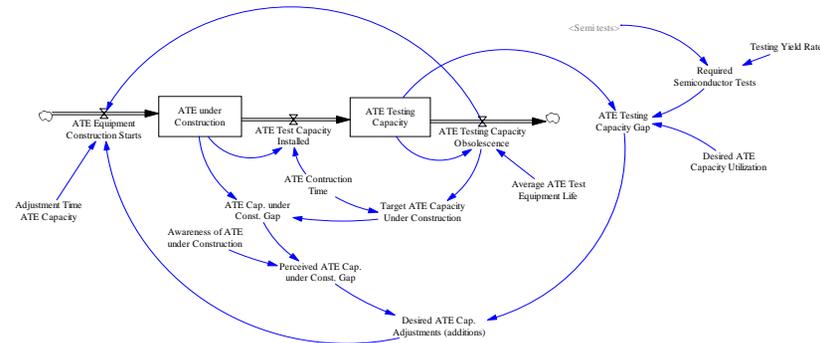
Momentum Policies

- Internal
  - Temporary employment
  - Expandable and contractable capacity
  - Long customer lead times (order to receipt)
  - Surge capacity
  - Shorten component lead times
- External
  - Talk to customers to forecast better

Even with perfect forecasts, operational improvements will drive performance. However the effects of particular policies may not be obvious

Causal Loops – Process Insights

- Quick way to improve understanding of the industry dynamics

- Great way to capture causal relationships

- Expands viewpoint to big picture

- Valuable by themselves

- Easy to understand and work with

Causal Loops – System Insights

- Growth in market size
    - Due to growth in consumer electronics demand
    - Due to growth in semiconductor content in electronics
- Oscillation in market size
    - Due to forecasting methods and delays in capacity adjustment
- Increasing amplitude of oscillation in market size
    - Due to change in industry structure – increasing use of subcontractors

Model Construction

- Forces deep thought on each link of chain, hence detailed understanding of contributing factors
- Leads to revision of dynamic hypotheses
- Time consuming, hence costly

Conclusions and Insights

When to use small policy models?

- Small system dynamics models are better suited to studying internal systems than forecasting external events

- A forecasting model is really only useful if better than current forecasting approach
    - Numerical accuracy is important

- A small forecasting model may lead to a better understanding of exogenous industry structure, but most firms have few high leverage policies available to influence industry structure.

Forecasting drives oscillations

- Oscillations are largely driven by the individual players in the industry trying to predict demand
  - Production decisions throughout the industry are based on demand forecasts due to long production lead times
- Reducing oscillations in the industry will require more accurate forecasting among all players
  - Decreasing forecast horizon improves accuracy and reduces oscillation
  - Decreasing time of historical trend increases responsiveness, but increases magnification
  - Sharing information between firms may also improve forecasting
- Responding quickly to changes in required capacity does not significantly affect oscillation magnitude unless forecast horizons are changed

Setting Customer Lead Times

- Longer delivery lead times increase volatility in customer orders
  - Requires customers to make longer term forecasts about equipment requirements
  - Results in less accurate ordering - cancelled orders and pushbacks may become more common
- Balance increased risks from volatility against reduced inventory risks from forcing customers to commit early prior to inventory investments

Oscillations Aren't All Bad

- Industry cyclicality is good for total sales.
- Oscillating demand for ATE results in more ATE sales
- Testing capacity is driven by peak demand

Forecasting Isn't Everything

- Even a perfect forecast won't solve Teradyne's problems
- Problems stem from the rapid oscillations of demand relative to speed Teradyne can adjust inventory and capacity
- Competitive pressure makes reduction in production hard despite knowing that current growth is not sustainable
  - Customer lock-in increases the risks associated with limiting capacity
  - Large percentage of total sales are made during booms

Bullwhip effect is severe and worsening

- Disaggregation of industry leads to increased volatility
- Increasing numbers of firms in supply chain increases forecasting errors
    - Less information sharing
    - More steps in the value chain with forecasts at each step
- IDMs and subcontractors respond to different market signals and probably set ATE capacity targets differently
    - Forecasting may improve by considering IDM and subcontractor purchase decisions differently

Next steps

- Integrate insights into forecasting efforts
  - Investigate regression model including growth and size of the semiconductor market
  - Consider time delays in systems – use regression models with time lags
- Choose how to use System Dynamics in the future
  - Continue with current forecasting approach without System Dynamics
  - Continue policy model level efforts internally to improve system level understanding and improve current methodology
  - Consider value of investing in fully calibrated System Dynamics model for forecasting