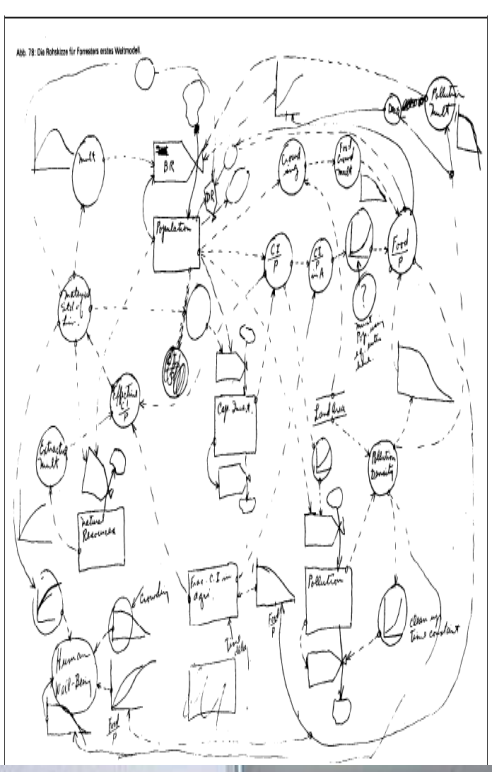
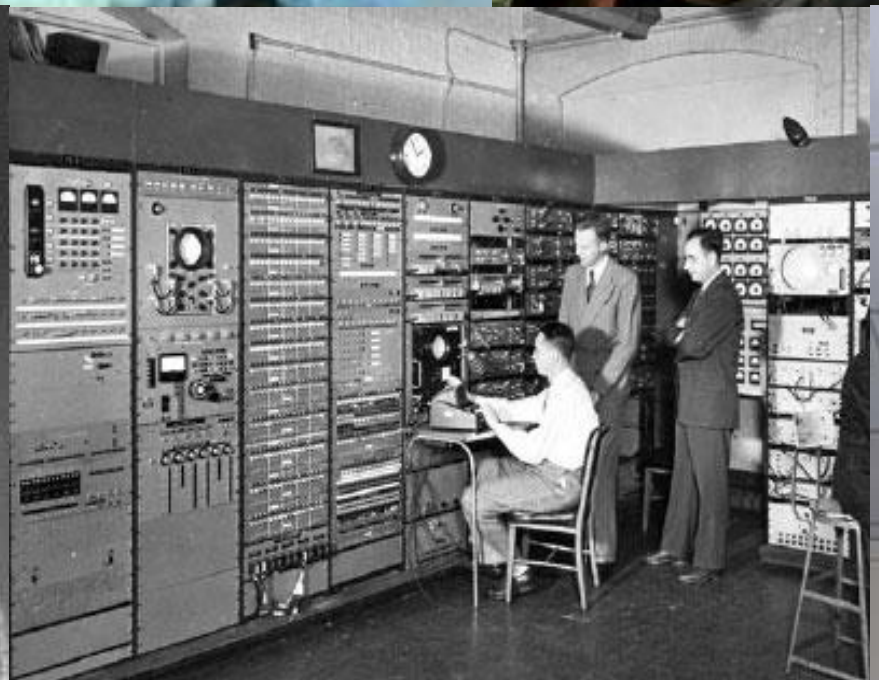
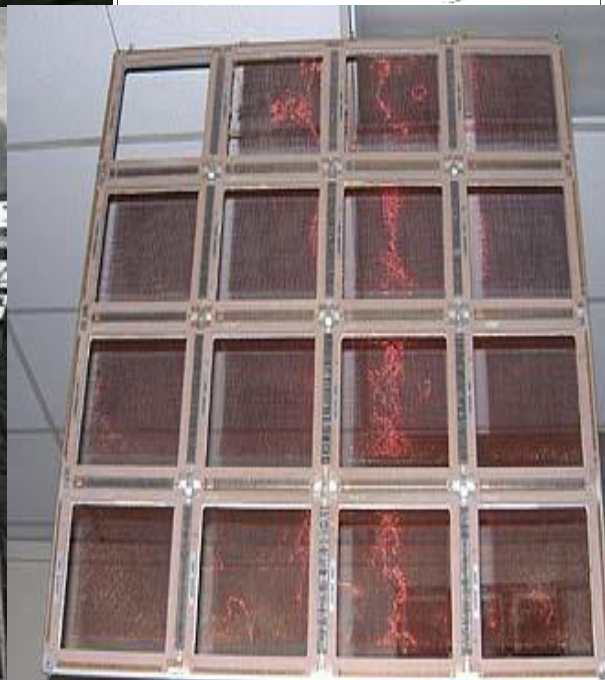
Principles of Systems Dynamics Modeling and Analysis

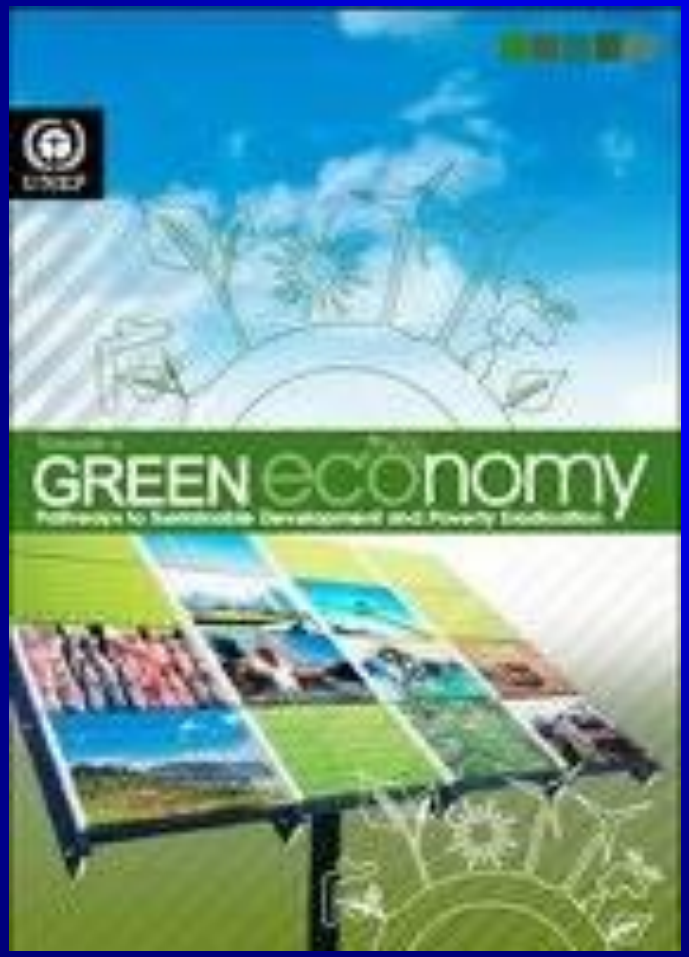
Pål I. Davidsen
pal.davidsen@geog.uib.no
Department of Geography,
University of Bergen,
N-5020 Bergen,
tel. 55 58 41 34

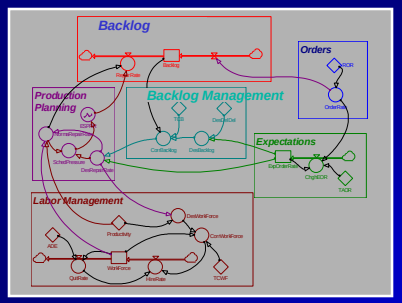
Jay Wright Forrester



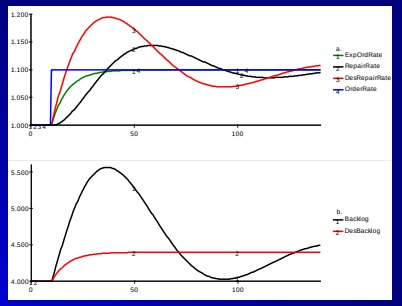





GREEN economy



Knowledge elicitation



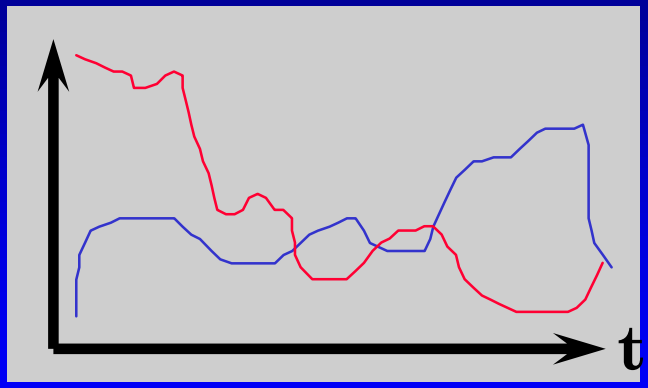
System Dynamics

Problem identification

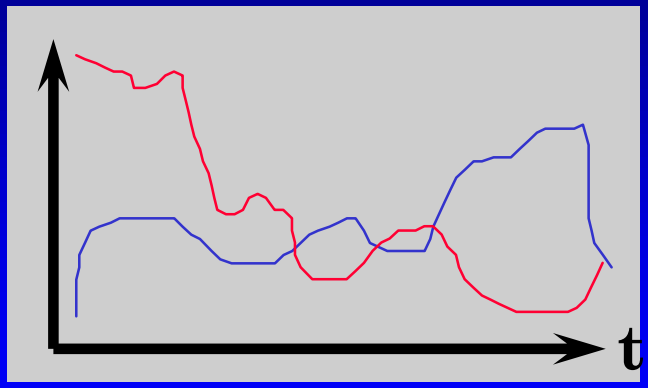
Problem solving

Management

Knowledge dissemination

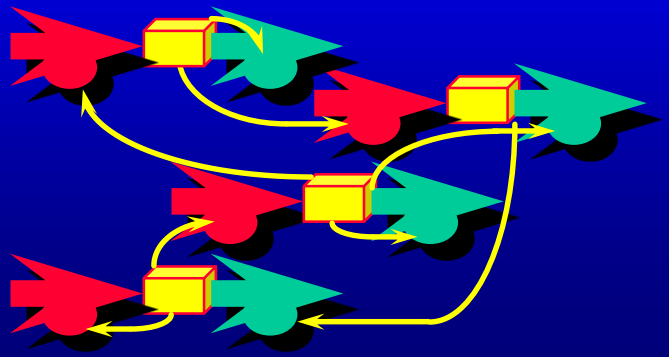


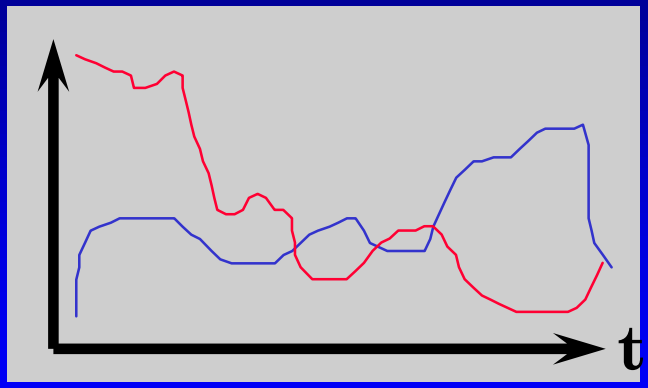
Behavior



Behavior

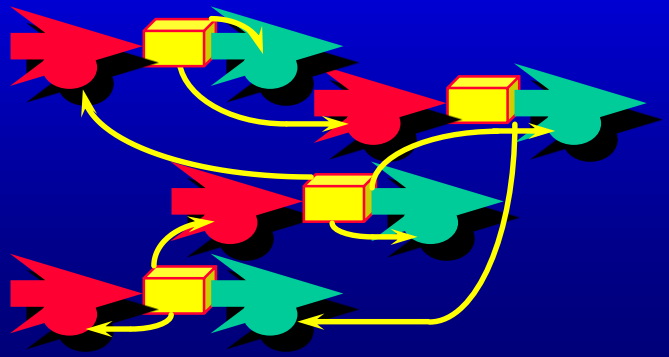
Structure

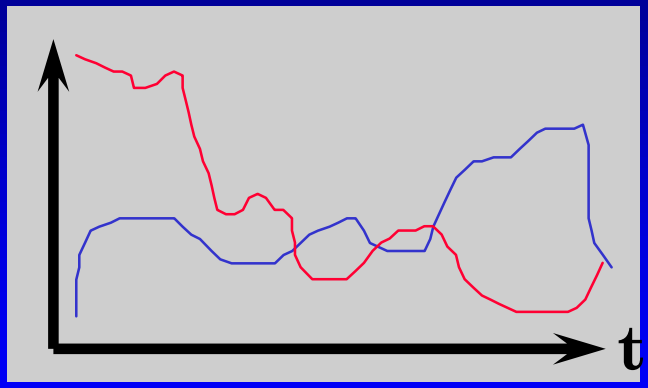




Behavior

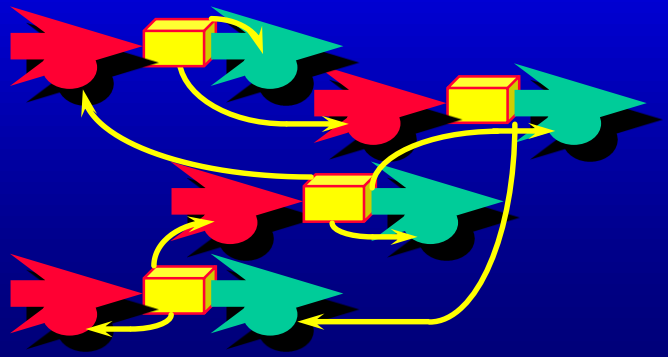
Structure



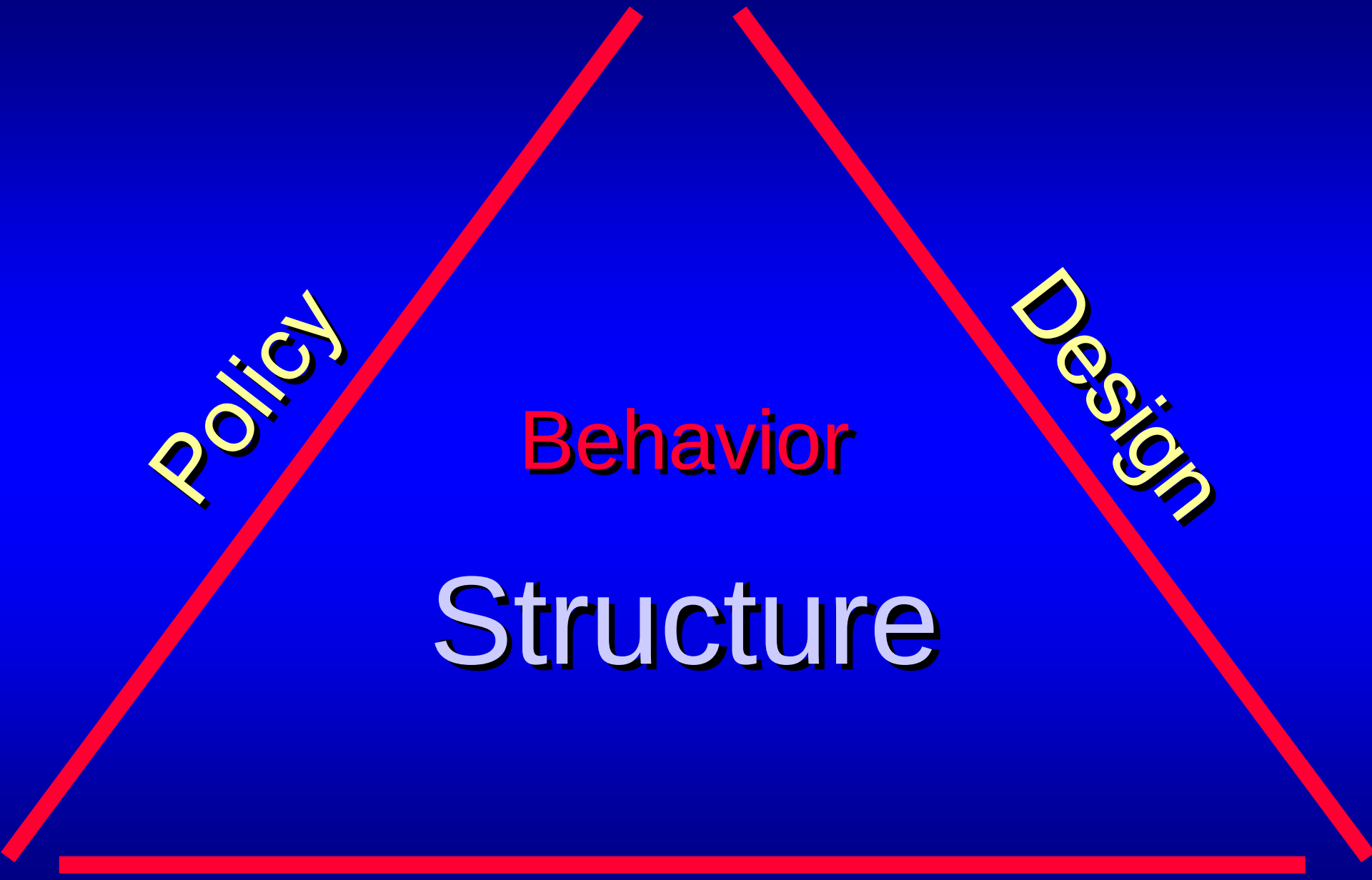


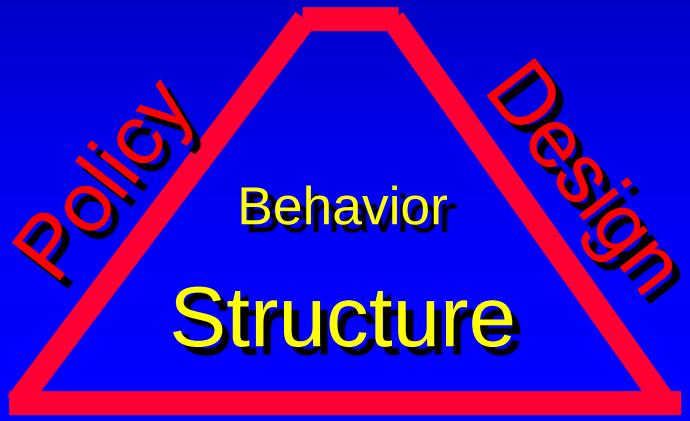
Behavior

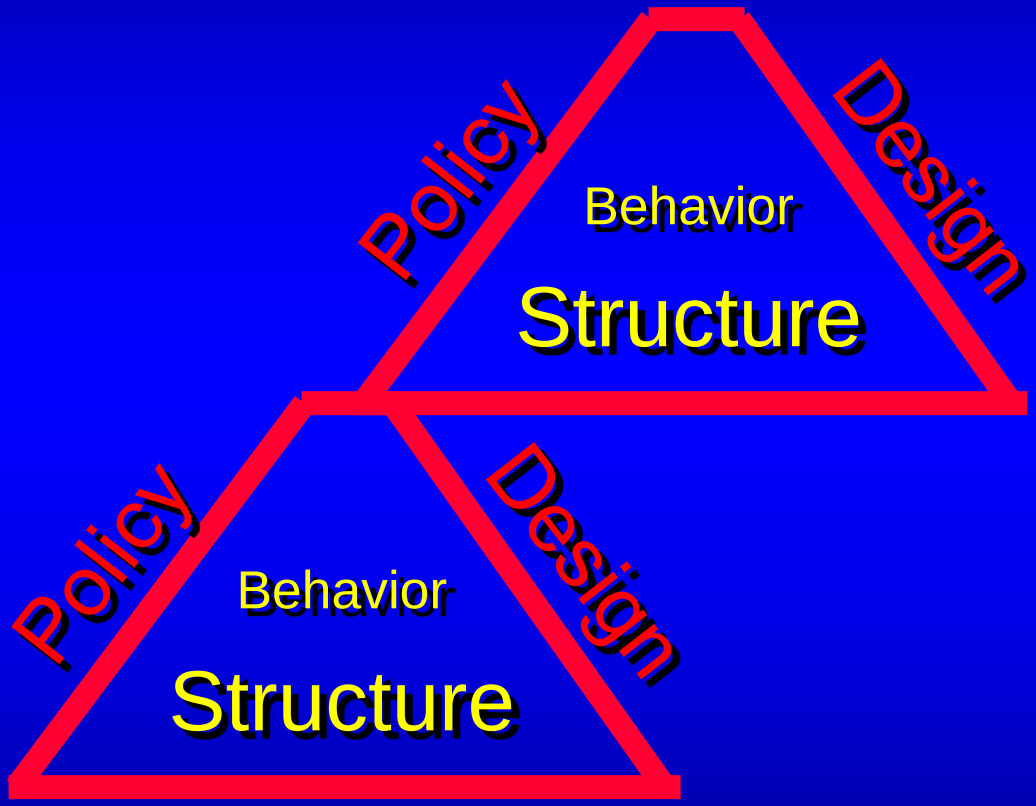
Structure

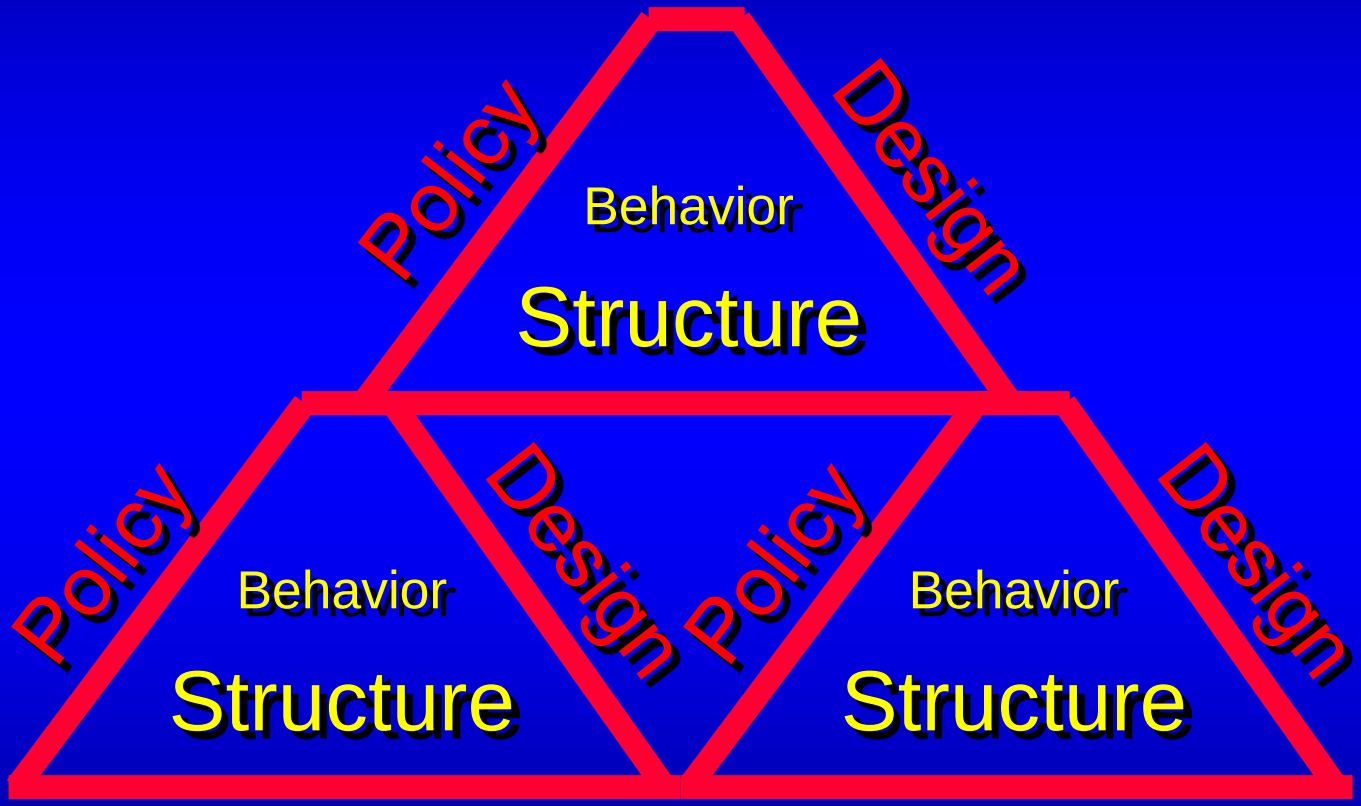


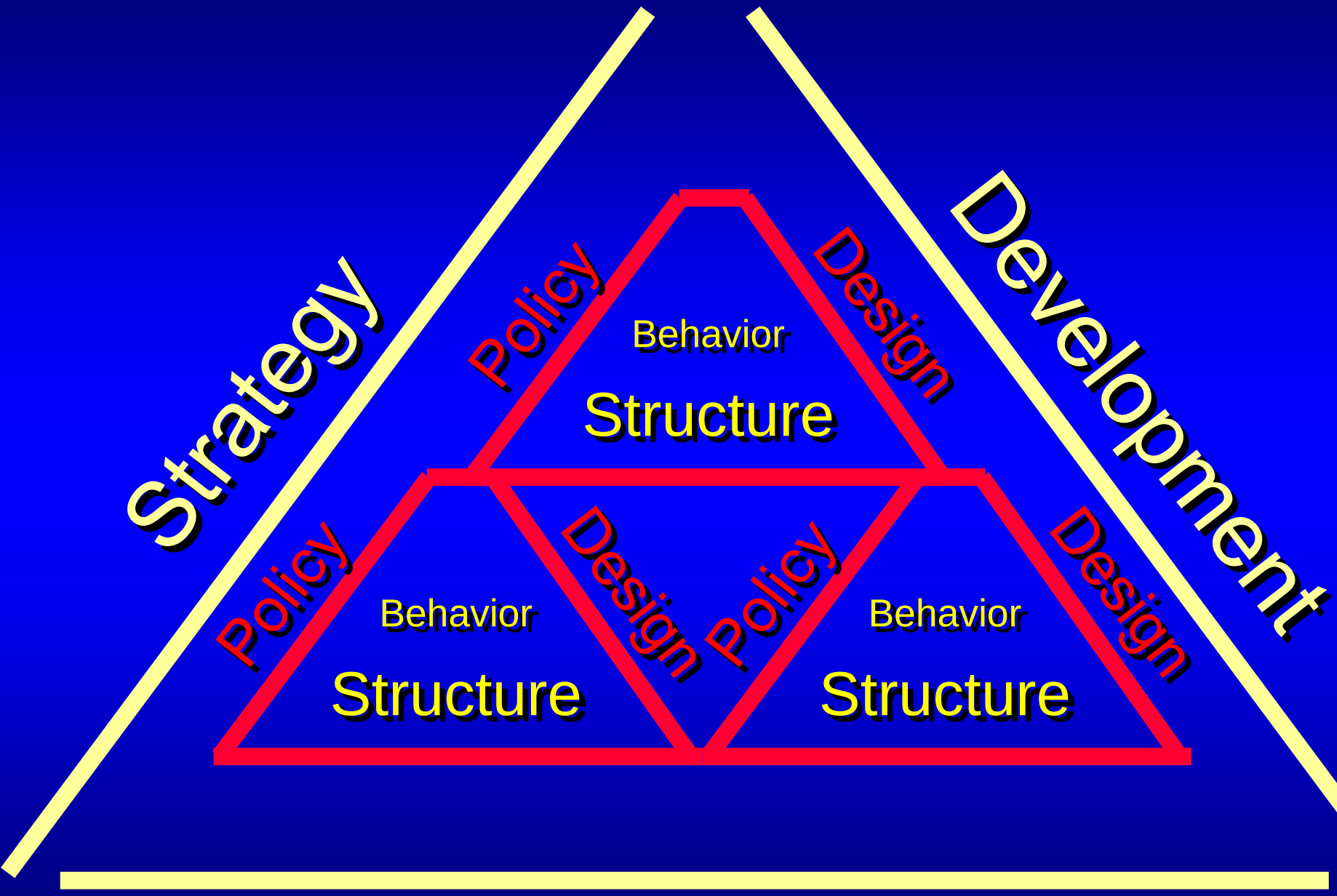

Behavior
Structure


Policy
Design
Behavior
Structure

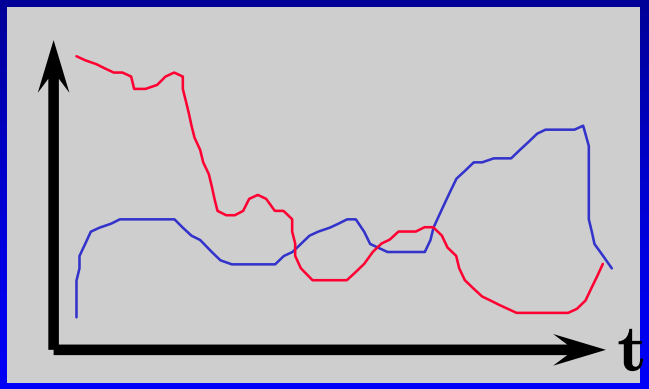

Policy
Design
Behavior
Structure


Policy
Design
Behavior
Structure
Policy
Design
Behavior
Structure

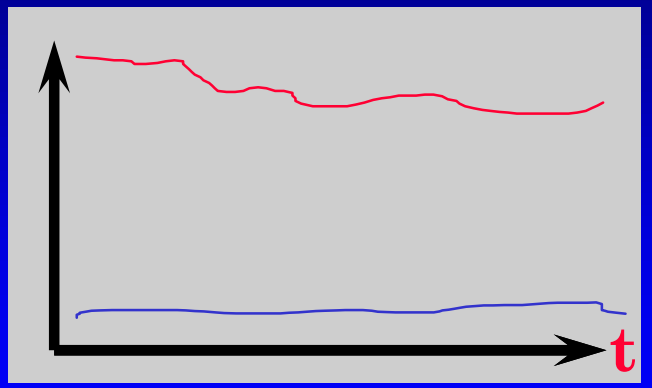

Policy
Design
Behavior
Structure
Policy
Design
Behavior
Structure
Policy
Design
Behavior
Structure


Strategy
Development
Policy
Design
Behavior
Structure
Policy
Design
Behavior
Structure
Policy
Design
Behavior
Structure

Problem

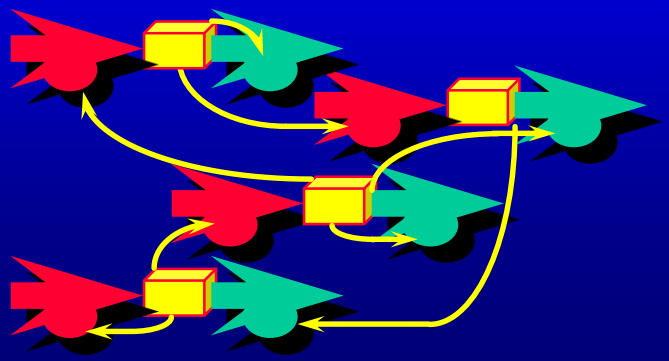


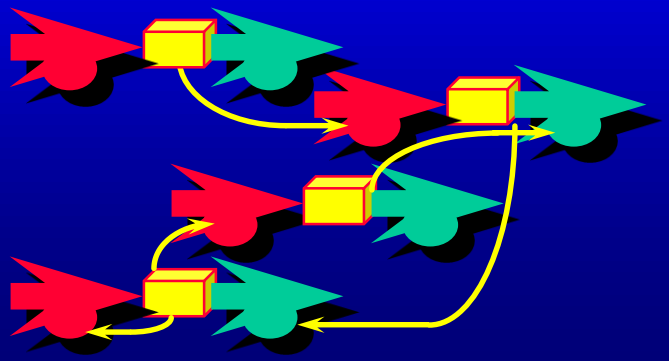
Solution



Behavior

Structure





System Dynamics:

Identify, understand, and utilize the relationship:

in

complex, dynamic systems

Accumulation

Feedback

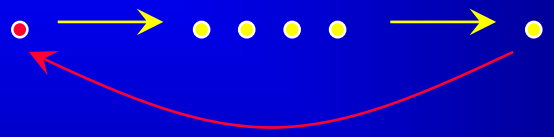
Complexity

Non-linearity

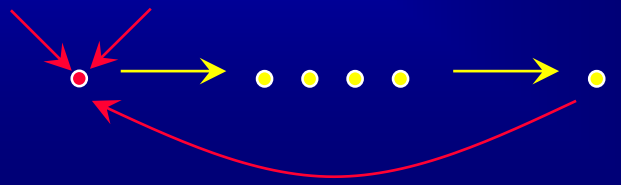
Complexity
a synergy of

Accumulations
≡ Latencies / Delays

Feedbacks



Non-linearities

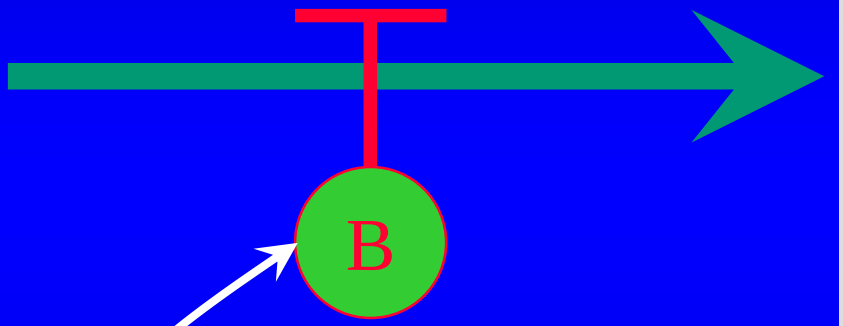


Complexity

Accumulations
≡ Latencies / Delays

… the origin of dynamics

Causality that spans time



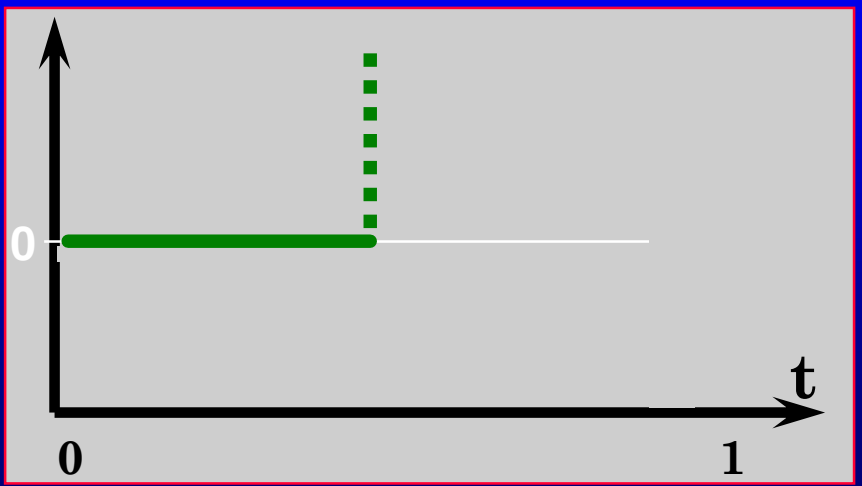
B

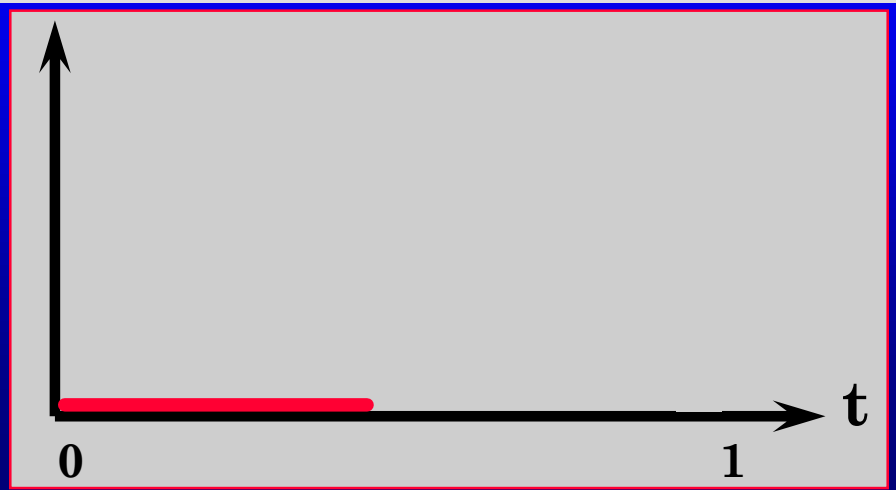
Instantaneous causality

A

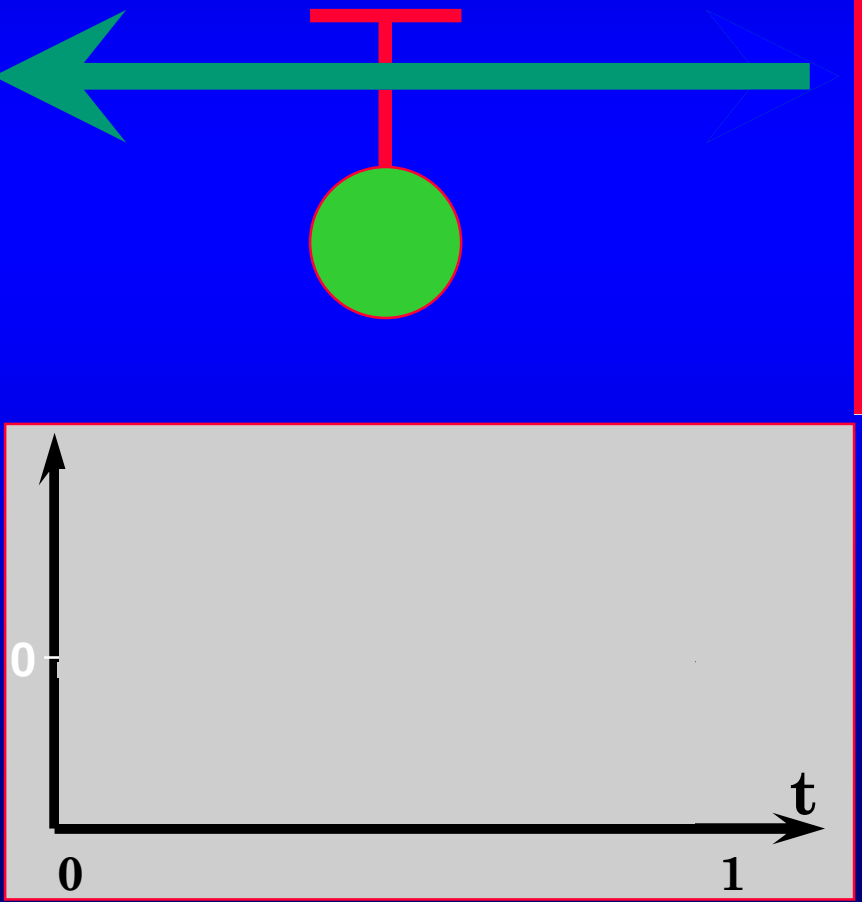
C

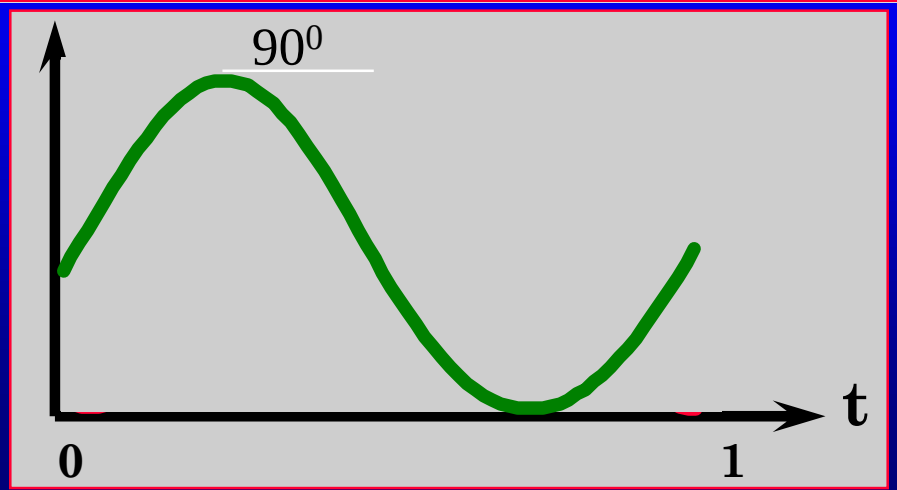
In a causality that spans time nothing happens instantaneously





Effects unfold over time





Accumulations

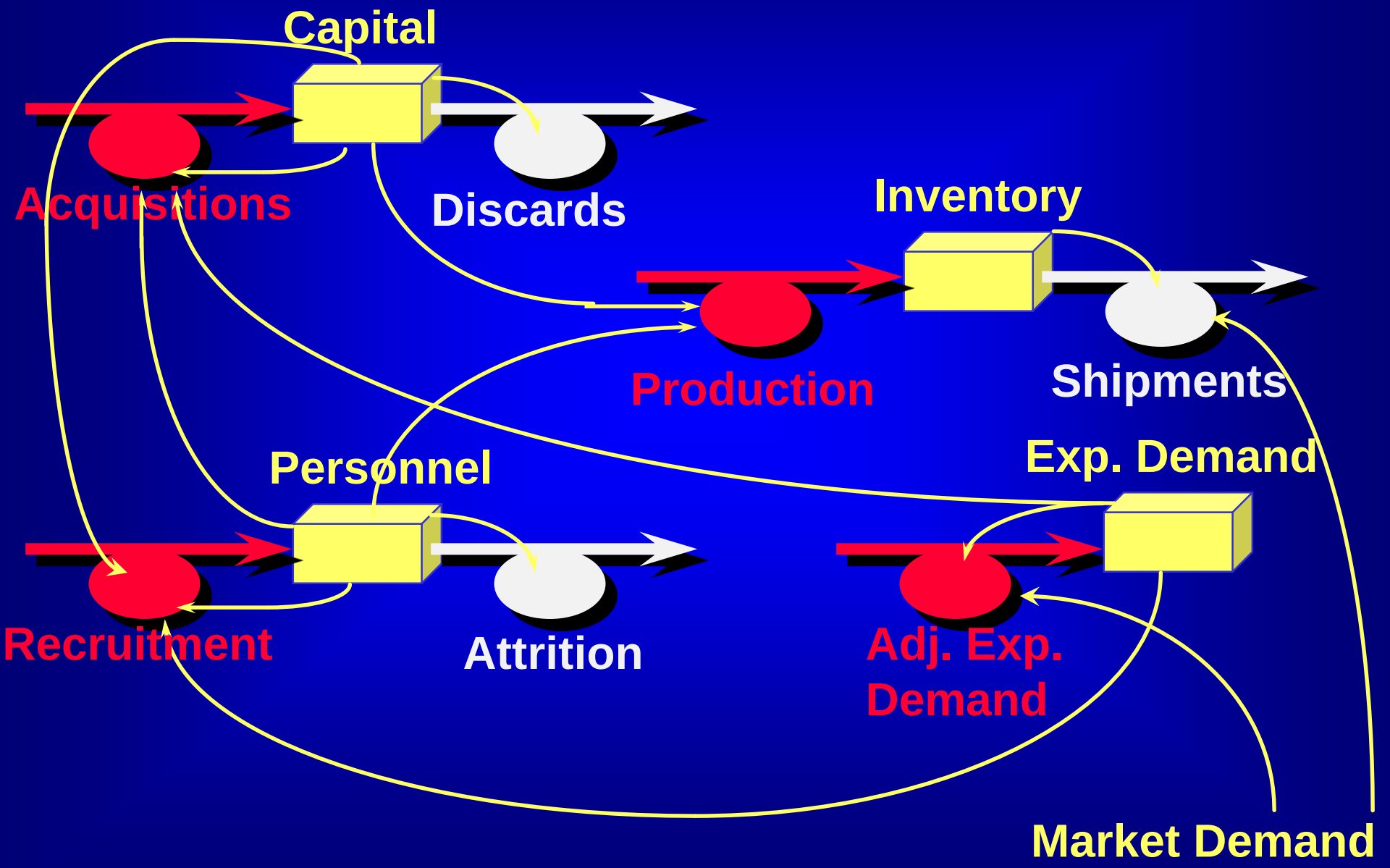
creates distance in time and space


Inventory
Production
Shipment


Personnel
Recruitment
Attrition


Capital
Acquisition
Discards

Just like driving a car .....



Accumulation

Feedback

Complexity

Non-linearity

Complexity

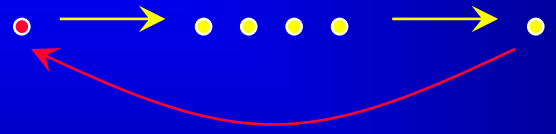
Accumulations
≡ Latency / Delay

From the origin of dynamics to…

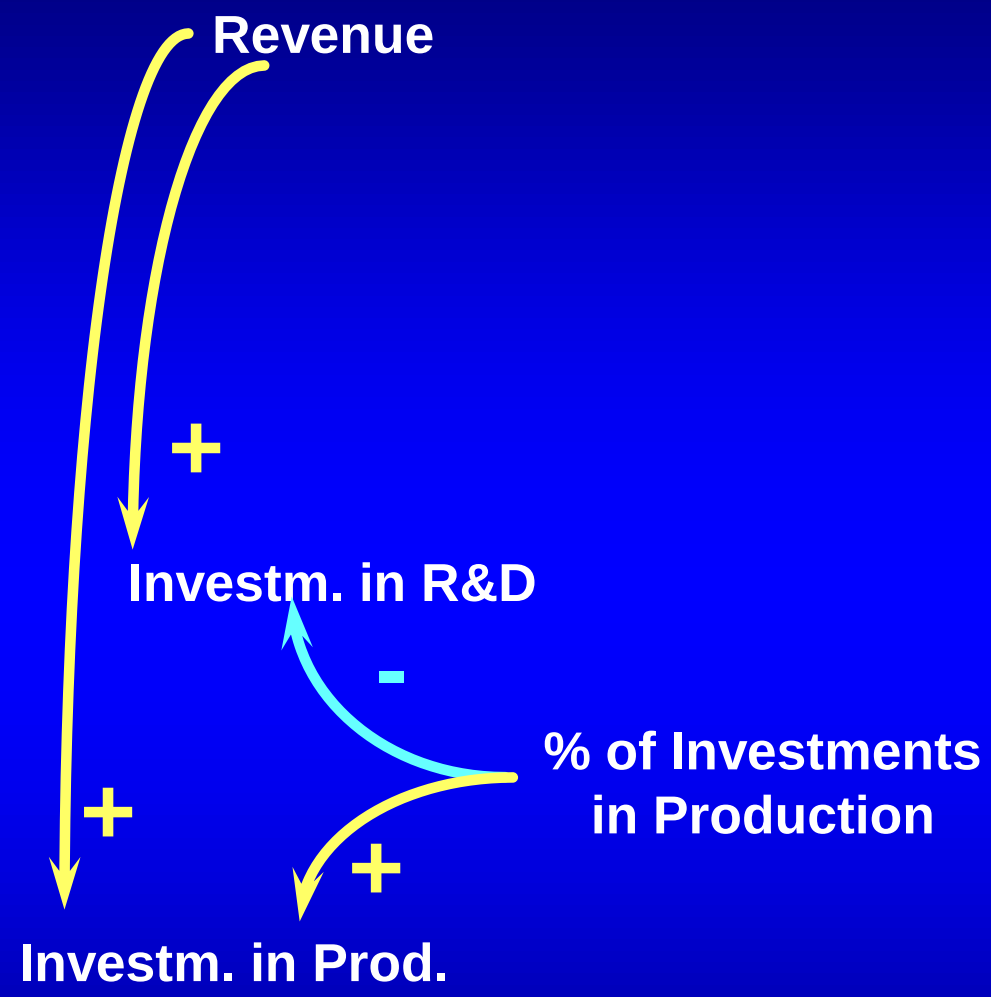
Complexity

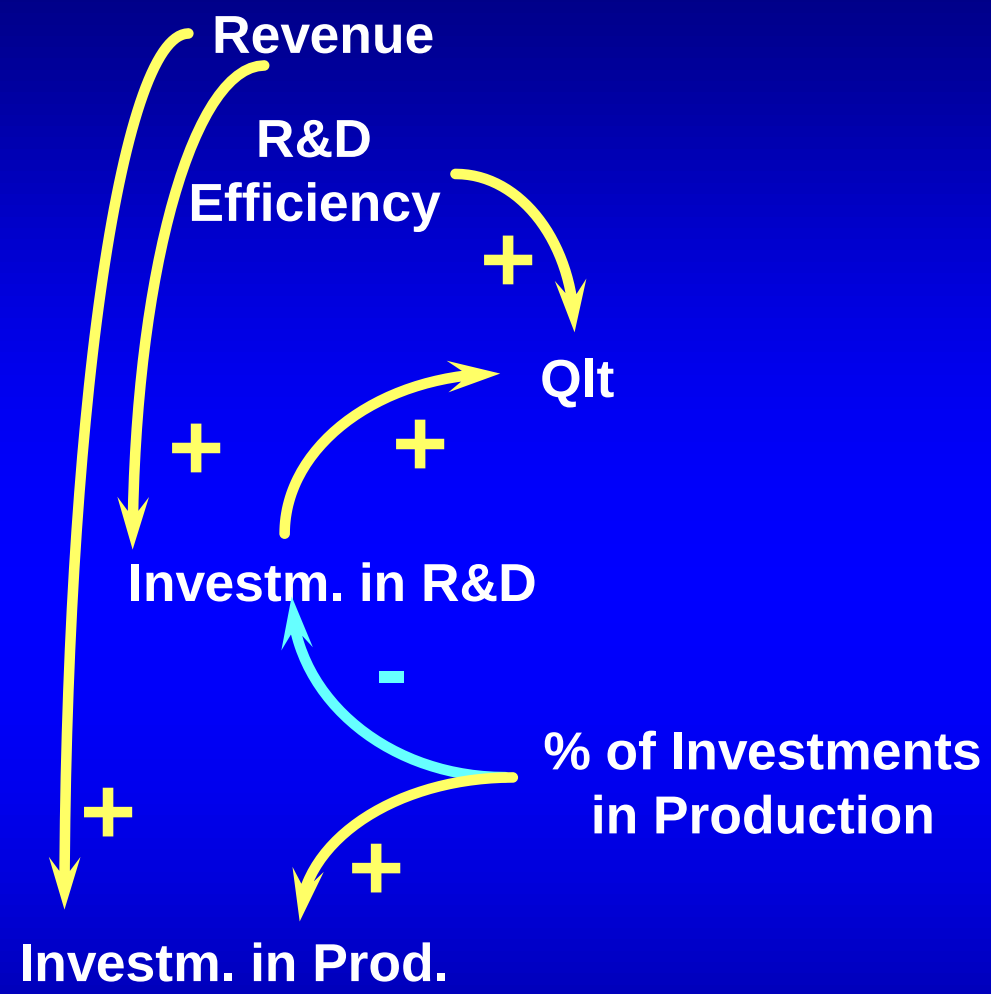
Accumulations
≡ Latency / Delay

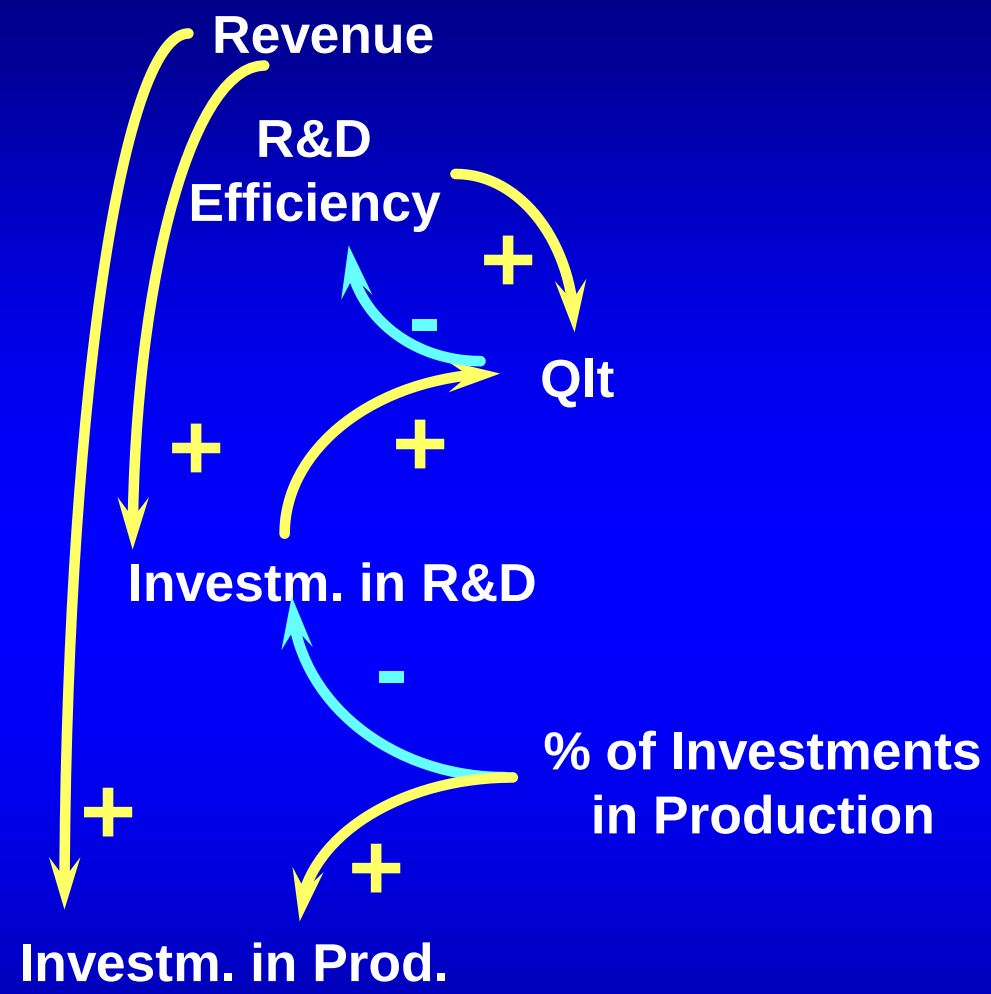
Feedback

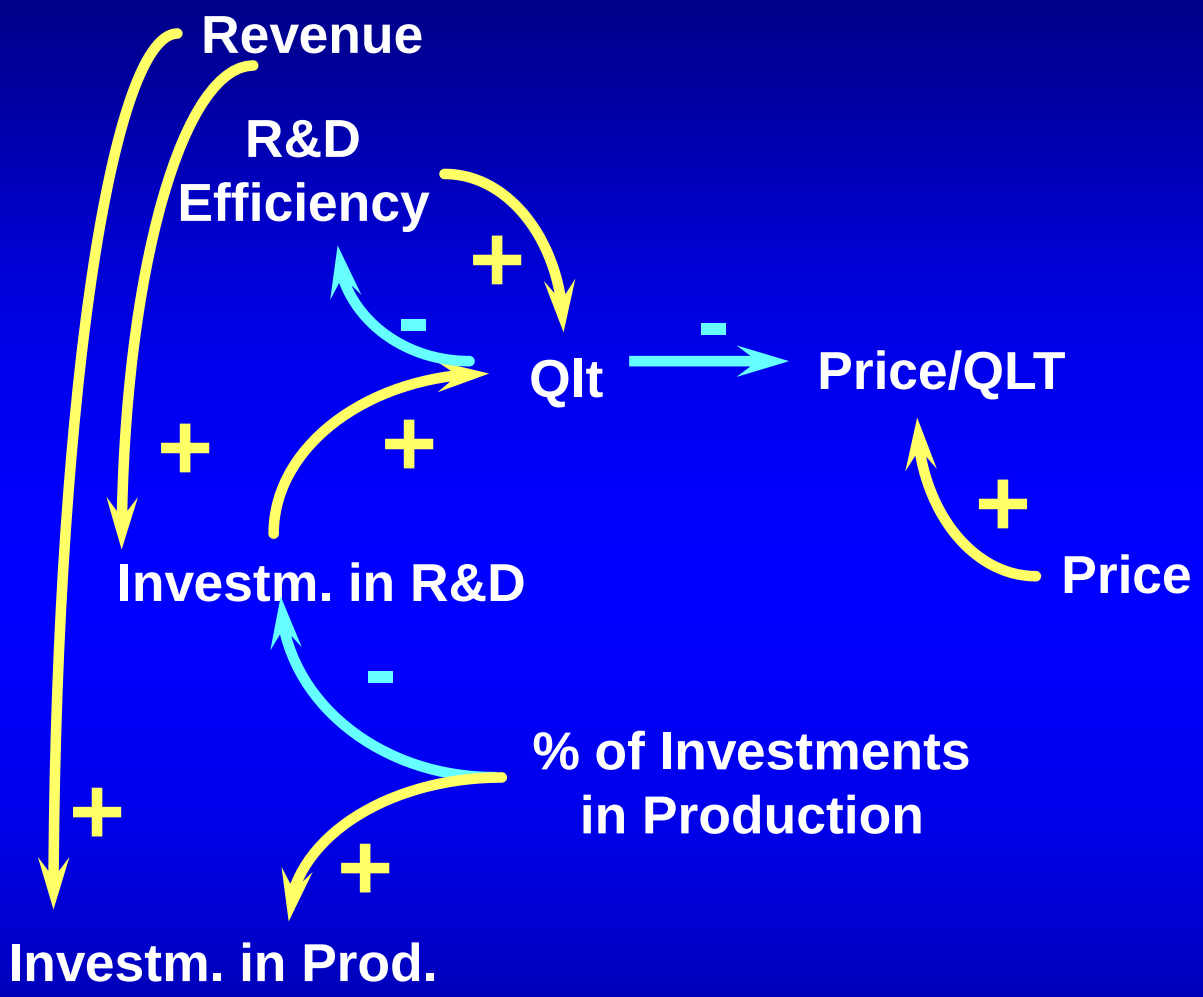


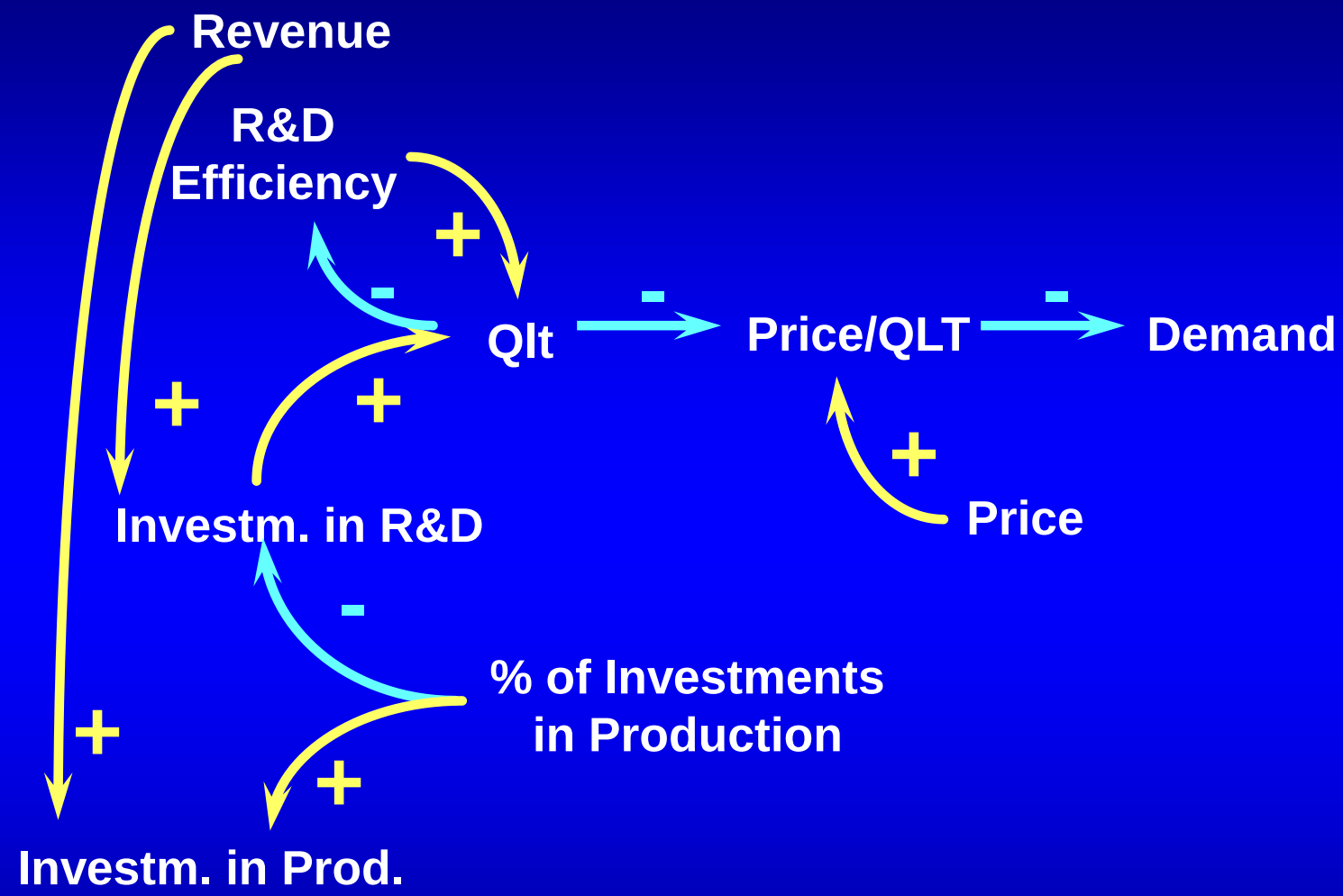
… circular causality

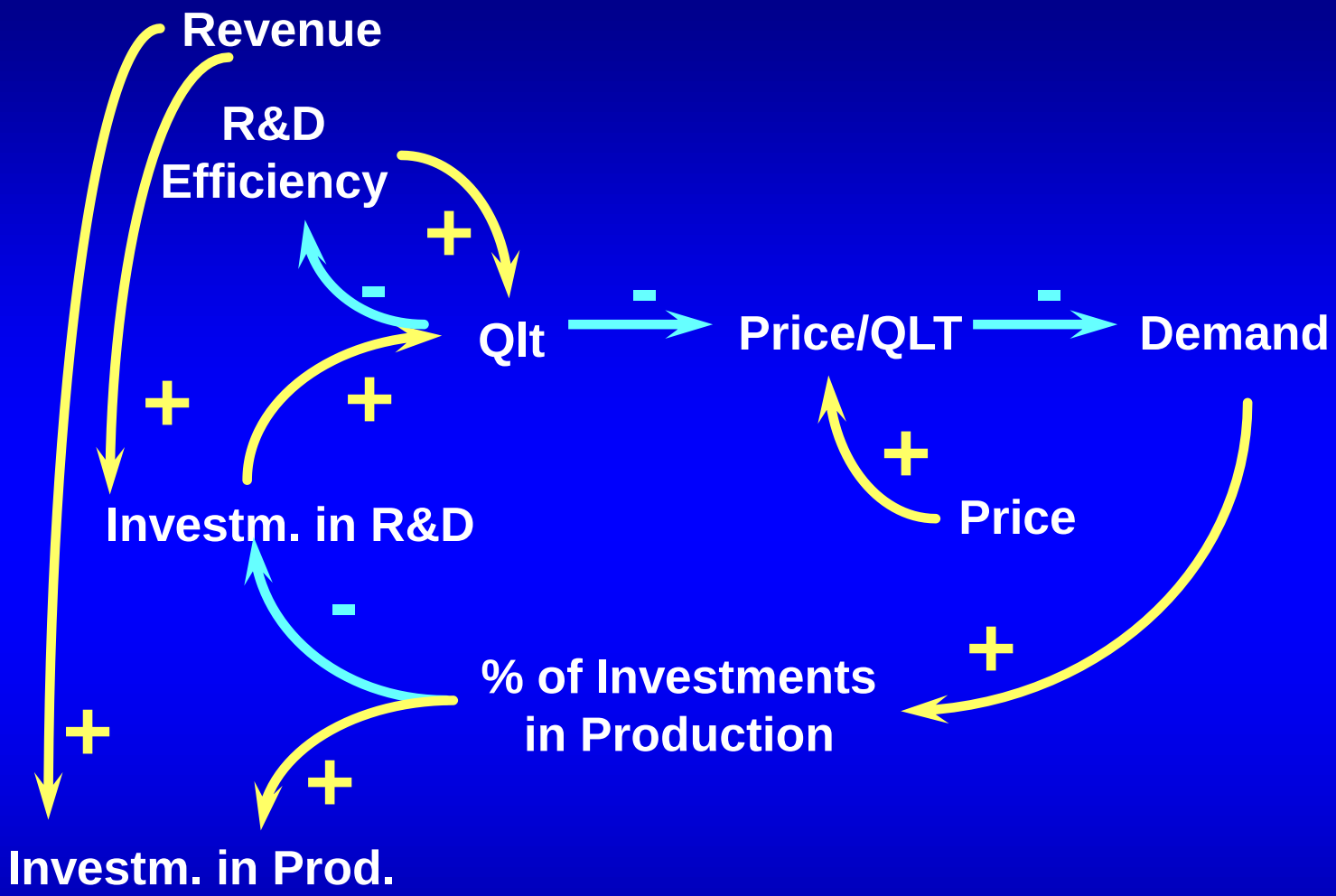

Revenue
+
Investm. in R&D
-
% of Investments
in Production
+
+
Investm. in Prod.

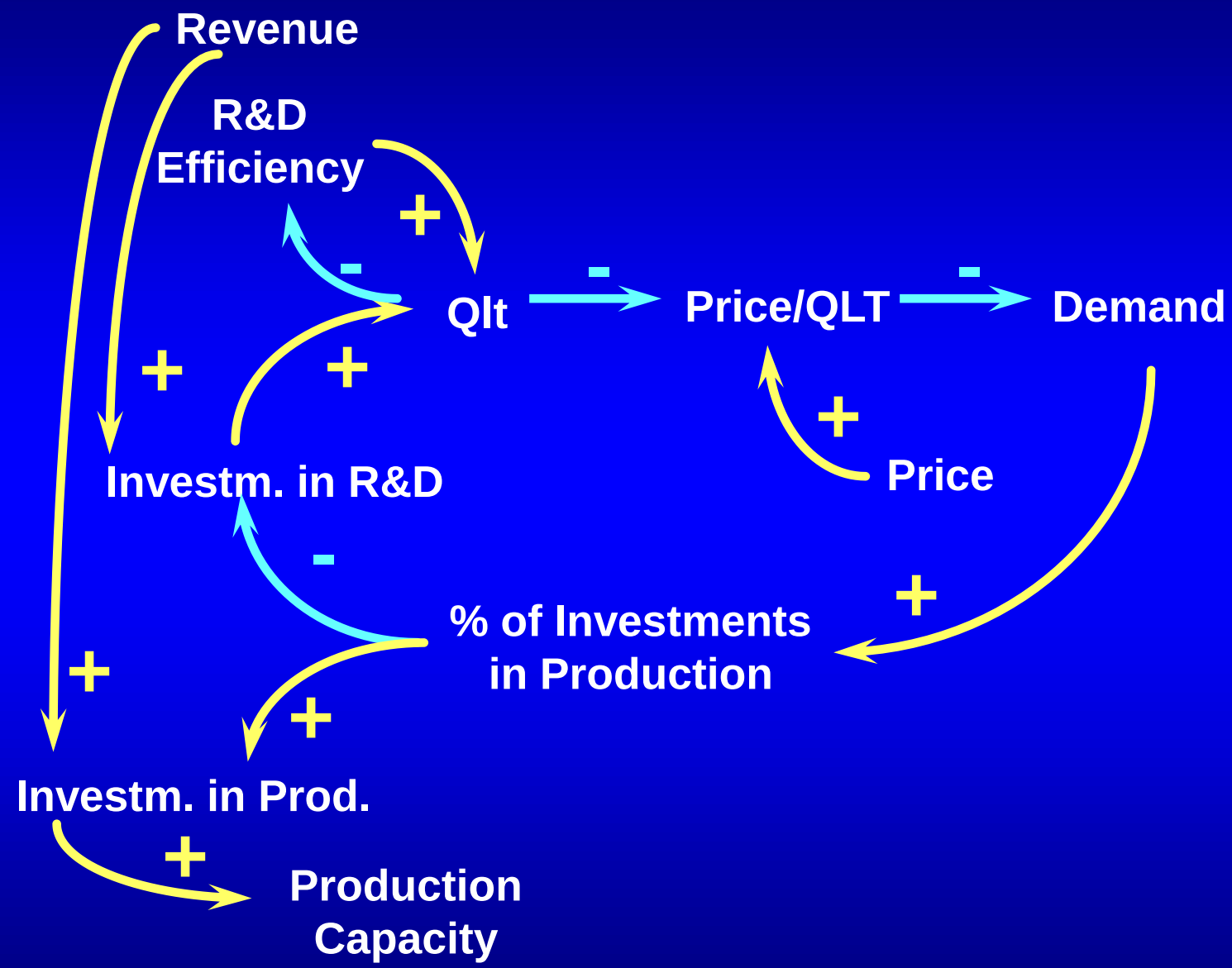

Revenue
R&D
Efficiency
+
Qlt
+
+
Investm. in R&D
-
% of Investments
in Production
+
+
Investm. in Prod.

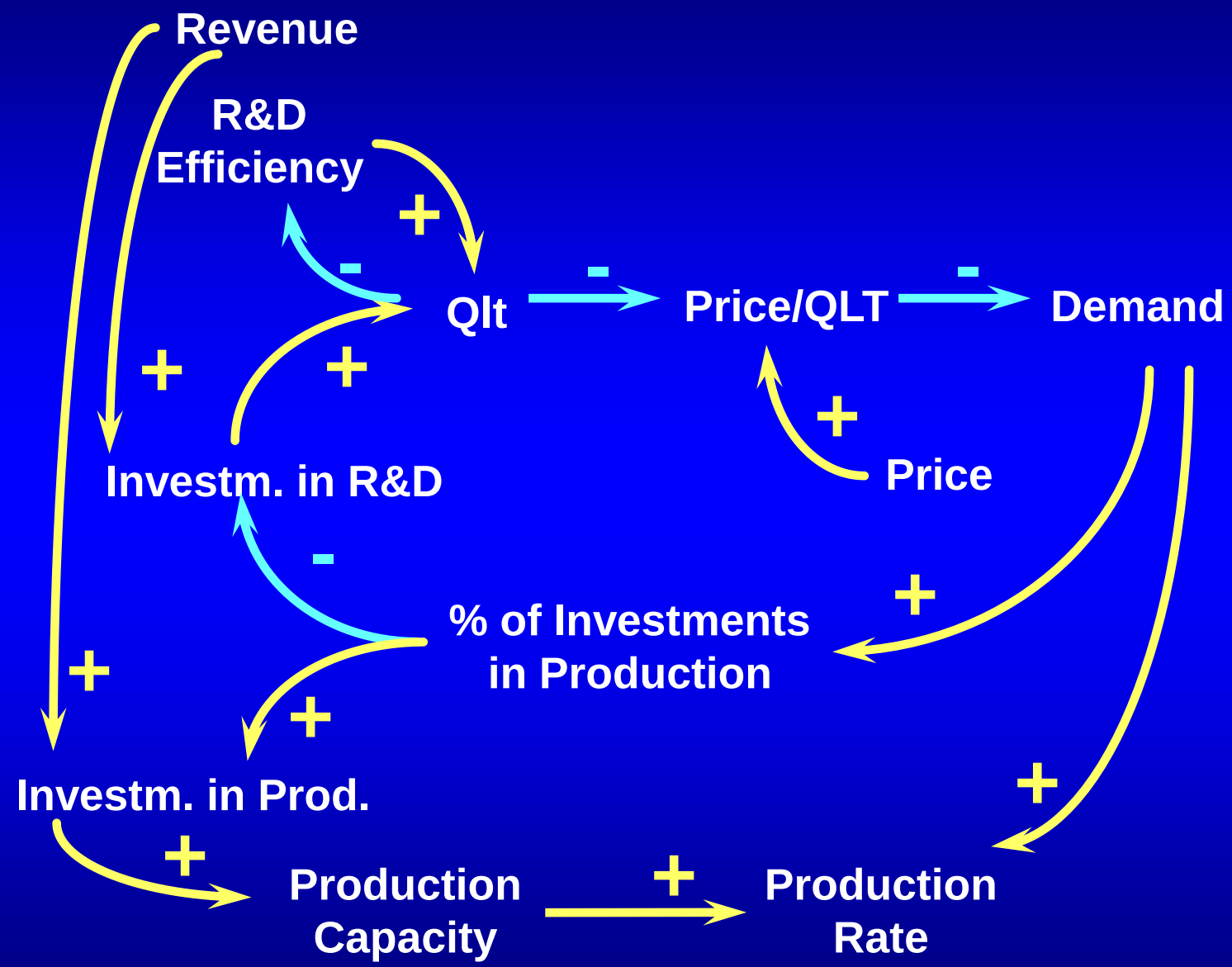

Revenue
R&D
Efficiency
+
-
Qlt
+
+
Investm. in R&D
-
% of Investments
in Production
+
+
Investm. in Prod.

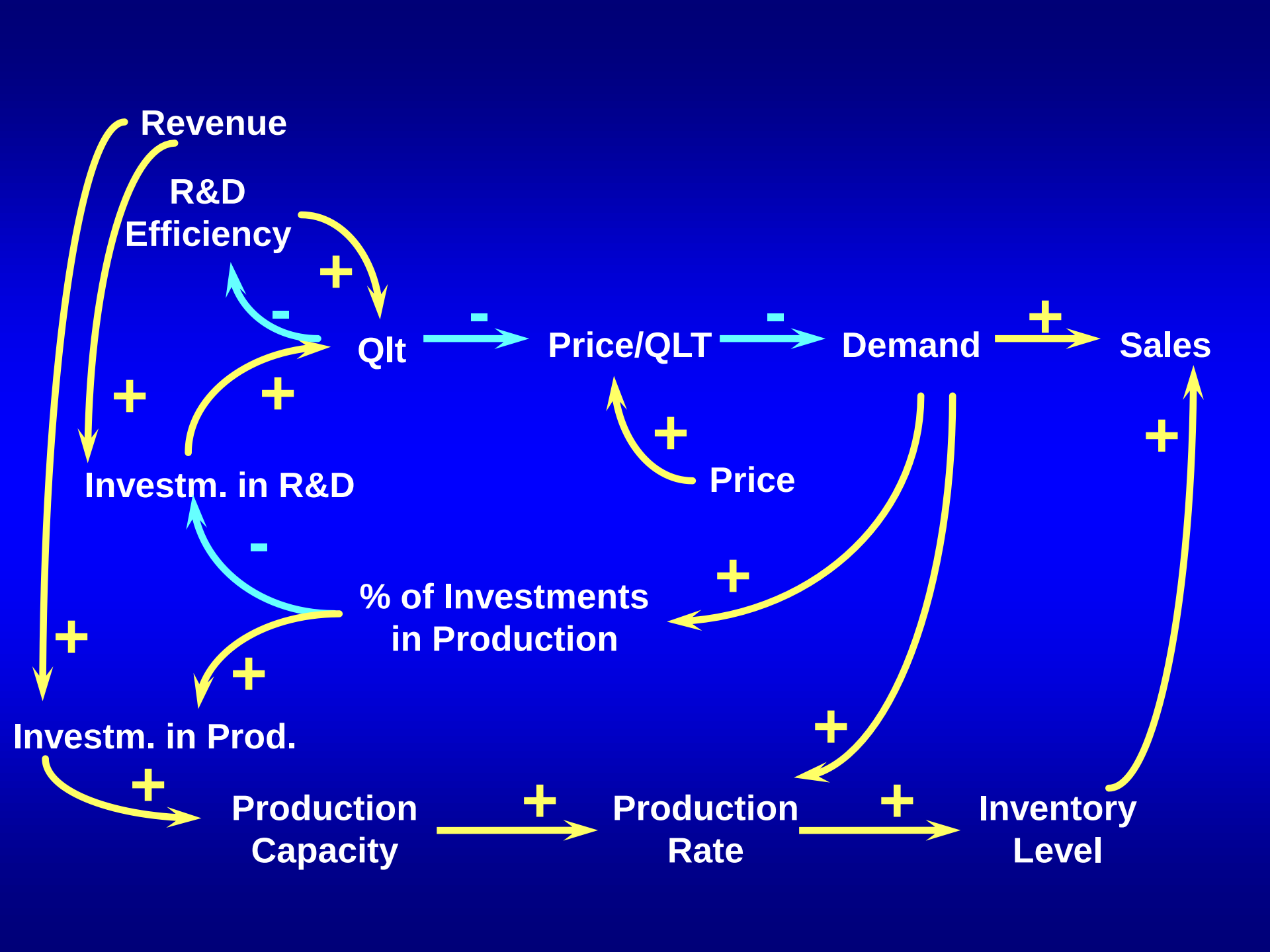

Revenue
R&D
Efficiency
+
-
QIt
-
Price/QLT
+
+
+
Price
Investm. in R&D
-
% of Investments
in Production
+
+
Investm. in Prod.

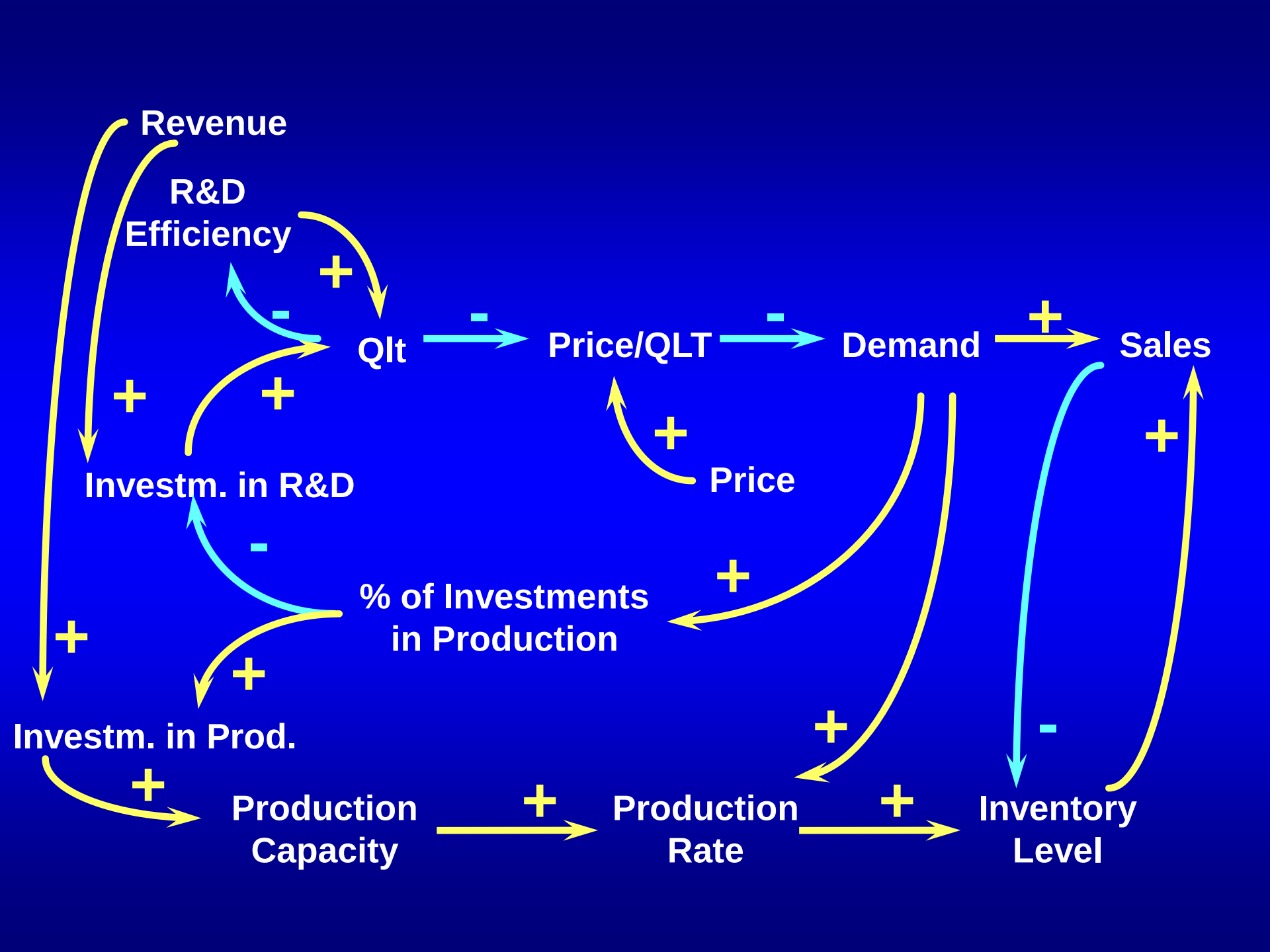

Revenue
R&D
Efficiency
+
-
QIt
-
Price/QLT
-
Demand
+
+
+
Price
Investm. in R&D
-
% of Investments
in Production
+
+
Investm. in Prod.

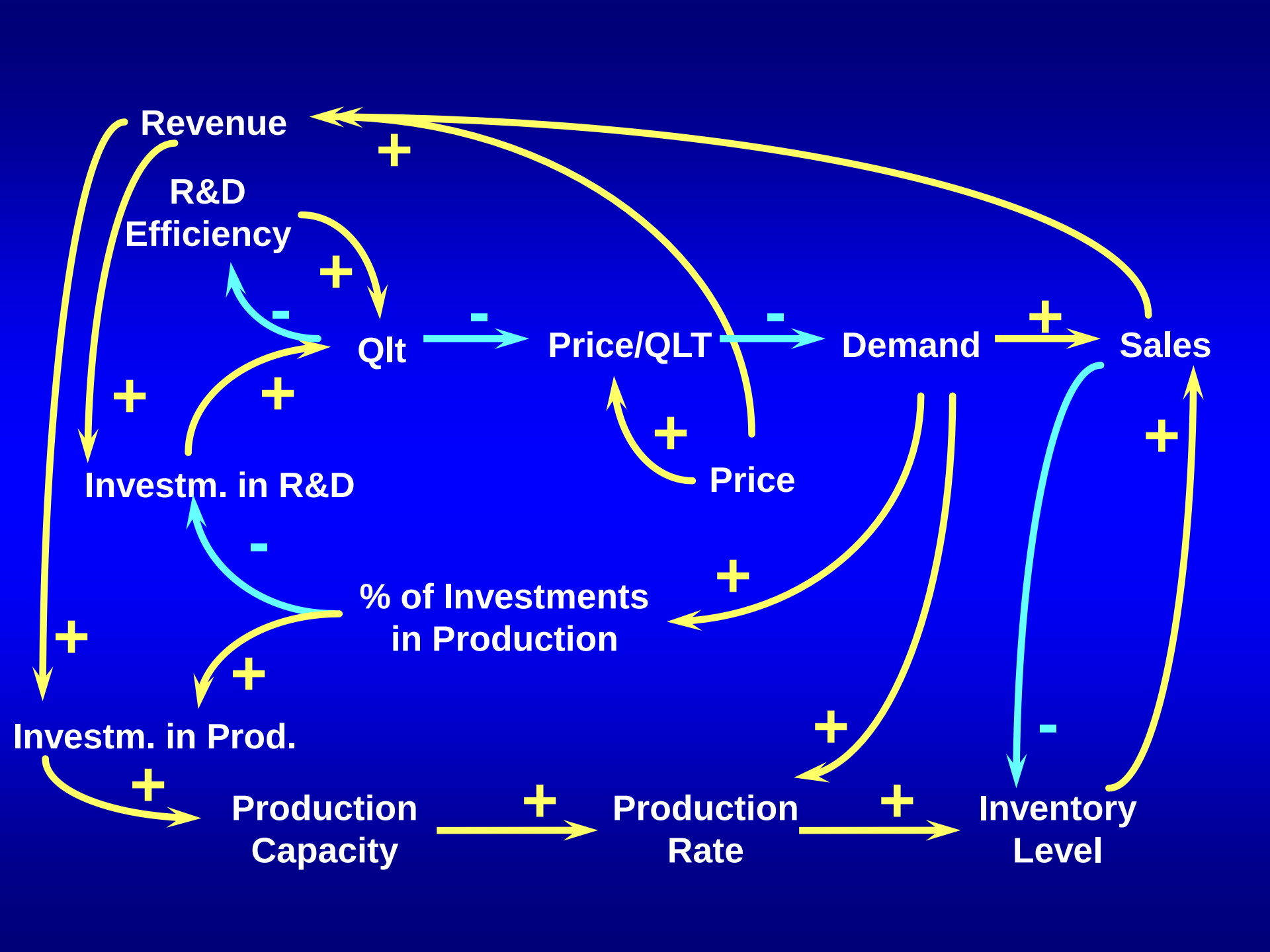

Revenue
R&D
Efficiency
+
-
QIt
-
Price/QLT
-
Demand
+
+
+
Price
Investm. in R&D
-
% of Investments
in Production
+
+
+
Investm. in Prod.

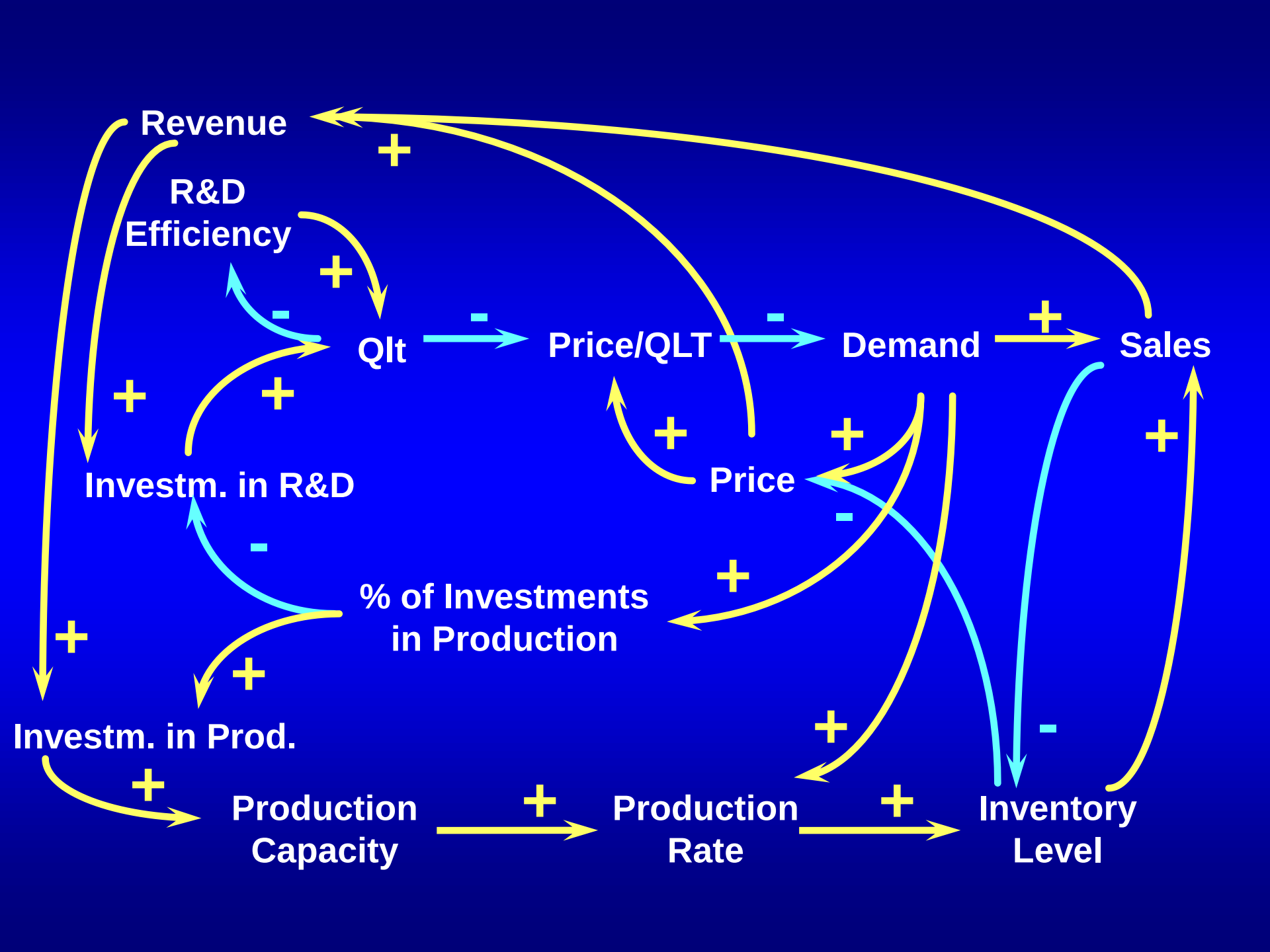

Revenue
R&D
Efficiency
+
-
QIt
-
Price/QLT
-
Demand
+
+
+
Price
Investm. in R&D
-
% of Investments
in Production
+
+
+
Investm. in Prod.
+
Production
Capacity


Revenue
R&D Efficiency
+
-
QIt
-
Price/QLT
-
Demand
+
+
+
Price
Investm. in R&D
-
% of Investments in Production
+
+
+
+
Investm. in Prod.
+
Production Capacity
+
Production Rate


Revenue
R&D Efficiency
+
-
QIt
-
Price/QLT
-
Demand
+
Sales
+
+
+
Price
+
Investm. in R&D
-
% of Investments in Production
+
+
+
+
Investm. in Prod.
+
Production Capacity
+
Production Rate
+
Inventory Level


Revenue
R&D Efficiency
+
-
QIt
-
Price/QLT
-
Demand
+
Sales
+
+
+
Price
+
Investm. in R&D
-
% of Investments in Production
+
+
+
+
Investm. in Prod.
+
Production Capacity
+
Production Rate
+
Inventory Level
-

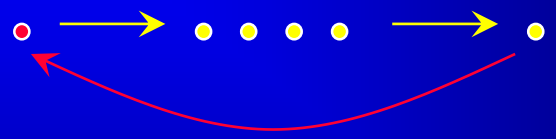

Revenue
R&D Efficiency
QIt
Price/QLT
Demand
Sales
Price
Investm. in R&D
% of Investments in Production
Investm. in Prod.
Production Capacity
Production Rate
Inventory Level


Revenue
R&D Efficiency
Qlt
Price/QLT
Demand
Sales
Investm. in R&D
Price
% of Investments in Production
Investm. in Prod.
Production Capacity
Production Rate
Inventory Level

... not only do

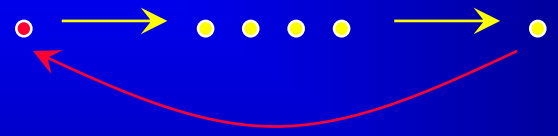
Effects take time

Effects feed back

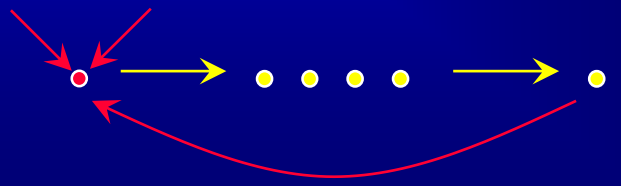


Effects take time

Effects feed back



Effects also synergize

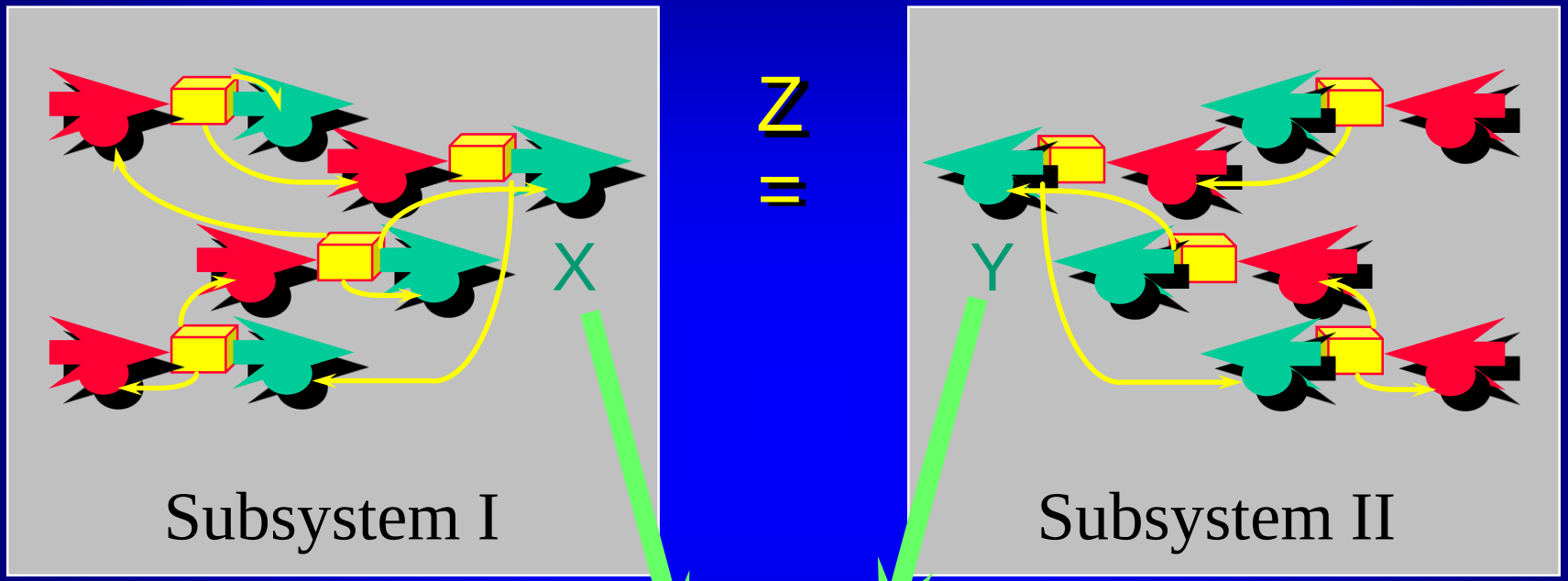


Accumulation

Feedback

Complexity

Non-linearity



X * Y

or

X / Y

rather than

X + Y or X - Y

Yield

=

Investments * Productivity

=

Investments

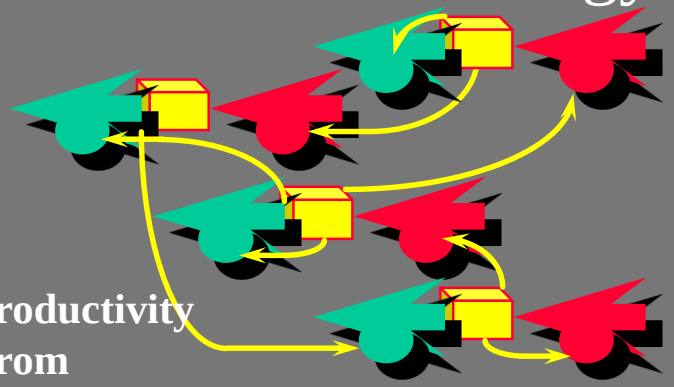
*

Productivity From Technology

*

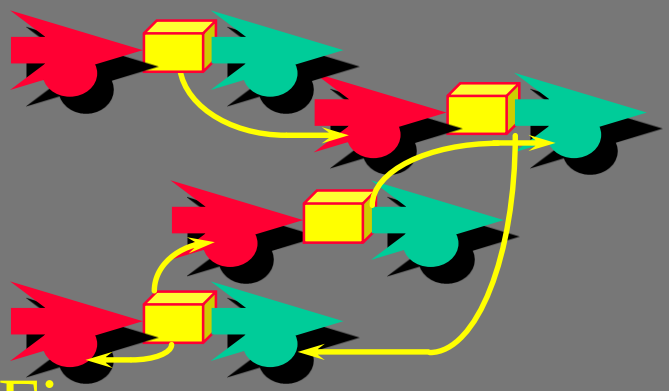
Effect Of Resource Availability On Productivity

Technology



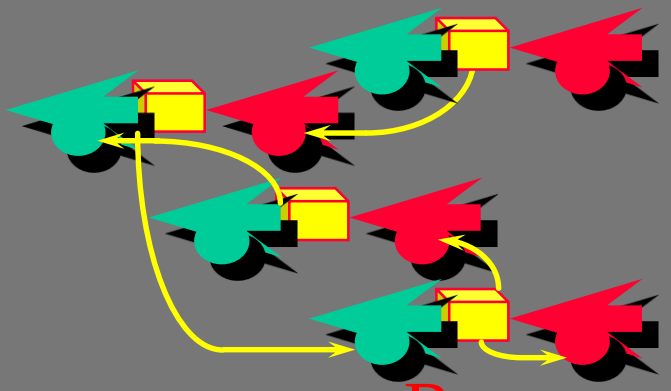
Productivity From Technology

Investments

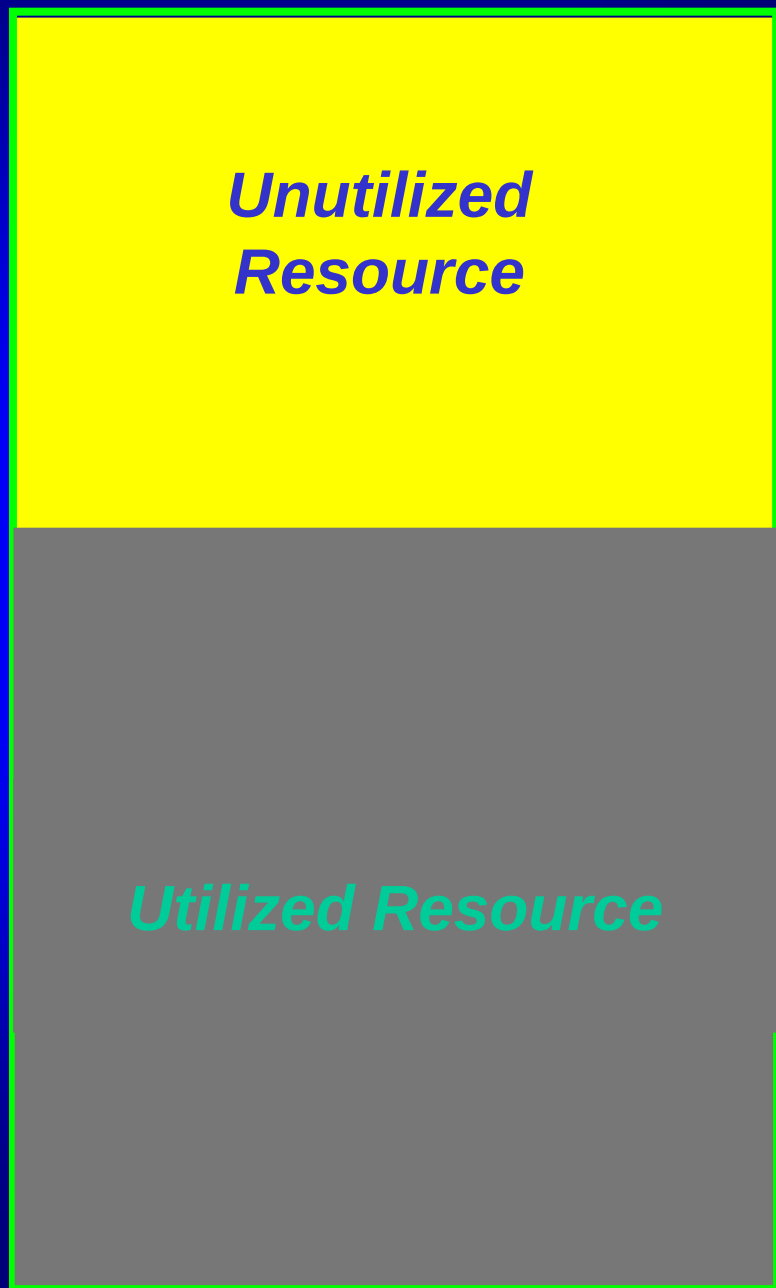


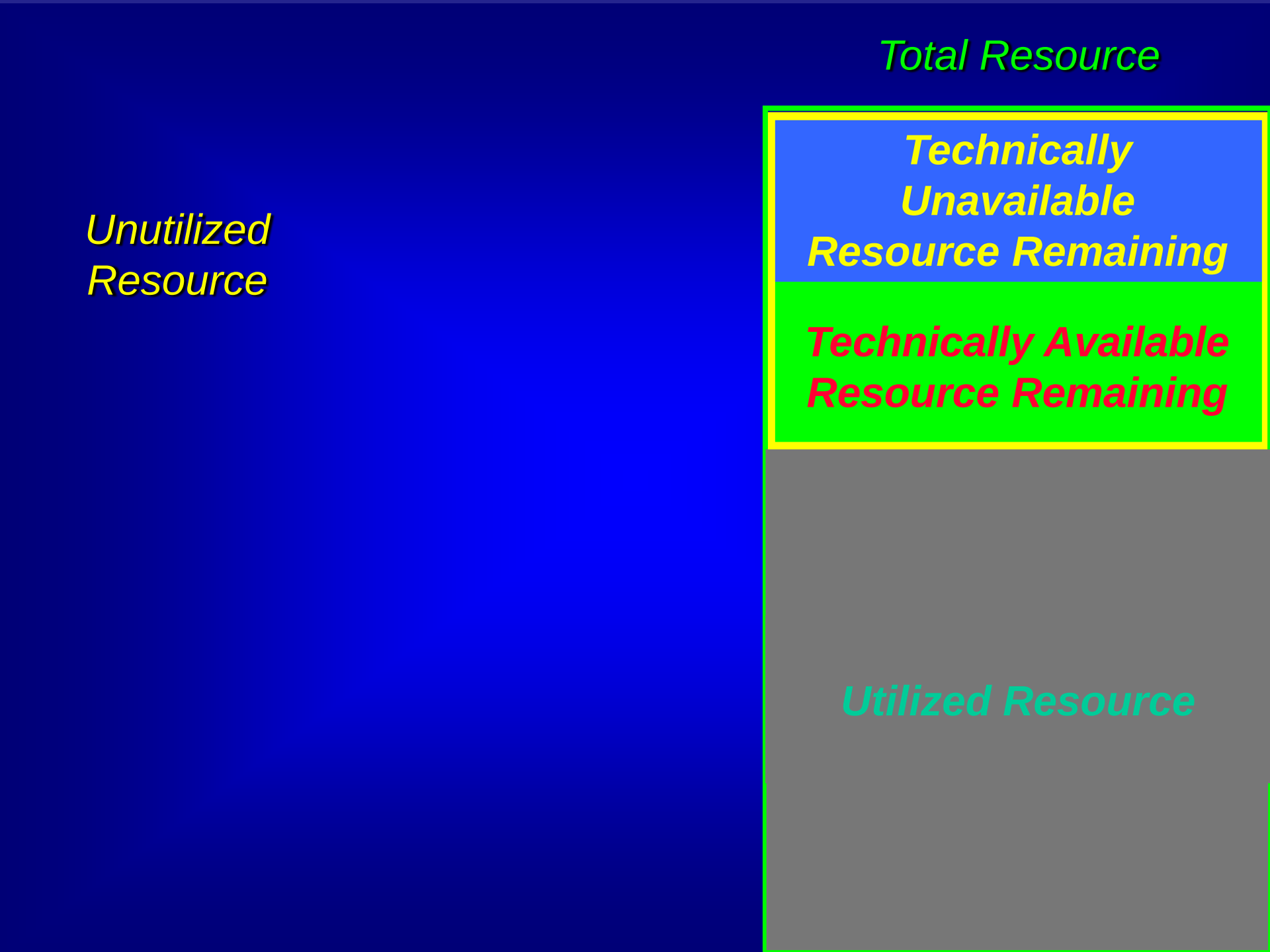
Finance

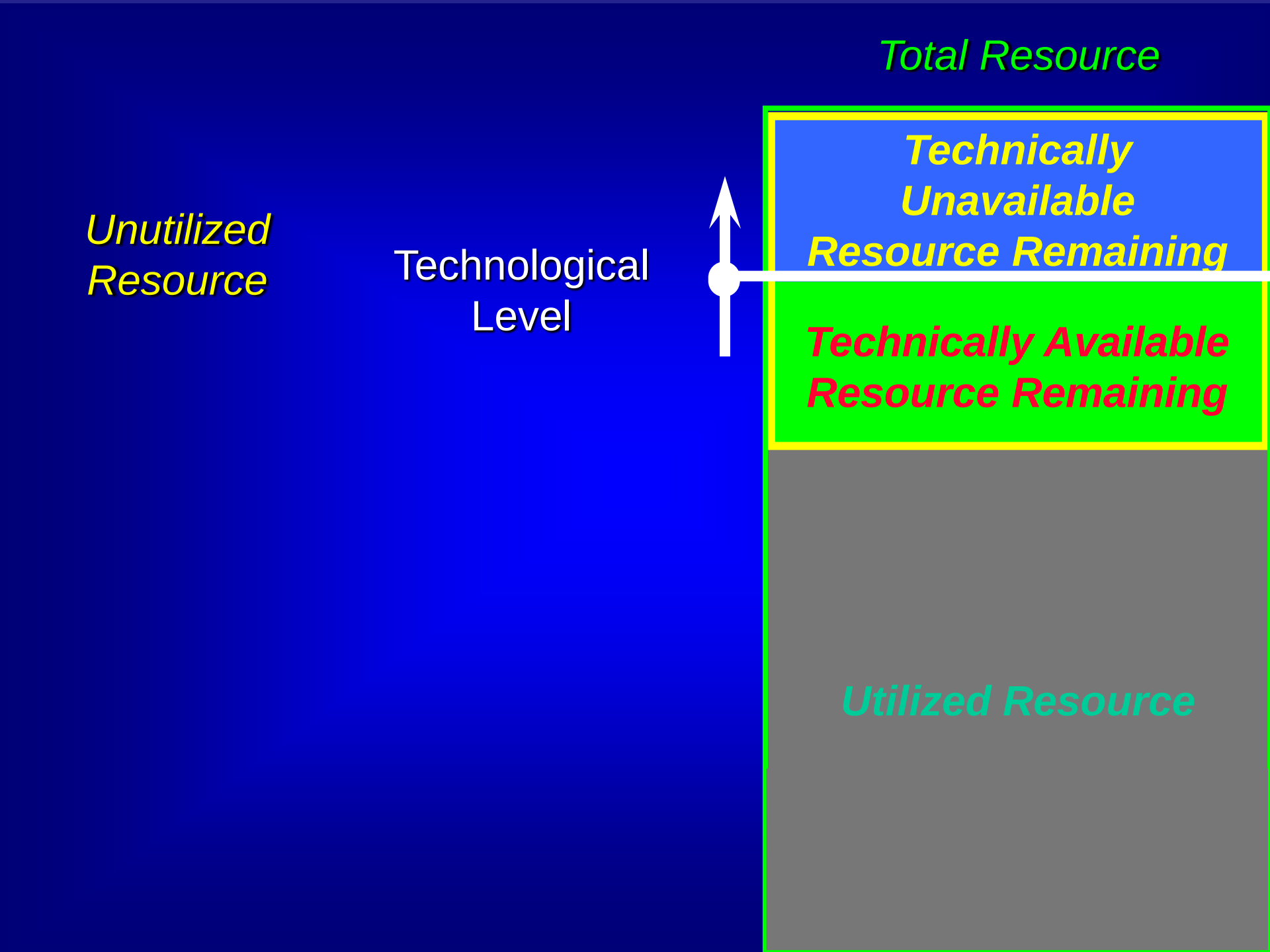
Eff. Of Resource Availability On Productivity

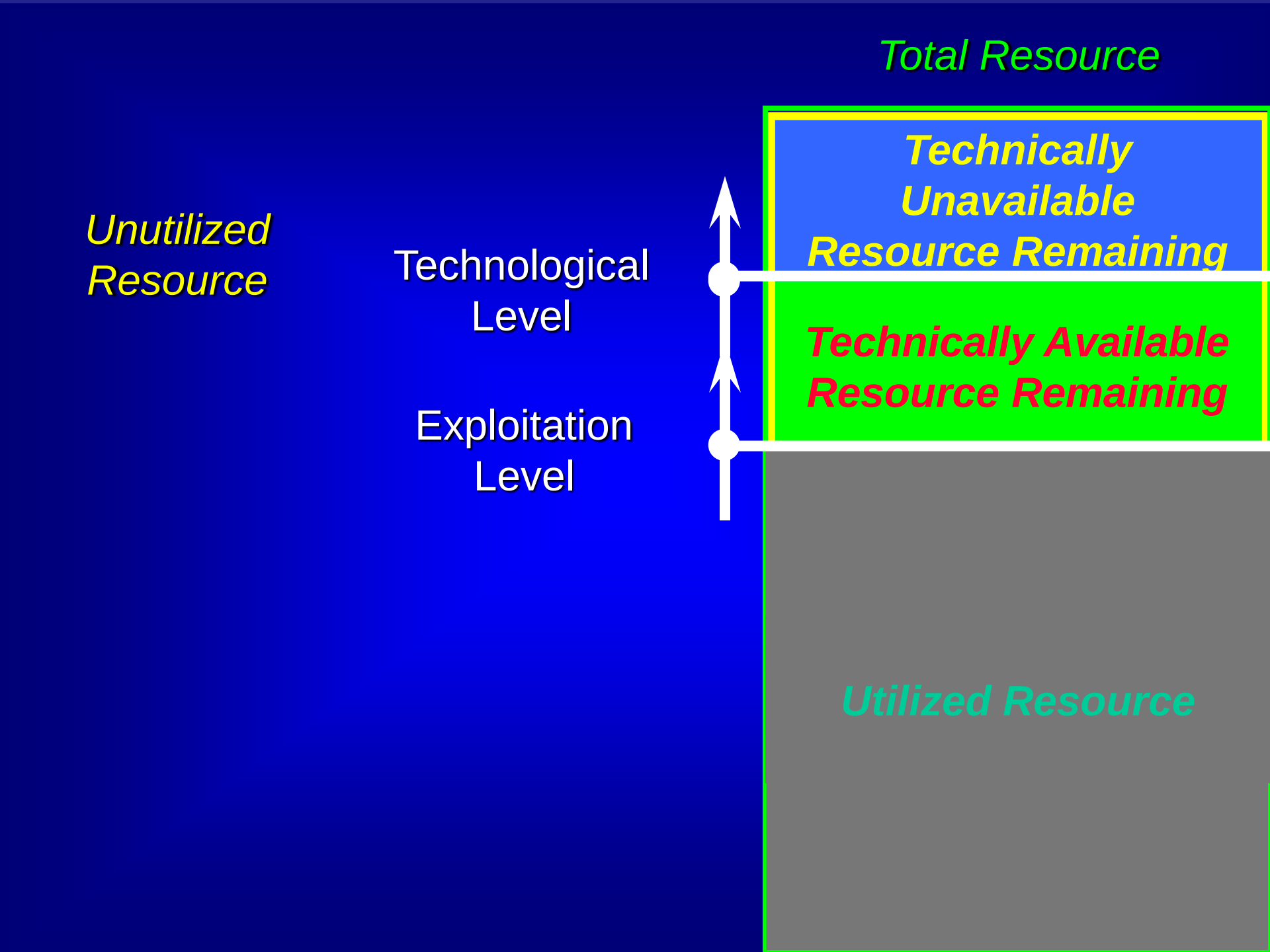


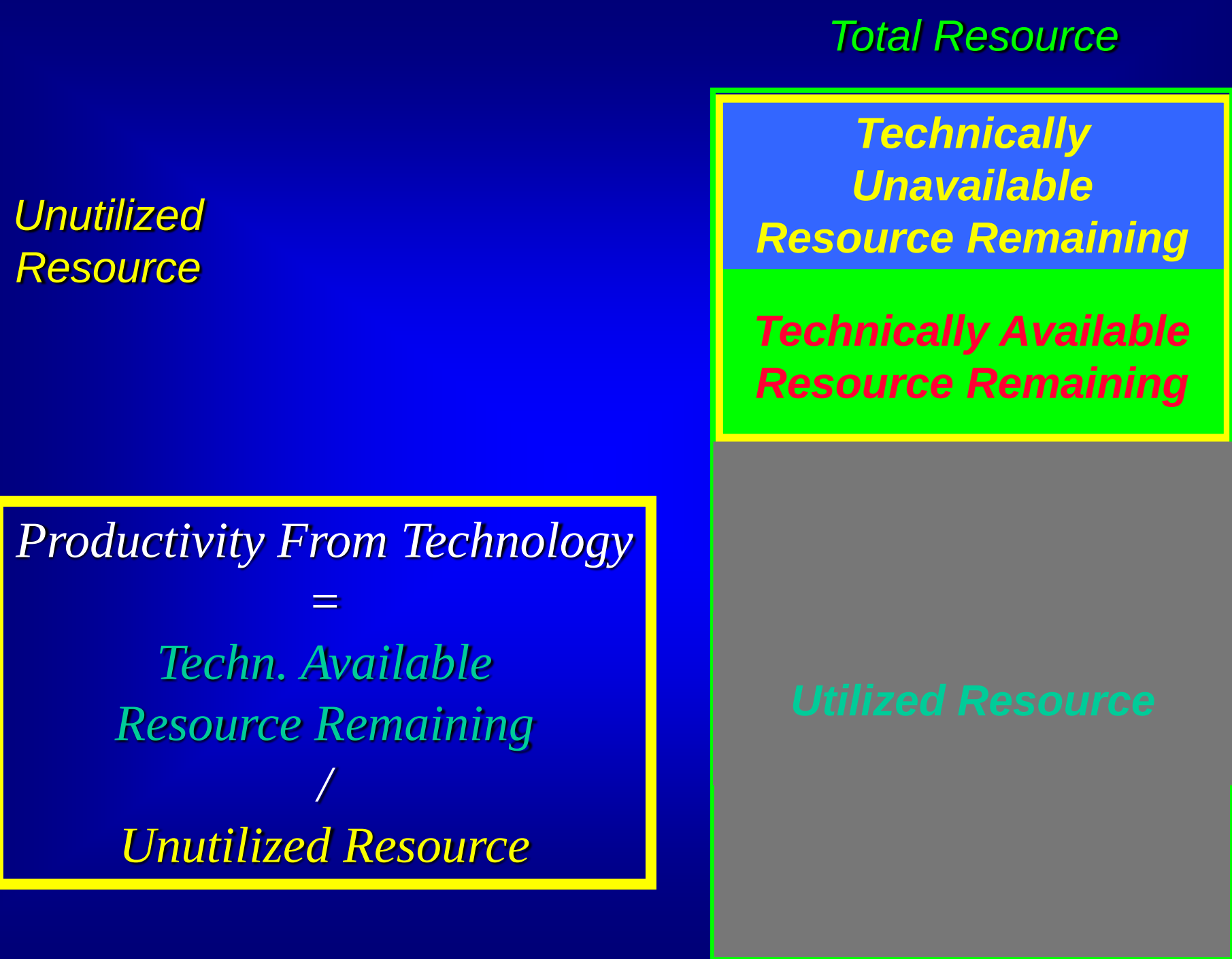
Resource

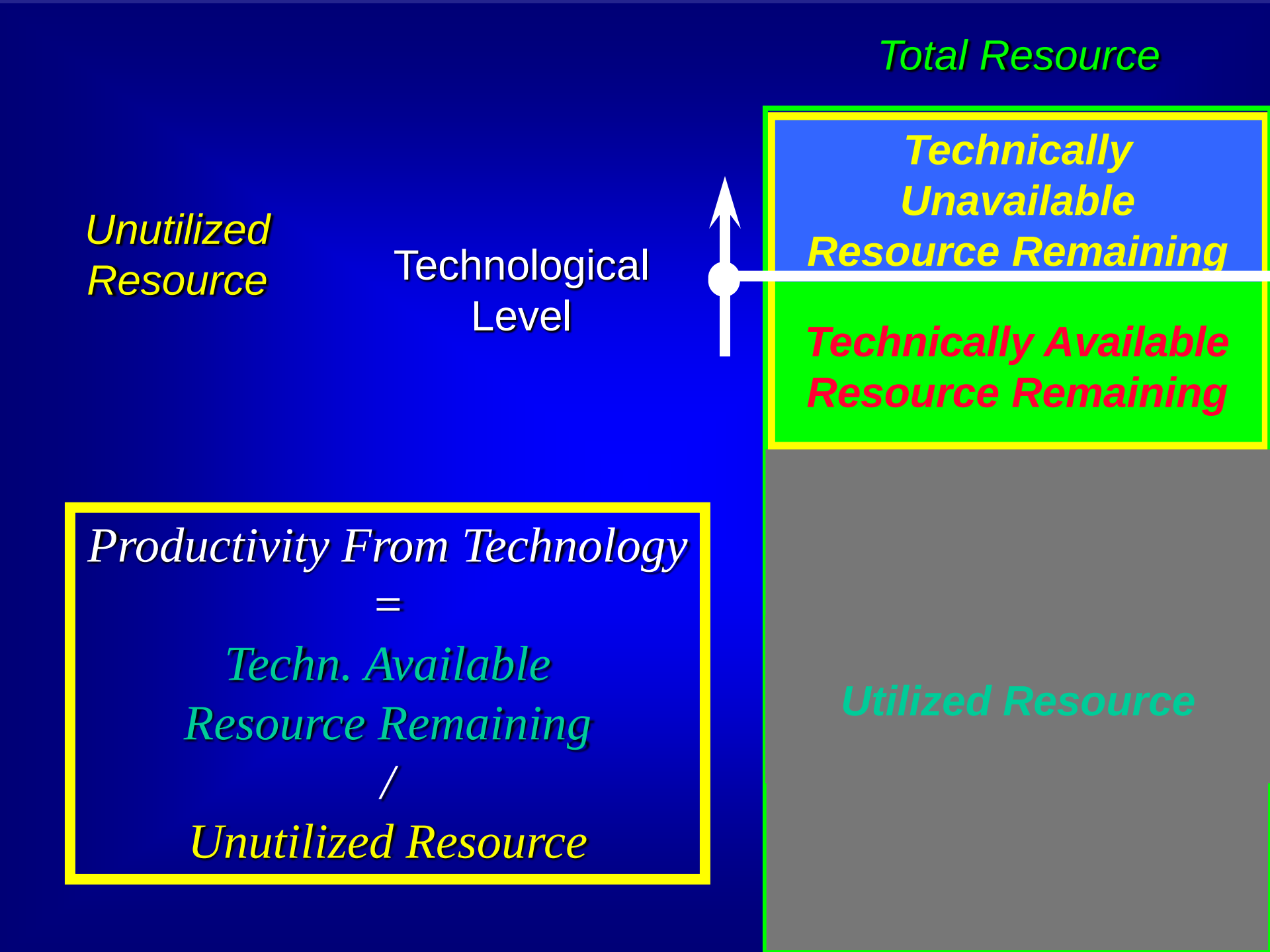

Total Resource
Unutilized Resource
Utilized Resource


Total Resource
Technically Unavailable Resource Remaining
Technically Available Resource Remaining
Utilized Resource
Unutilized Resource


Total Resource
Technically Unavailable Resource Remaining
Technically Available Resource Remaining
Utilized Resource
Unutilized Resource
Technological Level

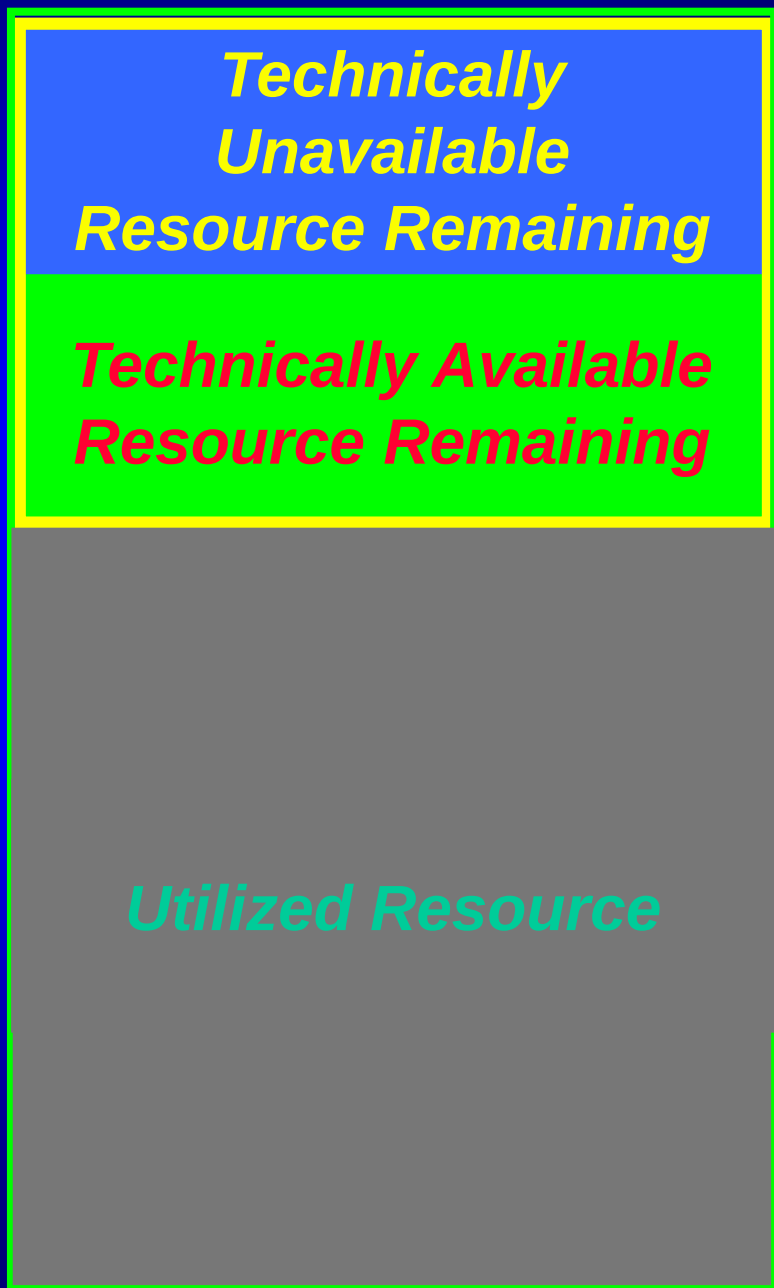

Total Resource
Technically Unavailable Resource Remaining
Technically Available Resource Remaining
Utilized Resource
Unutilized Resource
Technological Level
Exploitation Level


Total Resource
Technically Unavailable Resource Remaining
Technically Available Resource Remaining
Utilized Resource
Unutilized Resource
Productivity From Technology
=
Techn. Available Resource Remaining
/
Unutilized Resource


Total Resource
Technically Unavailable Resource Remaining
Technically Available Resource Remaining
Utilized Resource
Unutilized Resource
Technological Level
Productivity From Technology
=
Techn. Available Resource Remaining
/
Unutilized Resource

Total Resource

Unutilized Resource



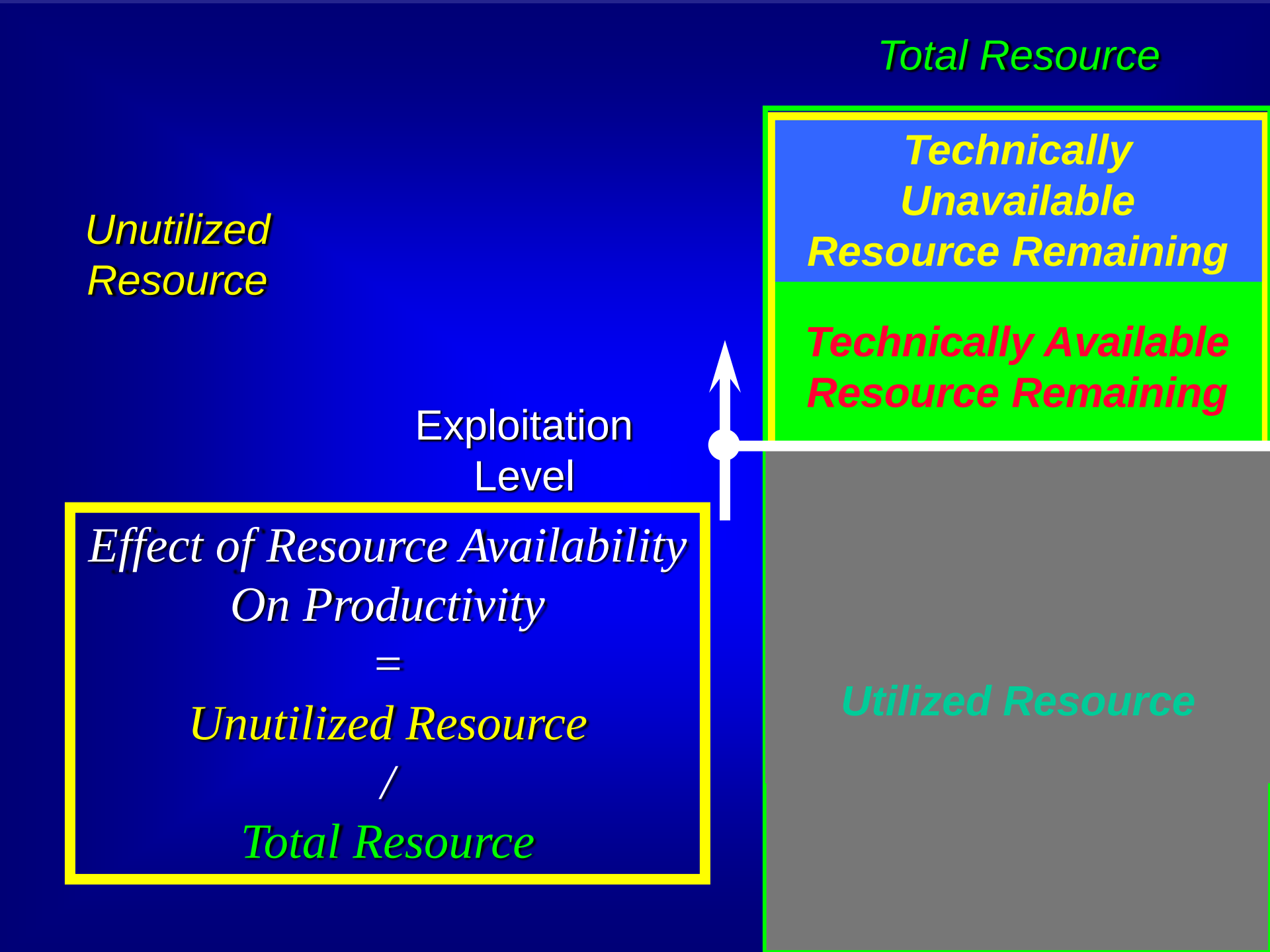
Effect of Resource Availability On Productivity

=

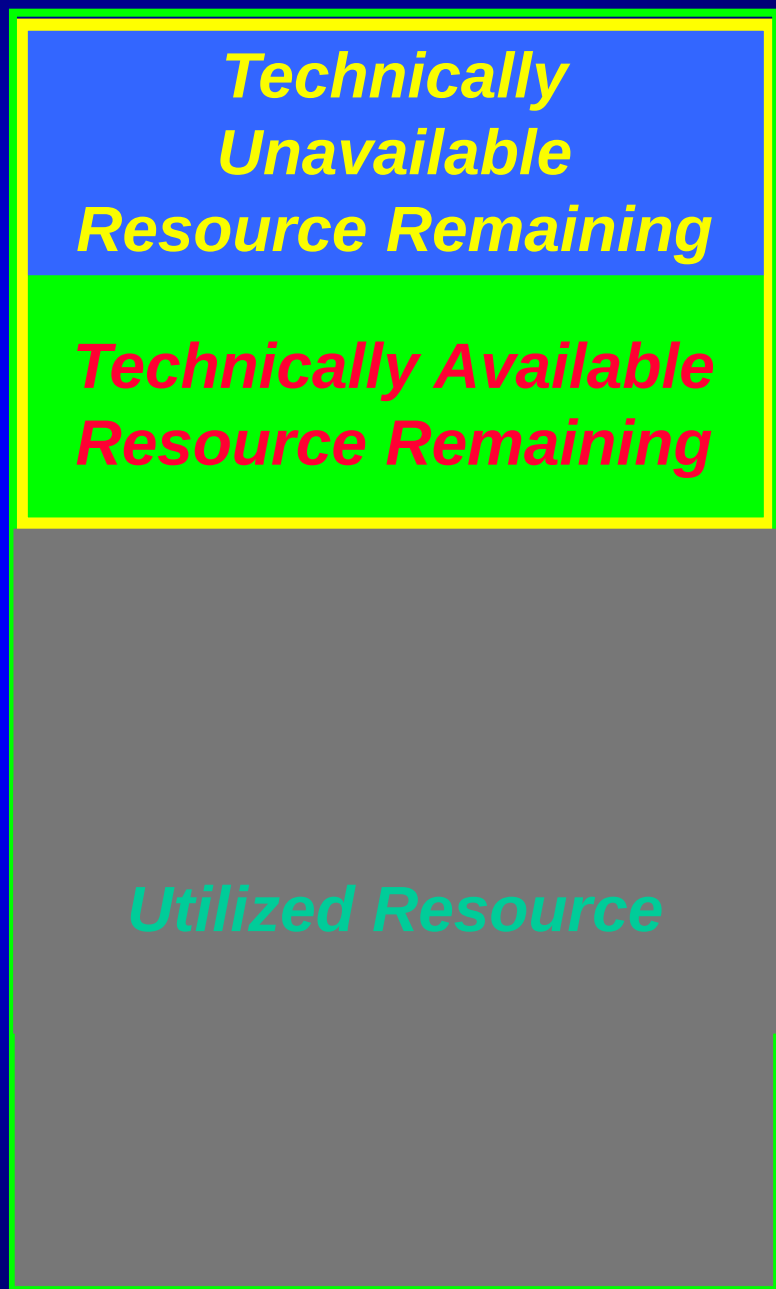
Unutilized Resource

/

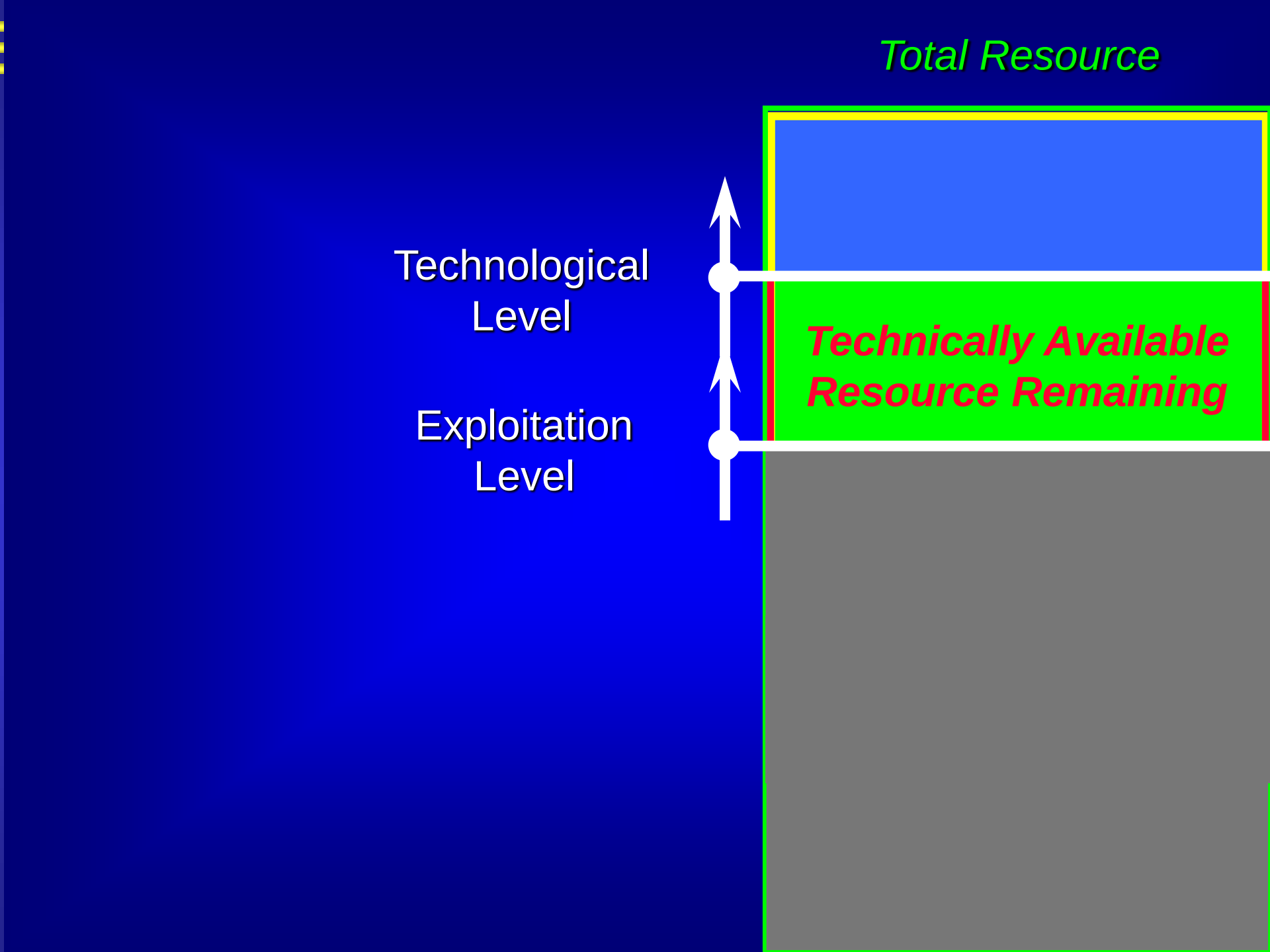
Total Resource


Total Resource
Unutilized Resource
Technically Unavailable Resource Remaining
Technically Available Resource Remaining
Exploitation Level
Utilized Resource
Effect of Resource Availability On Productivity
=
Unutilized Resource
/
Total Resource

Yield
=
Investments * Productivity
=
Investments
*
Techn. Available Resource Remaining
/
Unutilized Resource
*
Unutilized Resource
/
Total Resource



Yield
=
Investments * Productivity
=
Investments
*
Techn. Available
Resource Remaining
/
Total Resource

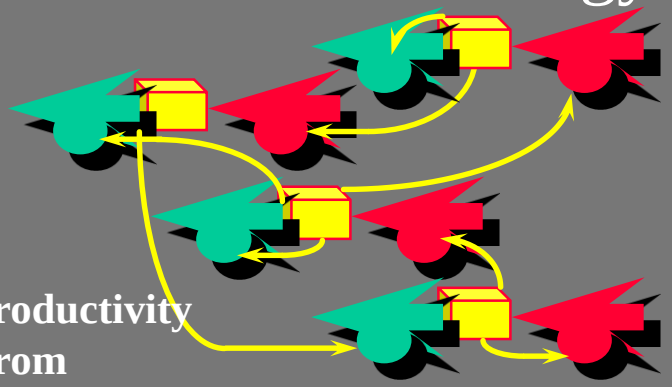

Total Resource
Technological Level
Exploitation Level
Technically Available Resource Remaining

…so that
non-linearity

causes

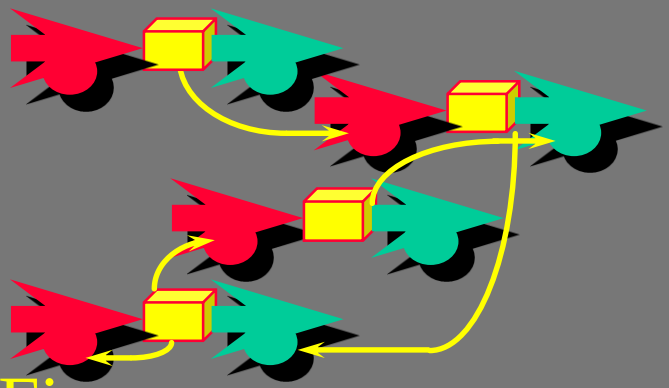
effects to become
blended

Technology



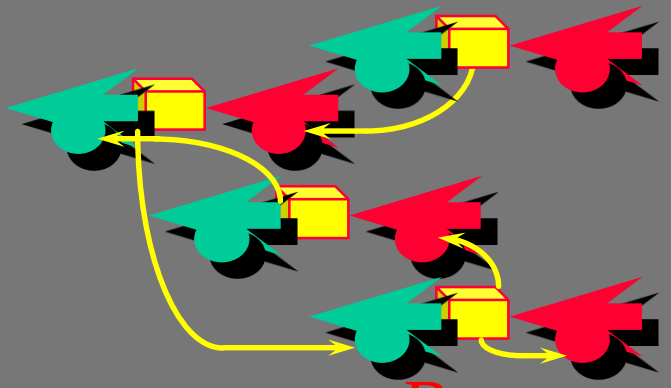
Productivity
From
Technology

Investments



Finance

Eff. Of Resource
Availability
On Productivity

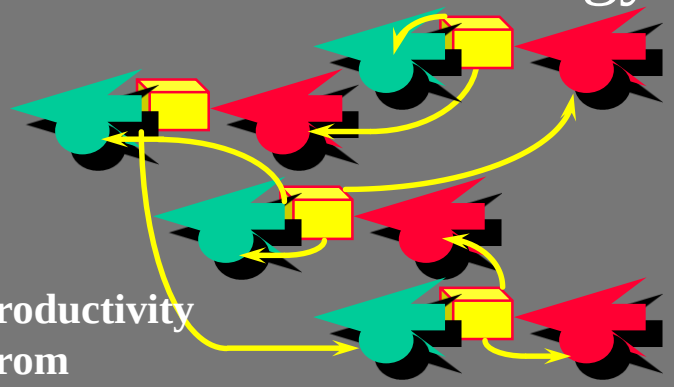


Resource

=>
it difficult to

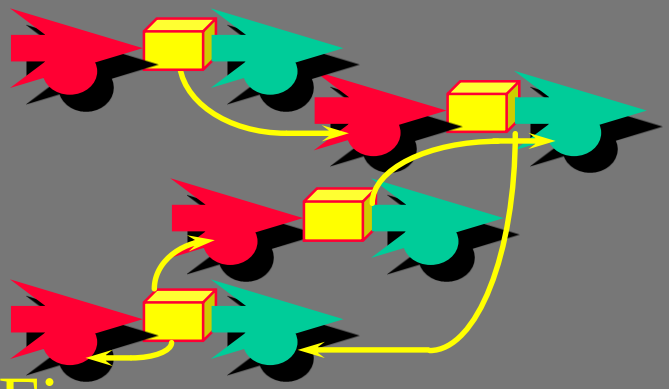
establish experience
with respect to
underlying causes
(diagnosis)
and
leverage points, doses and timing
(treatment)

Technology



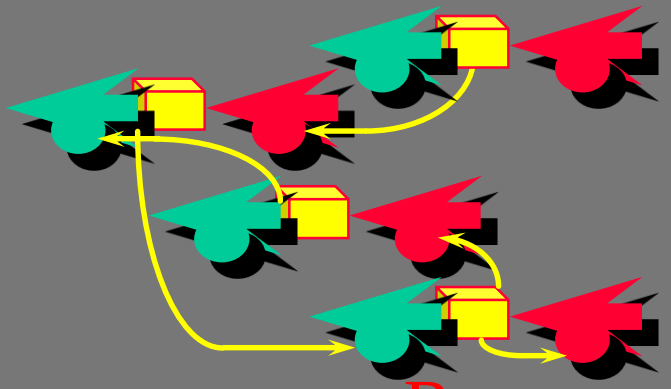
Productivity
From
Technology

Investments



Finance

Eff. Of Resource
Availability
On Productivity



Resource

Investment loop dominance

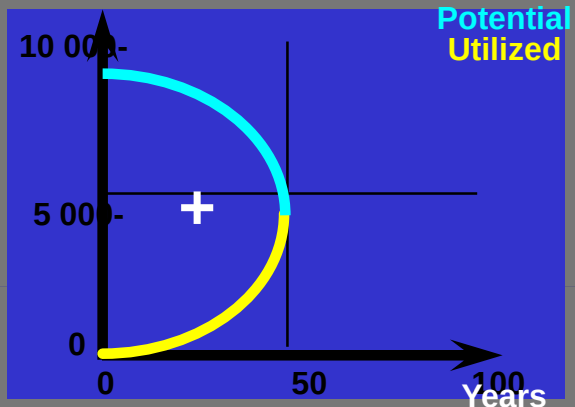
Total Resource

Technically Unavailable Resource Remaining

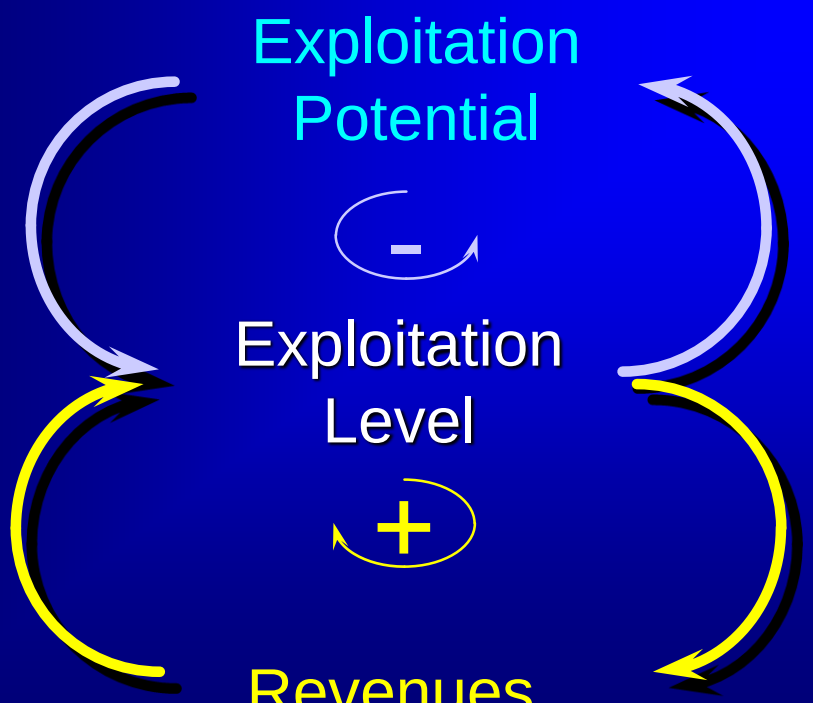
Technically Available Resource Remaining

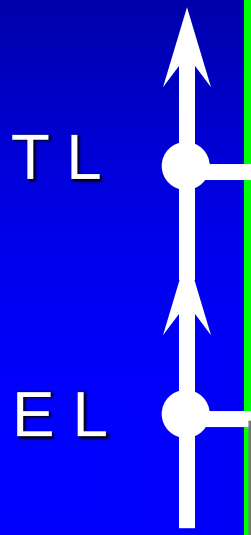
Technological Level

Exploitation Level



Depletion loop dominance

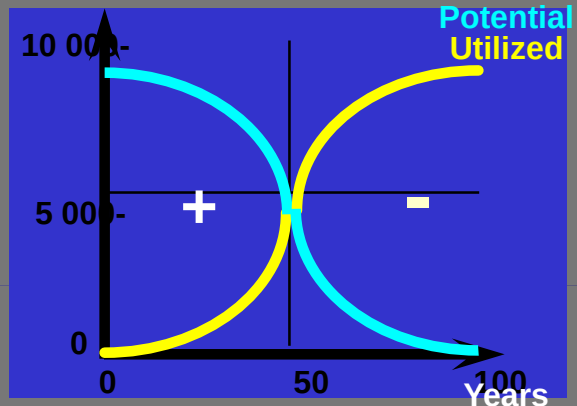




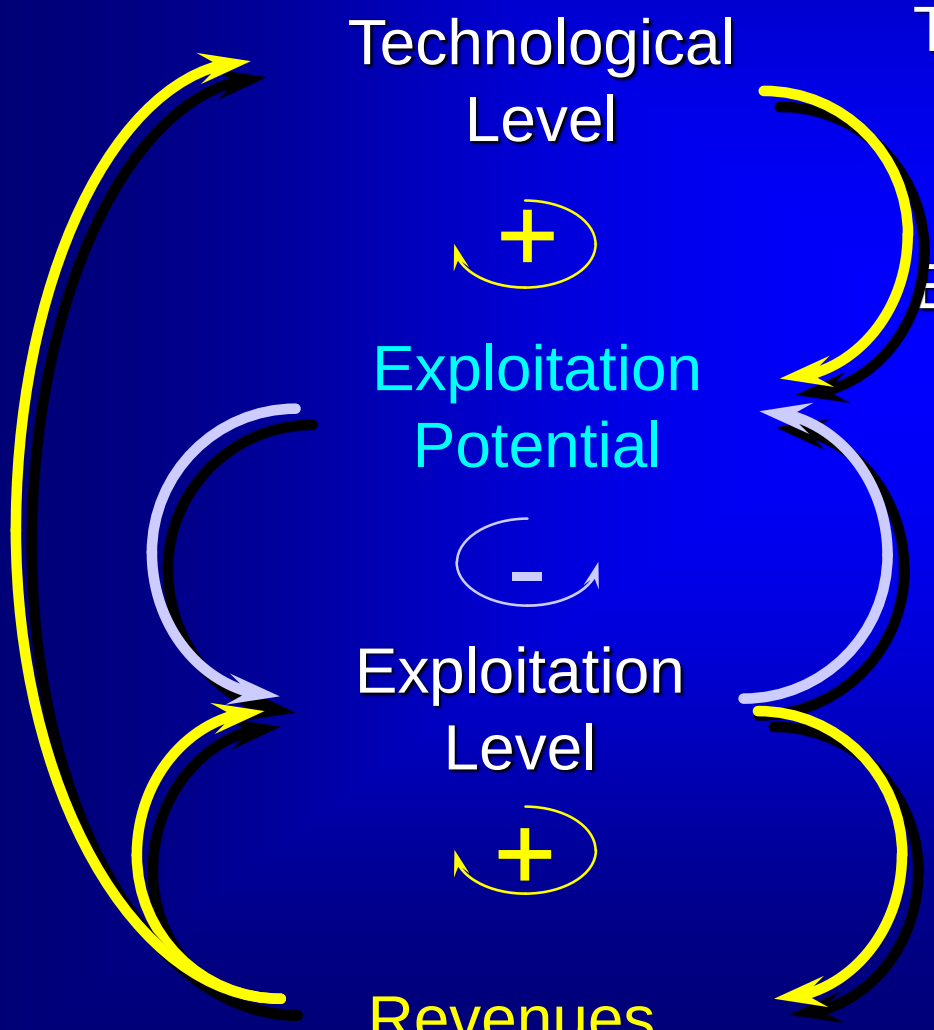
Total Resource

Technically Unavailable Resource Remaining

Technically Available Resource Remaining



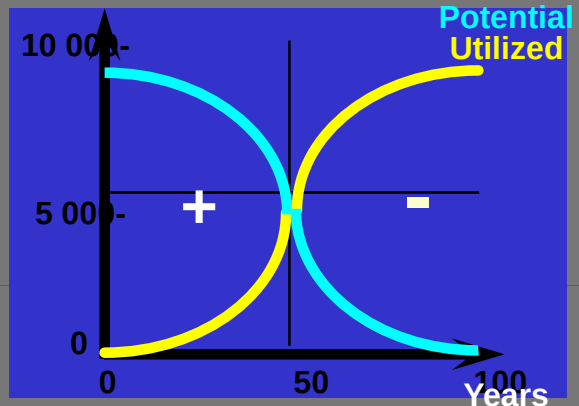
Compensating for the depletion loop dominance by the technology investment loop



Total Resource

Technically Unavailable Resource Remaining

Technically Available Resource Remaining



Management

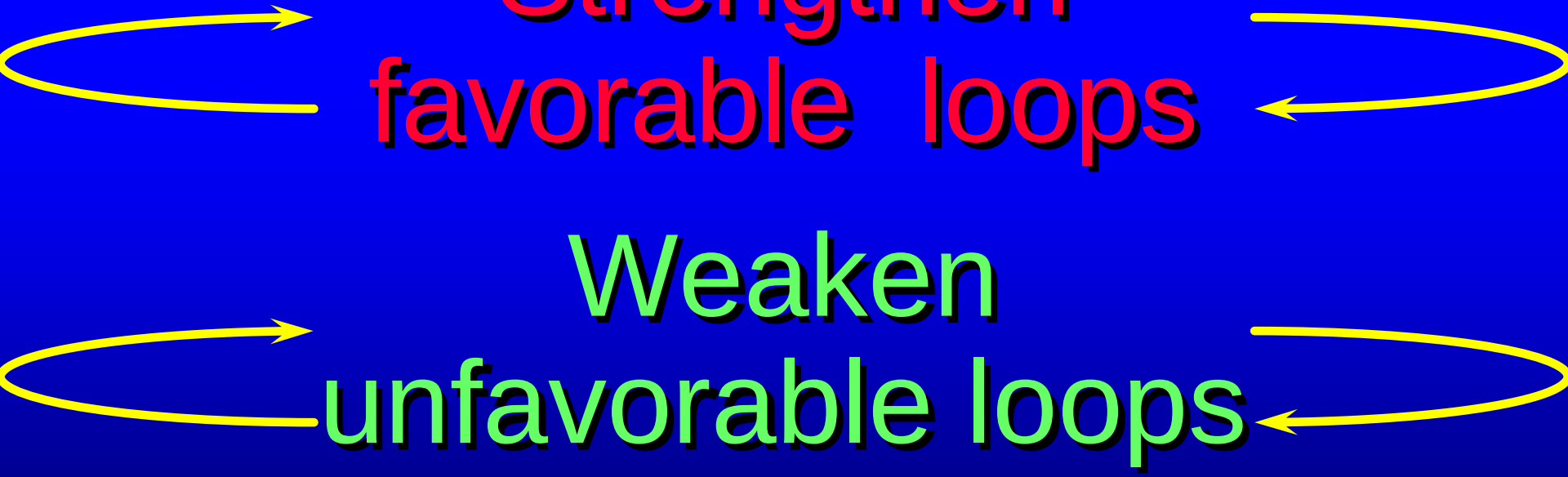
from a
System Dynamics
perspective

Management

from a
System Dynamics
perspective

Management

from a
System Dynamics
perspective



Challenge:

What loops are
favorable or unfavorable
varies
from one point in time
to the next
…

Biotechonomy

A system dynamics approach

Pål I. Davidsen
Professor
Department of Geography
University of Bergen
pal.davidsen@uib.no