Facility Management Services in UK Hospitals: in-house or outsourcing?

A. Podaneva P. Picard[1]

[1]Faculty of Law, Economics and Finance
University of Luxembourg

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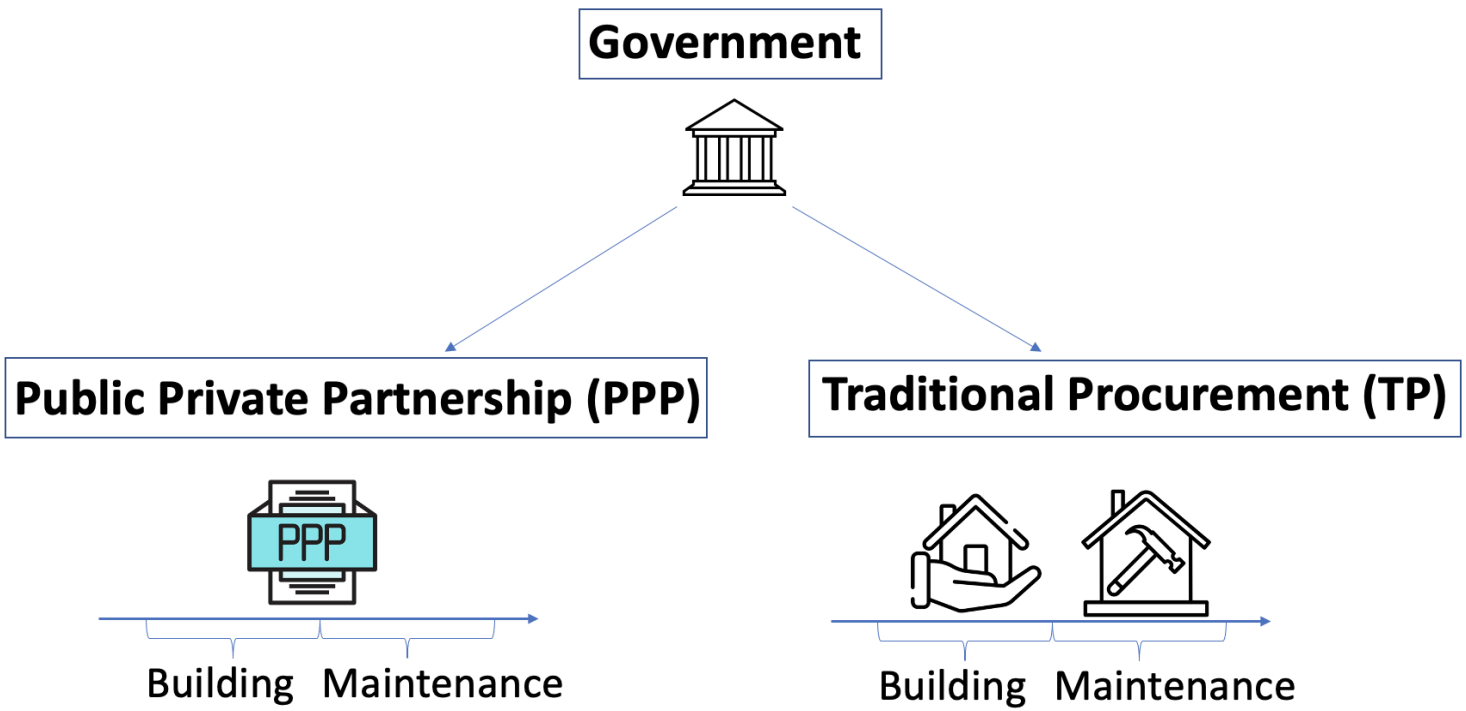
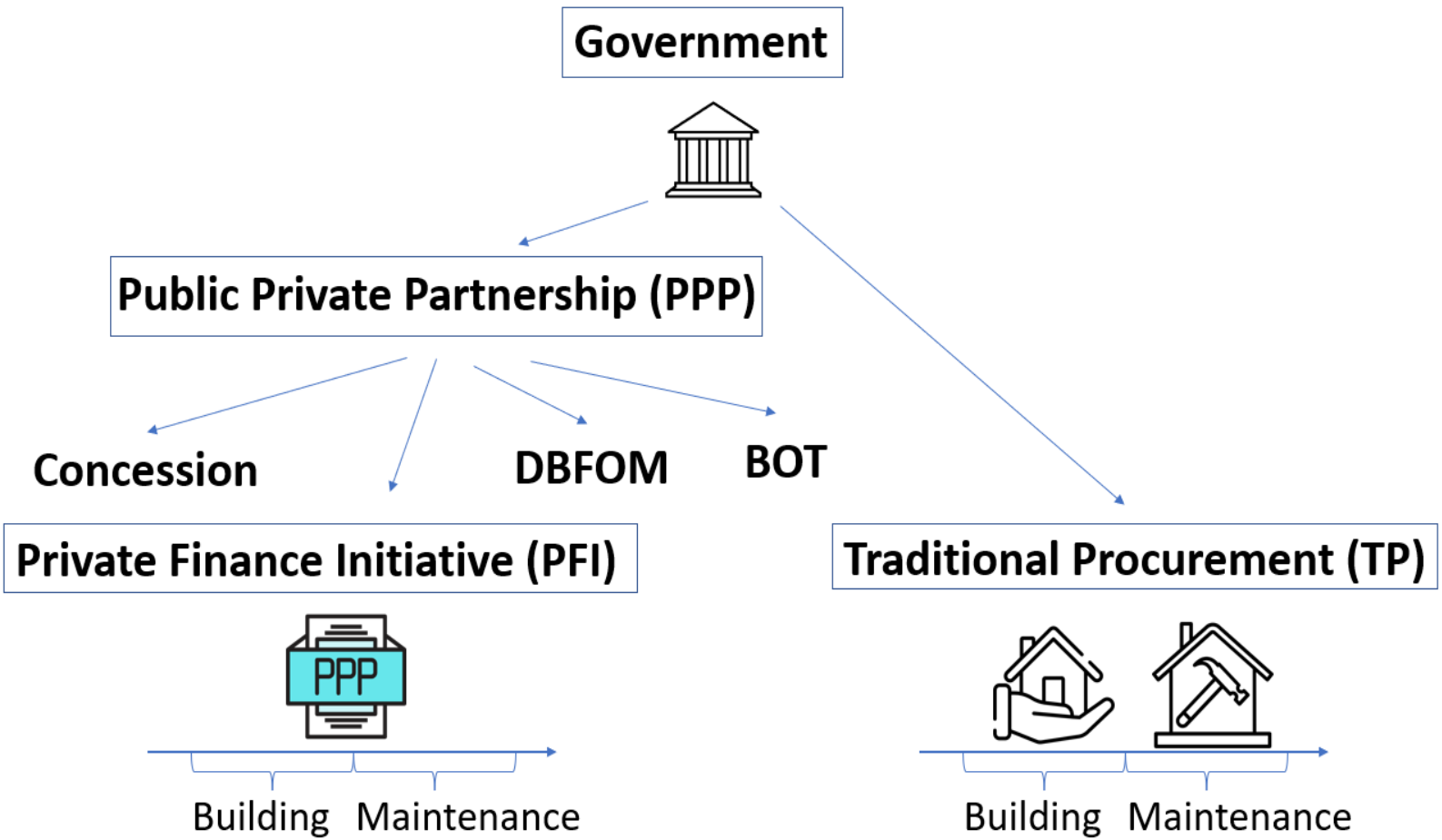
Procurement types

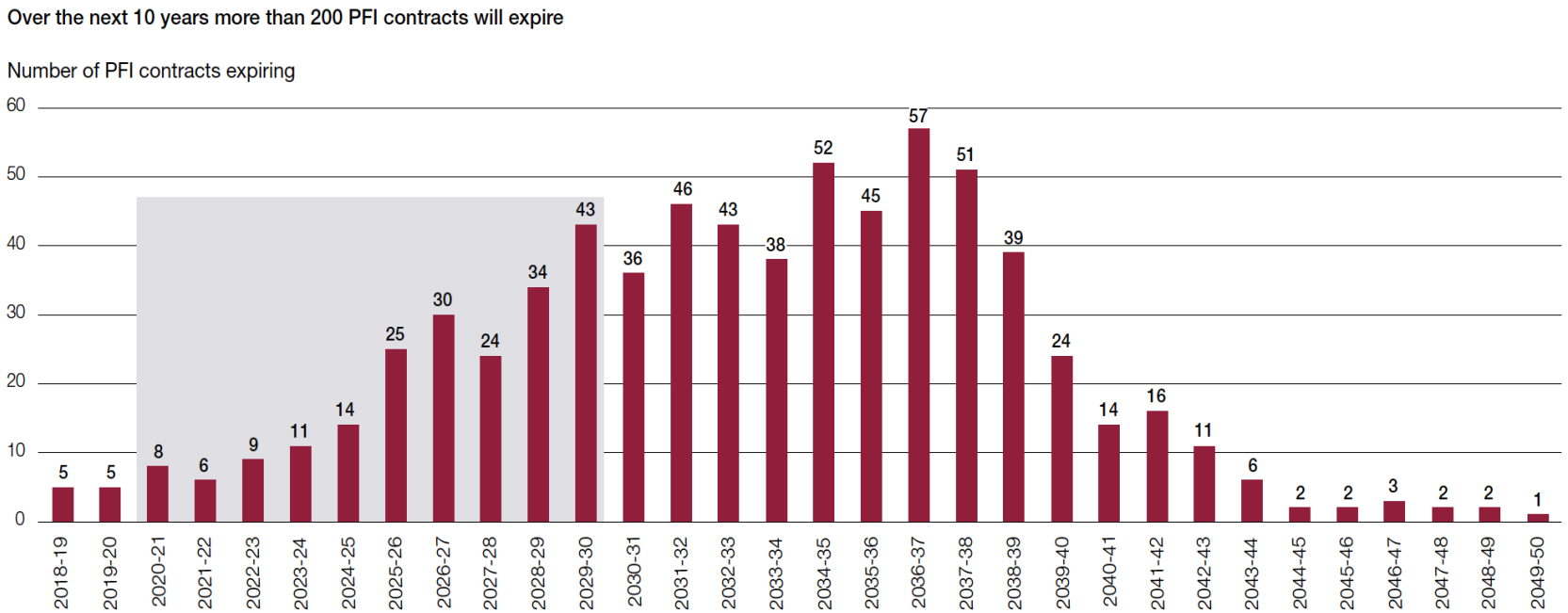
- Public procurement refers to
  - purchase by governments of goods, services, and works
  - choice of model to fund and develop public infrastructure projects



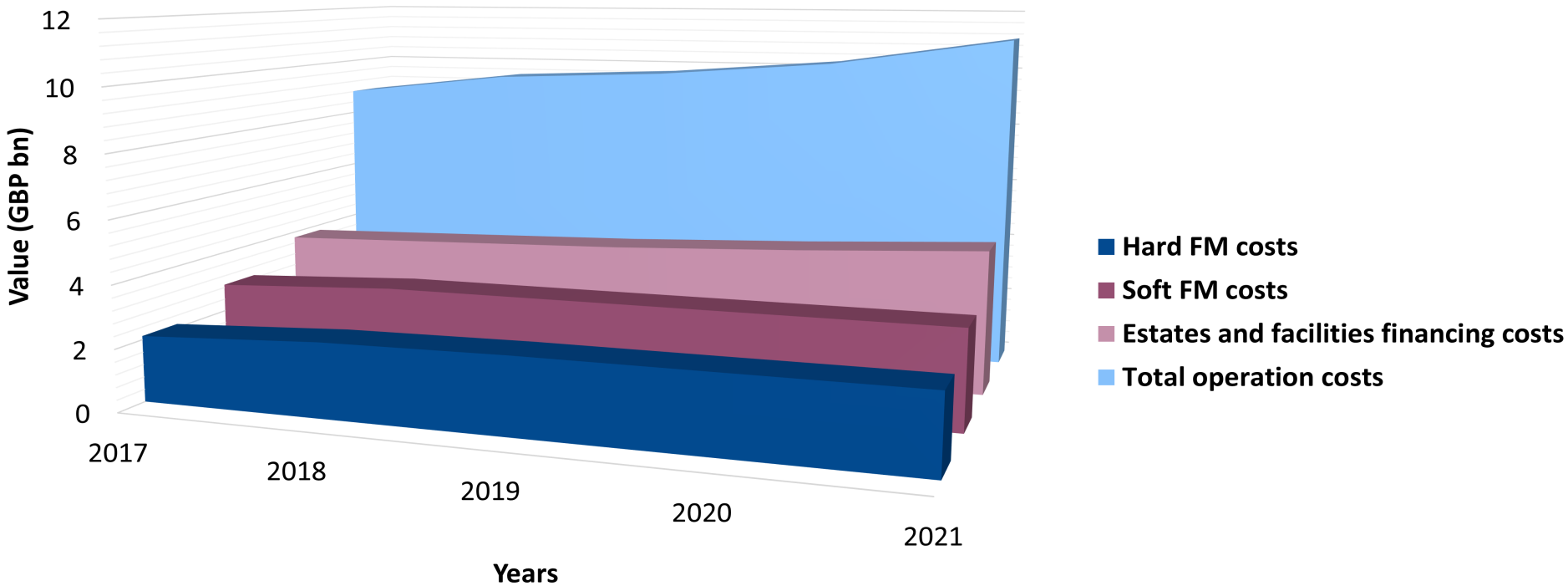
PFI is a specific type of Public-Private Partnership



PFI expiration time frame

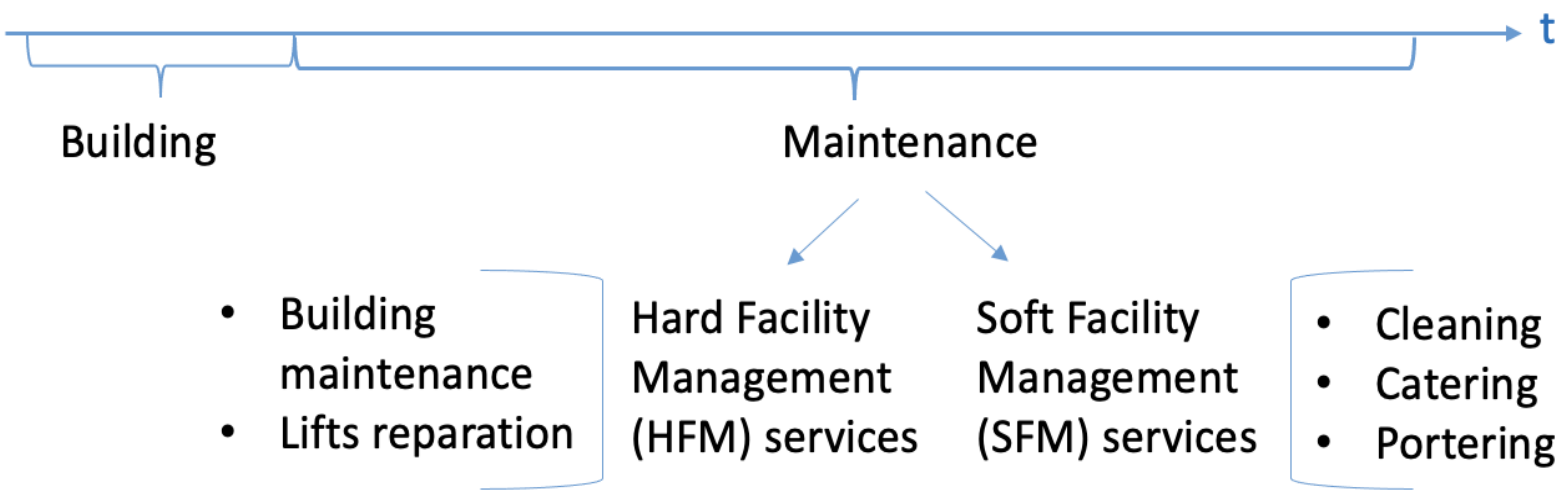


Total costs of running the UK hospitals



- Total operational costs account for 13% of the total costs of UK hospitals.

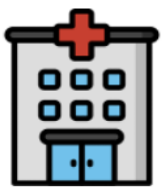
Facility management services

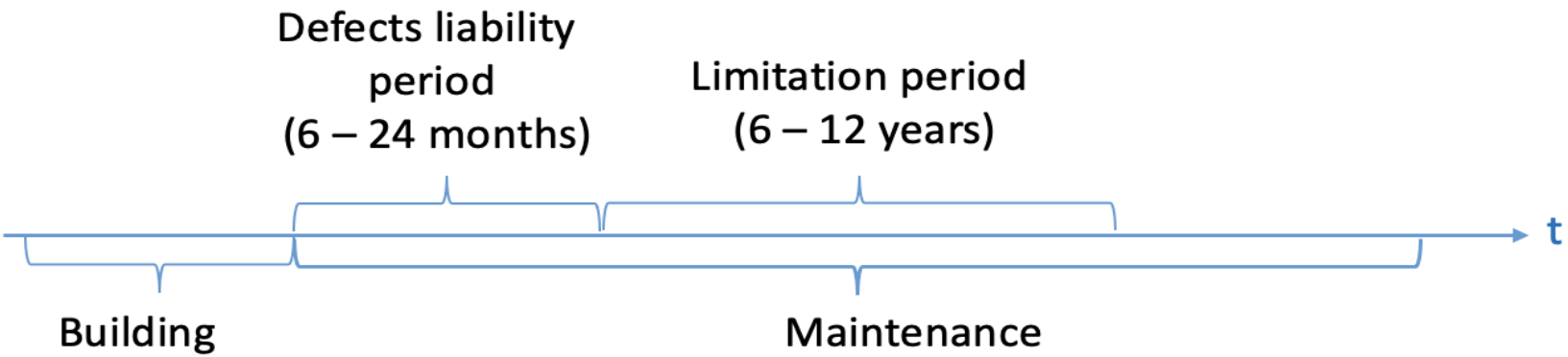


Research questions

- What is the preferred approach for PFI and traditional hospitals: outsourcing FM services or managing them in-house?
- How do risk and builder's structural warranty influence a foundation trust's choice between PFI and traditional procurement of hospitals?

Structural warranty



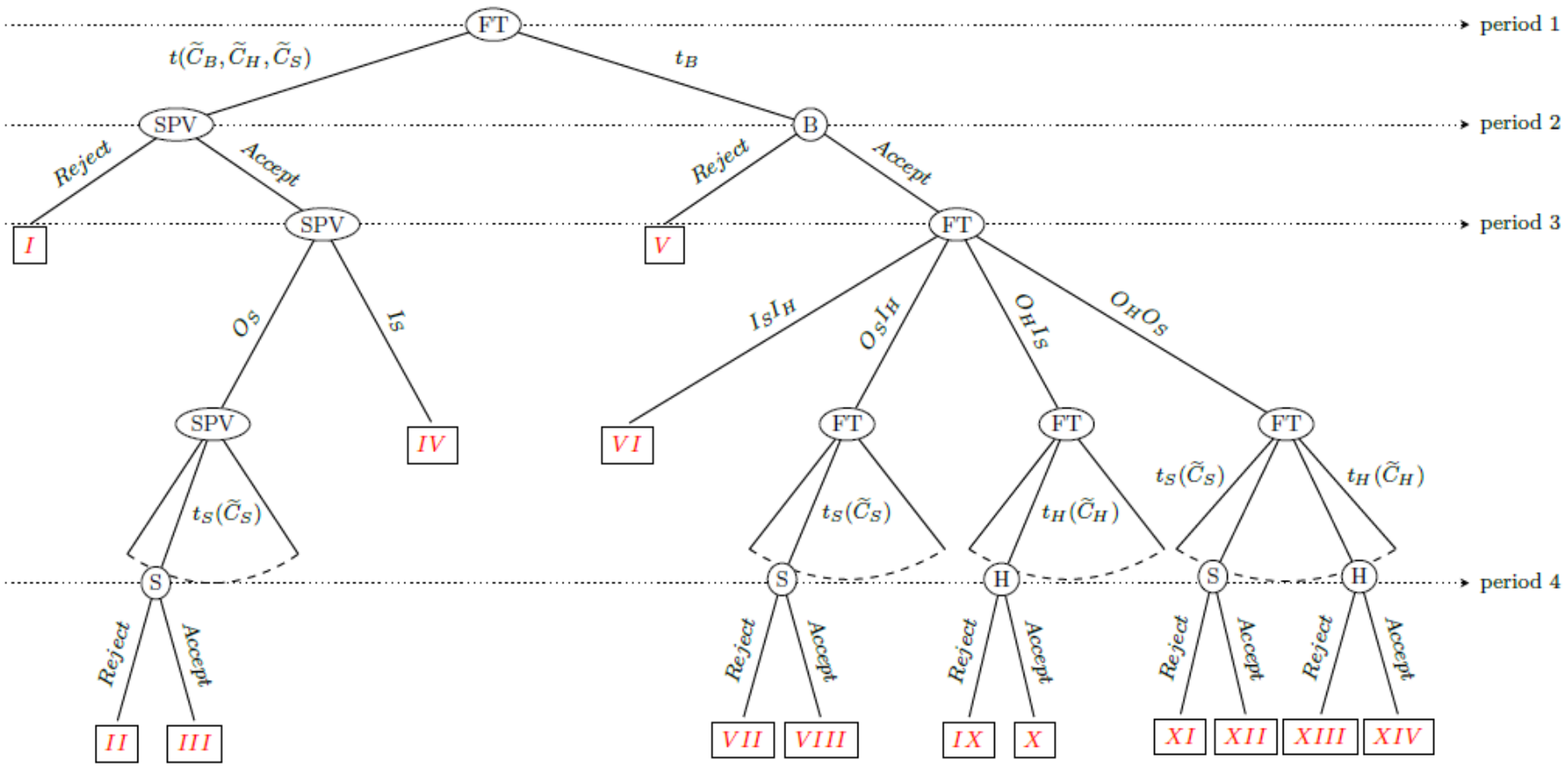


Builder's warranty : $\theta \in [0,1]$

Methodology

- **Method**: We build upon the principal-agent model by Iossa and Martimort (2015), extending it to incorporate:
  - three-tier delegation structure: foundation trust - PFI - outsourcing firm.
  - delegation of multiple services at the operating stage, encompassing both HFM and SFM services.
  - builder's structural warranty.

Game tree


FT
$t(\widetilde{C}_B, \widetilde{C}_H, \widetilde{C}_S)$
t_B
period 1
SPV
B
Reject
Accept
Reject
Accept
period 2
I
SPV
V
FT
period 3
O_S
I_S
$I_S I_H$
$O_S I_H$
$O_H I_S$
$O_H O_S$
SPV
IV
VI
FT
FT
FT
$t_S(\widetilde{C}_S)$
$t_H(\widetilde{C}_H)$
$t_S(\widetilde{C}_S)$
$t_H(\widetilde{C}_H)$
$t_S(\widetilde{C}_S)$
$t_H(\widetilde{C}_H)$
S
S
H
S
H
period 4
Reject
Accept
Reject
Accept
Reject
Accept
Reject
Accept
II
III
VII
VIII
IX
X
XI
XII
XIII
XIV

Social benefit function of hospital activity

$$B = b_0 + b_B e_B + b_H e_H + b_S e_s \tag{1}$$

- $b_0 \geq 0$ - baseline social benefit generated by the hospital without efforts from any agent.
- $e_B \geq 0$ - effort invested by the builder to enhance building quality.
- $e_H, e_S \geq 0$ - efforts of hard and soft facilities managers to improve the quality of their respective services.
- $b_B, b_H, b_S > 0$ - marginal benefits derived from enhancing quality.

Cost functions and Utilities

$$\widetilde{C}_B = \phi_0 + (1-\theta)\widetilde{C}_H \qquad u(t_B - \widetilde{C}_B - e_B^2/2)$$

$$\widetilde{C}_H = \delta_0 - \delta_B e_B - \delta_H e_H + \widetilde{\varepsilon}_H \qquad u(t_H(\widetilde{C}_H) - \theta\widetilde{C}_H - e_H^2/2)$$

$$\widetilde{C}_S = \gamma_0 - \gamma_S e_S + \widetilde{\varepsilon}_S \qquad u(t_S(\widetilde{C}_S) - \widetilde{C}_S - e_s^2/2)$$

- ϕ_0, δ_0, γ_0 - production costs of the hospital's building, base level expenses of hard and soft facility management services, respectively.
- A builder covers the idiosyncratic cost of hard facility management services through structural warranty $(1-\theta)$.
- $\delta_B > 0$ - a positive externality between the builder and the hard facility manager.
- δ_H, $\gamma_S > 0$ - marginal costs incurred due to quality enhancement.
- $\widetilde{\varepsilon}_H$, $\widetilde{\varepsilon}_S$ are i.i.d. random shocks $\approx (\sigma_i^2;0)$, where $i = H, S$
  $\widetilde{\varepsilon}_H$ - earthquake, $\widetilde{\varepsilon}_S$ - coronavirus

Cost-reimbursement rules

$$t_B = \alpha_B \in \mathbb{R} \tag{2}$$

$$t_H(\widetilde{C}_H) = \alpha_H + (1 - \beta_H)(\theta \widetilde{C}_H) \tag{3}$$

$$t_S(\widetilde{C}_S) = \alpha_S + (1 - \beta_S)(\widetilde{C}_S) \tag{4}$$

$$t(\widetilde{C}_B, \widetilde{C}_S, \widetilde{C}_H) = \alpha + (1 - \beta)(\widetilde{C}_B + \widetilde{C}_S + \theta \widetilde{C}_H) \tag{5}$$

- $\alpha_B, \alpha_H, \alpha_S, \alpha$ - fixed compensations for the builder, hard and soft facility managers, and the special purpose vehicle.
- $\beta_H, \beta_S, \beta \in [0, 1]$ - powers of hard and soft facility management services and the special purpose vehicle contracts.

First best

- In the first best, the FT performs all construction and maintenance tasks by itself and incurs the cost of the respective efforts

$$\max_{e_B(\cdot),e_H(\cdot),e_S(\cdot)} \mathbb{E}[B - \widetilde{C}_B - \theta\widetilde{C}_H - \widetilde{C}_S - \frac{1}{2}e_B(\cdot)^2 - \frac{1}{2}e_H(\cdot)^2 - \frac{1}{2}e_S(\cdot)^2]$$

- $\mathbb{E}[\cdot]$ represents the expectation operator over both random variables $\widetilde{\varepsilon}_H$ and $\widetilde{\varepsilon}_S$.
- $e_i(\cdot), i \in B, H, S$ denotes the effort level as a function of the random variables realization.
- $\frac{1}{2}e_i(\cdot)^2, i \in B, H, S$ corresponds to the cost of agents' efforts.

Second best: Private Finance Initiative

Stage 1: Principal's problem

$$\boxed{W^{**} = \max_{\alpha,\beta} \mathbb{E}\left[B - t(\widetilde{C}_B, \widetilde{C}_S, \widetilde{C}_H)\right]} \qquad (IC_1, PC_1) : \max\{V^i, V^o\} \geq 0$$

Stage 2: Agents' problems

- Under in-house soft facility management

$$\boxed{V^i = \max_{e_B(\cdot), e_H(\cdot), e_S(\cdot)} \mathbb{E}\ u[t(\widetilde{C}_B, \widetilde{C}_S, \widetilde{C}_H) - \tfrac{e_B(\cdot)^2}{2} - \theta\widetilde{C}_H - \tfrac{e_H(\cdot)^2}{2} - \widetilde{C}_S - \tfrac{e_S(\cdot)^2}{2}]}$$

- Under outsourced soft facility management

$$\boxed{V^o = \max_{e_B(\cdot), e_H(\cdot), \alpha_S, \beta_S} \mathbb{E}\ u[t(\widetilde{C}_B, \widetilde{C}_S, \widetilde{C}_H) - \tfrac{e_B(\cdot)^2}{2} - \theta\widetilde{C}_H - \tfrac{e_H(\cdot)^2}{2} - t_S(\widetilde{C}_S)]}$$

$(IC_2) : \pi_S = \mathbb{E}\left[\max_{e_S(\cdot)} u(t_S(\widetilde{C}_S) - \widetilde{C}_S - \tfrac{e_S(\cdot)^2}{2}\right],$

$u(\cdot) = e^{-\rho x}$ with risk aversion parameter $\rho > 0$ $(\rho = -u''/u')$

$(PC_2) : \pi_S \geq u(0)$

Stage 2

SFM in-house

- $e_B^{**} = \beta\delta_B$, $e_H^{**} = \beta\delta_H$, $e_S^{**} = \beta\gamma_S$

SFM outsourced

- $e_B^{**} = \beta\delta_B$, $e_H^{**} = \beta\delta_H$, $e_S^{**} = \beta_S\gamma_S$

SFM power of incentives

$\beta_S^{**} = \beta I_S^{**} \in [0, \beta]$, where $I_S^{**} = \frac{\gamma_S^{**} + \rho\sigma_S^2}{\gamma_S^{**} + 2\rho\sigma_S^2}$

- No risk $\rightarrow \beta_S^{**} = \beta$
- SFM risk presence $\rightarrow$ SPV benefits from sharing risk with outsourcing firm

$V^{o**} > V^{i**}$

Explanation

- The SPV optimally sets the contract power to the outsourcing firm equal to $\beta_S^{**} = \beta I_S^{**} \in [0, \beta]$, where $I_S^{**} = \frac{\gamma_S^{**} + \rho\sigma_S^2}{\gamma_S^{**} + 2\rho\sigma_S^2}$ is a decreasing function of risk variance.
- Thus, higher risk augments the latter's risk premium, the SPV finds it optimal to reduce the contract power with higher risk variance (as β_S^{**} falls with σ_S^2).

Proposition 1

Under Private Finance Initiatives, the Foundation Trust outsources the Soft Facility Management services.

Second Best: Traditional Procurement

Stage 1: Principal's problem

$$\boxed{W^* = \max_{\alpha_B \geq 0} \mathbb{E}\left[V - t_B\right]} \qquad (IC_1, PC_1): \max_{e_B(\cdot)\geq 0} \mathbb{E}\left[u(t_B - \widetilde{C}_B - \frac{e_B(\cdot)^2}{2})\right] \geq 0$$

$$V = \max_{k,l\in\{i,o\}} V^{kl}$$

Stage 2: Agents' problems

- Under in-house soft and hard facility management

$$\boxed{V^{ii} = \max_{e_H(\cdot),e_S(\cdot)} \mathbb{E}\ u[B - \theta\widetilde{C}_H - \frac{e_H(\cdot)^2}{2} - \widetilde{C}_S - \frac{e_S(\cdot)^2}{2}]}$$

- Under outsourced soft and hard facility management

$$\boxed{V^{oo} = \max_{\alpha_H,\beta_H,\alpha_S,\beta_S} \mathbb{E}\ u[B - t_H(\widetilde{C}_H) - t_S(\widetilde{C}_S)]}$$

$$(IC_2): \pi_S = \mathbb{E}\left[\max_{e_S(\cdot)} u(t_S(\widetilde{C}_S) - \widetilde{C}_S - \frac{e_S(\cdot)^2}{2}\right] \qquad (PC_2): \pi_S \geq u(0)$$

$$(IC_3): \pi_H = \mathbb{E}\left[\max_{e_H(\cdot)} u(t_H(\widetilde{C}_H) - \widetilde{C}_H - \frac{e_H(\cdot)^2}{2}\right] \qquad (PC_3): \pi_H \geq u(0)$$

Stage 2

Proposition 2

Under Traditional Procurement, the Foundation Trust delivers Hard Facility Management and Soft Facility Management services in-house.

Stage 1

$$\mathbb{E}\, W^* = b_0 - (\delta_0 + \gamma_0 + \phi_0) + \frac{1}{2}(b_S + \gamma_S)^2 \quad + \frac{1}{2}(b_H + \delta_H)^2$$
$$+ \frac{1}{2}(1-\theta)[2\delta_B b_B + (1+\theta)\delta_B^2 - (1-\theta)\delta_H^2] \tag{6}$$
$$- \frac{1}{2}\rho(1-\theta)\sigma_H^2$$

absence of a warranty ($\theta = 1$) and $\sigma_H^2 = 0$

(6) matches the first-best net benefit achieved in HFM and SFM services

Stage 1

$$\mathbb{E}\,W^* = b_0 - (\delta_0 + \gamma_0 + \phi_0) + \frac{1}{2}(b_S + \gamma_S)^2 \quad + \frac{1}{2}(b_H + \delta_H)^2$$
$$+ \frac{1}{2}(1-\theta)[2\delta_B b_B + (1+\theta)\delta_B^2 - (1-\theta)\delta_H^2]$$
$$- \frac{1}{2}\rho(1-\theta)\sigma_H^2$$

presence of a warranty ($\theta = 0$), two effects are apparent

- The HFM risk decreases the net benefit because the FT must compensate the builder for the HFM risk after construction (see the third line).
- The warranty also incentivizes the builder to internalize the cost of HFM services (second line) $\rightarrow$ this effect is not clear because the warranty gives the HFM manager lower incentives to exert effort.
- Indeed, there exists a 'reverse' moral hazard as the warranty shifts to the builder a share of the HFM cost that is also subject to the effort exerted by the HFM manager.

Results

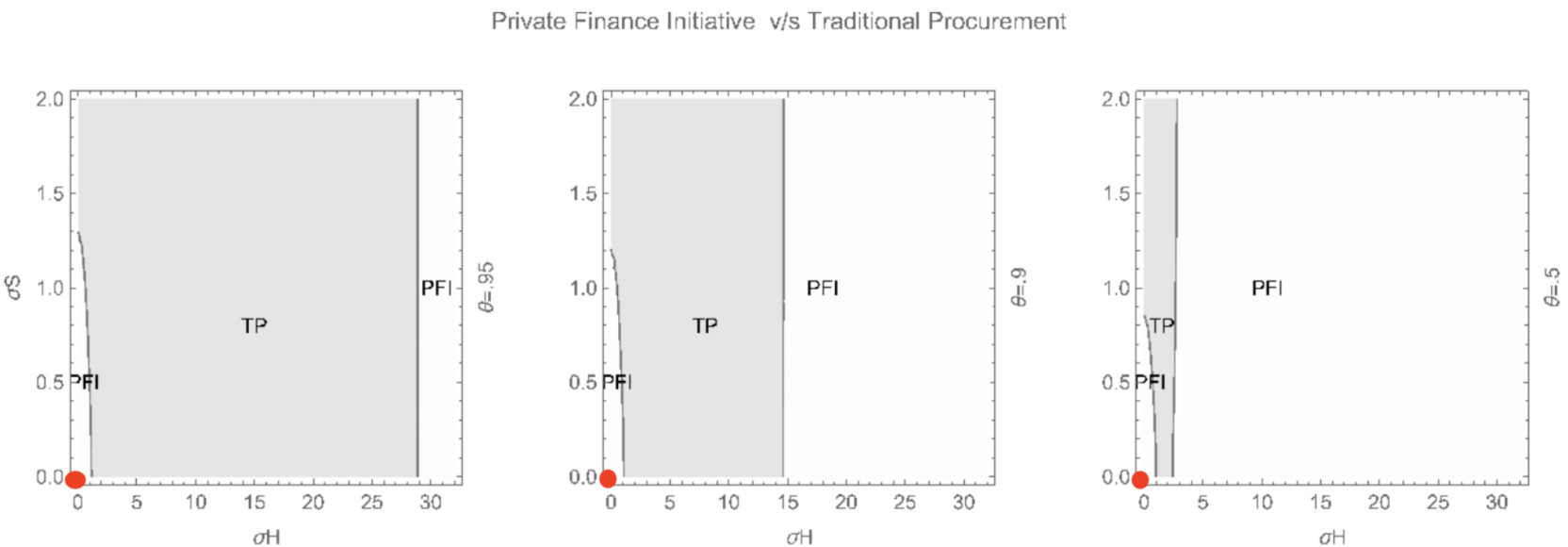
$$
\begin{array}{ll}
\mathbb{E}\, W^{*} = & b_0 - (\delta_0 + \gamma_0 + \phi_0) + \frac{1}{2}(b_S + \gamma_S)^2 + \frac{1}{2}(b_H + \delta_H)^2 \\
& + \frac{1}{2}(1-\theta)[2\delta_B b_B + (1+\theta)\delta_B^2) - (1-\theta)\delta_H^2] \\
& - \frac{1}{2}\rho(1-\theta)\sigma_H^2 \\
\hline
\mathbb{E}\, W^{**} = & b_0 - (\delta_0 + \gamma_0 + \phi_0) + \frac{1}{2}(\beta^{**}\delta_B)^2 + \frac{1}{2}(\beta^{**}\delta_H)^2 + \frac{1}{2}(\beta^{**}\gamma_S)^2 \\
& + \frac{1}{2}\rho\sigma_H^2(\beta^{**})^2 - \frac{1}{2}\rho\sigma_S^2(\beta^{**})^2 \frac{\gamma_S^2 - \rho\sigma_S^2}{\gamma_S^2 + 2\rho\sigma_S^2}
\end{array}
$$

- Scenario 1: $b_i = 0$ and $\sigma_j^2 = 0$
- Scenario 2: $b_i = 0$ and $\sigma_S^2 = 0, \sigma_H^2 > 0$
- Scenario 3: $b_i = 0$ and $\sigma_H^2 = 0, \sigma_S^2 > 0$
- Scenario 4: $b_i > 0$ and $\sigma_j^2 > 0$ and $\delta_B = 0, \gamma_j = 0$

where $i = \{H, S, B\}$ and $j = \{H, S\}$

Scenario 1: $b_i = 0$ and $\sigma_j^2 = 0$

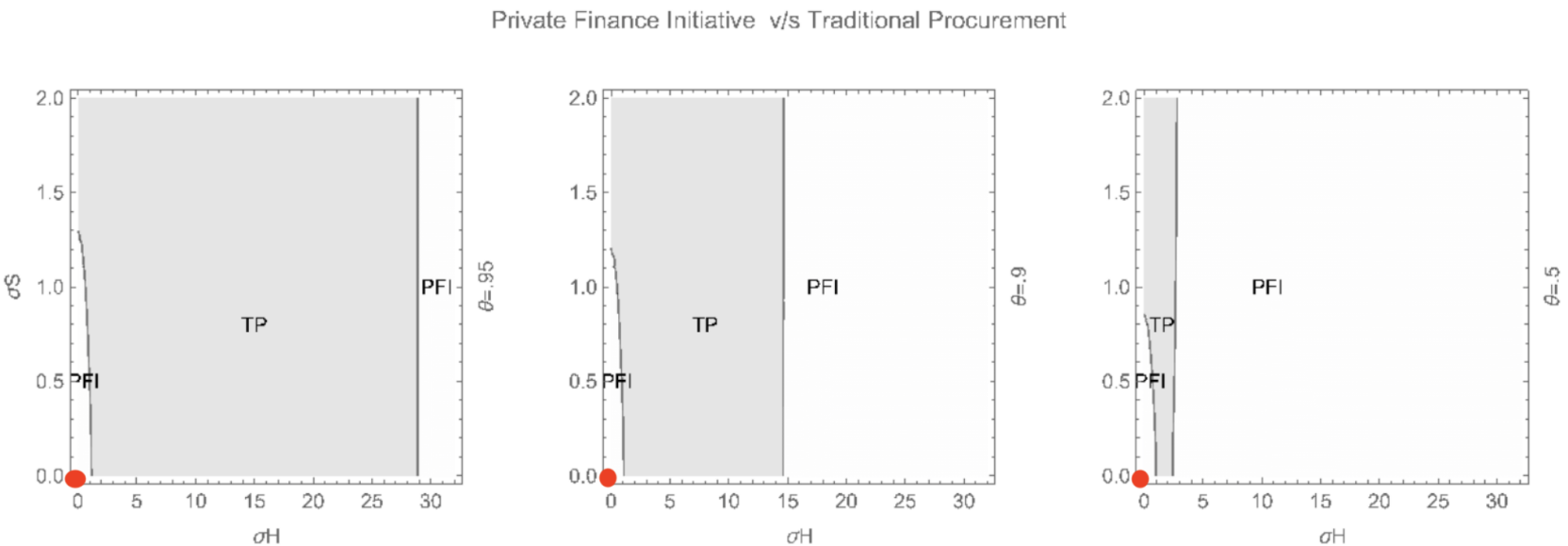
θ	δ_B	σ_H^2	σ_S^2	Procurement	The advantage of the PFI structure lies in the ...
1	> 0	0	0	PFI	internalization of externality between the builder and the HFM services supplier.
0	> 0	0	0	PFI	importance of marginal cost reductions in HFM services that are not implemented in TP.
$(0, 1)$	> 0	0	0	PFI	(7) is a U-shaped function $\rightarrow$ advantage is maximal either for full or no warranty.



Scenario 1: $b_i = 0$ and $\sigma_j^2 = 0$

The choice for PFI summarizes to its net benefit advantage

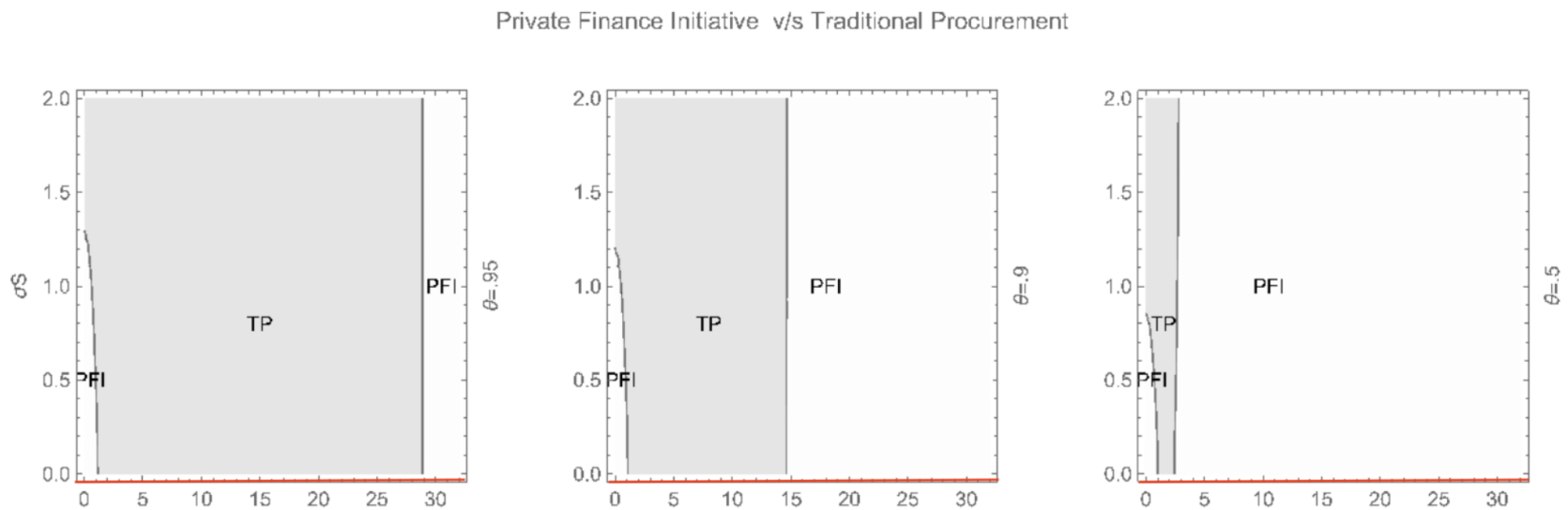
$$\mathbb{E}\, W^{**} - \mathbb{E}\, W^{*} = \frac{1}{2}[\delta_B^2\theta^2 + \delta_H^2(1-\theta)^2] > 0 \tag{7}$$



Scenario 2 : $b_i = 0$ and $\sigma_S^2 = 0, \sigma_H^2 > 0$

Proposition 3:

Suppose no SFM risk. Then, in the absence of warranty ($\theta = 1$), the FT prefers the PFI if the externality between builder and HFM is strong ($\delta_B > 1$). Otherwise ($\delta_B \leq 1$) it chooses PFI only for low enough HFM risk. In the presence of weak warranty $\theta \in (\overline{\theta}, 1)$, the FT prefers the PFI either for sufficiently low or high HFM risks and chooses traditional procurement for intermediate HFM risks. Finally, in the presence of strong warranty $\theta \in [0, \overline{\theta})$, it always prefers PFI.



Scenario 2 : $b_i = 0$ and $\sigma_S^2 = 0, \sigma_H^2 > 0$

θ	δ_B	σ_H^2	σ_S^2	Procurement
1	> 1	> 0	0	PFI
	$(0, 1]$	low		PFI
	$(0, 1]$	high		TP
$(\overline{\theta}, 1)$	> 0	low & high	0	PFI
		intermediate		TP
$(0, \overline{\theta}]$	> 0	> 0	0	PFI

- For HFM small risks, the PFI is always preferred because it internalizes better the externality between builder and HFM.
- For larger risks, traditional procurement is preferred because the risk neutral FT is a better entity to bear risk.
- However, traditional procurement transfers HFM risk to the builder and is exposed to the reverse moral hazard in the presence of a warranty.
- Thus, reverse moral hazard dominates in case of high HFM risks or solid warranty $\rightarrow$ PFI prevails.

Scenario 2 : $b_i = 0$ and $\sigma_S^2 = 0, \sigma_H^2 > 0$

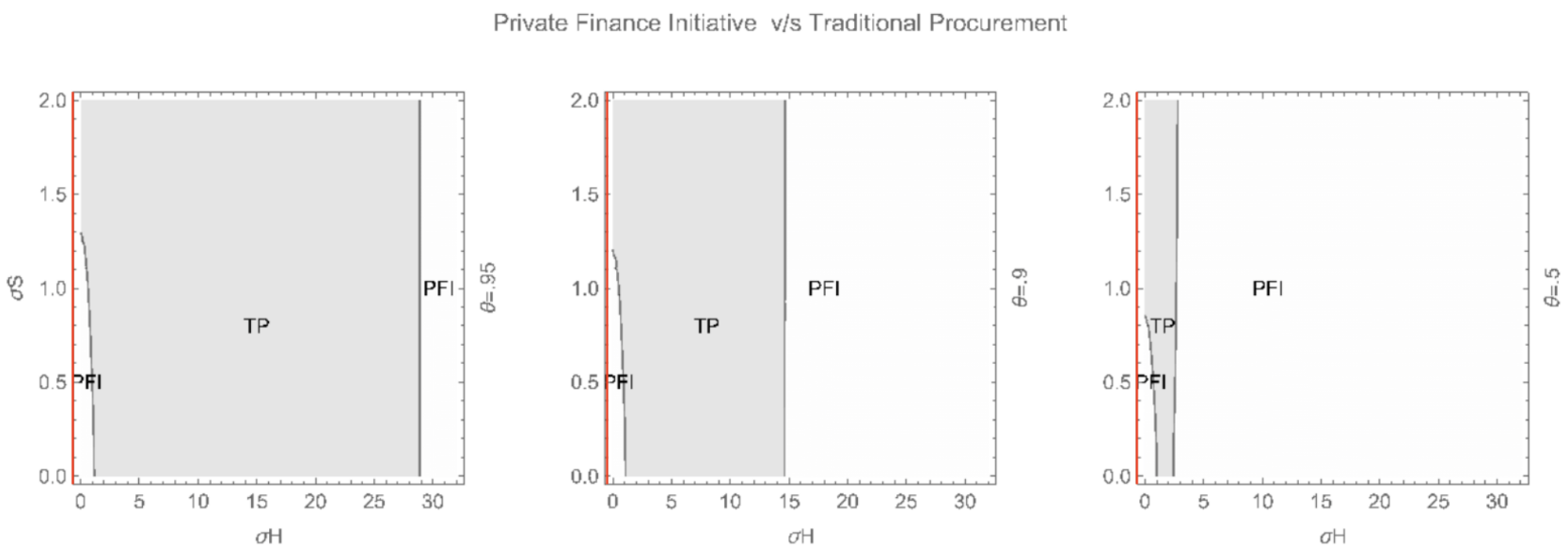
$$\begin{aligned}\mathbb{E}\, W^{**} - \mathbb{E}\, W^{*} = & \frac{1}{2}[\delta_B^2\theta^2 + \delta_H^2(1-\theta)^2] \\ & - \frac{1}{2}\rho\sigma_H^2[1-(1-\theta)^2 - \frac{\rho\sigma_H^2}{\delta_B^2 + \delta_H^2 + \gamma_S^2 + \rho\sigma_H^2}]\end{aligned} \tag{8}$$

Scenario 3 : $b_i = 0$ and $\sigma_H^2 = 0, \sigma_S^2 > 0$

θ	δ_B	σ_H^2	σ_S^2	Procurement	Reason
$[0,1]$	> 0	0	$\geq \overline{\sigma}_S^2$	TP	TP bears large SFM risk better
			$< \overline{\sigma}_S^2$	PFI	

Proposition 4:

Suppose no HFM risk. Then, the FT prefers the PFI for sufficiently low SFM risk and traditional procurement for HFM risk.



Scenario 3 : $b_i = 0$ and $\sigma_H^2 = 0, \sigma_S^2 > 0$

$$\begin{aligned} \mathbb{E}\, W^{**} - \mathbb{E}\, W^{*} &= \frac{1}{2}[\delta_B^2\theta^2 + \delta_H^2(1-\theta)^2] - \frac{1}{2}F, \text{where} \\ F &= \frac{1}{\frac{1}{\rho\sigma_S^2(1-I_S)} + \frac{1}{\delta_B^2+\delta_H^2+I_S\gamma_S^2}} + (1-I_S)\gamma_S^2 > 0 \end{aligned} \tag{9}$$

Scenario 4: $b_B, b_H, b_S > 0$ and $\delta_B = \gamma_H = \gamma_S = 0$

Proposition 5:

Suppose no cost reduction potential. Then, the Foundation Trust prefers the Traditional Procurement if the HFM risk and builder's warranty are not too strong.

Proposition 5: explanation

Proposition 5:

Suppose no cost reduction potential. Then, the Foundation Trust prefers the Traditional Procurement if the HFM risk and builder's warranty are not too strong.

- This result reflects the fact that the PFI is not an appropriate structure when HFM and SFM service quality is at stake.
- In this case the FT sets the power of the SPV contract, β^{**}, to zero.
- The SPV has no incentive to exert effort in any quality enhancing activities. Note that the effect of builder's quality is not apparent in this comparison.
- In the presence of a warranty, stronger HFM risks increases the net benefit of a PFI.
- Indeed, on the one hand, PFI is reimbursed with the risk premium. Higher risk leads to a larger risk premium paid by the authority. On the other hand, the longevity and diversity of services covered under the warranty in the contract assume higher compensation from the SPV side in case of unforeseen circumstances, e.g. building damages and a more costly transfer from the authority side.

Results

- The PFI is optimal for both sufficiently small and sufficiently high HFM risks, while TP is preferred for intermediate HFM risk.
- TP should be chosen for a large SFM risk, and PFI for a small one.
- With the growth of the builder's structural warranty, PFI dominates.

Thanks!