# Double Moral Hazard and the Energy Efficiency Gap

Louis-Gaëtan Giraudet (CIRED)
Sébastien Houde (U. Maryland)

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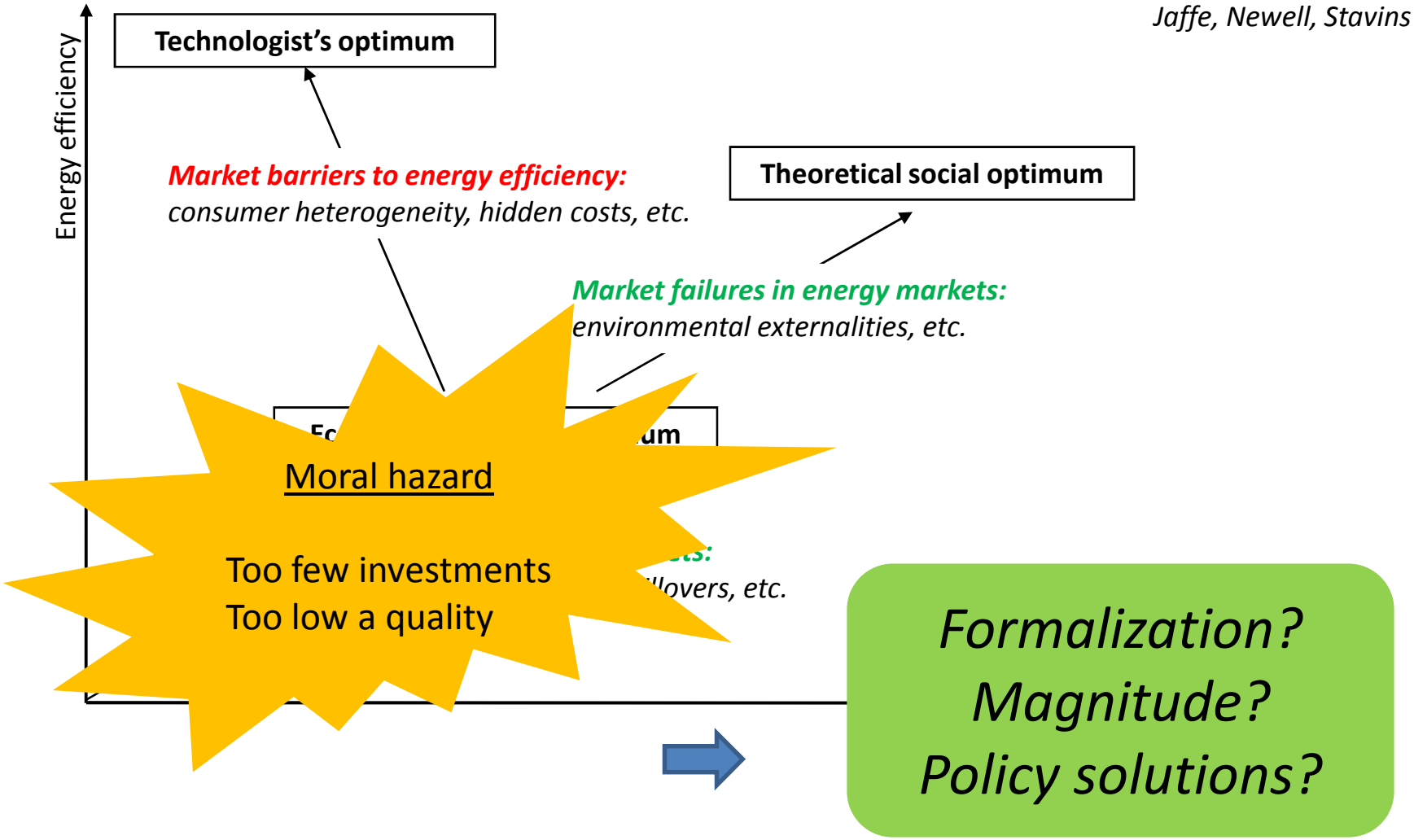
# Moral Hazard: *e.g.* Home Energy Retrofit

*2013 Winner*
***"Best Construction Defect" Photo Contest***
*Awarded by AQC, the French Construction Quality Agency*


*check out more! http://www.qualiteconstruction.com/manifestations/concours-photo/2013.html*

# The Energy Efficiency Gap



# Model

# Two Hidden Actions

***Energy use for space heating***

$$\tilde{E}(s,q)$$

Homeowner's **energy service**

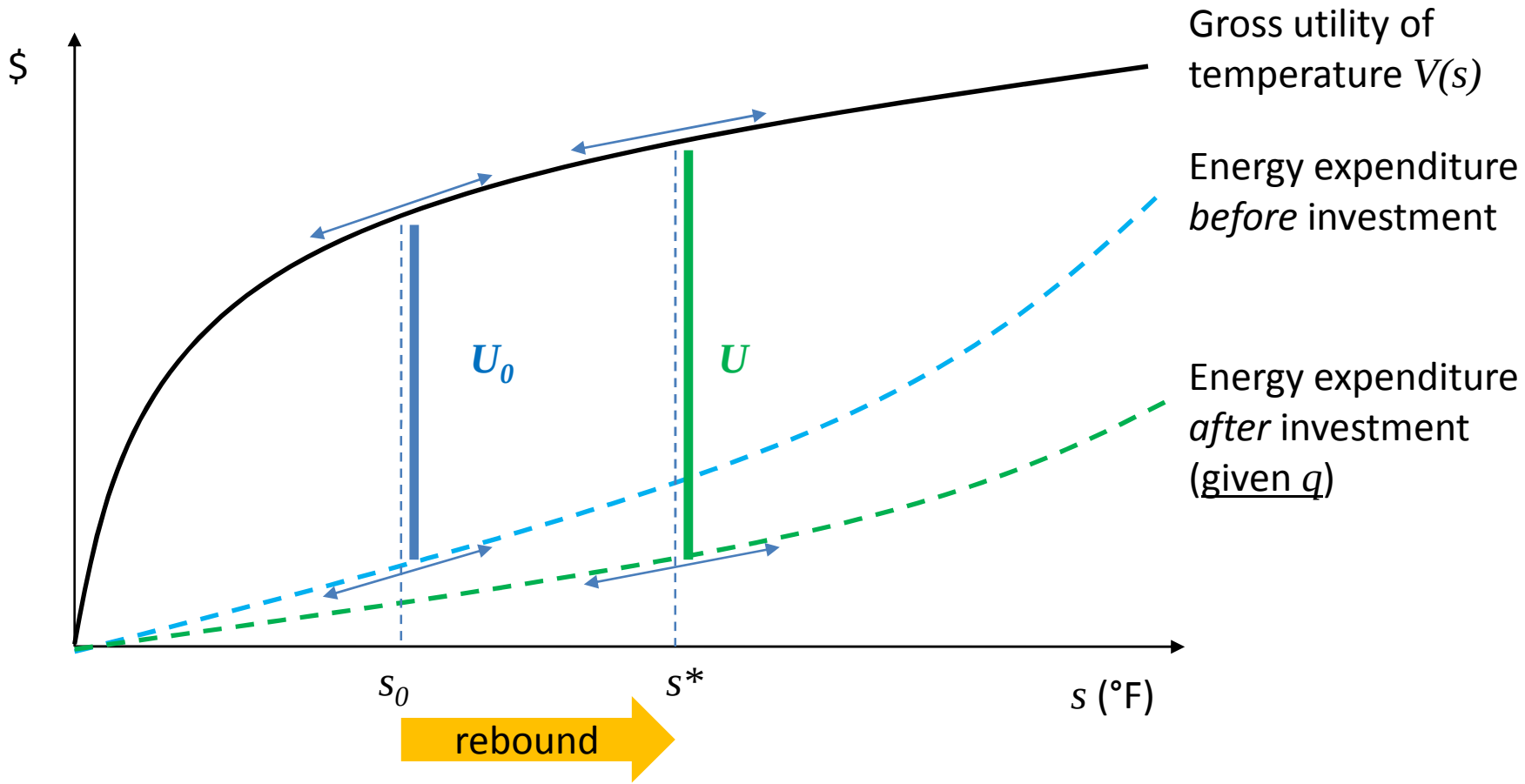
→ *unobservable to the contractor*

Contractor's **quality** of installation

→ *unobservable to the homeowner*

# Consumer sets $s$, given $q$

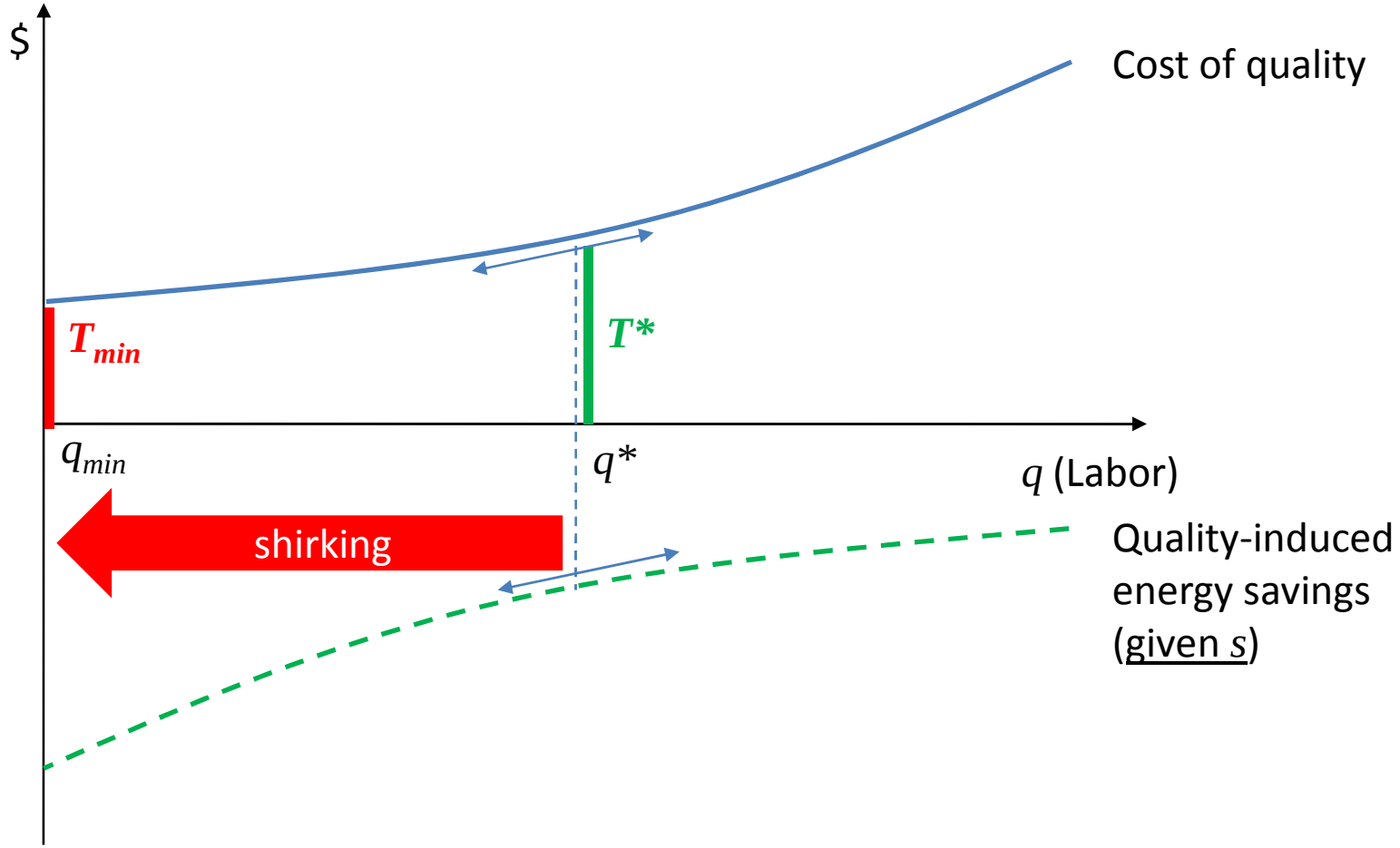
**Stage 2**




**Stage 1** Participation iif $U - U_0 \geq T$

# Firm sets $q$, given $s$

**Stage 2**

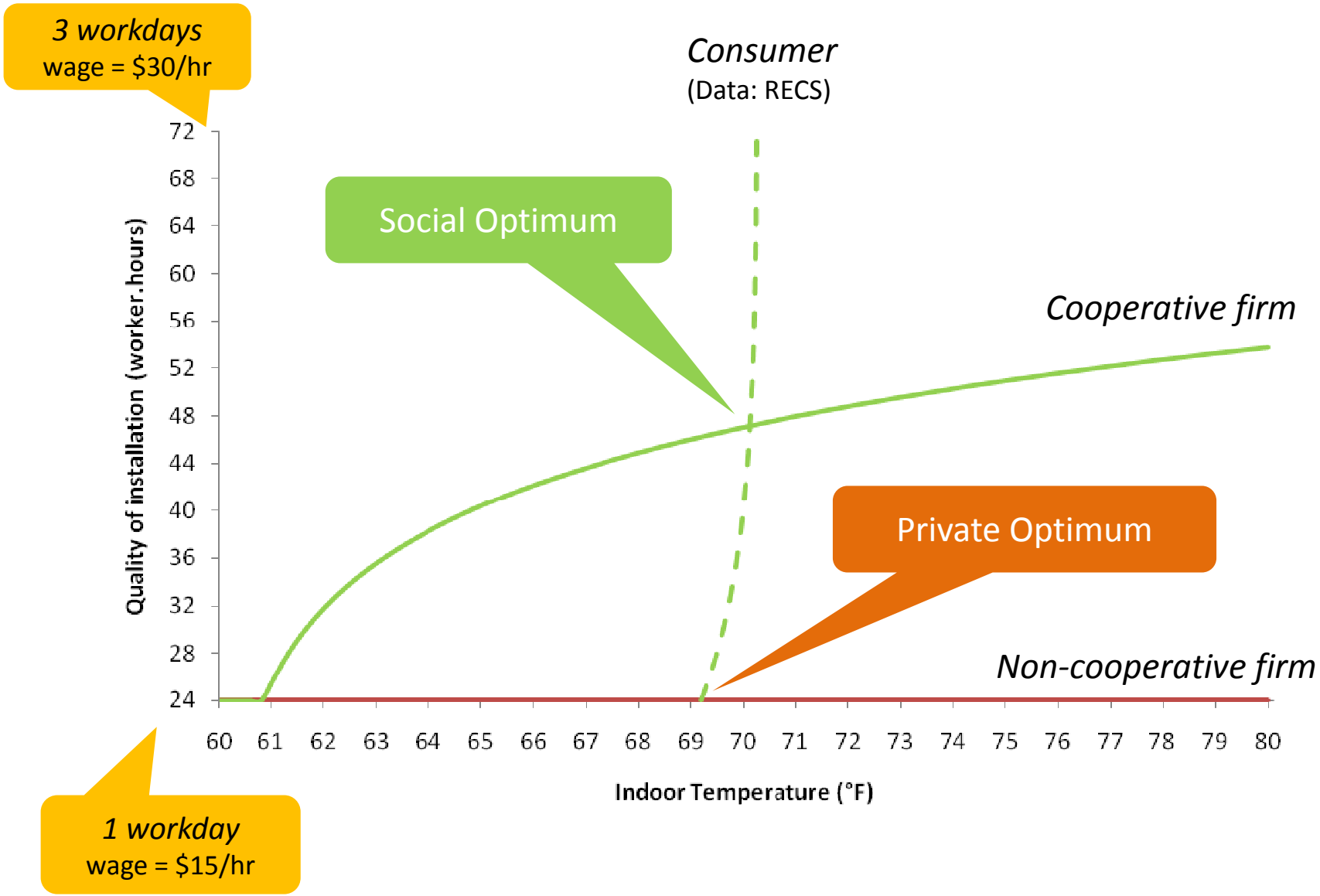



**Stage 1**

$$T = C(q)$$

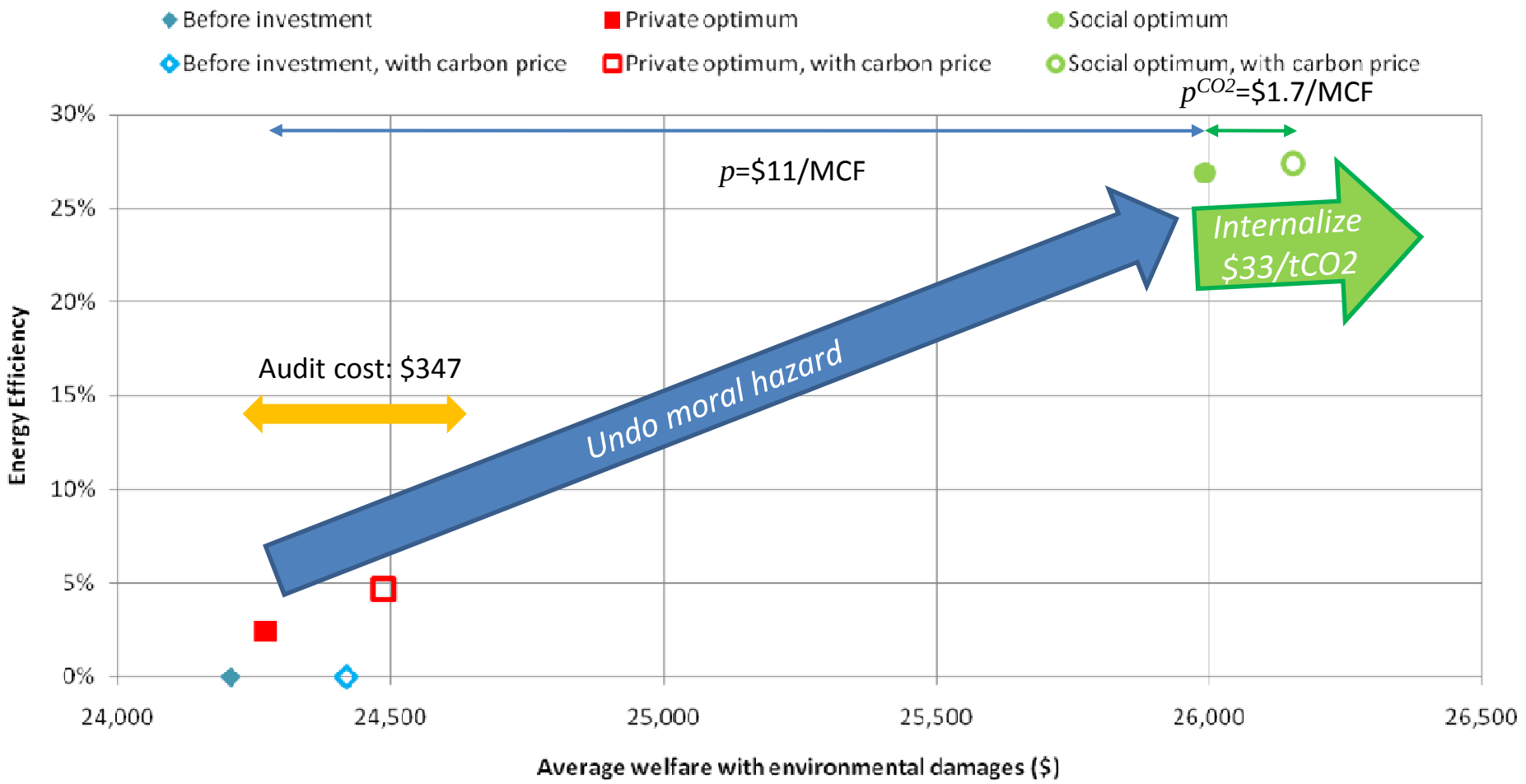
Perfect competition assumption

# Best Response Equilibria (*e.g.* insulation)

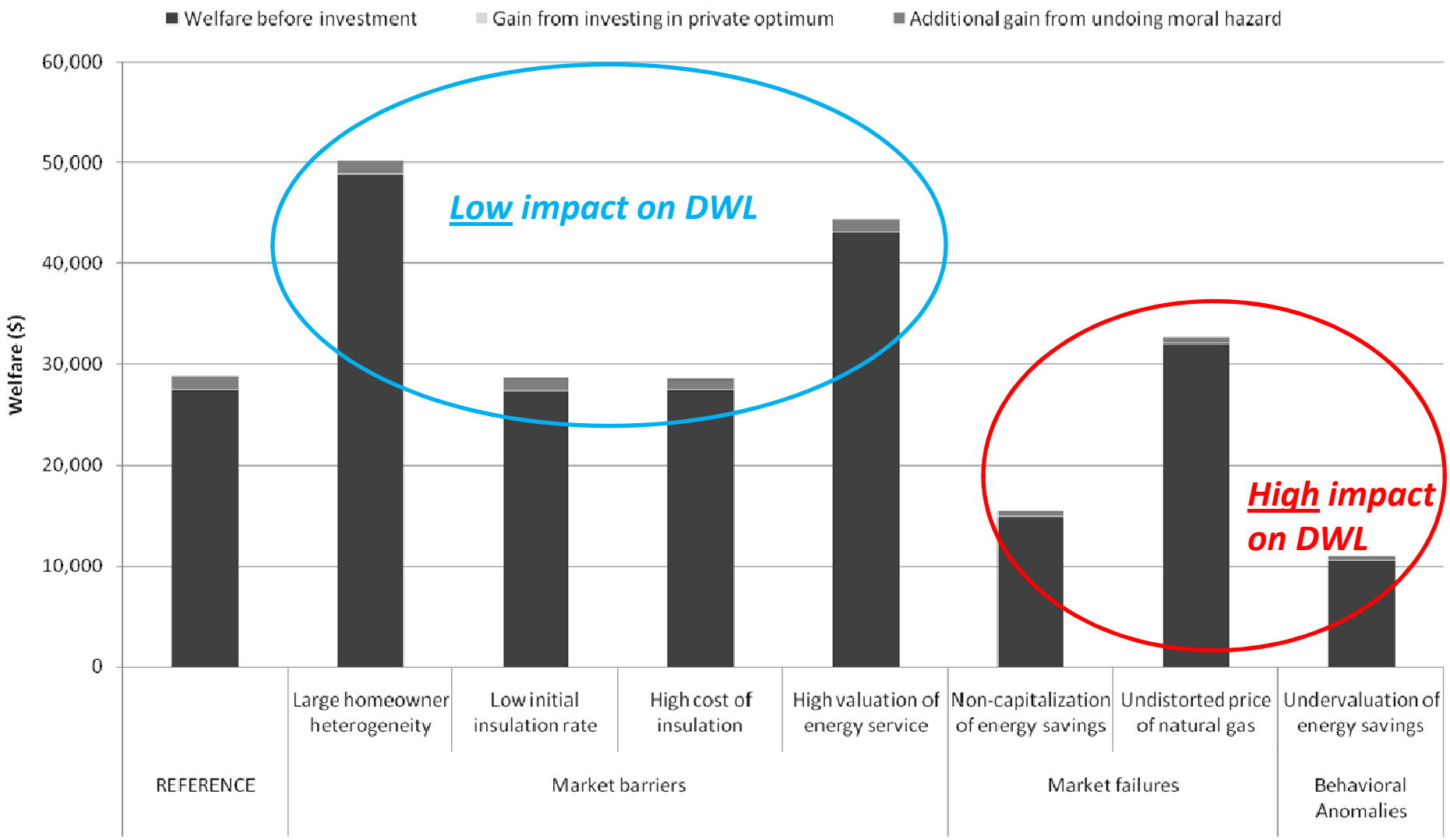


# Magnitude

# Energy Efficiency Gap



# Sensitivity Analysis of Deadweight Loss




Implied discount rates: 15-35% (against 7%)

# Engineer's Heuristics as a Sufficient Statistic

*Discounted monetary savings* *Upfront* cost

$$\Delta_q W \geq -p\Delta_q E(s,q)\Gamma(r,l) - \Delta_q C(q)$$

Economic information needed

NOT needed: Rebound effect ($V(s)$)

| Scenario | REF | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| Exact DWL | 1,258 | 1,239 | 1,206 | 1,085 | 1,260 | 517 | 486 | 289 | 1,258 |
| Suff. Stat. | 1,158 | 1,158 | 1,158 | 997 | 1,158 | 473 | 443 | 263 | 1,158 |
| ***Approxi-mation*** | ***-7.9%*** | ***-6.5%*** | ***-3.9%*** | ***-8.1%*** | ***-8.1%*** | ***-8.6%*** | ***-9.0%*** | ***-9.1%*** | ***-7.9%*** |

# Policy solutions

# Remedies Found in the Marketplace (U.S.)

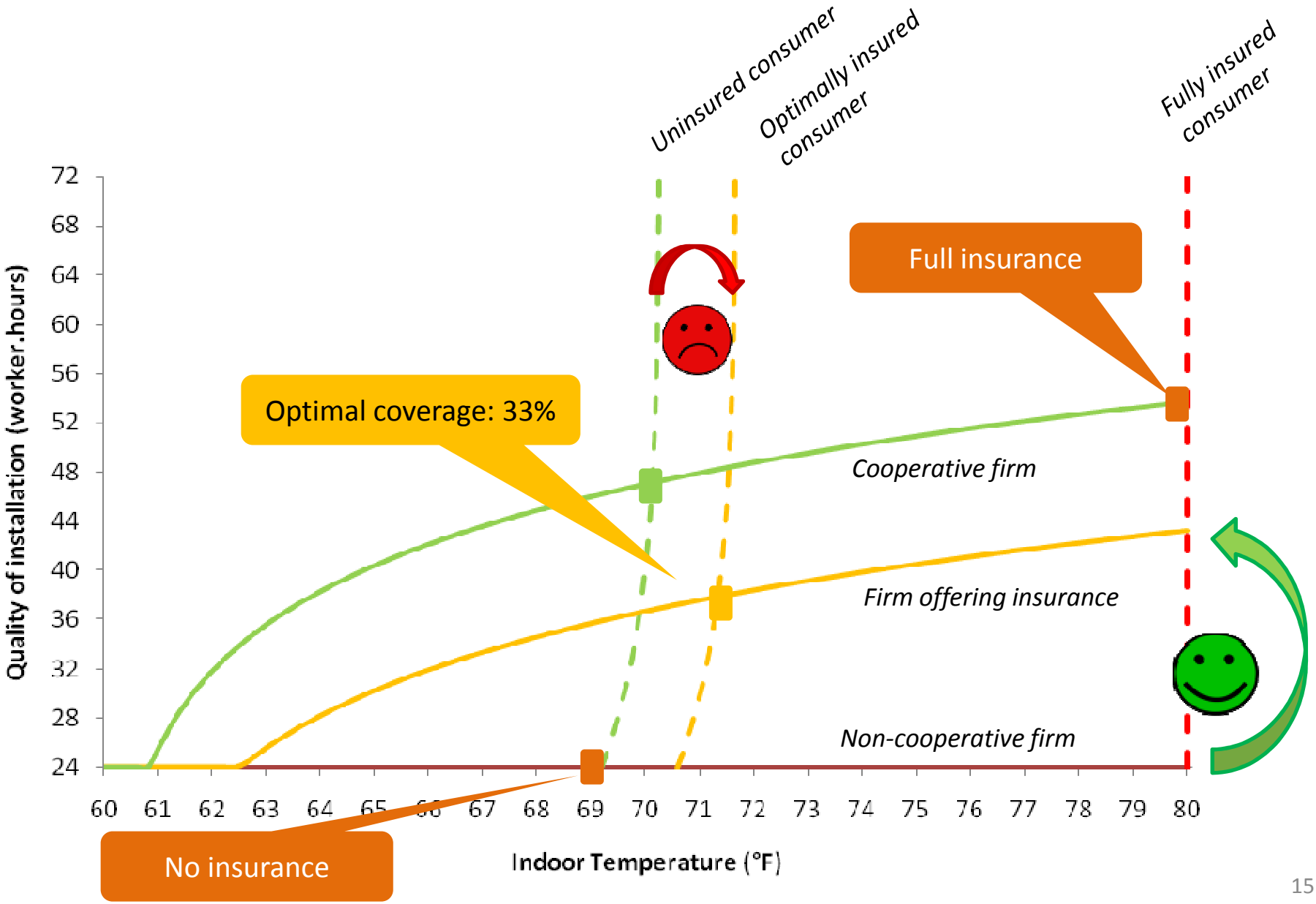
**Voluntary certifications**

**Incentives**

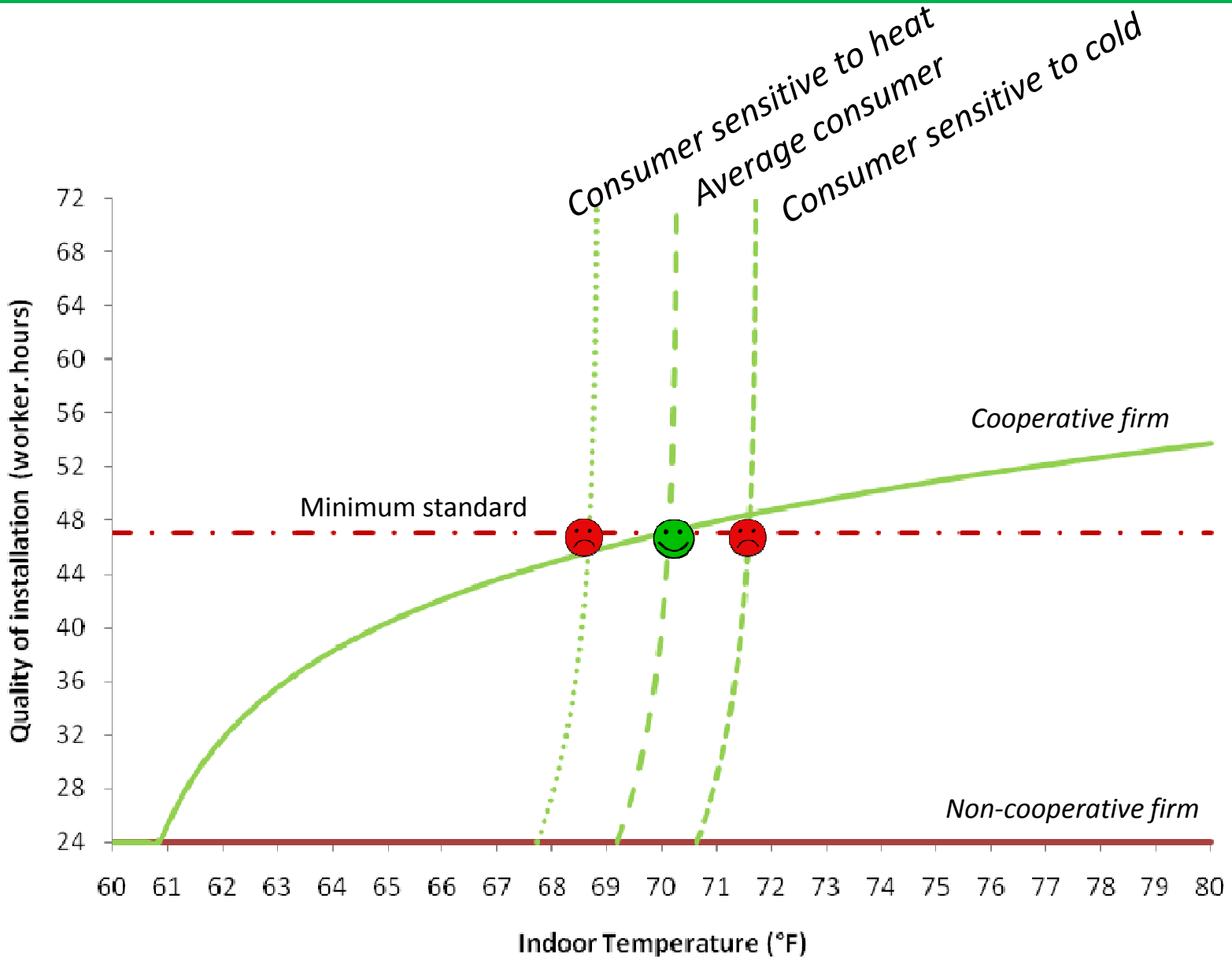




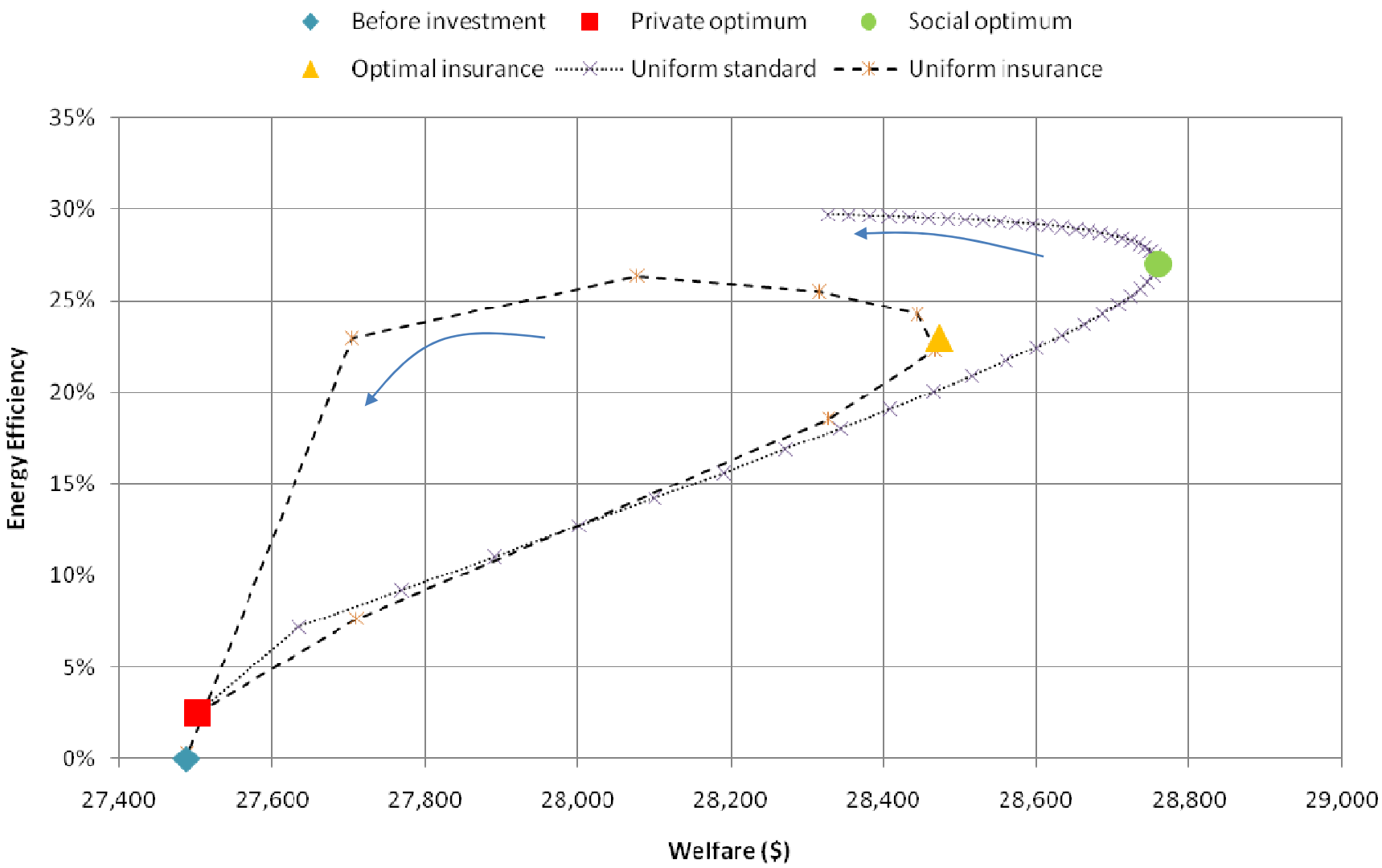

# Energy-Savings Insurance



# Minimum Quality Standard



# Uniform Standards and Insurance



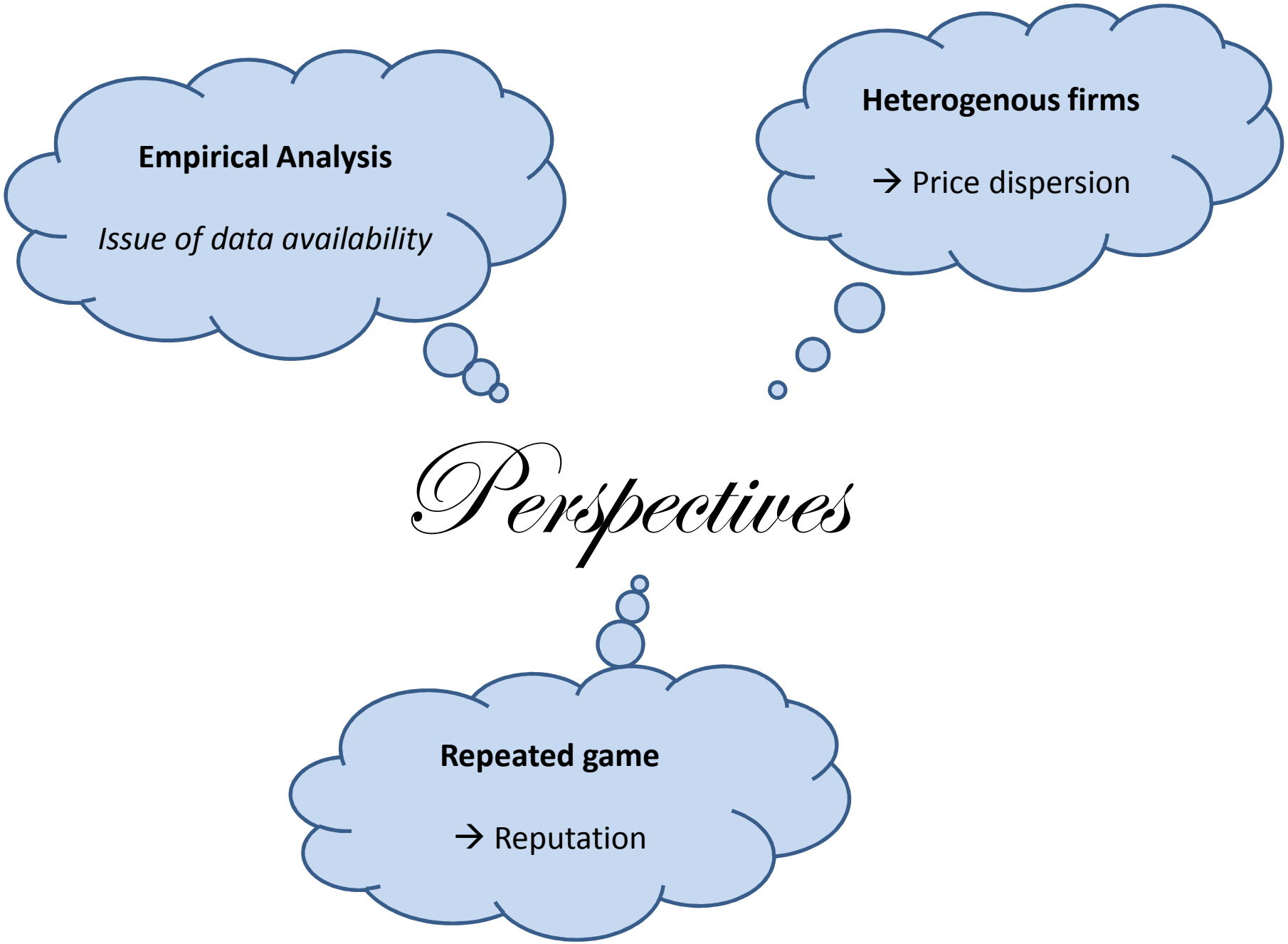
# Conclusions

*Assuming perfect rationality and risk-neutrality…*

⇒ *Formally*, moral hazard can cause an energy efficiency gap: too low a quality, too few investments ($2.4 bl/yr)

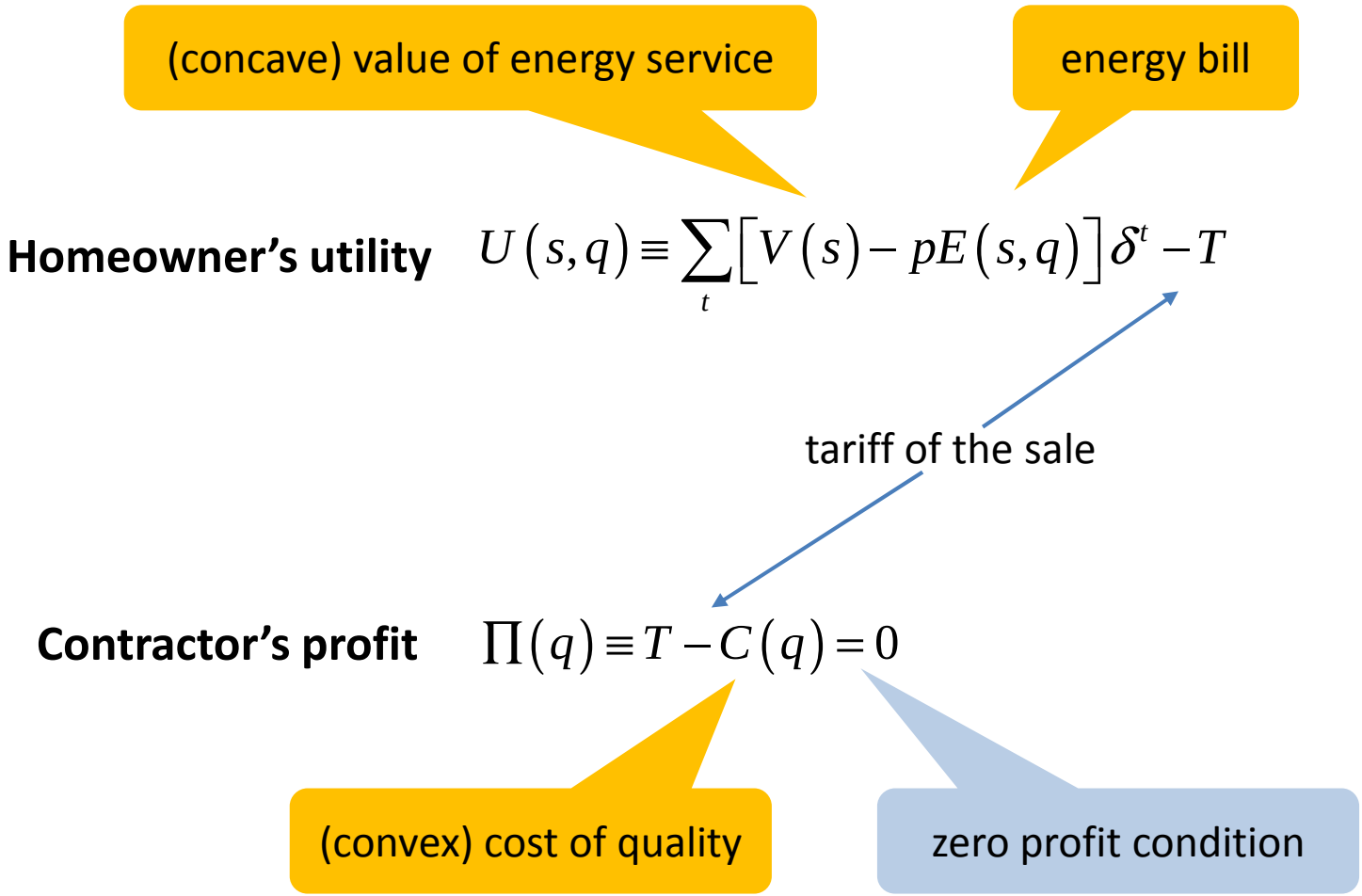
⇒ *Quantitatively*, it motivates public intervention beyond what is needed to internalize energy-use externalities

⇒ *Policy solutions* are only second-best because moral hazard is two-sided


Empirical Analysis
Issue of data availability
Heterogenous firms
→ Price dispersion
Perspectives
Repeated game
→ Reputation

# Supplementary Material

# MODEL: Objective Functions



# MODEL: Social *vs.* Private Optimum

**Social, cooperative setting (*)**

$$\underset{s,q}{Max}\left[U(s,q)+\Pi(q)\right] \xrightarrow{\text{F.O.C}} \begin{cases} V'(s) = p\dfrac{\partial E}{\partial s} \quad \forall t \\ C'(q) = -\sum_t p\dfrac{\partial E}{\partial q}\delta^t \end{cases}$$

*Agents set optimal effort so that marginal benefit equates marginal effect on energy bill*

**Private, non-cooperative setting (#)**

$$\begin{cases} \underset{s}{Max}\, U(s,q) \\ \underset{q}{Max}\, \Pi(q) \end{cases} \xrightarrow{\text{F.O.C.}} \begin{cases} V'(s) = p\dfrac{\partial E}{\partial s} \quad \forall t \\ q = \underset{q \geq q_{\min}}{\arg\min}\, C(q) = q_{\min} \end{cases}$$

*The contractor does not internalize the benefits his action delivers on the energy bill*

# MODEL: Objective Functions with Insurance

Contractor bears a share *k* of the risk

*e.g. pays any shortfall in energy savings below a pre-agreed baseline*

$$\begin{cases} \Pi(q) \equiv T - C(q) - k\sum_t pE(s,q)\,\delta^t \\ U(s,q) \equiv \sum_t \left[V(s) - (1-k)\,pE(s,q)\right]\delta^t - T \end{cases}$$

# MODEL: Insurance Optimum

Second stage of the game is non-cooperative

$$\begin{cases} V'(s) = (1-k)\, p \dfrac{\partial E}{\partial s} & \forall t \\ C'(q) = -k \sum_t p \dfrac{\partial E}{\partial q} \delta^t \end{cases}$$

*Consumption of energy service is **optimal** if the homeowner is NOT insured **(k = 0)***

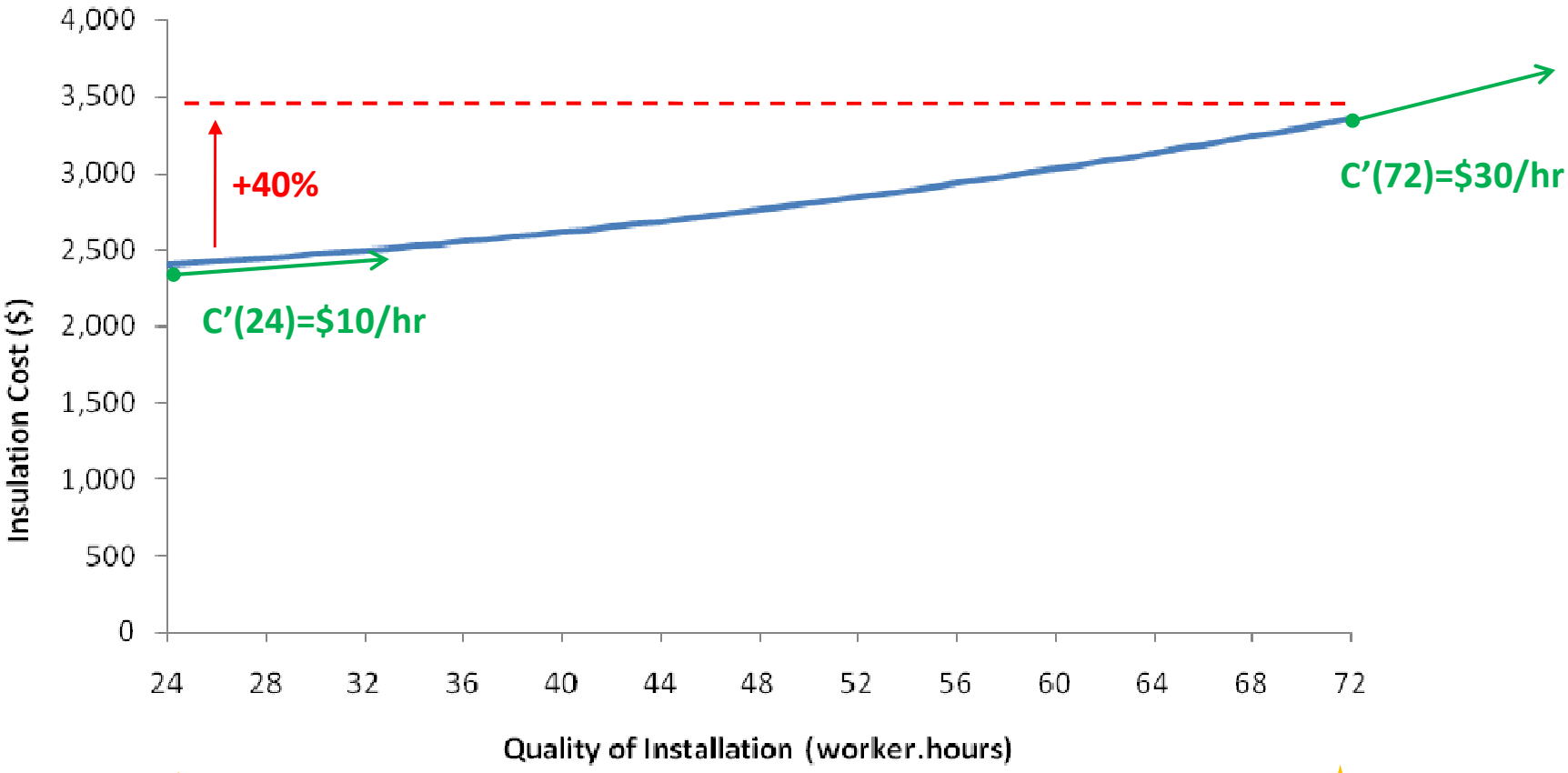
Contract necessarily **incomplete**

*Contractor provides **optimal** quality if he FULLY insures the energy savings **(k = 1)***

First stage of the game is cooperative

$$\underset{k}{Max}\left[U\left(\hat{s}(k), \hat{q}(k)\right) + \Pi\left(\hat{q}(k)\right)\right] \rightarrow \hat{k}$$

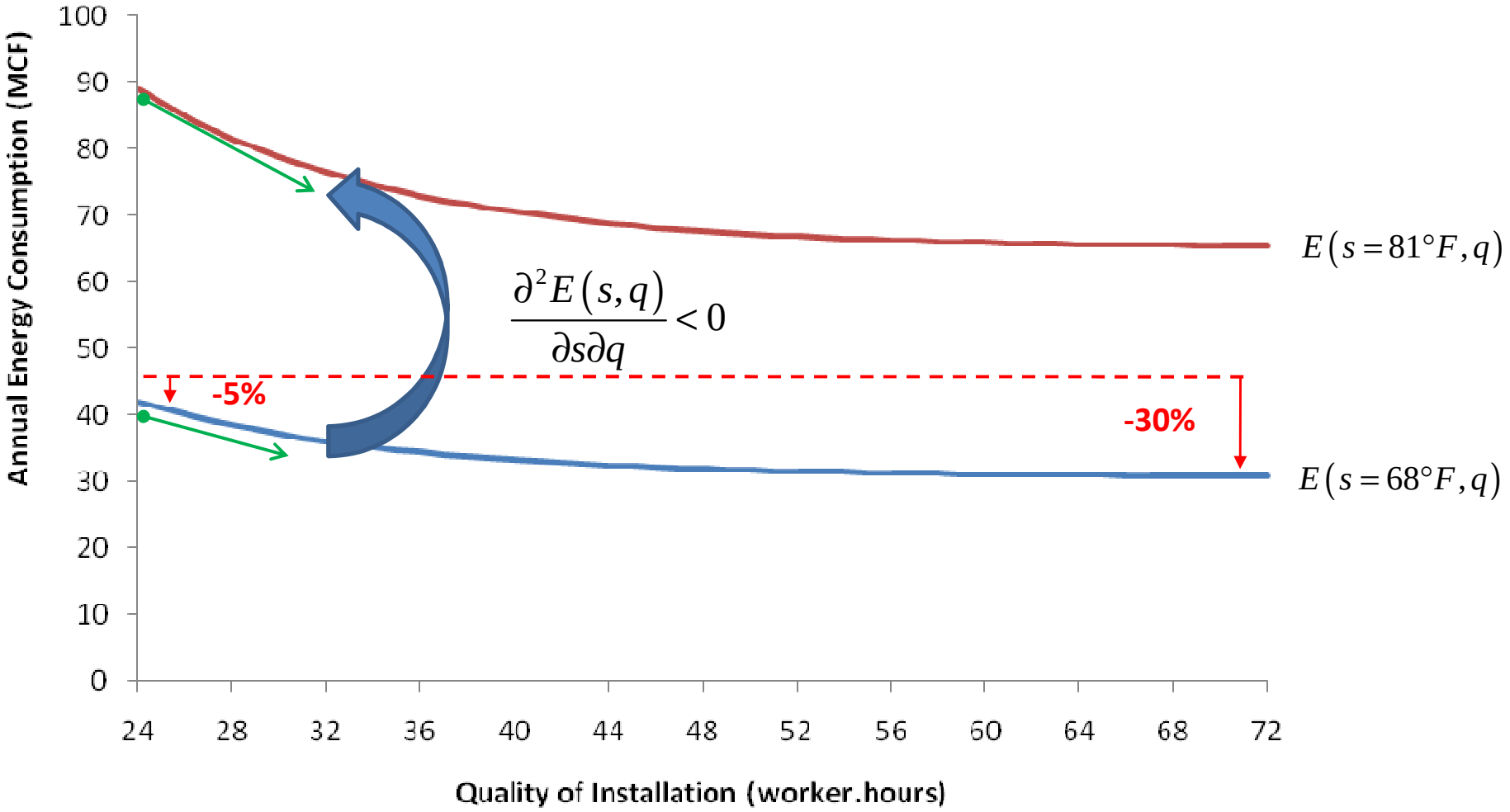
# CALIBRATION: Insulation cost



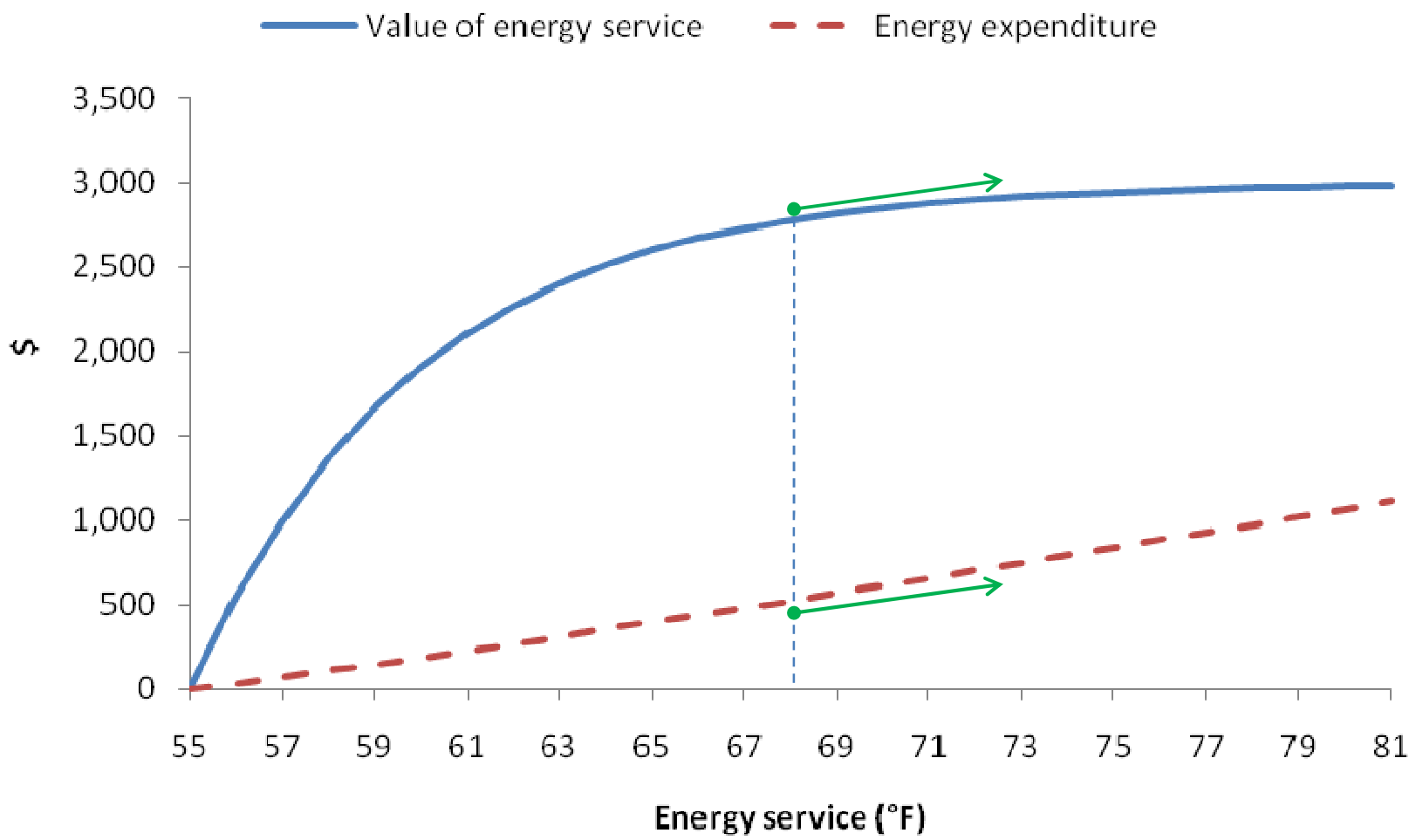

*1 workday = 3 installers working 8 hours each*

*3 workdays*

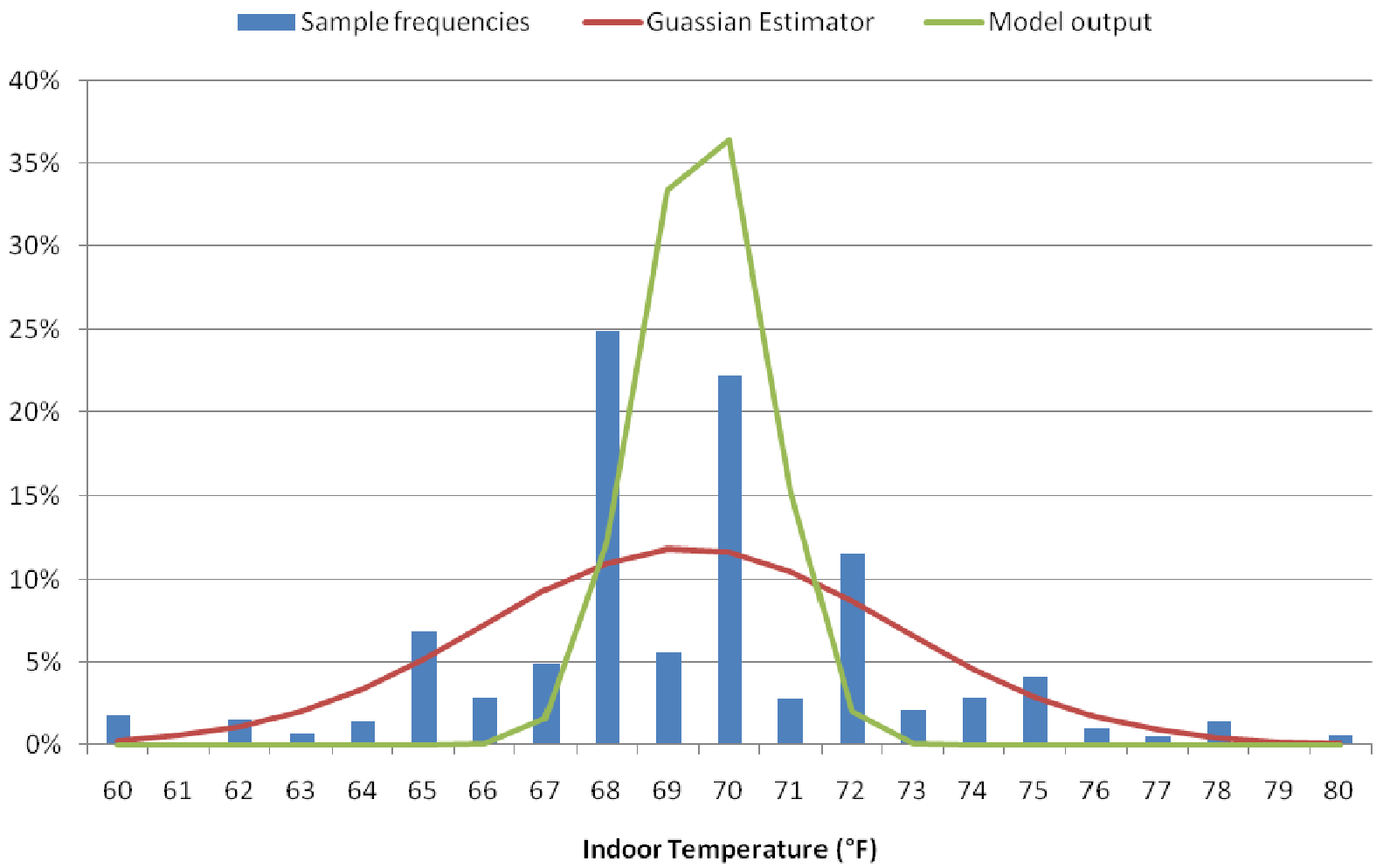
# CALIBRATION: Natural Gas Consumption



# CALIBRATION: Utility

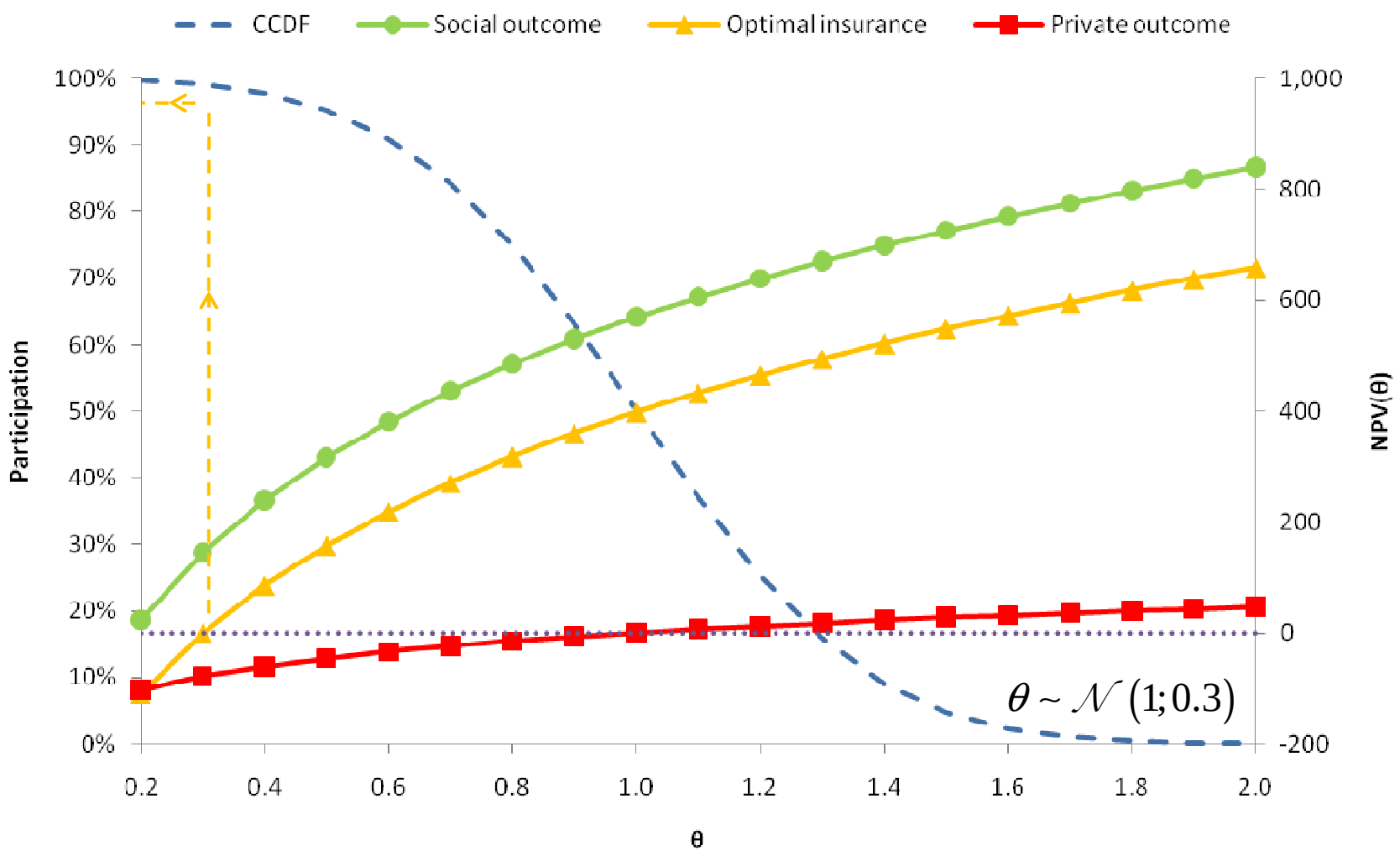


# CALIBRATION: Consumer Heterogeneity

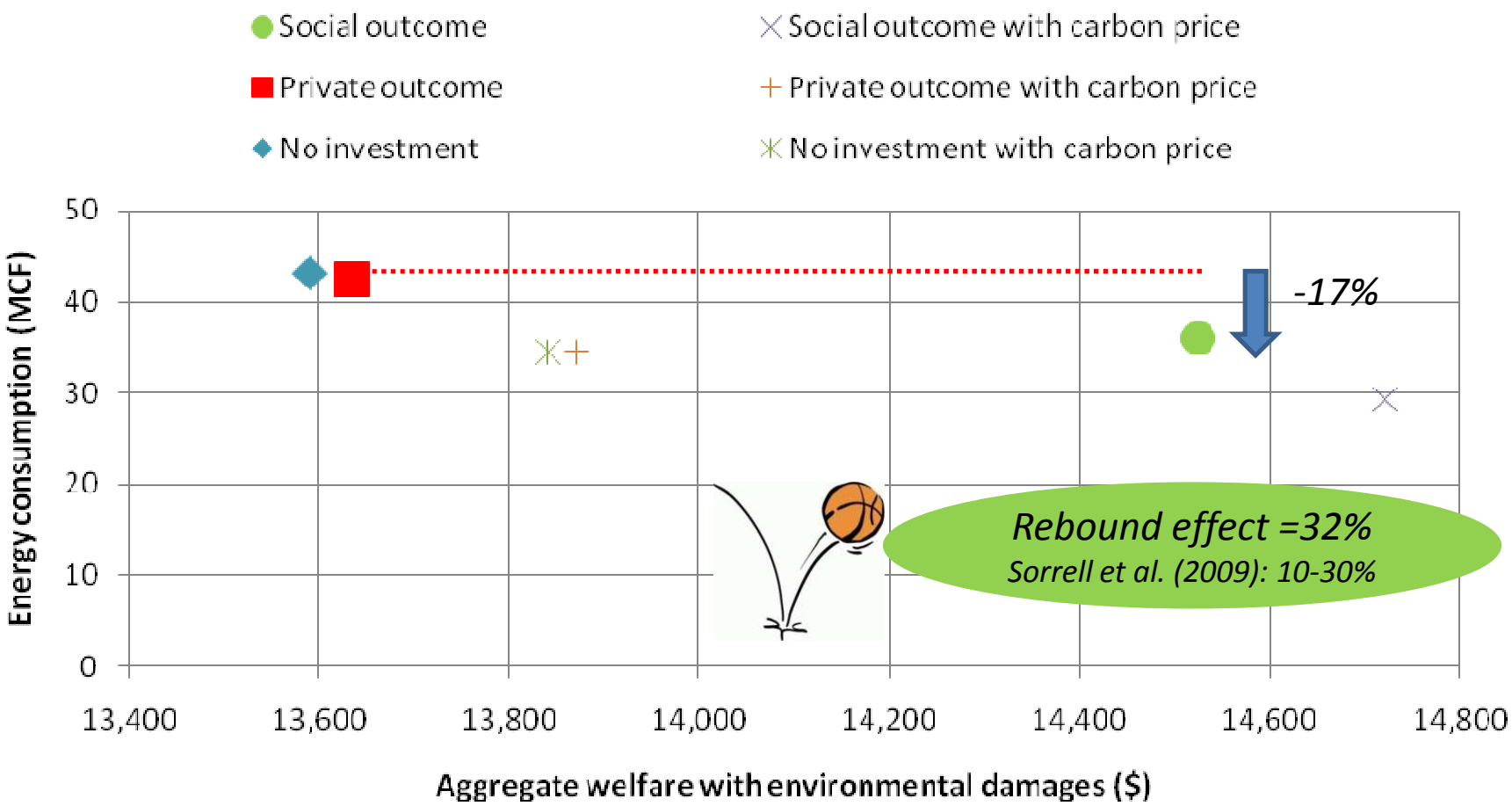


# CALIBRATION: Consumer Participation

$$NPV(\theta) \equiv U(\theta) - T(\theta) - U_0(\theta)$$



# Energy Gap and the Rebound Effect




***Sufficient** condition for **joint** intervention: **No 'backfire'** rebound effect*

# Picture Credits

- Slide 2: *http://www.qualiteconstruction.com/manifestations/concours-photo/2013.html*
- Slide 5:
  - http://www.insidehousing.co.uk/pictures/626xAny/9/8/3/17983_WHISCERS_1.jpg
  - http://cdn2-b.examiner.com/sites/default/files/styles/imagecrop_large/hash/cc/ca/1341489915_2471_thermostat.jpg
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  - http://www.polyvore.com/cgi/img-thing?.out=jpg&size=l&tid=40887891