How Product Developers Create Flow

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Today's Topics

1. The world of product developers
2. Managing economics
3. Achieving flow
4. Rethinking variability

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Rough Agenda

1245-1300	The World of Product Developers (15m)
1300-1320	Managing Economics (20m)
1320-1345	Discussion (25m)
1345-1405	Achieving Flow (20m)
1405-1430	Discussion (25m)
1430-1500	Break (30m)
1500-1520	Rethinking Variability (20m)
1520-1545	Discussion (25m)

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The World of Product Developers

- **Why Lean Manufacturing makes money**
- **What is different about the product development domain**
- **The challenge of forecasting**

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How Lean Changed Manufacturing

TRADITIONAL MANUFACTURING

- Inventory is an Asset
- Focus on High Efficiency
- Use Large Batch Sizes
- Tolerate Expensive Set-ups
- Use Specialized Resources
- Control of Detailed Time Lines
- Emphasize Forecasting/MRP
- Long Cycle Time
- Heavy Status Reporting

LEAN MANUFACTURING

- Inventory is Waste
- Focus on Smooth Flow
- Use Small Batch Sizes
- Make Set-ups Cheap
- Create Flexible Resources
- Control of Queues
- React to WIP changes
- Short Cycle Time
- Little Status Reporting

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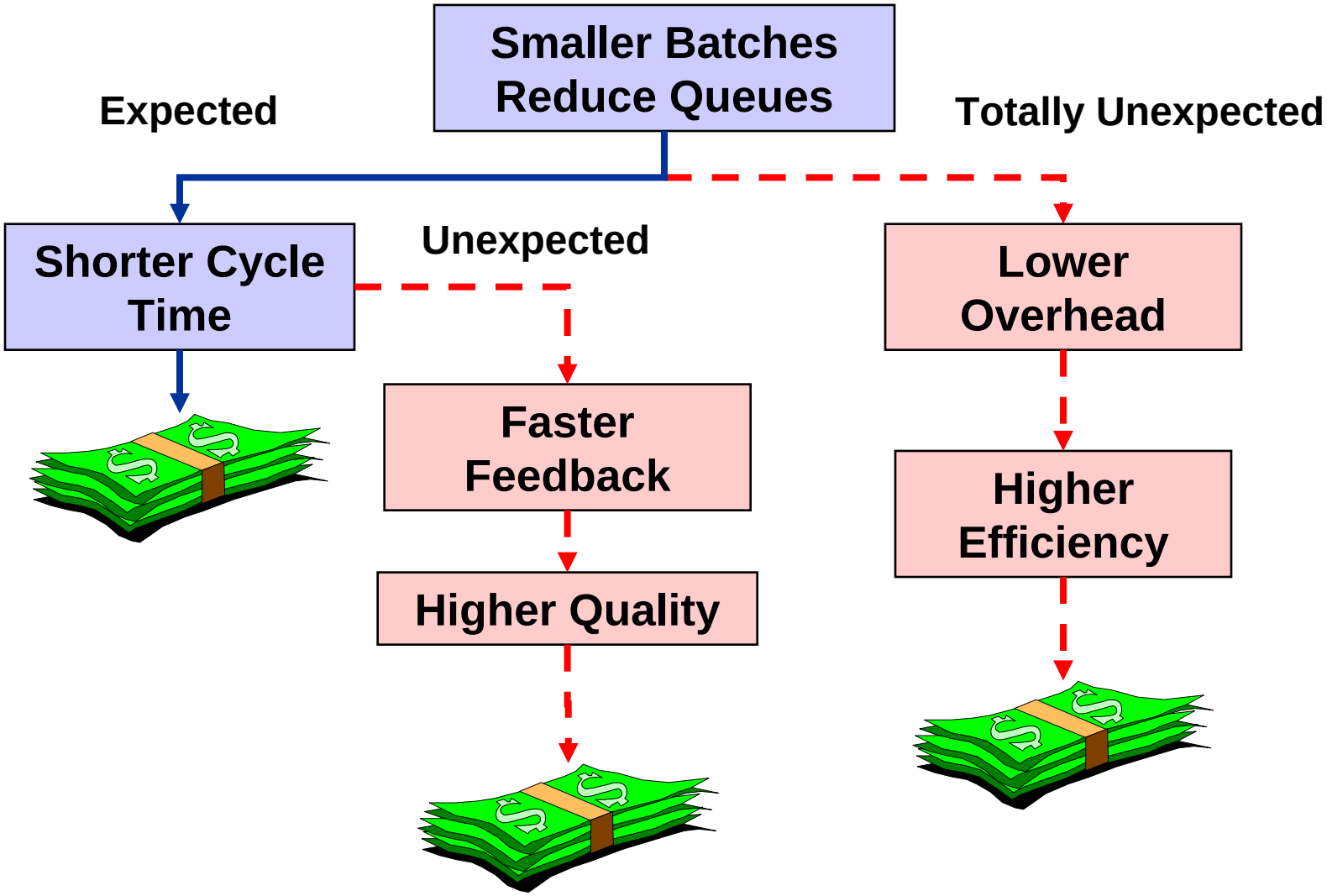
Why Lean Makes Money



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How Development is Different

	MANUFACTURING	DEVELOPMENT
Tasks are...	Repetitive	Non-repetitive
Tasks are...	Predictable	Unpredictable
Requirements are…	A Constraint	A Degree of Freedom
Requirements are...	Fixed	Evolving
Work is...	Bounded	Unbounded
Cost of Delay is...	Homogeneous	Non-homogeneous
Task Durations are...	Homogeneous	Non-homogeneous
Variability is...	Always Harmful	Sometimes Required
Inventory is...	Visible	Invisible
Inventory is...	Physical Objects	Information

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Tomahawk (TLAM-C)

- **Highly accurate: GPS, TERCOM**
- **Subsonic: < Mach 1**
- **Low observability**

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AIM-120 AMRAAM

- **Air-to-Air**
- **Mach 4**
- **Radar-guided**

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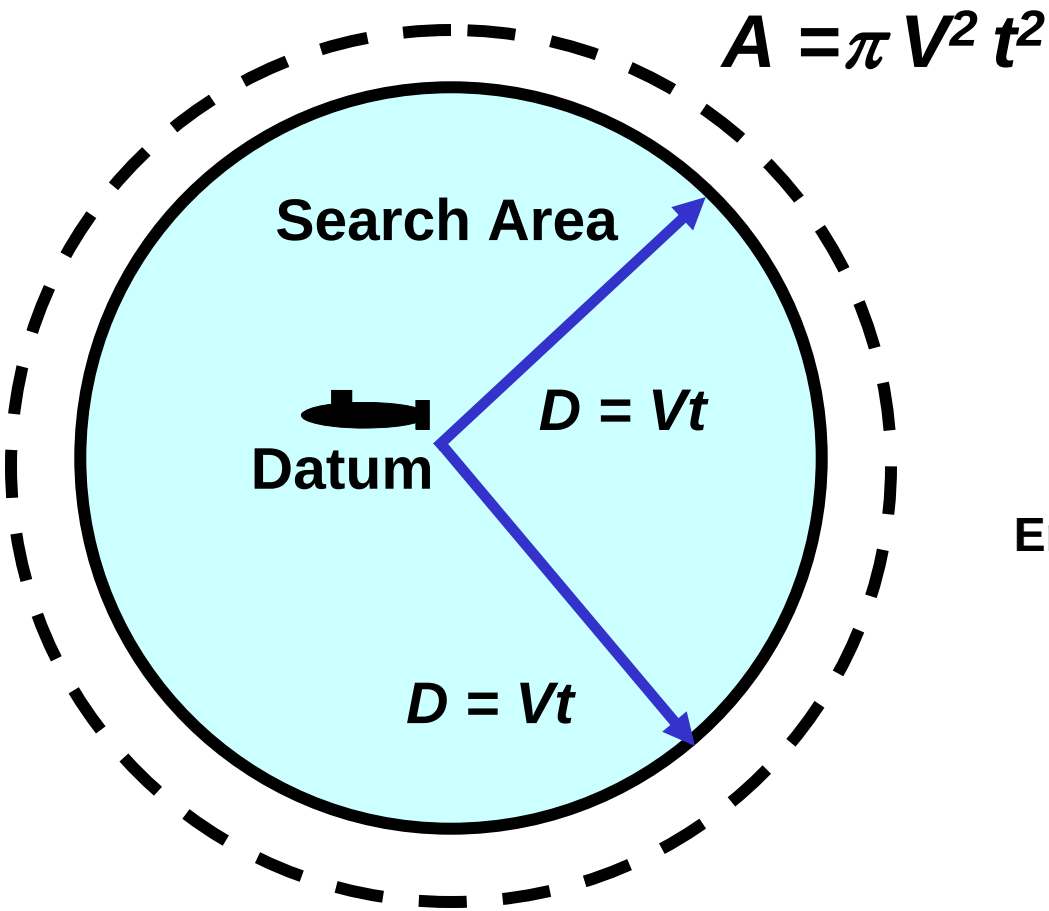
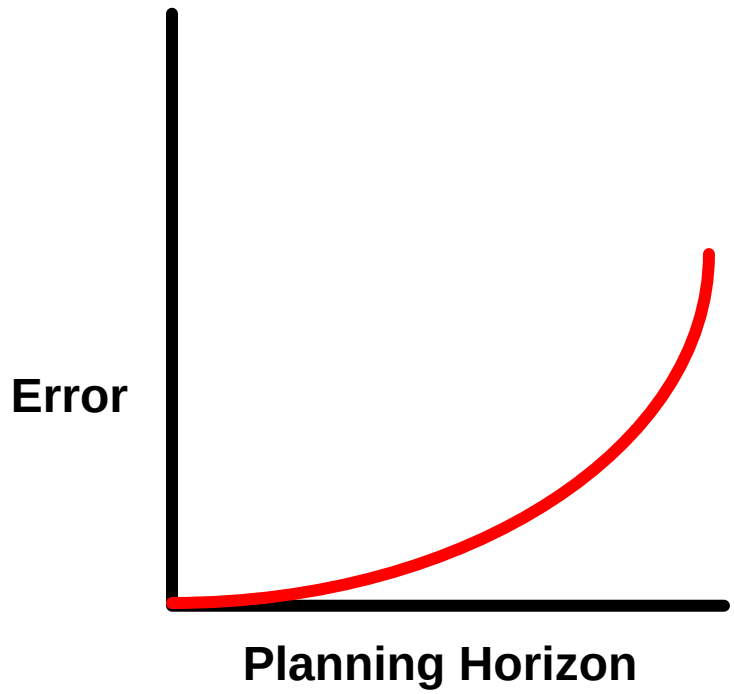
The Forecasting Challenge





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Managed Adaptation Is Vital

- **Complexity is rising – more degrees of freedom.**
- **Uncertainty is rising – higher velocity of change.**
- **Forecasting is getting exponentially harder.**
- **We can’t front load decisions.**
- **We must make important decisions quickly, correctly, and continuously.**

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Managing Economics

- **The role of economic frameworks**
- **Influencing daily decisions**
- **Economically based priorities**

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Typical Questions

Should we operate the testing area at 80 percent utilization with a 2 week queue, or at 90 percent utilization with a 4 week queue?

How can we explain the logic of these choices to management?

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Nature of Our Economics

- **When you trade things of value for other thing of value, you should know what they are worth.**
- **Important decisions will affect multiple interconnected variables.**
- **We should select our actions based on quantified overall economic impact.**

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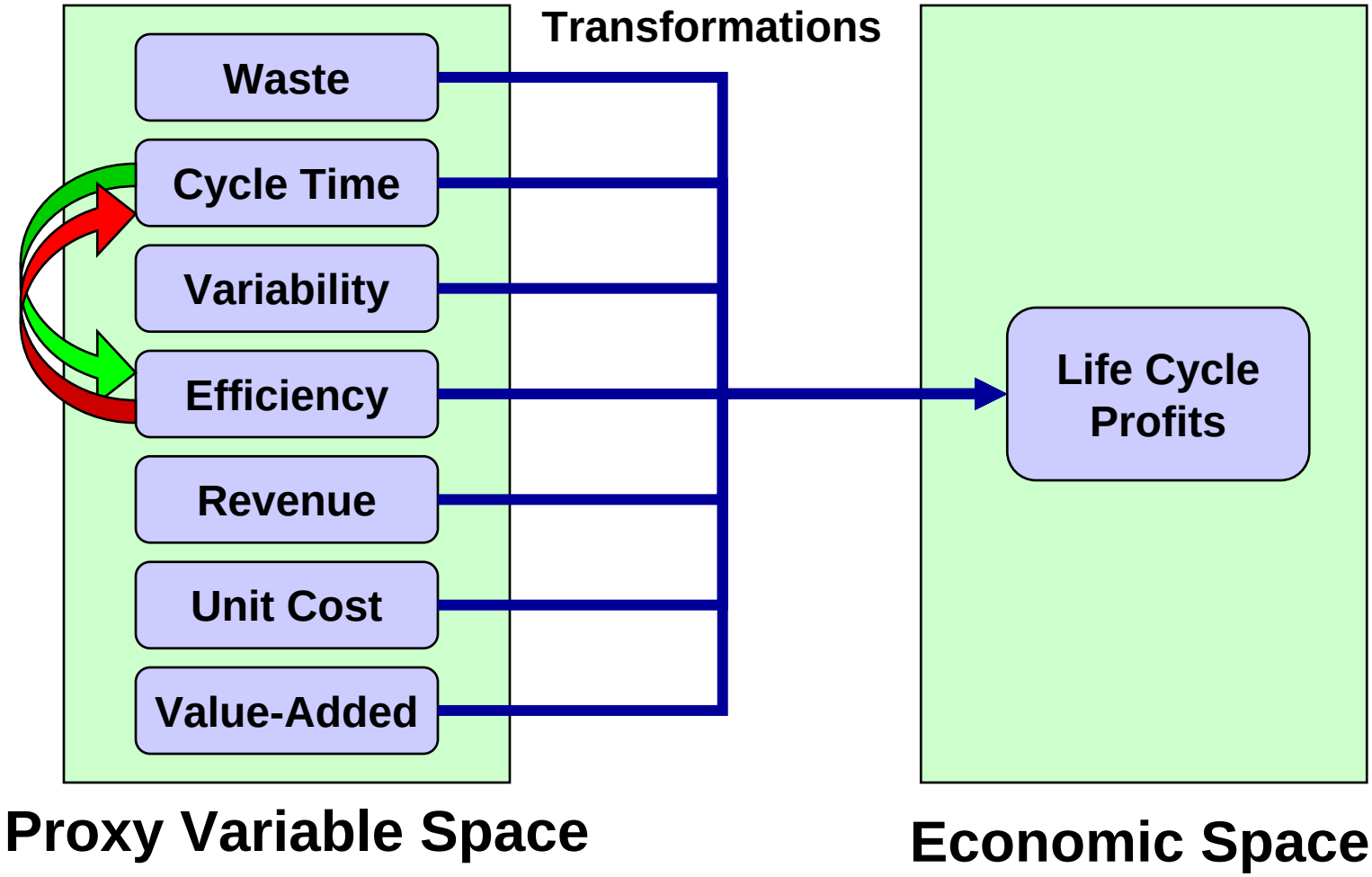
Making Economic Decisions



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Creating an Economic Framework

- **Treat the project like a black box.**
- **Identify key measures of performance (MOPs).**
- **Assess the overall economic consequences of deviating from objectives in each of these areas.**
- **Turn this into sensitivity factors or transfer functions.**
- **Quantify all consequences of a complex event in the same unit of measure: life-cycle profit impact.**
- **Use this quantification to choose the path that maximizes the overall system-level economic benefits.**

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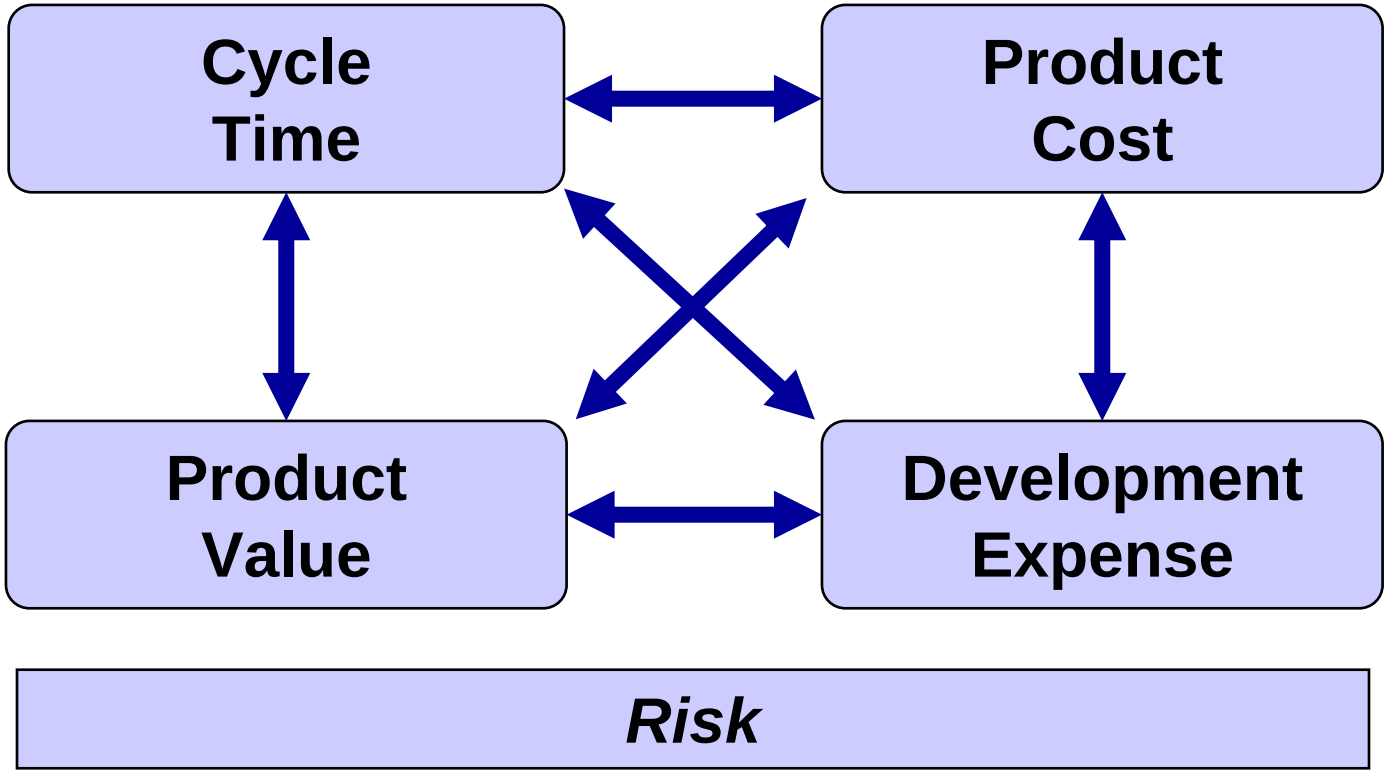
The Five Economic Objectives



Do sensitivities on the "currencies" that you trade for things of value.

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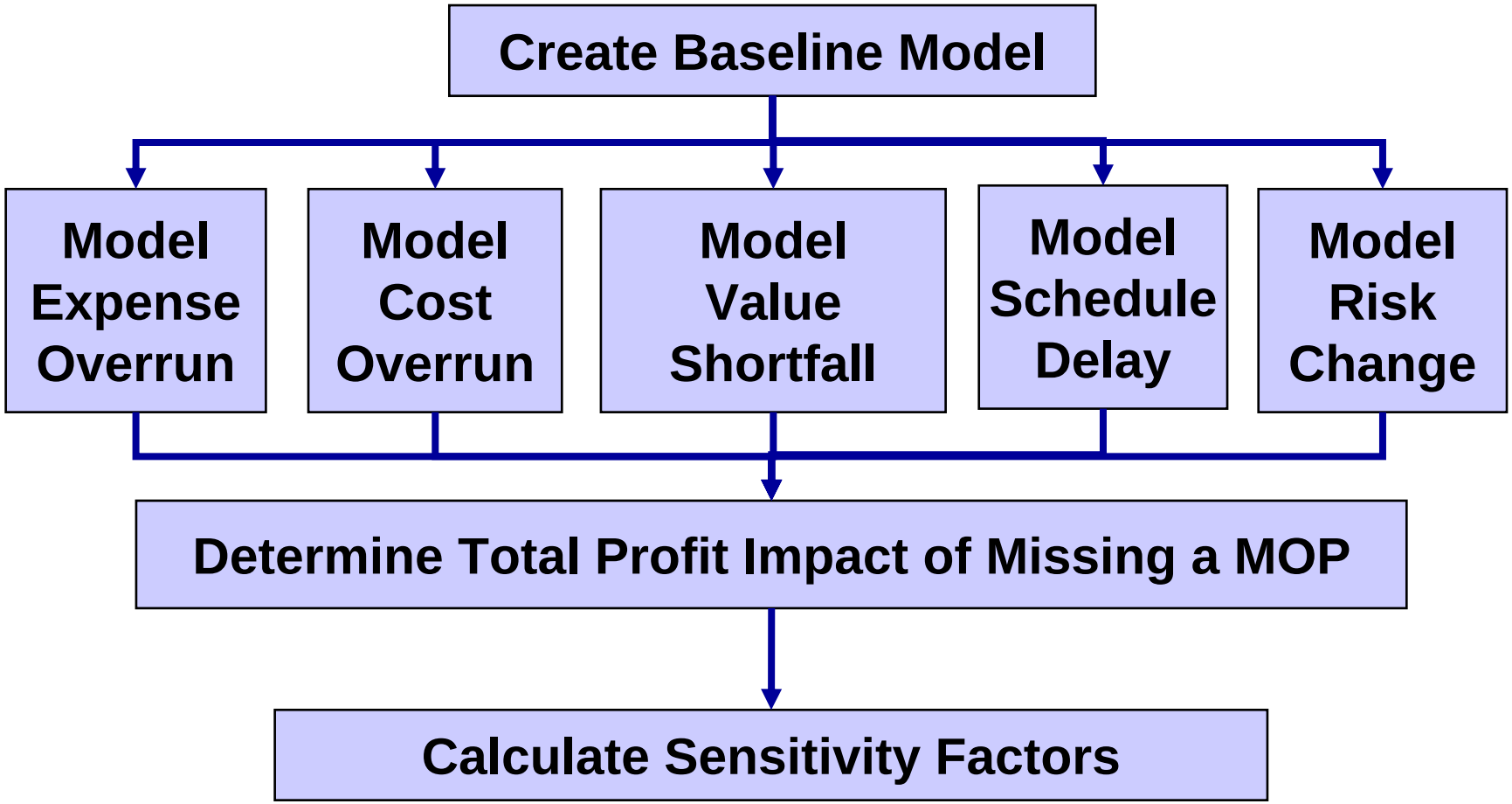
The Modeling Process



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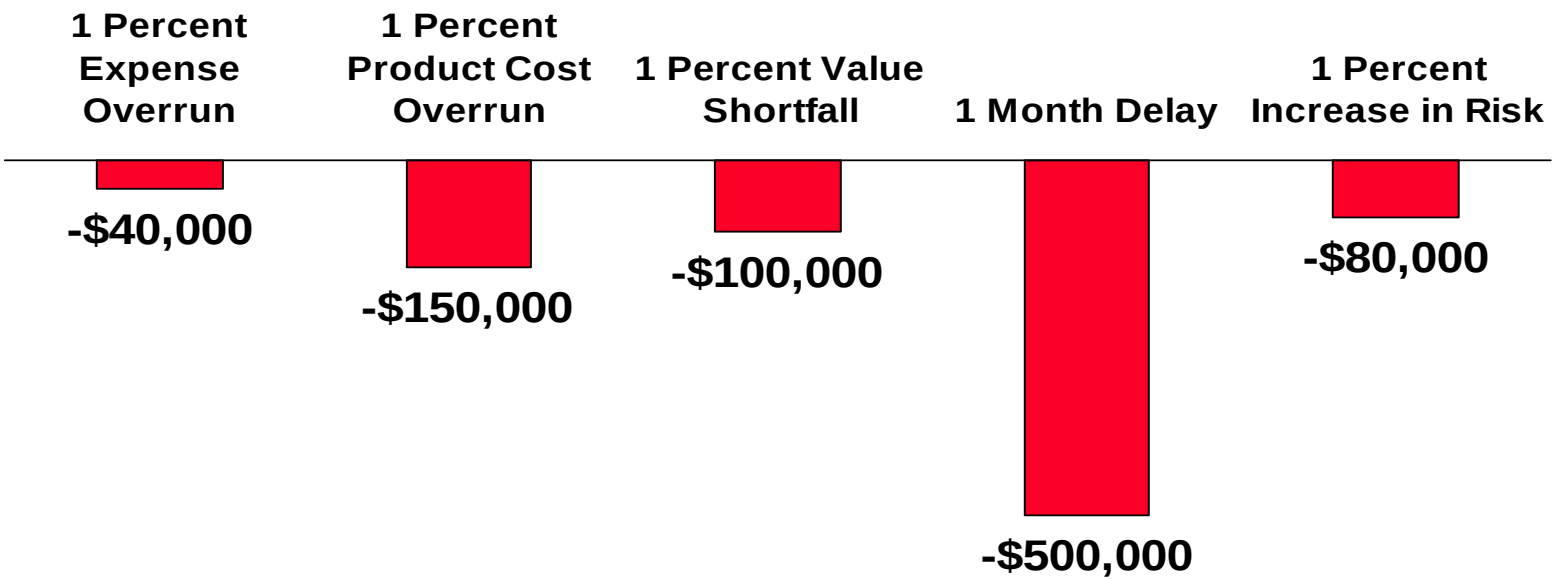
The Model Output

Life-Cycle Profit Impact



A Cost of Delay makes invisible queues financially visible.

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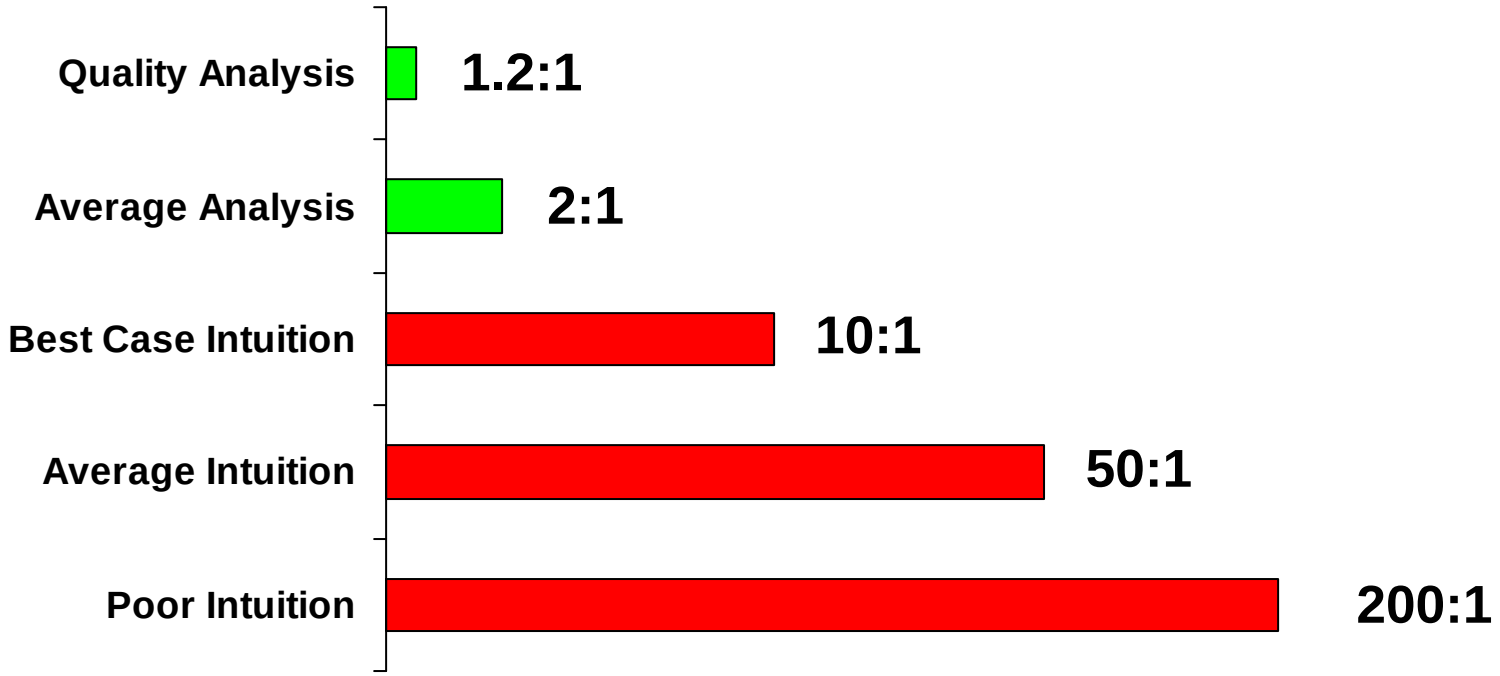
Any Analysis Beats Intuition

Range of Cost of Delay Estimates



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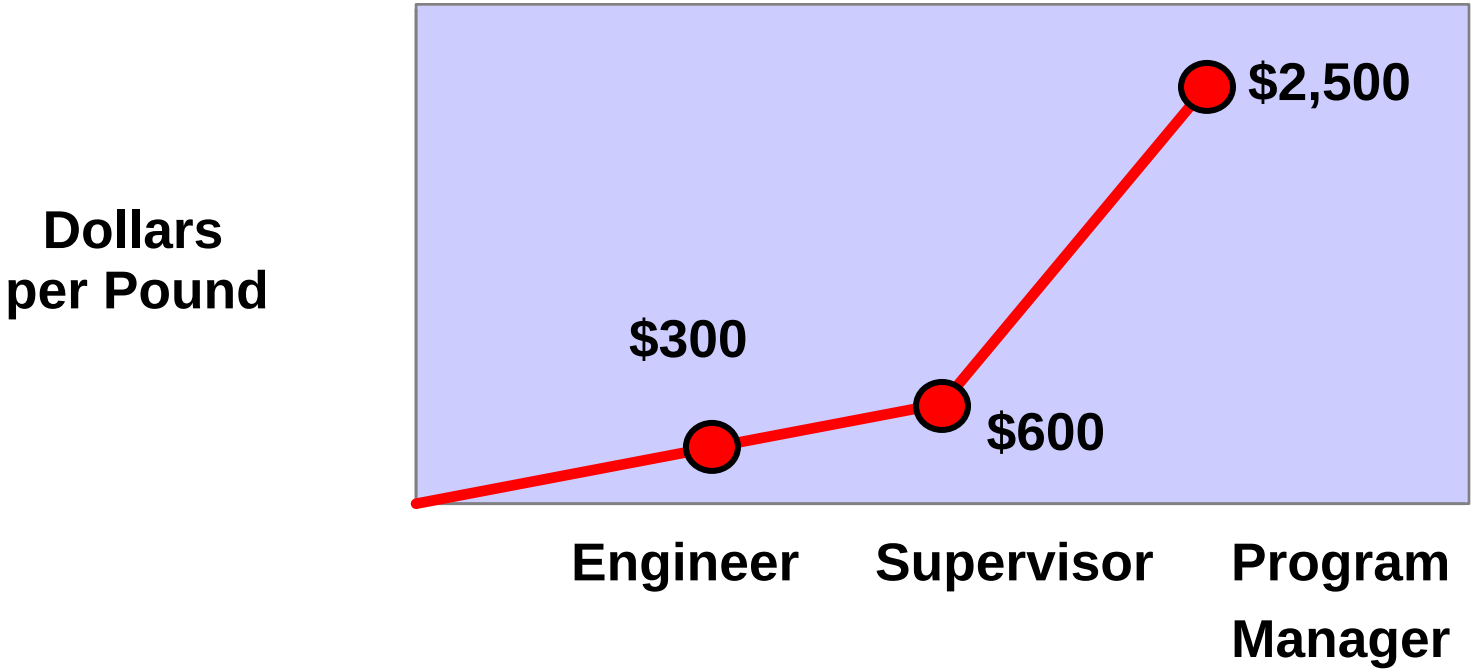
Decentralizing Control with Decision Rules

Boeing 777 Weight Reduction

Decision Authority



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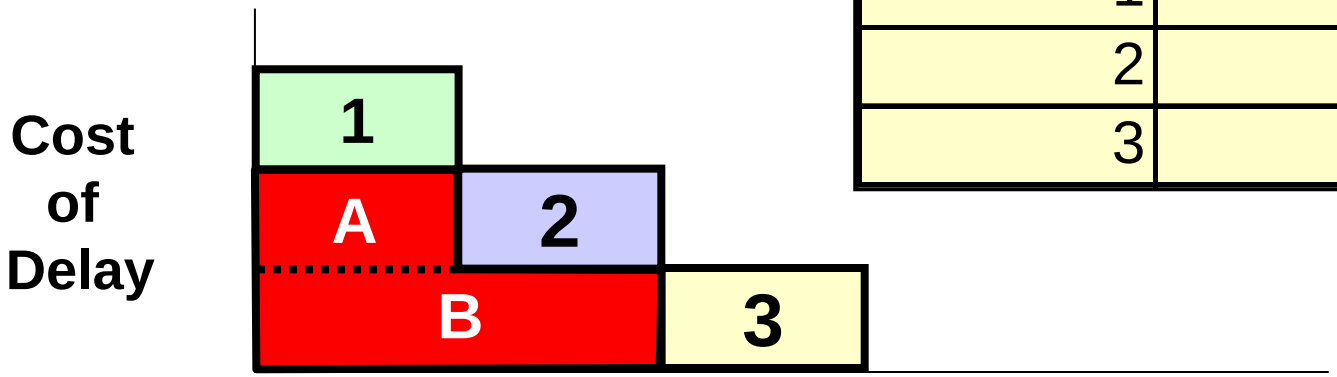
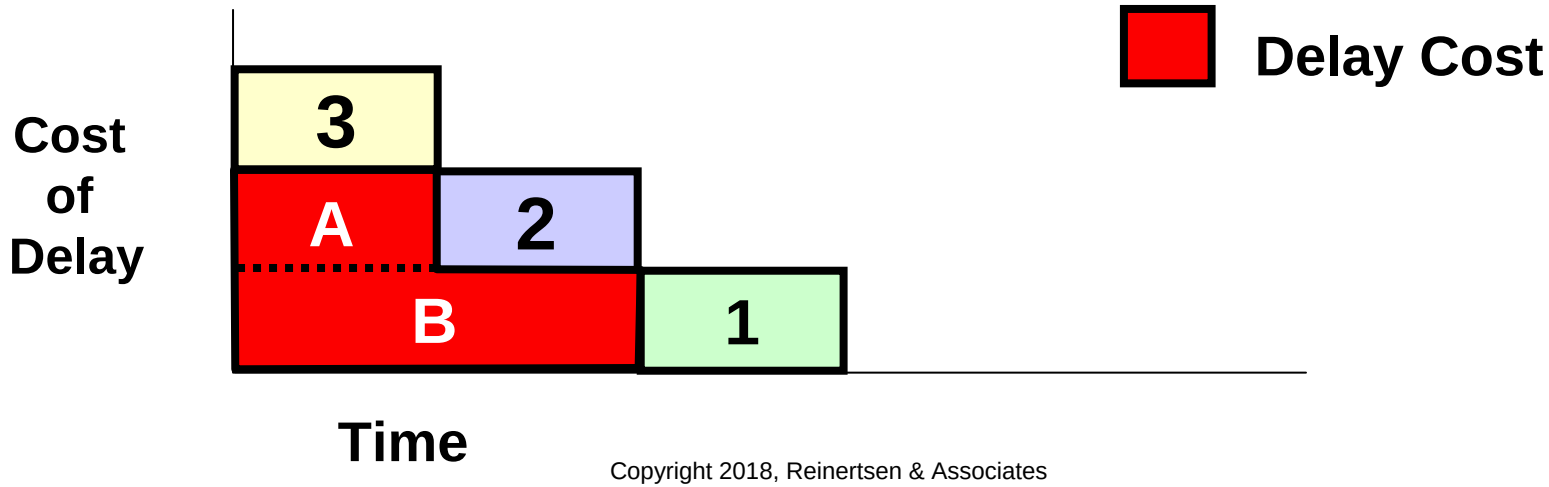
Use FIFO for Homogeneous Flow

Project	Duration	Cost of Delay
1	3	3
2	3	3
3	3	3

First-In First-Out



Last-In First-Out



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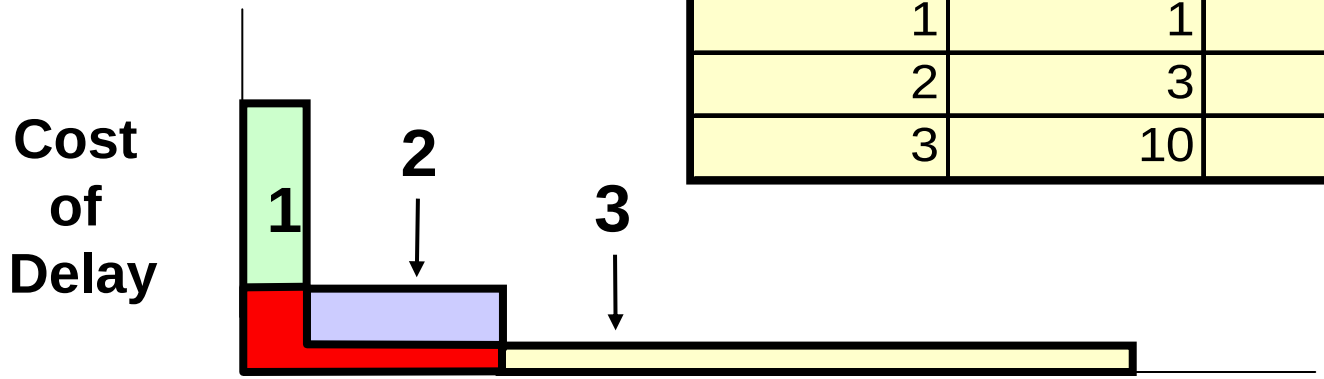
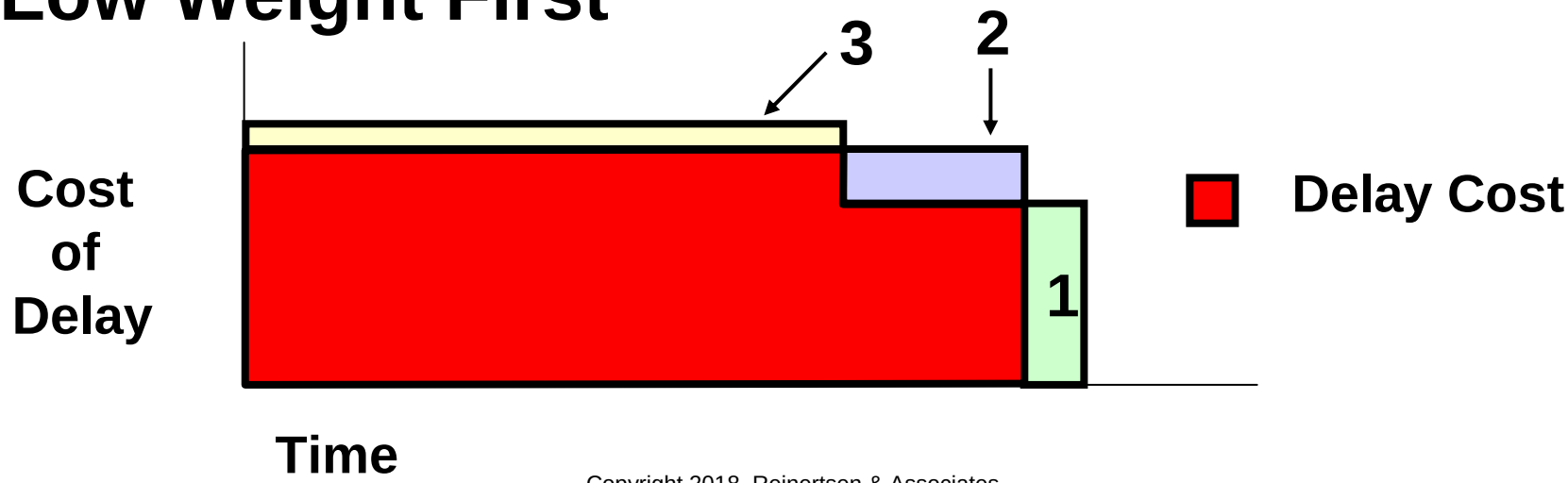
Weighted Shortest Job First (WSJF)

Project	Duration	Cost of Delay	Weight = COD/ Duration
1	1	10	10
2	3	3	1
3	10	1	0.1

High Weight First



Low Weight First



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A Possible Approach

Cost of Delay	Long	Medium	Short
High	4	2	1
Medium	7	5	3
Low	9	8	6

Duration

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Managing Economics: Discussion

- **The role of economic frameworks**
- **Influencing daily decisions**
- **Economically based priorities**

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Achieving Flow

- **Revealing invisible queues**
- **Reducing batch size**
- **Reducing WIP**
- **Monitoring WIP and flows**

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Traffic at rush hour illustrates the classic characteristics of a queueing system.

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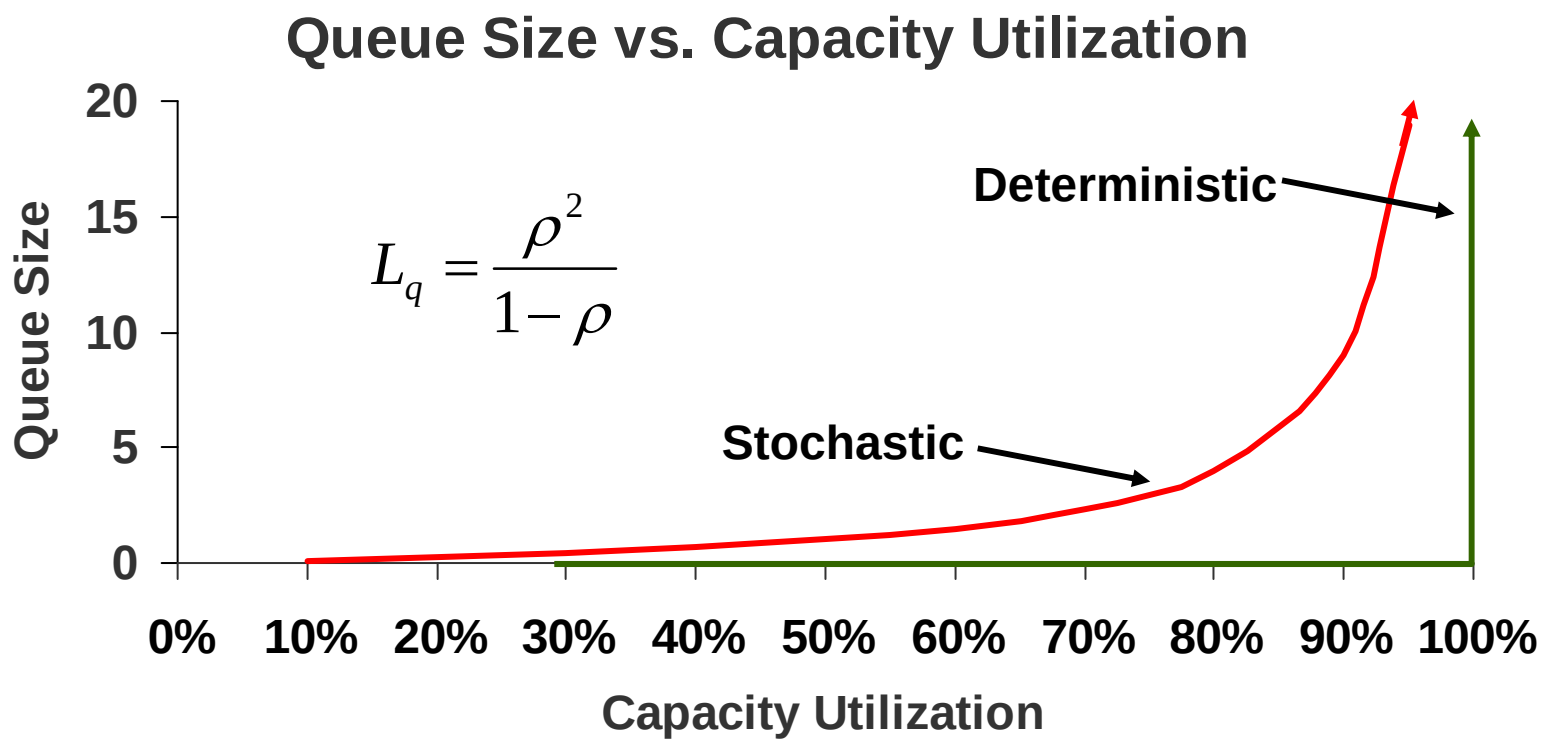
The Effect of Capacity Utilization



Notes: Assumes M/M/1/∞ Queue, ρ = Capacity Utilization, L_q = Length of Queue

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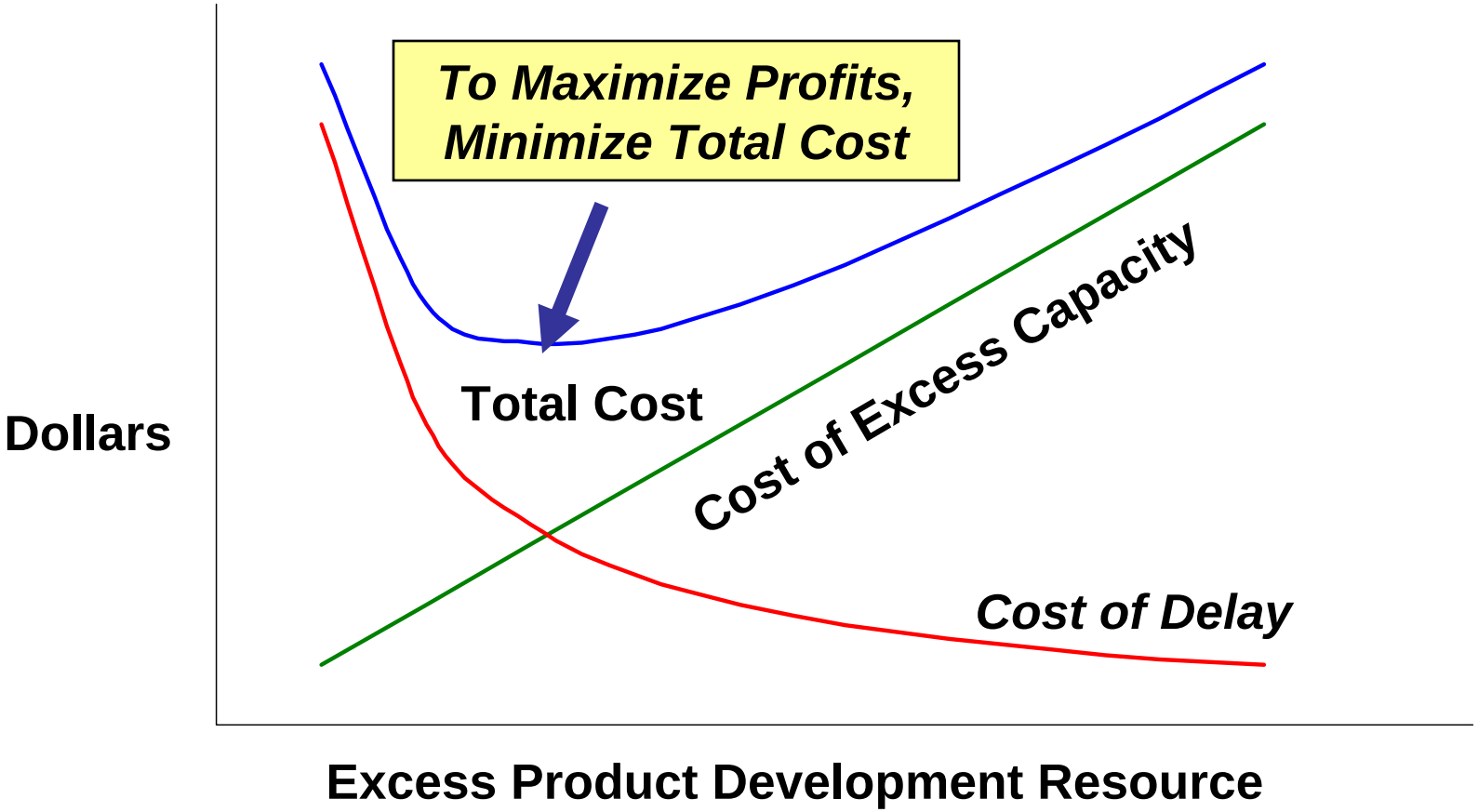
The Effect of Excess Capacity



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Why Queues Matter

Managing Queues is the key to improving product development economics.

Queues Create...

- **Longer Cycle Time**
- **Increased Risk**
- **More Variability**
- **More Overhead**
- **Lower Quality**
- **Less Motivation**

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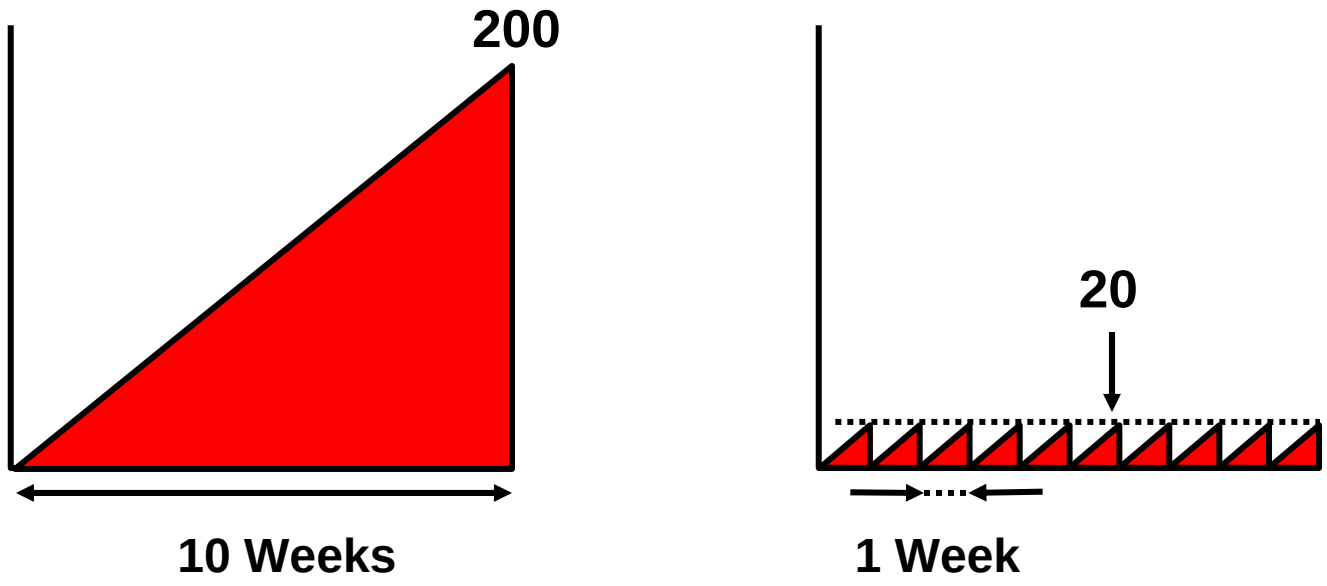
Drawing Review Process

Large Batch **Small Batches**



Unreviewed Drawings

Average feedback delay drops from 35 days to 3.5 days.

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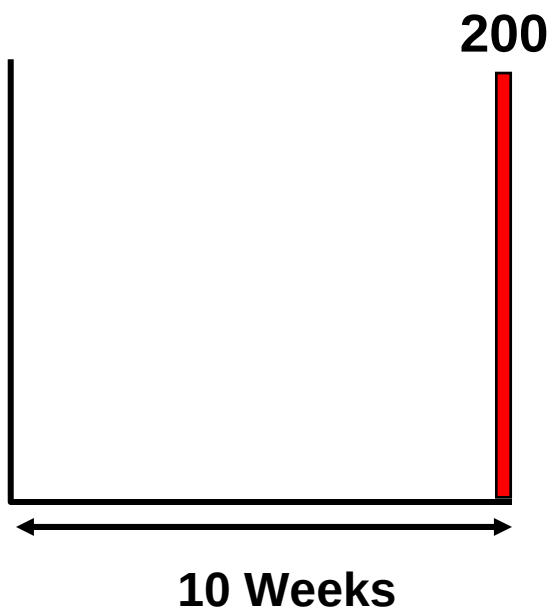
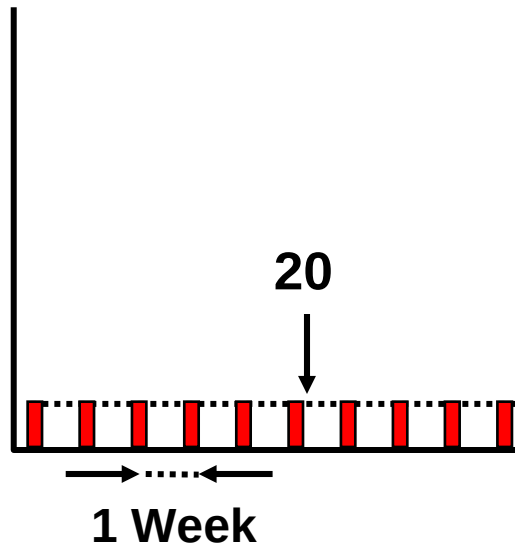
Drawing Arrival Rate

Large Batch



Small Batches



Unreviewed Drawings

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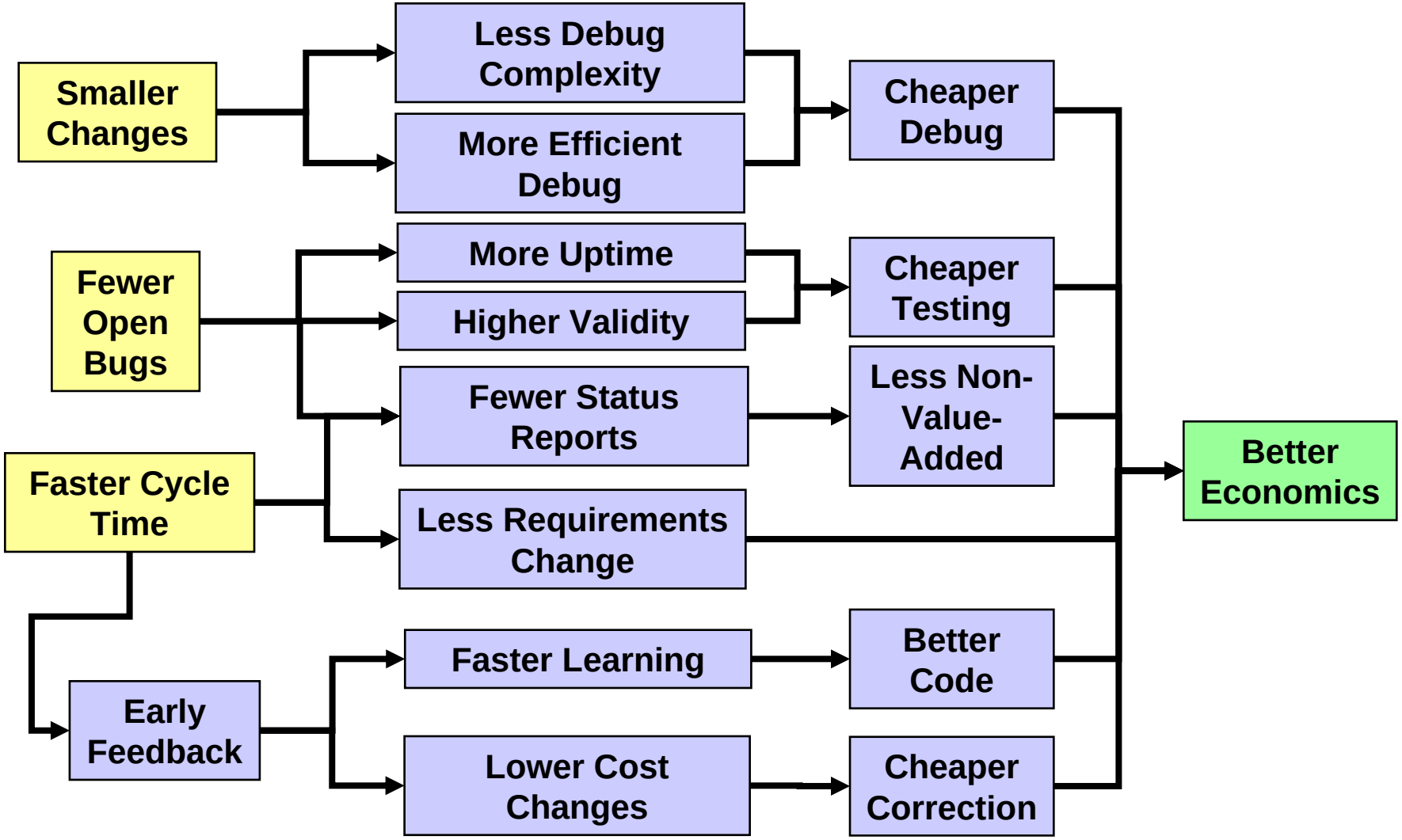
Benefits of Small Batch Testing



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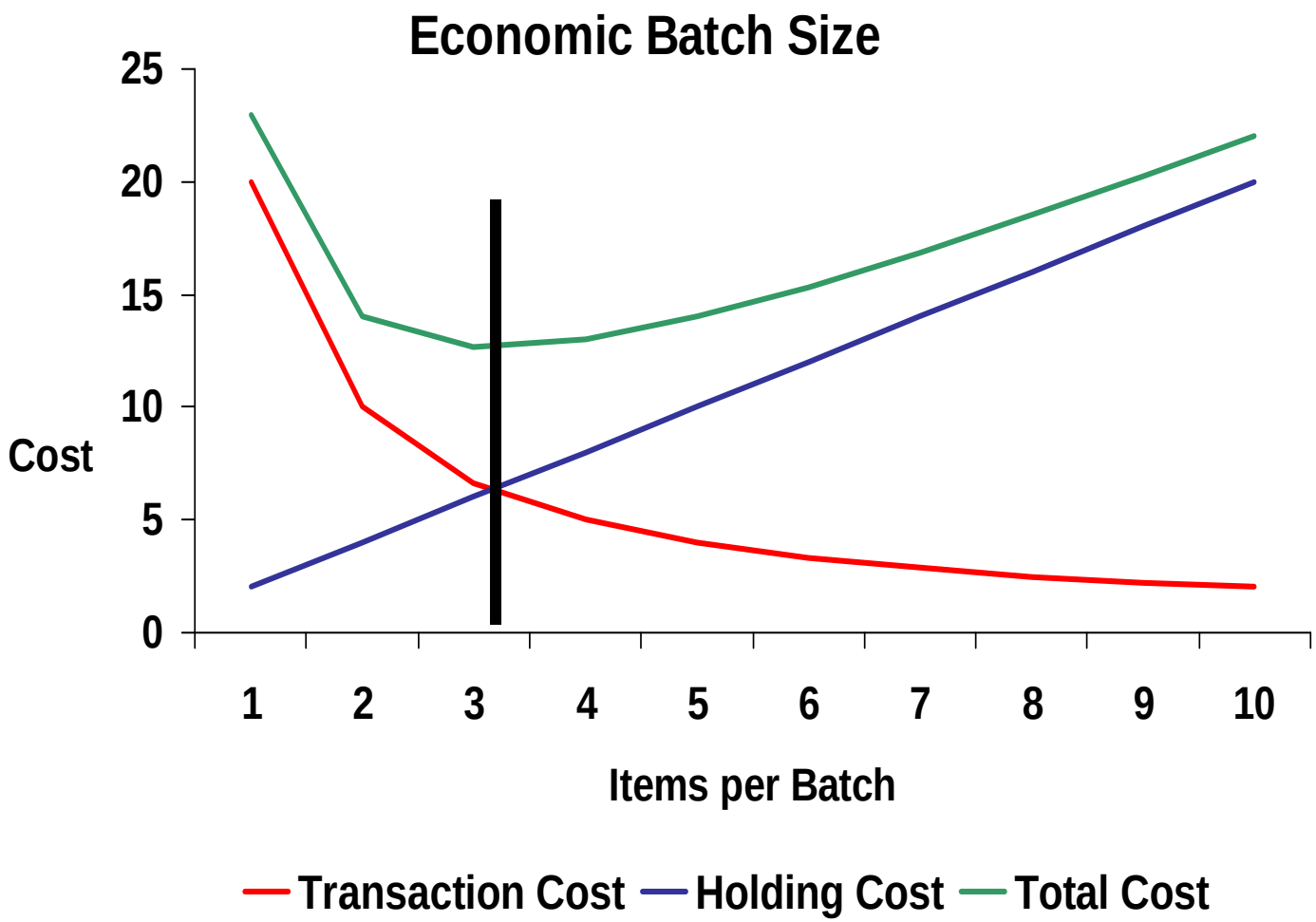
Finding Optimal Batch Size



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WIP Constraints

- **If we reject work that would shift system into a high queue state:**
  - **…we prevent the heavy damage done by these states,**
  - **…and we only have to block entry a small portion of the time.**
- **Like batch size, WIP constraints are cheap, easy, effective, granular, and reversible.**

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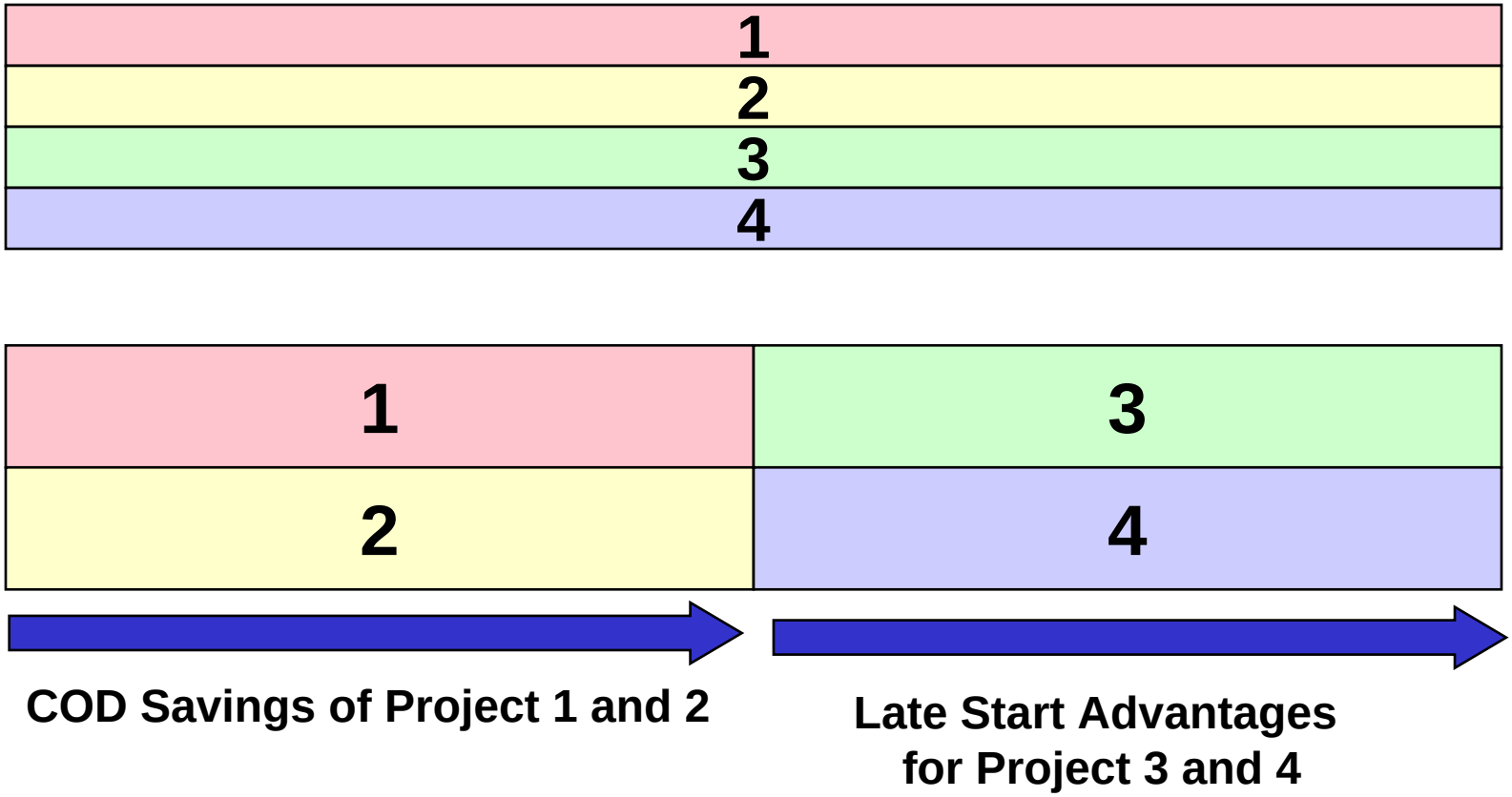
Limiting Active Projects by Blocking Entry



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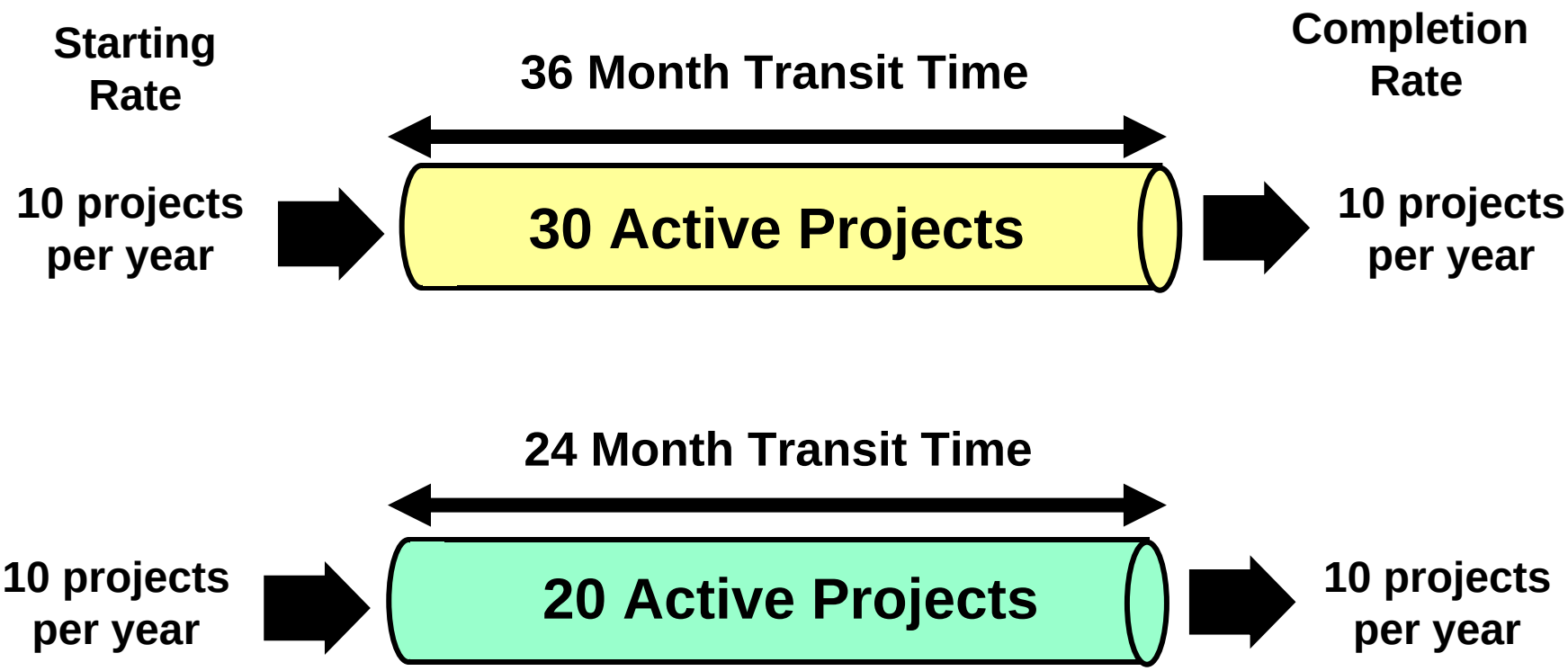
Reducing Occupancy



$$\text{Little's Law}: W_s = \frac{L_s}{\lambda}$$

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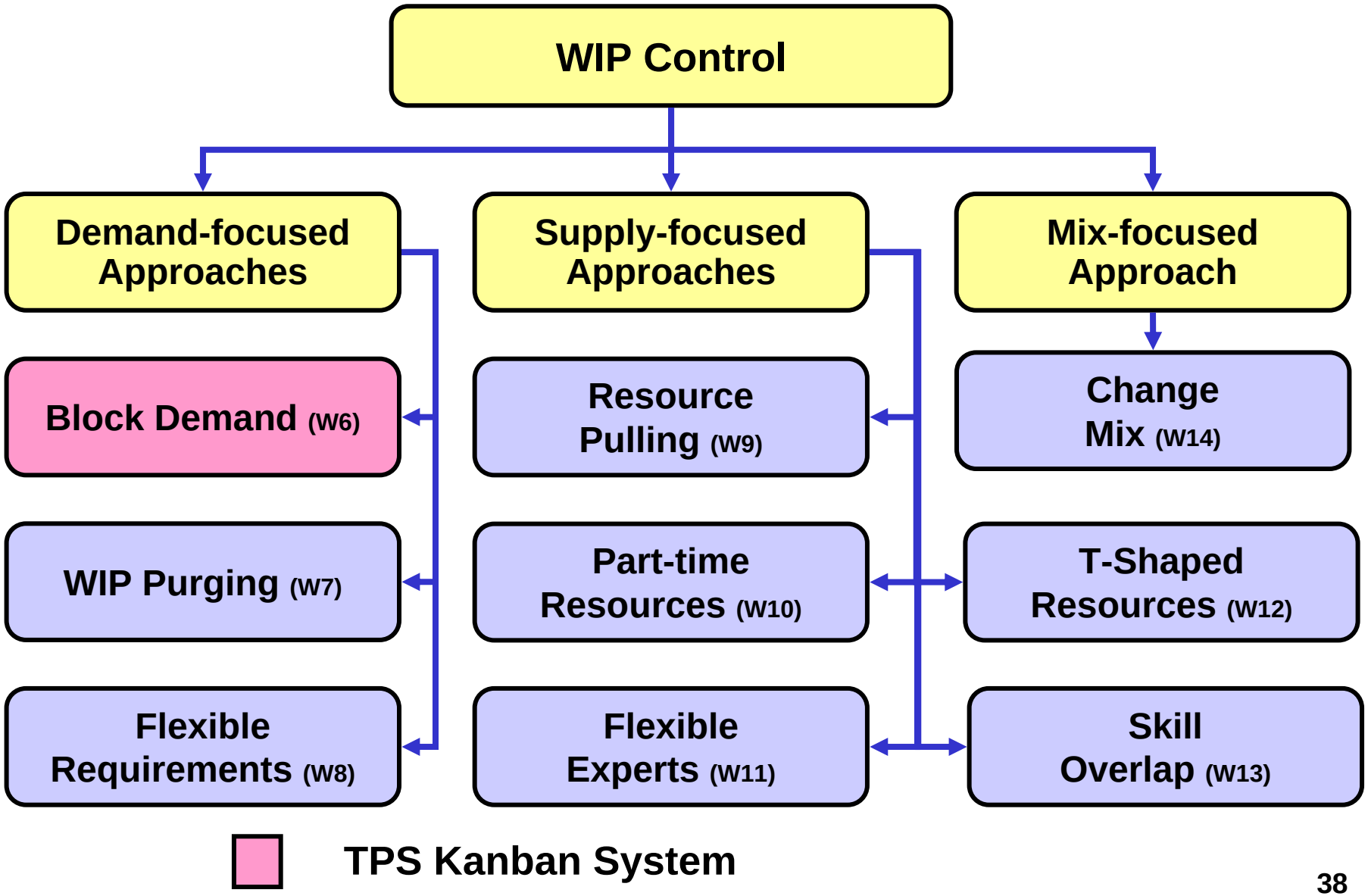
Methods of WIP Control



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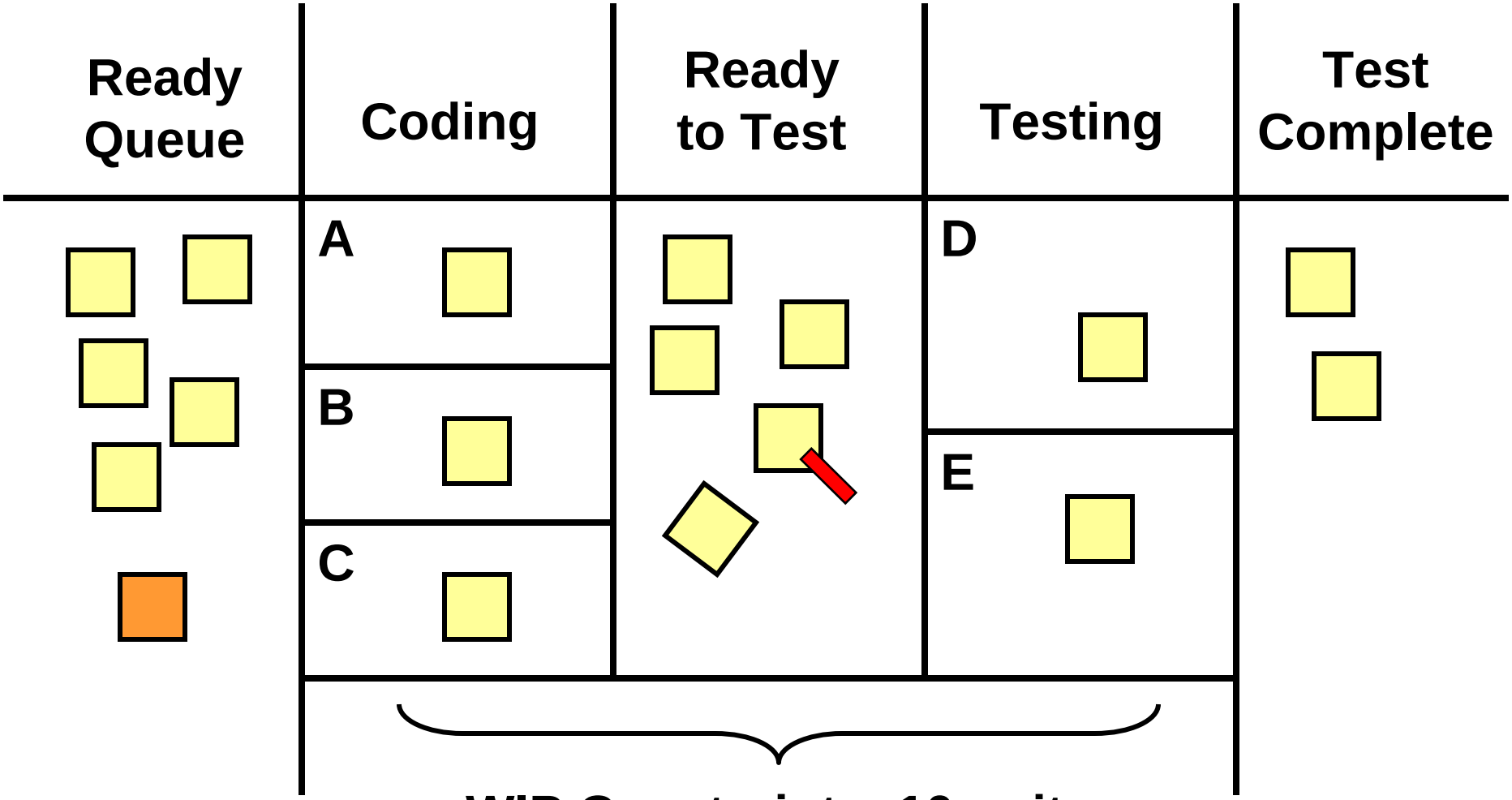
Visual WIP Control Boards



WIP Constraint = 10 units

WIP constraints can be local, regional, or global.

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Achieving Flow: Discussion

- **Revealing invisible queues**
- **Reducing batch size**
- **Reducing WIP**
- **Monitoring WIP and flows**

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Rethinking Variability

- **Understanding variability**
- **Creating antifragility**
- **Payload management**

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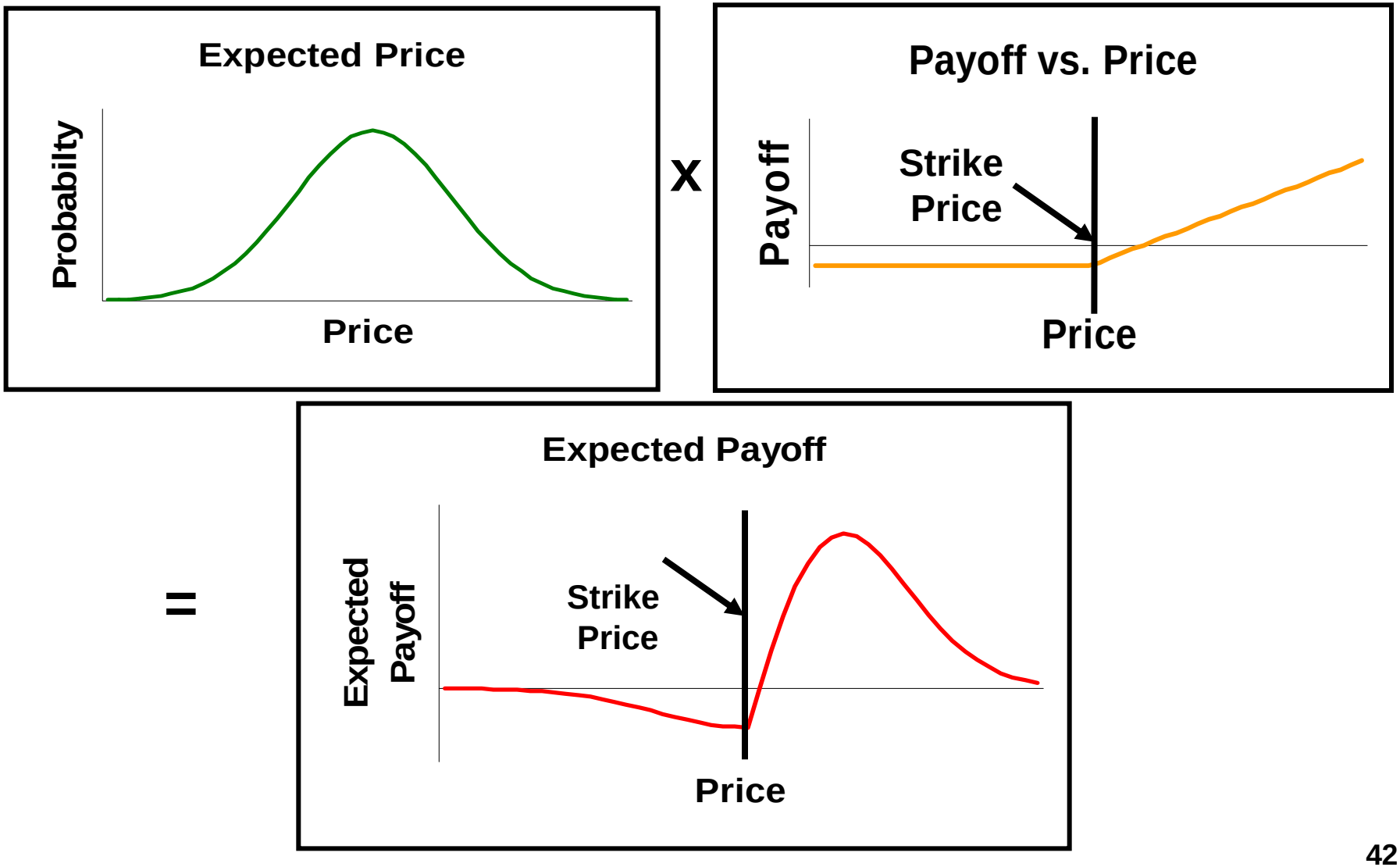
Asymmetric Payoffs and Option Pricing



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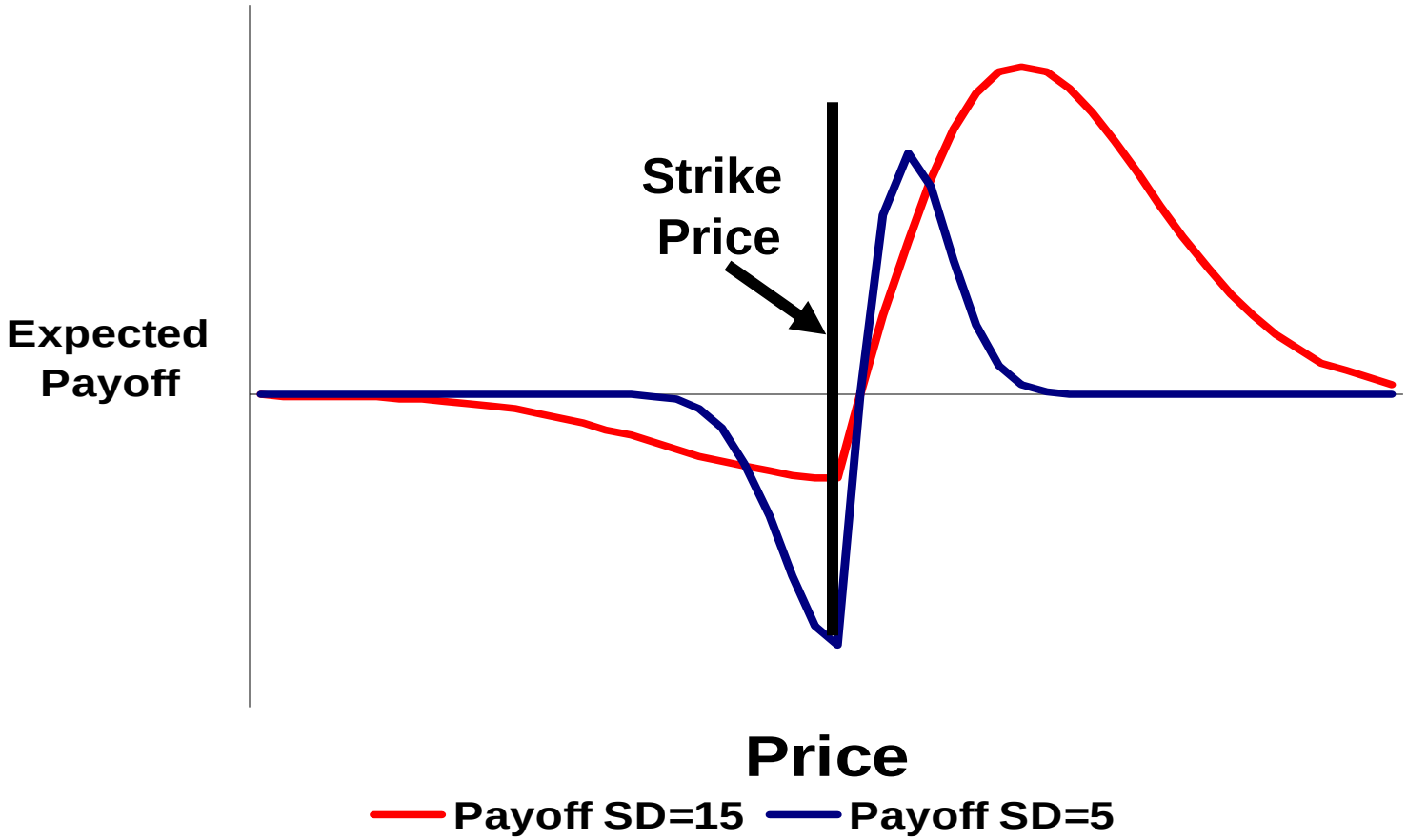
Higher Variability Raises This Payoff



Option Price = 2, Strike Price = 50,
Mean Price = 50, Standard Deviation = 5 and 15

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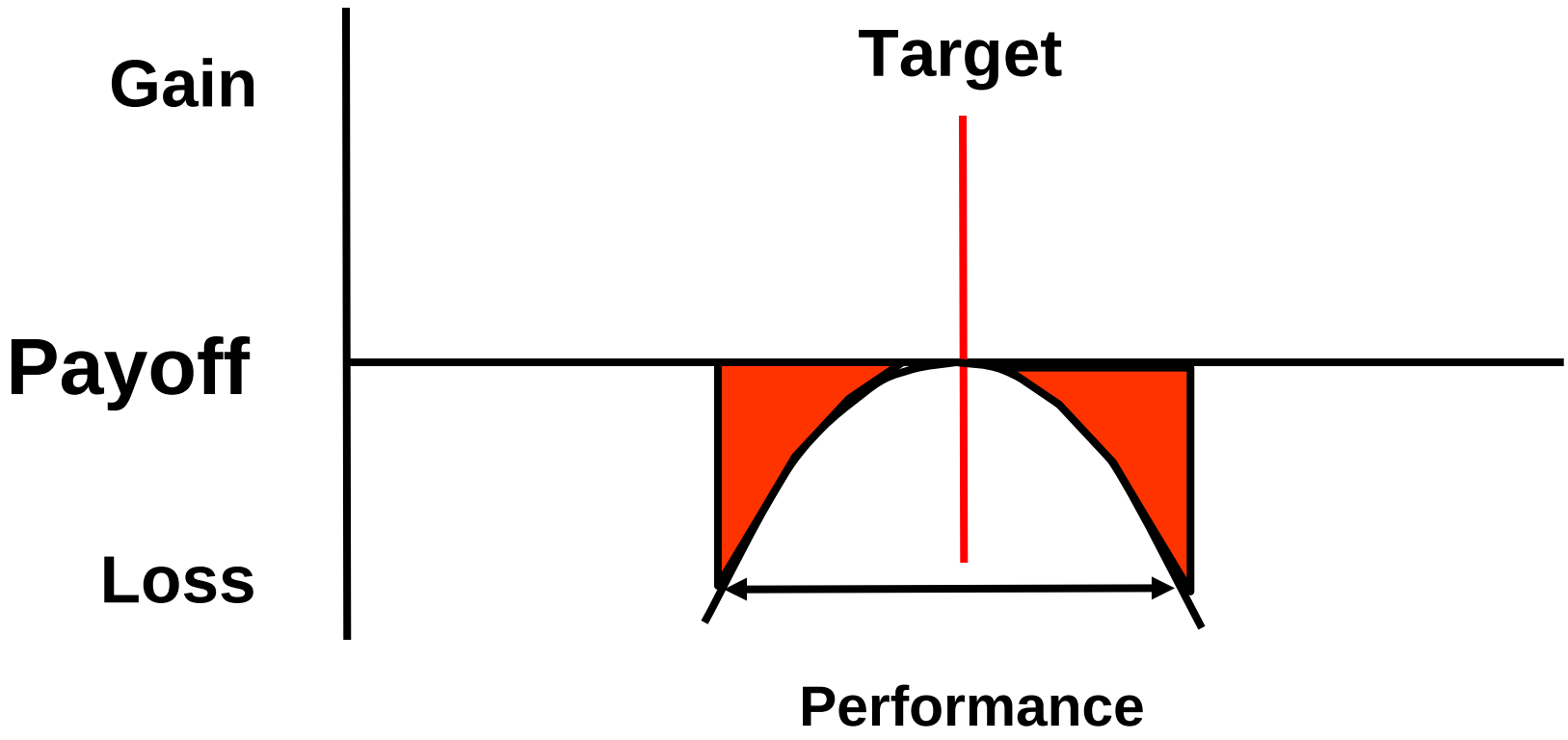
Manufacturing Payoff-Function



Larger Variances Create Larger Losses

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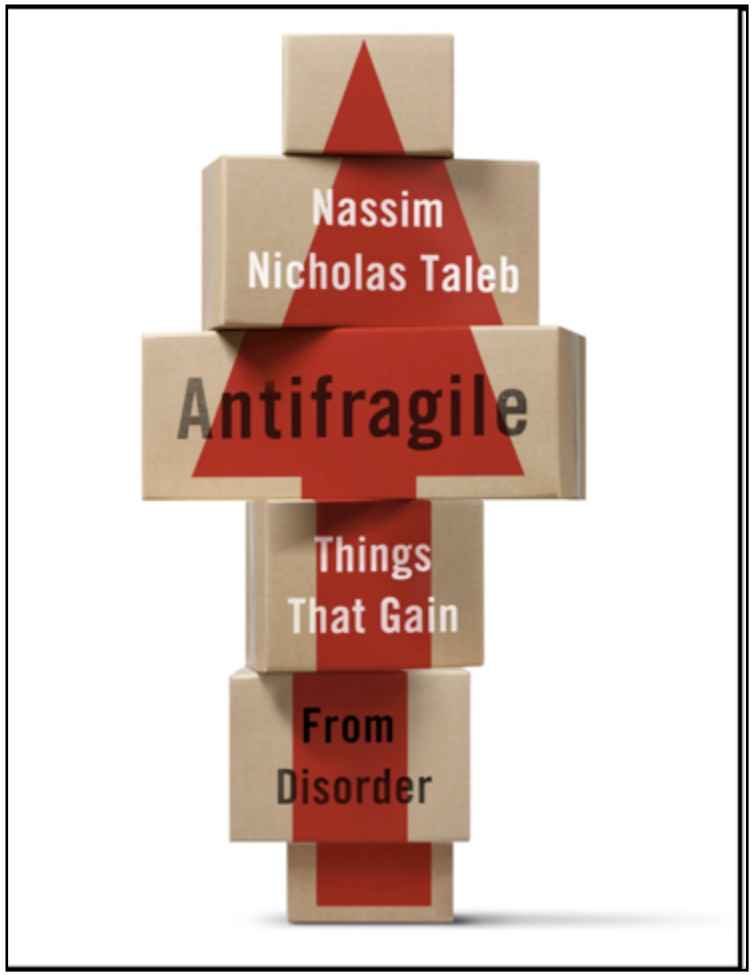
Nassim Taleb



- **Coined term Anti-Fragile**
- **Several excellent books on uncertainty.**
  - ***Fooled by Randomness.***
  - ***The Black Swan***
  - ***Antifragile***

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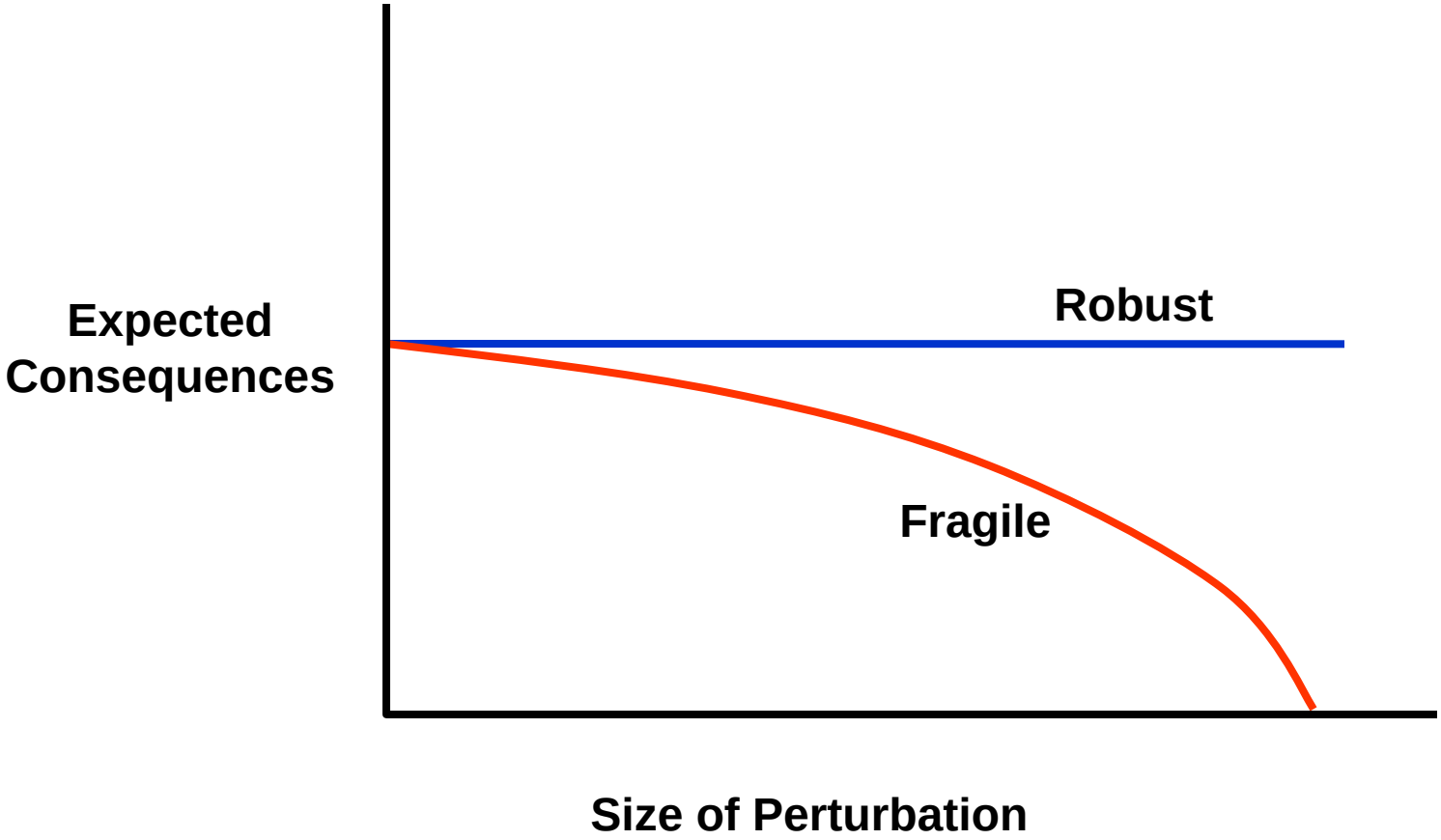
Fragility



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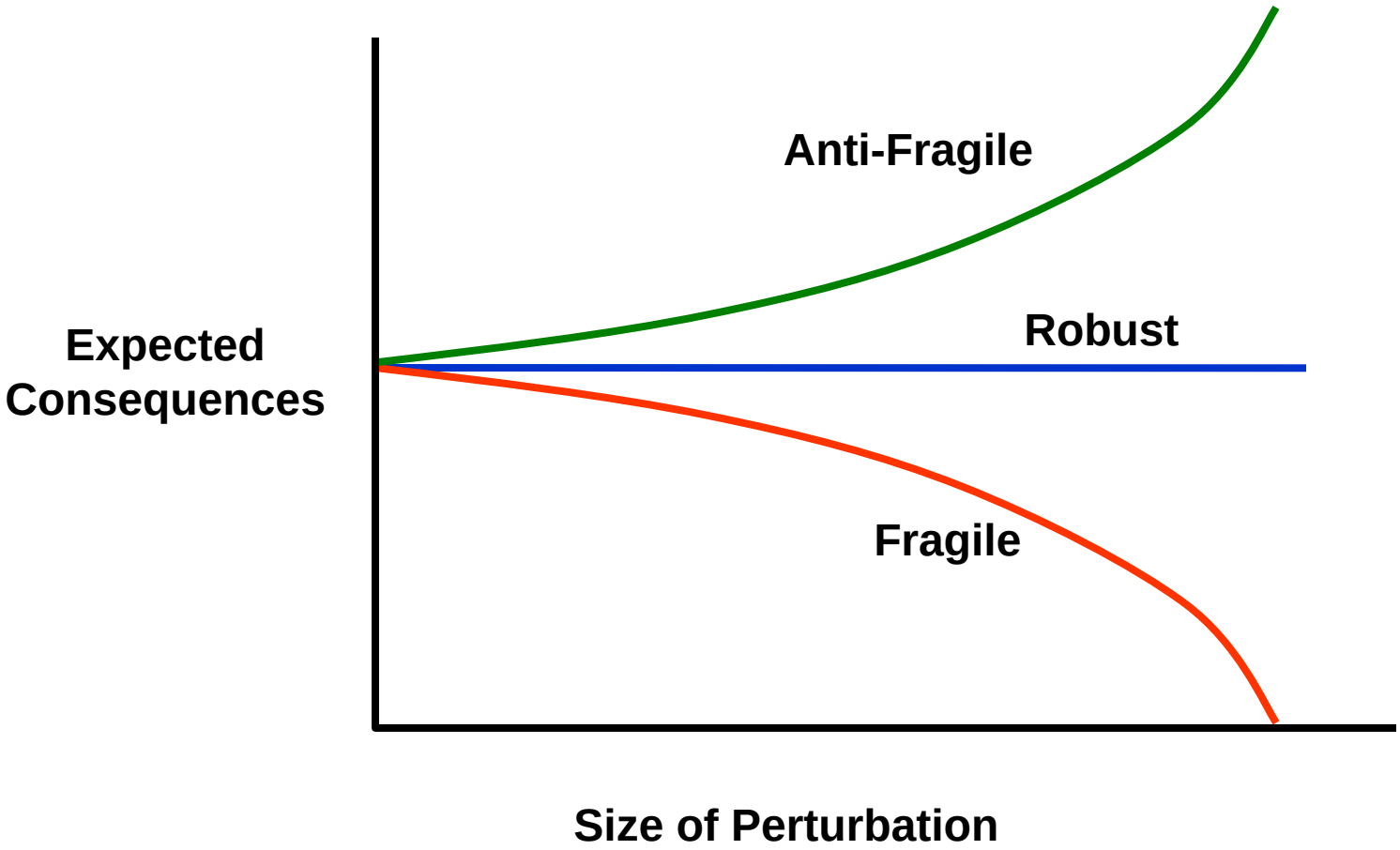
Anti-Fragility



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The Front-Loaded Lottery

- **A lottery ticket pays $3000 to the winning three digit number.**
- **You can pick the numbers in two ways:**
  - **Pay $3 to select all three digits at once.**
  - **Pay $1 for the first digit, find out if it is correct, then choose if you wish to pay $1 for the second digit, and then choose if you wish to pay $1 for the third digit.**

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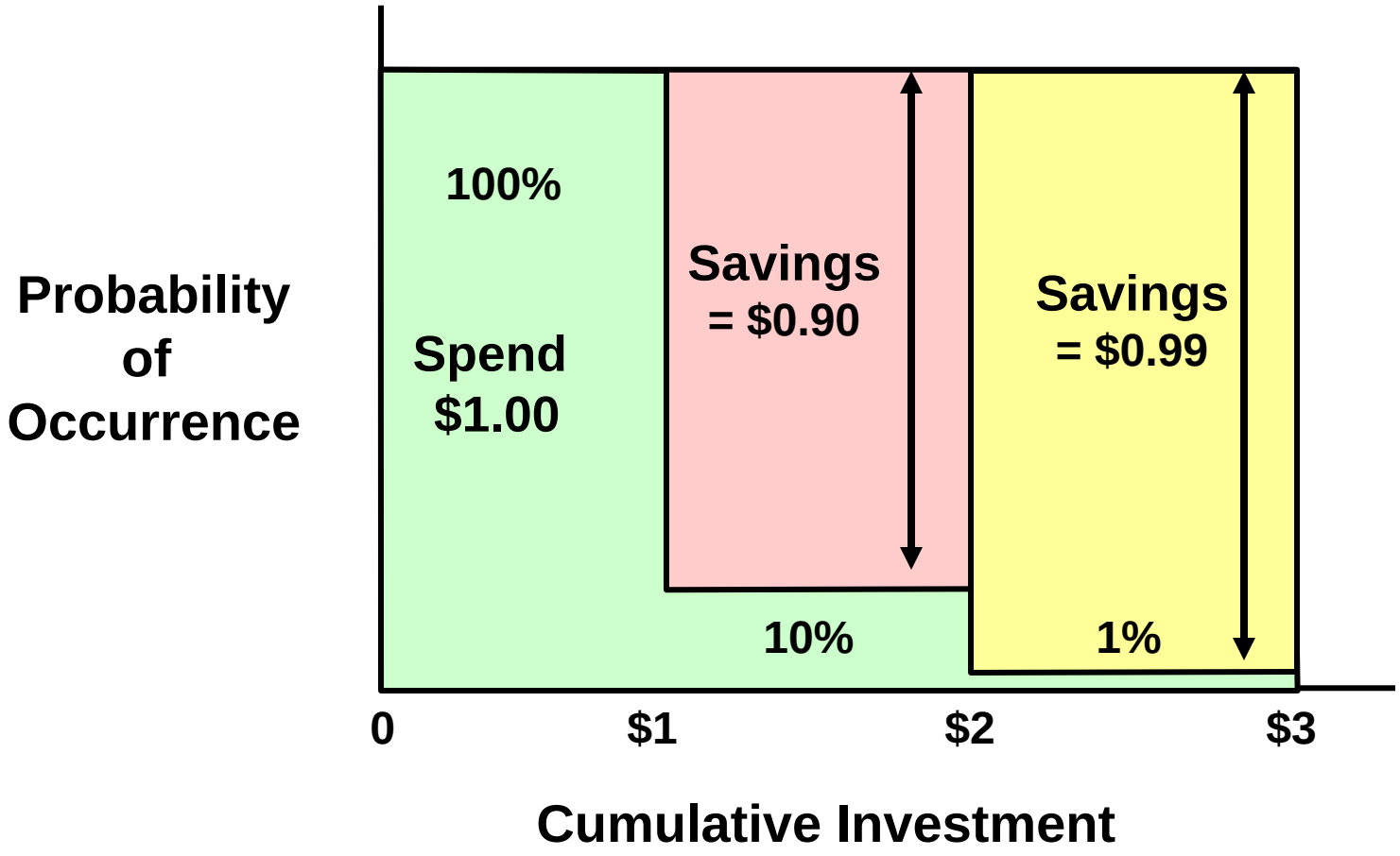
Value of Feedback



In this case, accelerated feedback reduces required investment by 63 percent. Savings are even greater when cumulative investment grows geometrically.

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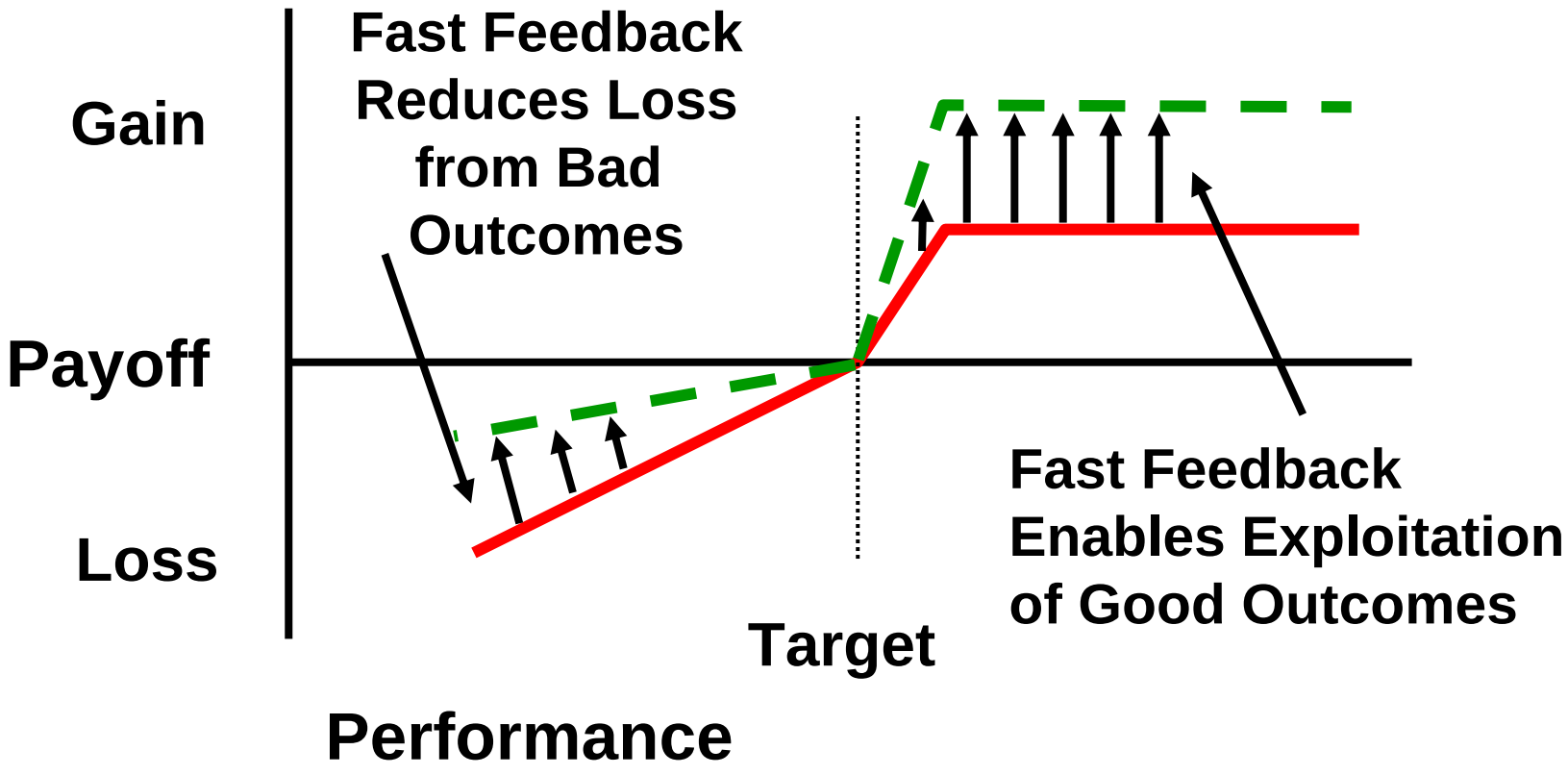
How to Change Payoff Functions



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Payload Management

Conform to Plan ⟷ **Make Good Economic Choices**

We hit all our planned cost, performance, and schedule targets. ⟷ **Everything we did was more valuable than everything we chose not to do.**

- **We exploited all the new information we received during the development process to make better economic choices.**
- **Nothing we left behind was more valuable than anything we carried forward to market.**

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Rethinking Variability: Discussion

- **Understanding variability**
- **Creating antifragility**
- **Payload management**

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LPD vs. Traditional Development

TRADITIONAL DEVELOPMENT

- We have no inventory
- We have no queues
- Seek efficiency
- High capacity utilization
- Eliminate variability
- We don’t know Cost of Delay
- What is batch size?
- Scope-based cadence
- Control time lines
- No WIP controls
- Use specialized resources

LEAN PRODUCT DEVELOPMENT

- Inventory is too high
- Queues are the problem
- Seek flow-through time
- Tradeoff utilization vs. queue size
- Exploit variability
- Cost of Delay is the golden key
- Reduce batch size
- Time-based cadence
- Control queues
- Use WIP constraints
- Use flexible resources

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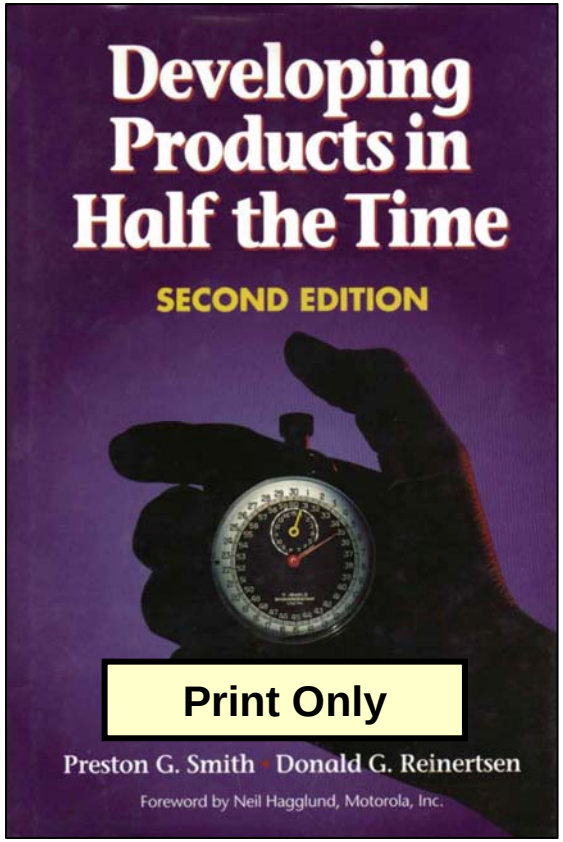
Going Further



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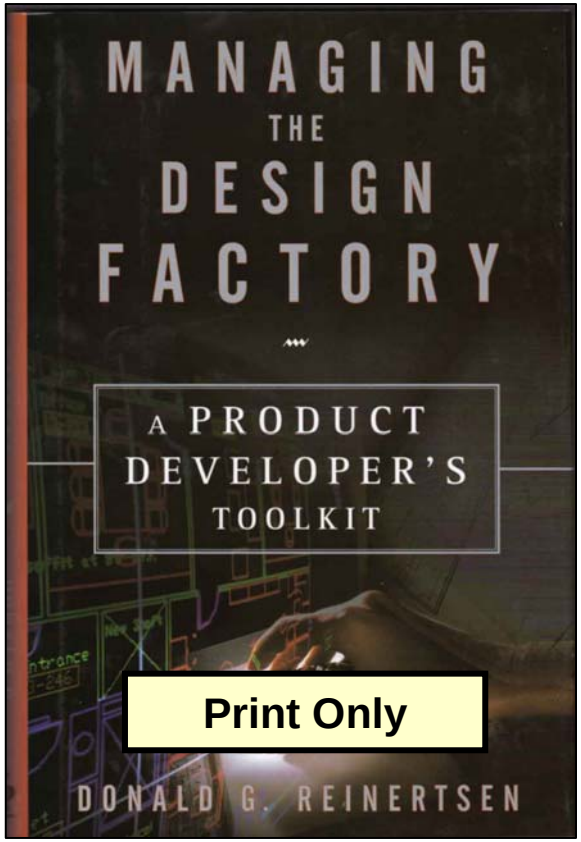

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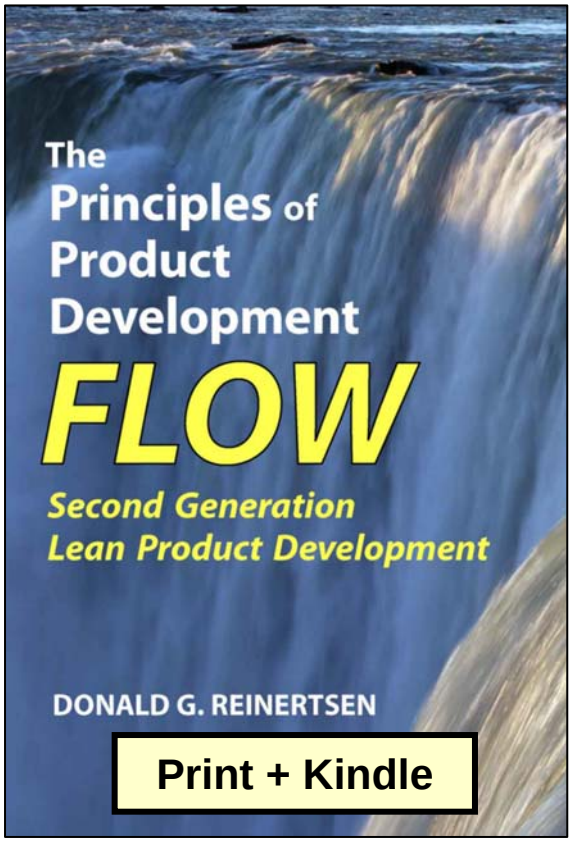

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2009

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