INVESTMENT REVERSIBILITY AND COORDINATION FAILURES

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HISTORY OF ECONOMIC THOUGHT ACCORDING TO OLIVER WILLIAMSON

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-Adam Smith (Lens of Choice)

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-Oliver Williamson (Lens of Contract)

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AN (IMPROVED) HISTORY OF ECONOMIC THOUGHT

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-Adam Smith (Lens of Choice)

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-Friedrich von Hayek (Economics as Adaptation to Uncertainty)

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-Oliver Williamson (Lens of Contract)

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MODEL AND RESULTS
Objectives and Summary

- Bilateral contract with exogenous uncertainty
- Technologies parametrized by reversibility
- Surplus allocated by ex-post bargaining
- Bargaining power related to outside options
- Computation of threshold frontier separating regimes by equilibrium behavior
- Two regimes: cooperation failure and coordination failure

Bayes-Nash Two-Stage Game

- $\theta < \theta^*$ Cooperation failure
  Single Pareto-inefficient equilibrium
  Prisoner's Dilemma

- $\theta > \theta^*$ Coordination failure
  Two equilibrium points
  Pareto-inefficient equilibrium dominates

- TRADITIONAL TRADE-OFFS:

  (Technology space)

Higher reversibility:

Lower productivity but higher flexibility and capacity for adaptation

- NEW TRADE-OFF:

  (Institutional design space)

Higher reversibility:

Options for design of mechanisms to coordinate on efficient equilibrium.

DEVELOPMENT & CONTRACT THEORY

-Clusters, global value chains

-Public-private partnerships

-Organizations and Institutions as Networks of Implicit Contracts

Complete contracts (Agency theory)

Incentive vs Insurance

Efficiency vs information rents

Renegotiation-proofness

Incomplete contracts

Ex-ante vs ex-post efficiency

Hold-up

Renegotiation protocols as completion rules

Incomplete Contract Theory

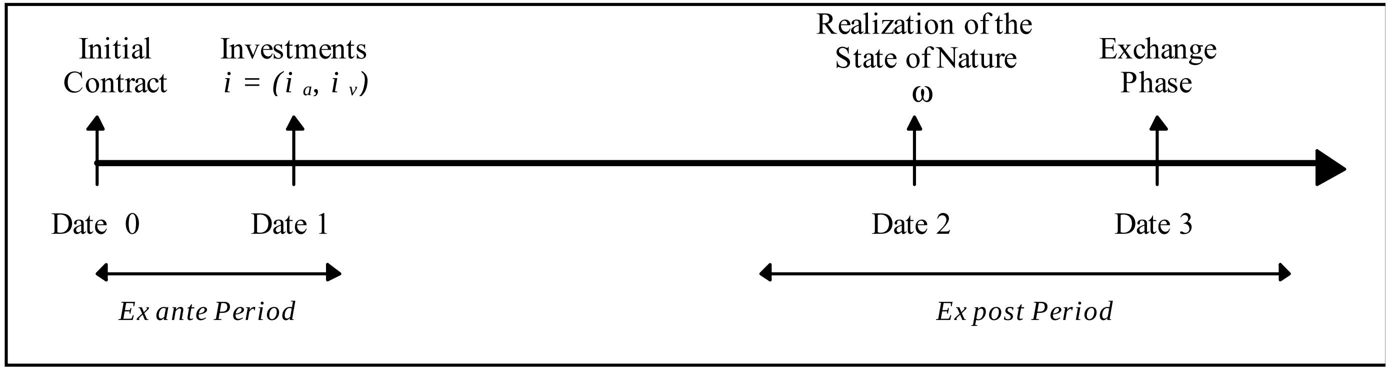
HOLD-UP PROBLEM

- Ex-post opportunism
- Under-investment bias (ex-ante inefficiency)

Williamson (1975),Grossman-Hart-Moore (1985)

SELF-ENFORCEMENT

- Relational contracts
- Reputation and trust
- Legal structures and endogenous enforcement
- Klein (1978), Baker-Gibbons-Murphy (2000, 2004)



Initial
Contract
Investments
i = (i a, i v)
Realization of the
State of Nature
ω
Exchange
Phase
Date 0
Date 1
Date 2
Date 3
Ex ante Period
Ex post Period

Ex -ante efficiency: optimal level of investment
Ex -post efficiency: trade only when it is gainful

Trade-off between commitment and flexibility:

Commitment :
Ex –ante efficiency but may impair ex -post efficiency—commit to an exchange that is not gainful.

Flexibility:
Ex--post efficiency but may impair ex –ante efficiency (hold-up)

Incomplete Contract Theory

- Coase (1937)
- Williamson (1975, 1985) Lens of Contract, TCE
- Incomplete ICT Hart Moore—based on explanation of hold-ups, property rights approach
- Vertical Integration as partial solution to hold-up
- Does not achieve first-best because of non-verifiability
- Supported by Williamson, NIE
- Challenged by Tirole—revelation mechanisms

- “Unbundling Institutions,” Acemoglu (2002)
- “Trade and Contract Enforcement” Anderson (2002)
- “Demand for Contract Enforcement and Gains from Trade,” Rubinchik & Samaniego (2005)

- Investment Reversibility—Single Agent

- Asset Specificity---Bilateral Contracting

  A.S. = Value of quasi-rents within relationship

  = gap relative to next-best alternative use

Parametrization of Reversibility θ

θ is reversible fraction, $0 \leq \theta \leq 1$. Fraction θ can be redeployed . Fraction (1-θ) is a sunk cost.

Date 0: Invest 1 unit

Date 1: Uncertain state realized

Prob (s_{good}) = p, return r_s

Prob (s_{bad}) = 1-p, return $R_{f,} < r_s$

Date 2: If s_{bad} obtains, redeploy fraction θ to outside option r*, $R_{f,} < r^* < r_s$

$$E[\ V\ ] = p.\ r_s + (1-p).\ R_f (1-\theta) + (1-p).r^*.\ \theta$$

NUMERICAL EXAMPLE

Investment in a production facility:

Cost $80M

Gross Revenues $ 130M with $p = ½$

$ 50M with $p = ½$

Reversibility θ

Reservation payoff $r^* = \$100M$

$$E[NPV_\theta] = 25\,\theta + 10$$

$$E[NPV_W] = 25$$

Invest Now vs. Wait to Invest

No-arbitrage condition:

$$E[NPV_{\theta}] = E[NPV_{W}]$$

$$25\,\theta + 10 = 25$$

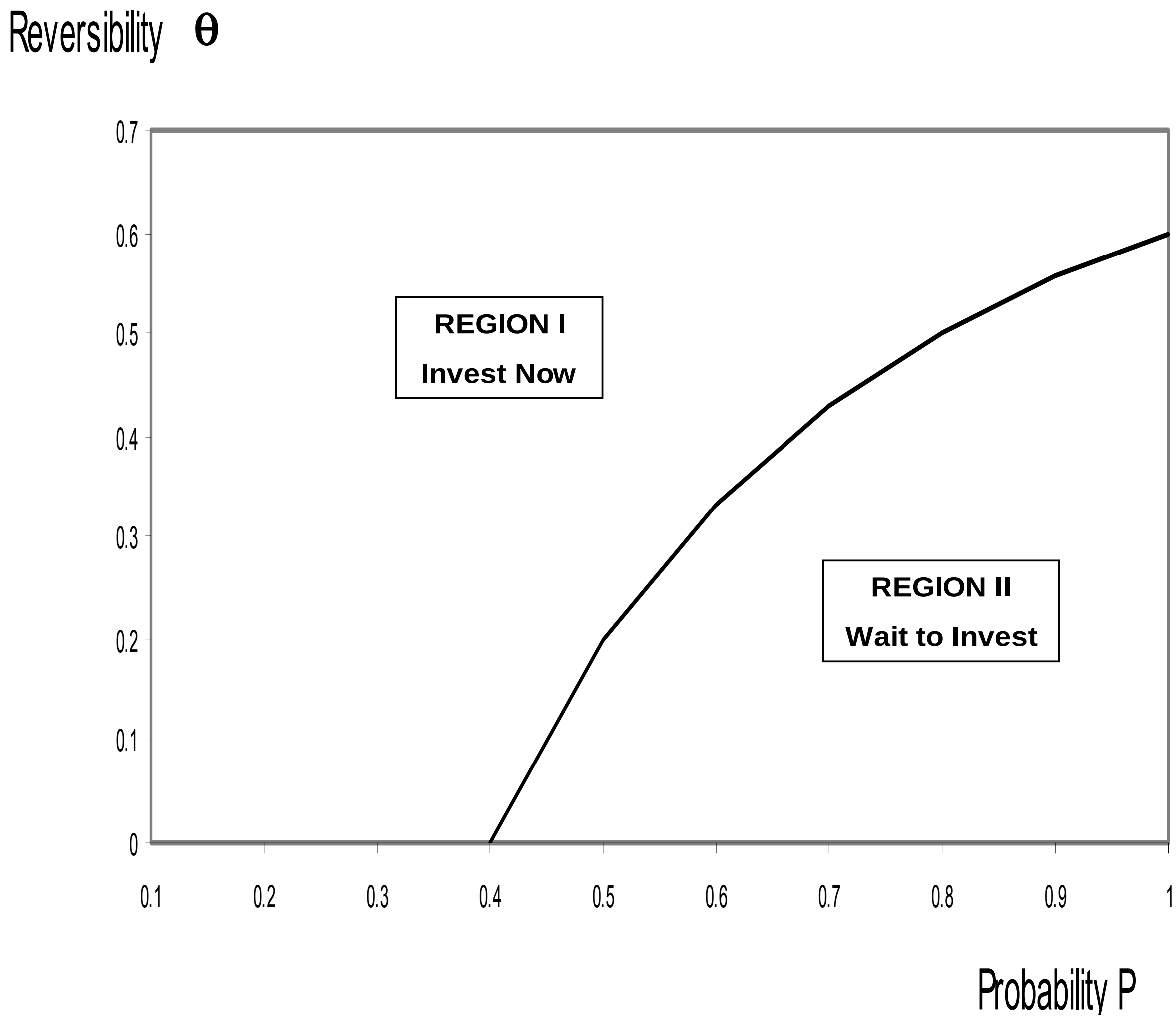
$$\theta^* = 0.6$$

Region I: Invest Now:

$$\theta > 0.6$$

Region II: Wait to Invest

$$\theta < 0.6$$



Partial Reversibility and the Decision to Invest

- Contract Game with a Continuum of Technologies-- θ_B, θ_S
- Canonical Contract Game
  - Partially Reversible θ
  - Irreversible ($\theta=0$)

(1) Olcina, G. & Peñarrubia, C., (2002)
"Specific investments and coordination failures"
Deterministic, exogenous technologies

(2) Muthoo, A., (1998)
"Sunk Costs and the Inefficiency of Relationship-Specific Investment,"
Deterministic cost structure, focus on bargaining protocol

(3) Caballero, R.., and Hammour, M.L. (2000)
"Creative Destruction and Development"
Creative destruction
Adjustment costs proportional to degree of irreversibility

Bilateral Contract with a Continuum of Technologies

- The contract game has two stages: the *investment stage* and the *bargaining stage*.
- In the first stage, the buyer and the seller each invest in a technology selected from $T = \{T(\theta), 0 \leq \theta \leq 1\}$. The cost of technology $T(\theta)$ is $c(\theta)$, $c'(\theta) \leq 0$, $c''(\theta) \geq 0$.
- Payoff to investment in technology $T(\theta)$ contingent on random state s. There are two states, $s = s_g$ *(good)* with probability p and $s = s_b$ (*bad),* with probability 1 – p.

- STAGE II: Bargaining Stage
- STAGE I: Investment Stage

- Investment decisions:

  Maximize the expected value of the share of the surplus given expectations about the bargaining outcome in the second stage.

KEY TRADE-OFF

- Higher reversibility θ yields lower productivity, but is associated with higher outside options, implying increased bargaining strength

Stage II: The Bargaining Stage

- $\Lambda = E[V(\theta_B, \theta_S)] = p.\ Rg\ (\theta_B, \theta_S) + (1-p)\ [(1-\theta_B)R_f + (1-\theta_S)R_f\ ]$
  $+ (1-p)\ [\theta_B\ r(\theta_B\ ) + \theta_S\ r(\theta_S)\ \ ] - c(\theta_B) - c(\theta_S)$

- $J_B(\theta_B, \theta_S) = \omega_B + ½\ [\Lambda + \omega_B - \omega_S]$
  $= ½\ \Lambda - ½\ [\omega_B - \omega_S\ ]$
- $J_S(\theta_B, \theta_S) = \omega_S + ½\ [\Lambda + \omega_S - \omega_B]$
  $= ½\ \Lambda - ½\ [\omega_S - \omega_B\ ]$

Given that $\partial\omega_B/\partial\theta_B \geq 0$, $\partial\omega_S/\partial\theta_S \geq 0$, higher reversibility, associated with higher outside options, yields increased bargaining strength

Investment Stage

θ^*_B = arg max {max ½ [p. R_g (θ_B, θ_S) + (1–p) [(1-θ_B)R_f + (1–θ_S)R_f]

θ_B θ_S + (1–p) [θ_B r(θ_B) + θ_S r(θ_S)]

– c(θ_B) - ½ .[ω_B - ω_S]]}

θ^*_S = arg max {max ½ [p. R_g (θ_B, θ_S) + (1–p) [(1-θ_B)R_f + (1–θ_S)R_f] θ_S θ_B

+ (1–p) [θ_B r(θ_B) + θ_S r(θ_S)]

– c(θ_B) - ½ [ω_S - ω_B]]}

Linear-Quadratic Bayes-Nash Equilibrium

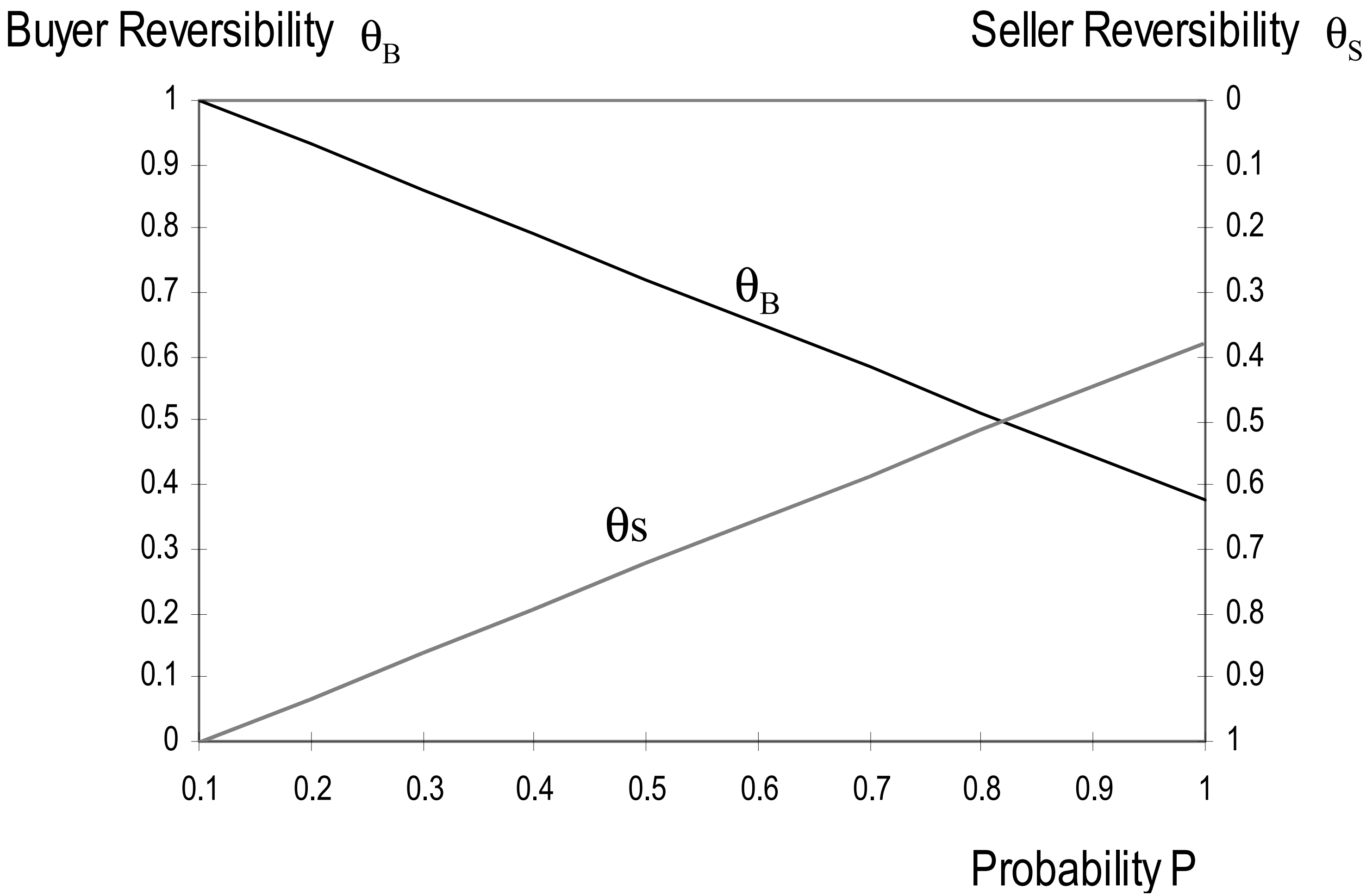
Let

$R_g(\theta_B, \theta_S) = 1 - (\theta_B + \theta_S) - \alpha (\theta_B - \theta^S)^2$

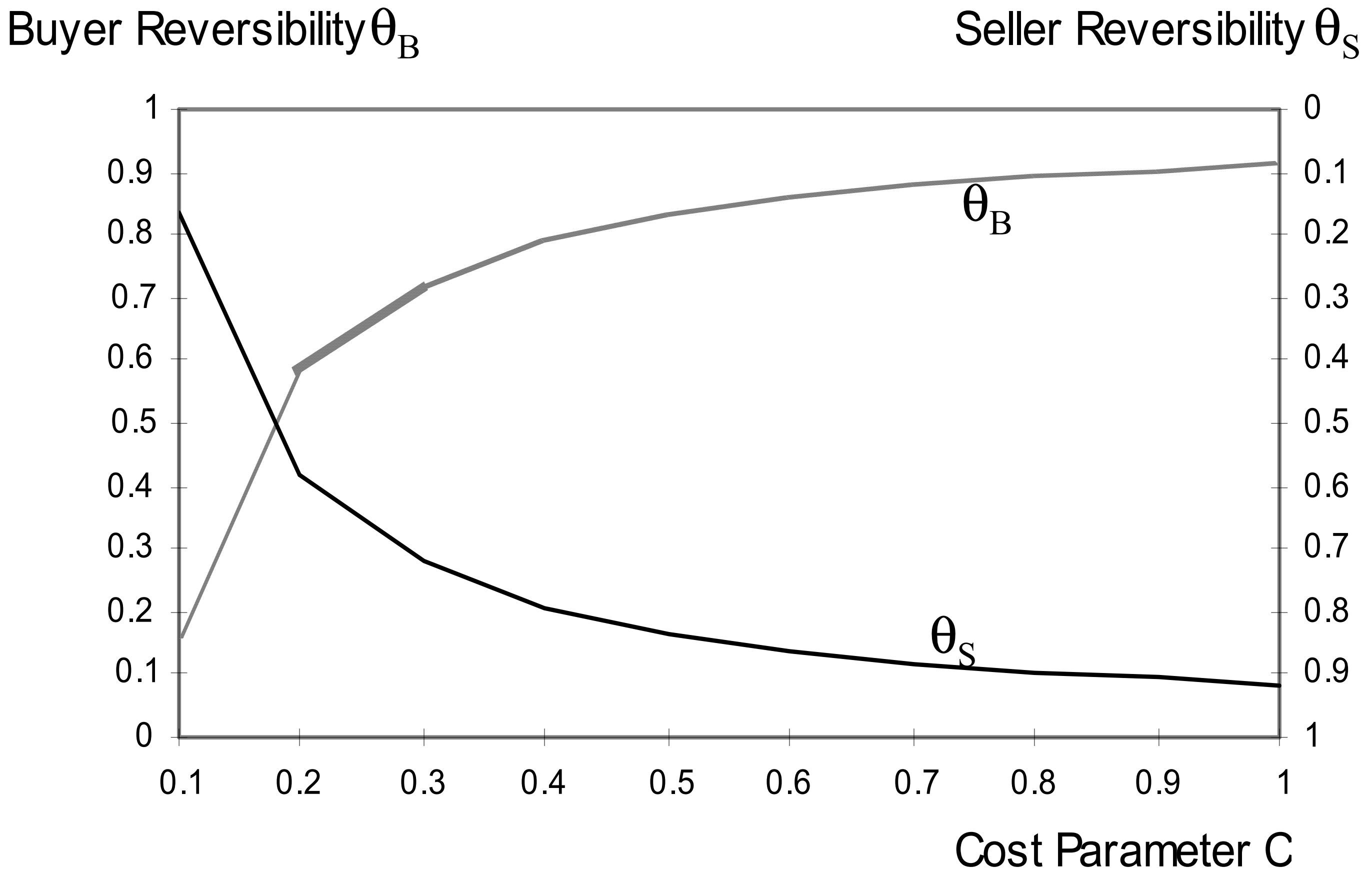
and $c(\theta_S) = c(1- \theta_S)2$, $c(\theta_B) = c(1- \theta_B)2$, $r(\theta_B) = r_B$, $r(\theta_S) = r_S$.

The optimal investment strategy (θ^*_B, θ^*_S), is the Nash equilibrium to the game, which solves:

- $\partial J_B(\theta_B, \theta_S) / \partial\theta_B = 2 p \alpha (\theta_S - \theta_B) + (1-p) (r_B - R_f) + 4c (1-\theta_B) - p = 0$
- $\partial J_S(\theta_B, \theta_S) / \partial\theta_S = 2 p \alpha (\theta_B - \theta_S) + (1-p) (r_S - R_f) + 4c (1-\theta_S) - p = 0$



Bayes – Nash Equilibrium Values



Bayes – Nash Equilibrium Values

The Canonical Contract Game

State-contingent contractual agreement specifying an investment stage and a bargaining stage.

<u>First Stage--Investment</u>

Buyer and seller choose between two technologies:

- H– Hi-tech, specific, irreversible , $\theta = 0$ Outside option 0
- General low-tech (L), partial reversibility parameter θ, $0 < \theta \leq 1$. Outside option ω

<u>Second Stage--Bargaining</u>

Joint surplus determined by the pair of investments chosen in the first stage.

- Cost of high-tech investment = c
- Cost of low-tech investment = $\psi = c(1-\theta)$

Backward induction:

Bargaining Stage:

Sub-Game I: H,H

Sub-Game II: H,L; L,H

Sub-Game III: L,L

Investment Stage:

Coordination Game/Prisoner’s Dilemma

- *Subgame 1: Both players invest in High-Tech*

  Both outside options are zero. The expected payoff is:

$$E[V^{HH}] = p\ Rg^{HH} + (1-p)\ R_f \ ; \quad R_g^{HH} > R_f$$

  and the share of the surplus accruing to each party is given by:

$$J^{HH} = ½[E[V^{HH}]] = ½[\ p\ R_g^{HH} + (1-p)\ R_f\ ]$$

Subgame 2: One player invests in High-Tech and the other in Low-Tech

$J^{B}_{HL} = ½[E[V^{HL}] - \omega]] = ½[p\ R_g^{HL}(\theta) + (1-p)\ R_f (1 - \theta) + (1-p).\ \theta\ r^* - \omega]$

$J^{S}_{HL} = ½[E[V^{HL}] + \omega]] = ½[p\ R_g^{LH}(\theta) + (1-p)\ R_f (1 - \theta) + (1-p).\theta\ r^* + \omega]$

where r^* is the reservation payoff , $Rg^{HH} > r^* > R_f$

$J^{B}_{LH} = ½[E[V^{LH}] + \omega]] = ½[p\ R_g^{HL}(\theta) + (1-p)\ R_f (1 - \theta) + (1-p).\ \theta\ r^* + \omega]$

$J^{S}_{LH} = ½[E[V^{LH}] - \omega]] = ½[p\ R_g^{LH}(\theta) + (1-p)\ R_f (1 - \theta) + (1-p).\ \theta\ r^* - \omega]$

Subgame 3: Both players invest in Low-Tech

Assume symmetric low-tech technologies:

i.e. $\theta_B = \theta_S = \theta$

Then the expected joint payoff is:

$J_{LL} = E[V_{LL}] = ½[p\ R_g^{LL}(\theta) + (1-p)\ R_f(1 - \theta) + (1-p).\ \theta\ r^* + \omega]$

SOLUTION CONCEPTS

(1) **Subgame perfect equilibrium (Nash):**

$$J_{HH} \geq \omega \geq J_{HL}$$

Coordination game: $J_{H,H} \geq J_{L,H}$

Prisoner's Dilemma $J_{HH} \leq J_{LH}$

(2) **Focal point—Risk dominance (Harsanyi-Selten)**

(3) **Repeated games---Trigger Strategies**

	H	L
H	J_{HH}, J_{HH}	J_{HL}, J_{LH}
L	J_{LH}, J_{HL}	ω, ω

	H	L
H	½ E[V_{HH}] – *c*, ½ E[V_{HH}] – *c*	½E[V_{HL}]- ω] - *c*, ½[E[V_{HL}]+ ω] – ψ
L	½E[V_{LH}]+ω] - ψ, ½[E[V_{LH}]-ω] - *c*	ω, ω

Threshold Reversibility Frontier

$$\sigma(\theta) = 0, \sigma(\theta) = \Gamma_{HH}(\theta) - \Gamma_{LH}(\theta)$$

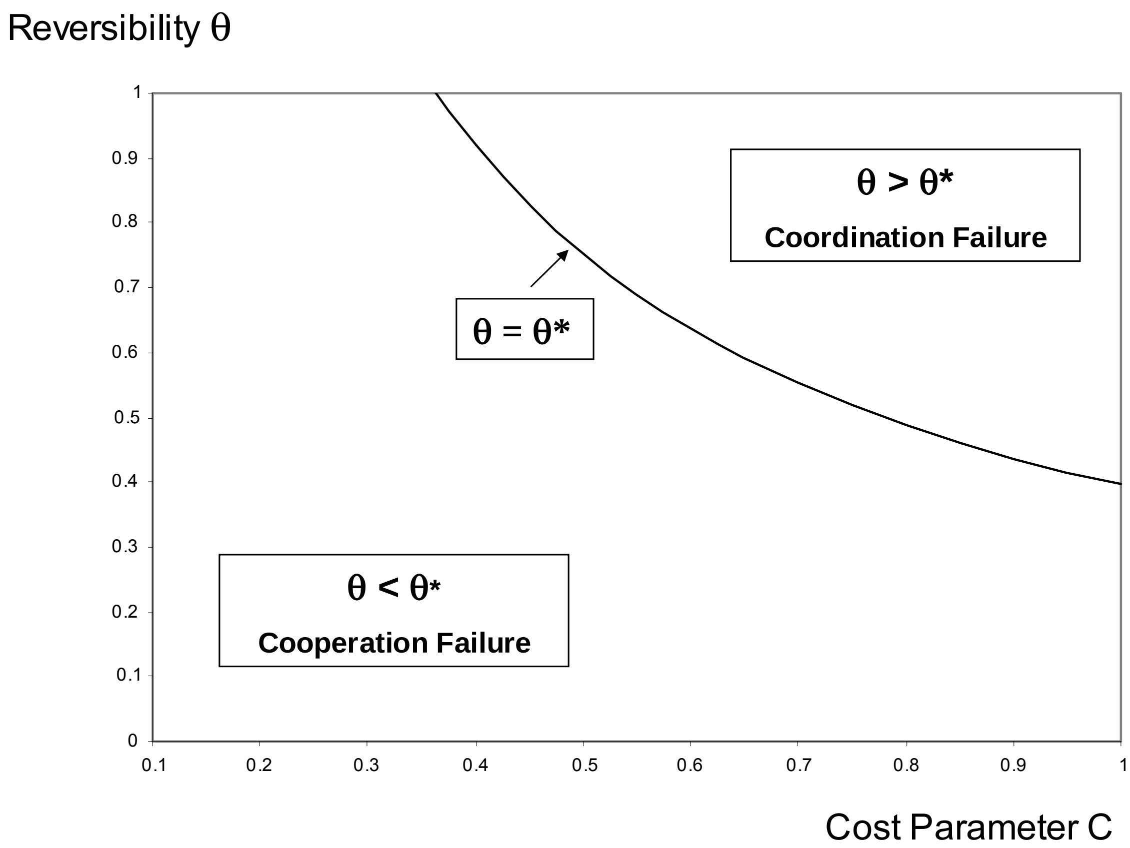
$\sigma(\theta) = 0, \sigma(\theta) = \Gamma_{HH}(\theta) - \Gamma_{LH}(\theta)$

- *Sub-Regime I,* $R_g^{LH} = (1-\theta) R_g^{HH}$

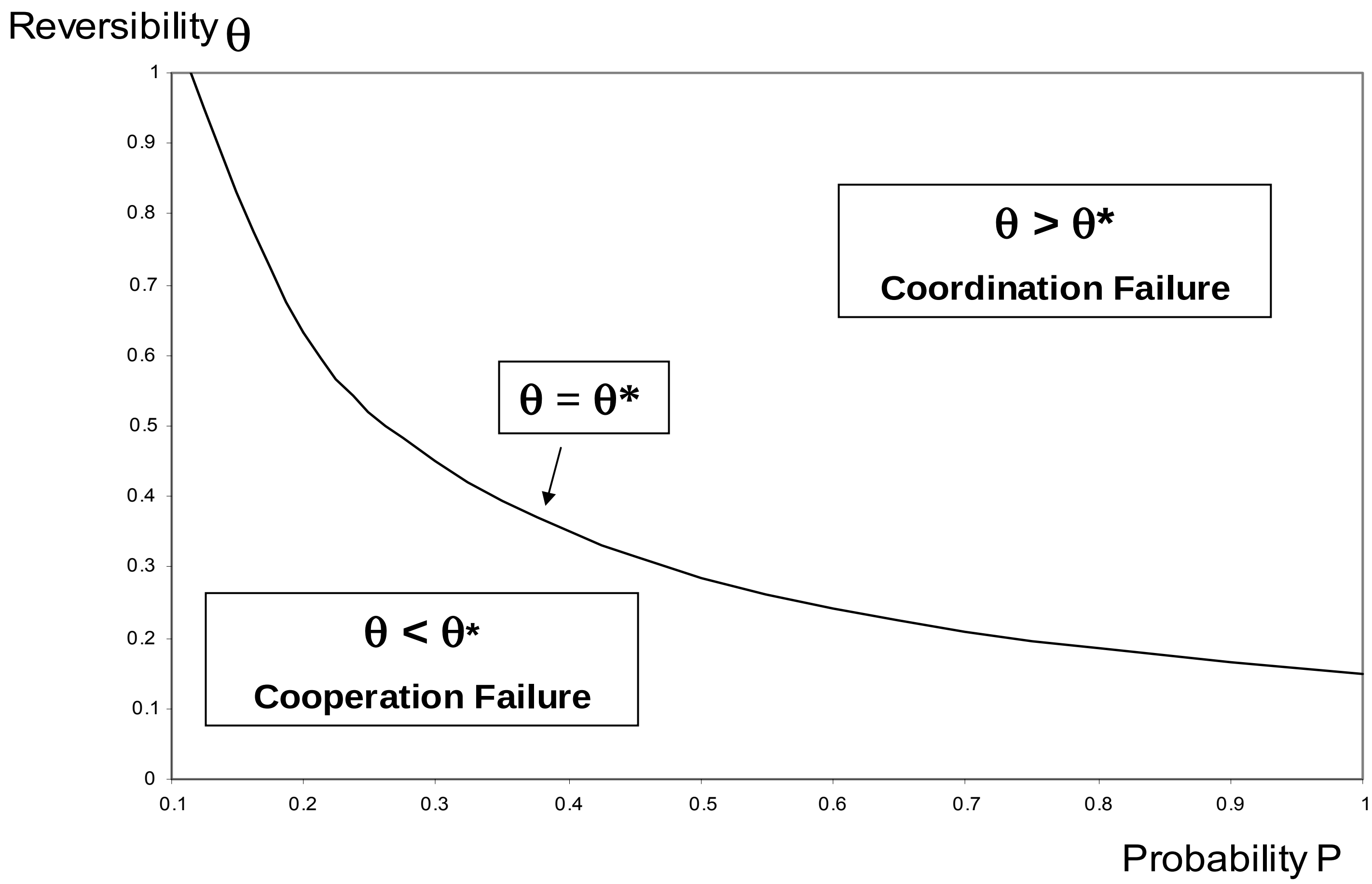
$$\theta^* = \{\omega / [(1-p)(r^* - R_f) - p R_g^{HH} - 2c]\}$$

$\theta < \theta^*$ Cooperation failure

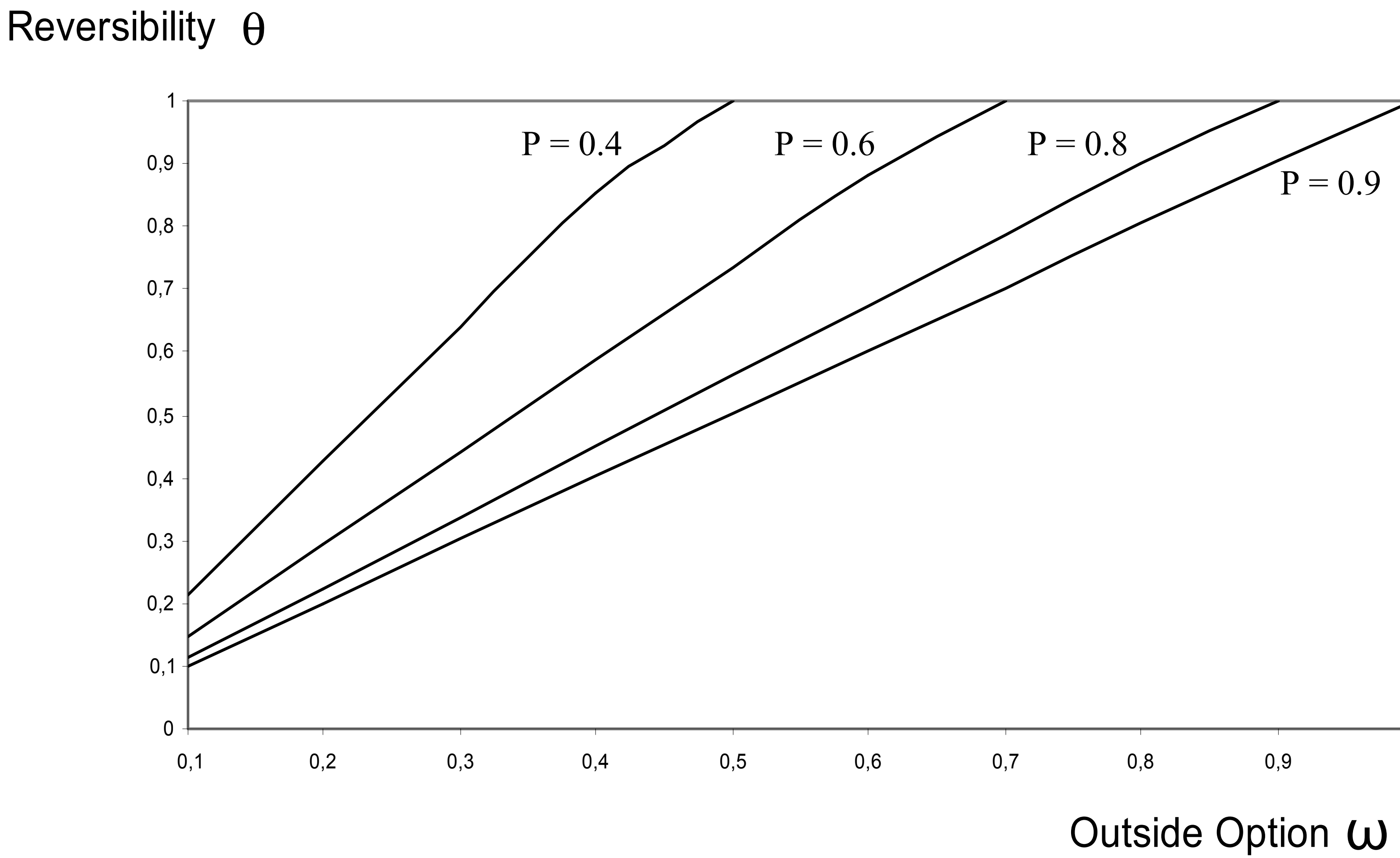
$\theta > \theta^*$ Coordination failure



Frontier Values of θ* at Regime Change



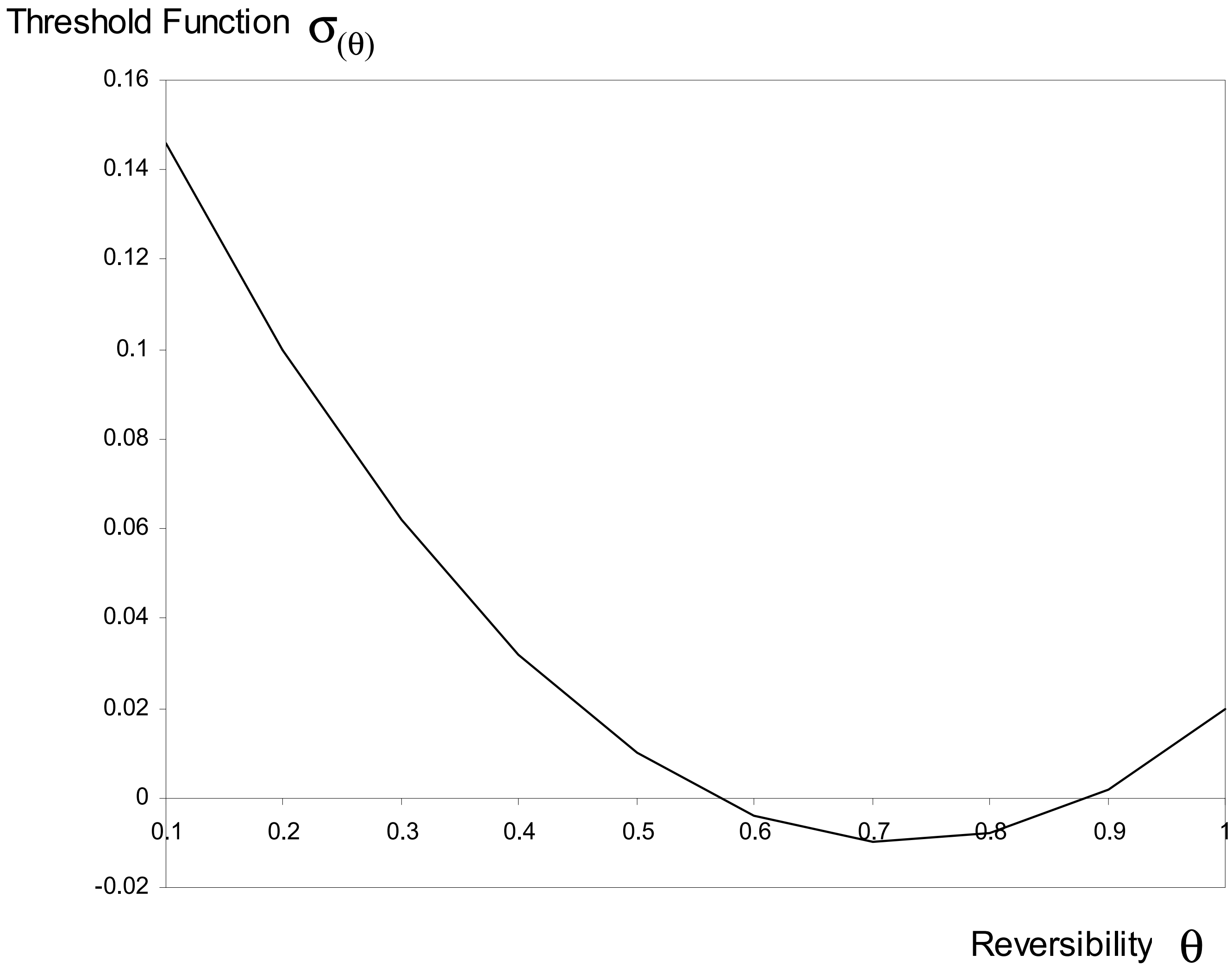
Frontier Values of θ* at Regime Change



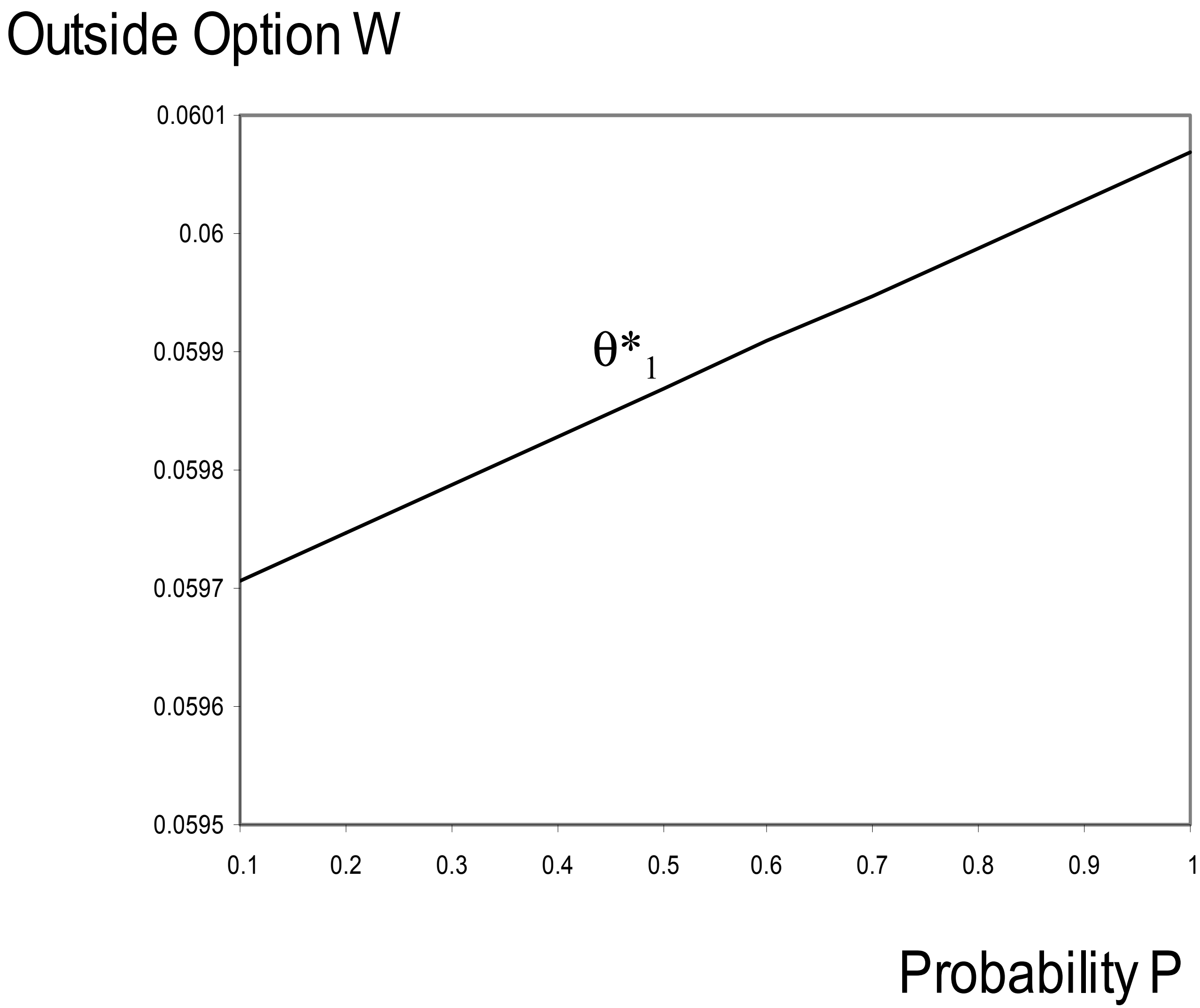
Frontier Values of θ^* at Regime Change

- *Sub-Regime II,* $Rg^{LH} = [\alpha(1, \theta) - \Phi(1, \theta)] R_g^{HH}$

$$\sigma(\theta) = \gamma Rg^{HH} \theta^2 + [(1-p)(R_f - r^*) + 1 - 2(\gamma + c)] Rg^{HH} \theta + \gamma Rg^{HH} - \omega$$



Frontier Values of θ*



Outside Option W
0.0601
0.06
0.0599
0.0598
0.0597
0.0596
0.0595
θ*1
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Probability P

CONCLUSIONS

- Implications of partial reversibility for contract design and performance in the presence of exogenous and strategic uncertainty
- Explicit modeling of partial reversibility permits examination of trade-offs between commitment and flexibility in organizational design
- Restructuring and adaptation are facilitated by more flexible and reversible techniques

- Reversible and more flexible techniques leave room for policy interventions which enhance efficiency in the presence of weak institutional structures

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