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Innovation incentive for regulated network industries

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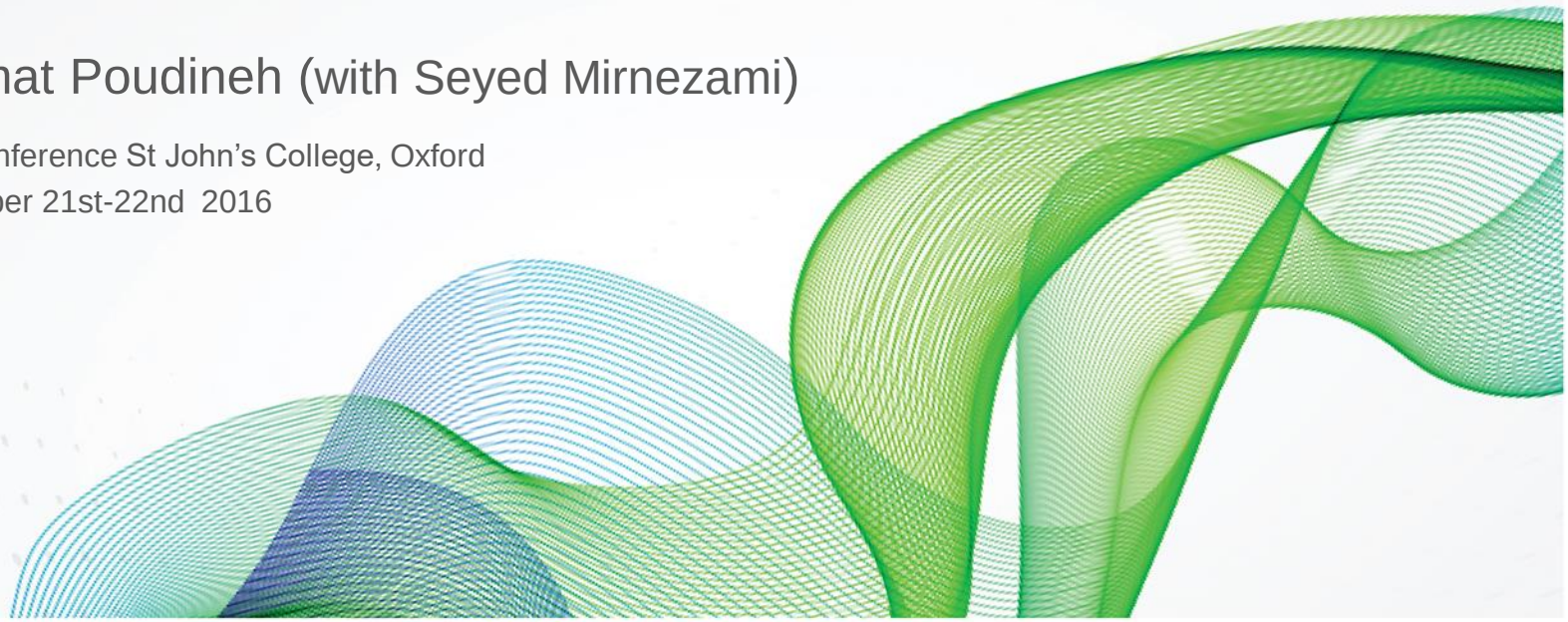
BIEE conference St John's College, Oxford
September 21st-22nd 2016



Outline

- Introduction
  - Electricity networks and the need for innovation
- How to treat innovation costs?
  - What happens when innovation costs are treated like other regulatory costs?
- How to share the risk of innovation activities between firms and their customers?
  - Unobservablility of firms' effort and performance based regulation
  - Incentive-insurance tradeoff
- Competitive schemes for innovation fund
  - The effect of potential value of the project on winning probability
  - The effect of firms' risk aversion on winning probability

Background

- The operating environment of electricity distribution networks are changing.
  - Distributed generation, electricity vehicles, interaction of end-users with grid, active network management, smart grid and smart meters.
- Traditionally regulatory regime of network companies emphasises on cost reduction.
- However, innovation activities are not only costly but also risky.
- How to incentivise regulated firms to undertake innovation given that it is a risky activity?

Treating innovation costs

- Imagine the following regulatory contract is offered to the company:

$$z = \beta + \alpha_1 x_1 + \alpha_2 x_2$$

  - $x_1 = e_1 + \varepsilon_1$ $\quad \varepsilon_1 \sim N(0, \sigma_1^2)$ normal efficiency gain
  - $x_2 = e_2 + \varepsilon_2$ $\quad \varepsilon_2 \sim N(0, \sigma_2^2)$ innovation gain
  - σ_{12} correlations of shocks

- Firm preferences are represented by $u(z) = -\exp(-rz)$
- The cost of firm is: $c(e_1, e_2) = \frac{1}{2}\rho(e_1^2 + e_1^2) + \theta e_1 e_2$ where $|\theta| < \rho$

$$\alpha_1^* = \frac{1 + r\theta(\sigma_{12} - \sigma_2^2) + r\rho(\sigma_2^2 - \sigma_{12})}{1 + r(2\theta\sigma_{12} + \rho\sigma_1^2 + \rho\sigma_2^2) + r^2(\rho^2 - \theta^2)(\sigma_1^2\sigma_2^2 - \sigma_{12}^2)}$$

$$\alpha_2^* = \frac{1 + r\theta(\sigma_{12} - \sigma_1^2) + r\rho(\sigma_1^2 - \sigma_{12})}{1 + r(2\theta\sigma_{12} + \rho\sigma_1^2 + \rho\sigma_2^2) + r^2(\rho^2 - \theta^2)(\sigma_1^2\sigma_2^2 - \sigma_{12}^2)}$$

The effect of random shock on outcome of two tasks are independent ($\sigma_{12} = 0$)

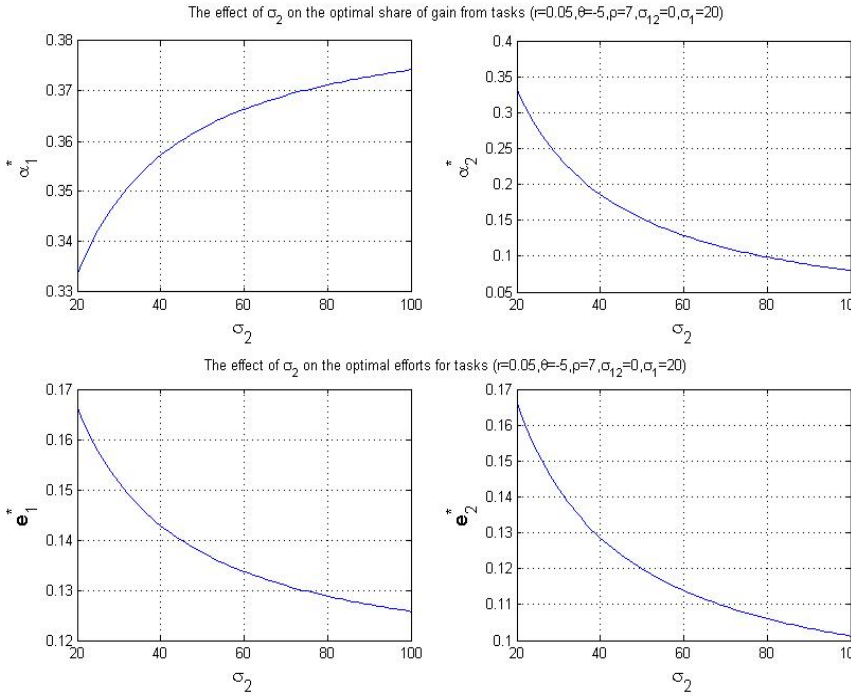


Figure 1: The effect of increase in uncertainties of innovation on optimal share of firm and its effort (when there is synergy between tasks-i.e., $\theta < 0$)

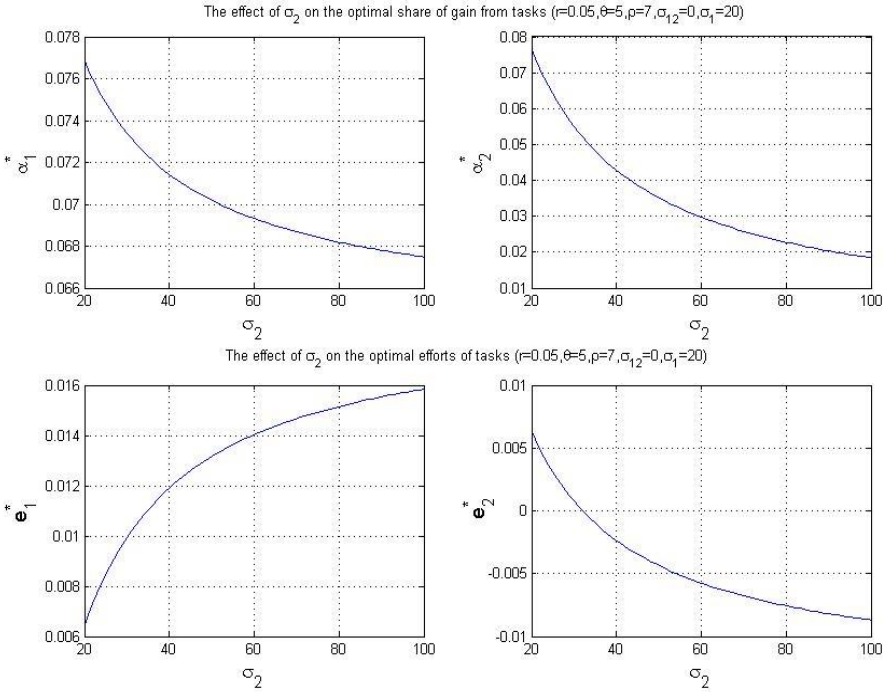


Figure 2: the effect of increase in uncertainties of innovation on the optimal share of firm and its effort (when there is no synergy between tasks-i.e., $\theta > 0$)

The effect of random shock on the outcome of two tasks are correlated (σ_{12}>0)

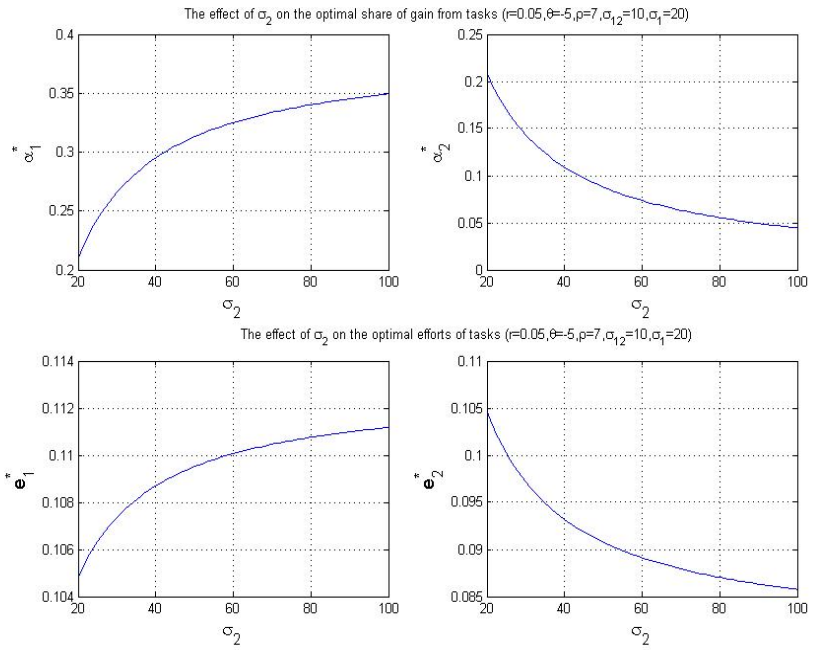


Figure 3: the effect of increase in uncertainties of innovation on the optimal share of firm and its effort (synergy between tasks)

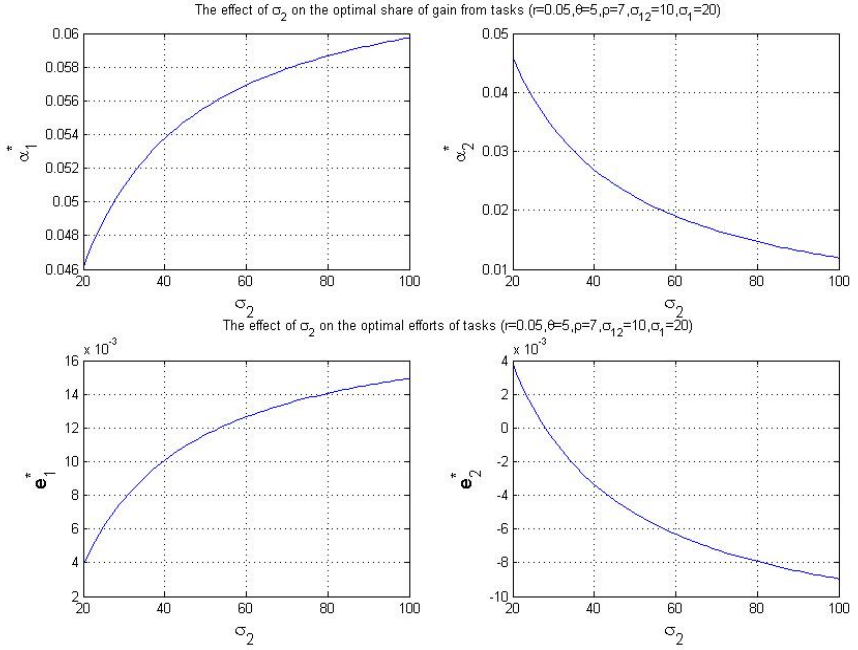


Figure 5: the effect of increase in uncertainties of innovation on the optimal share of firm and its effort (no synergy between tasks)

The effect of random shock on outcome of two tasks are correlated ($\sigma_{12}>0$)

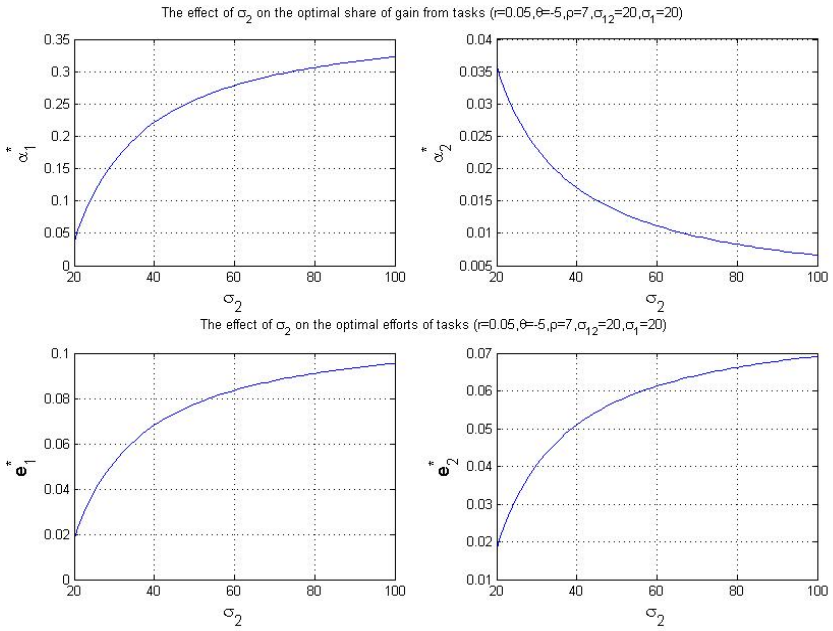
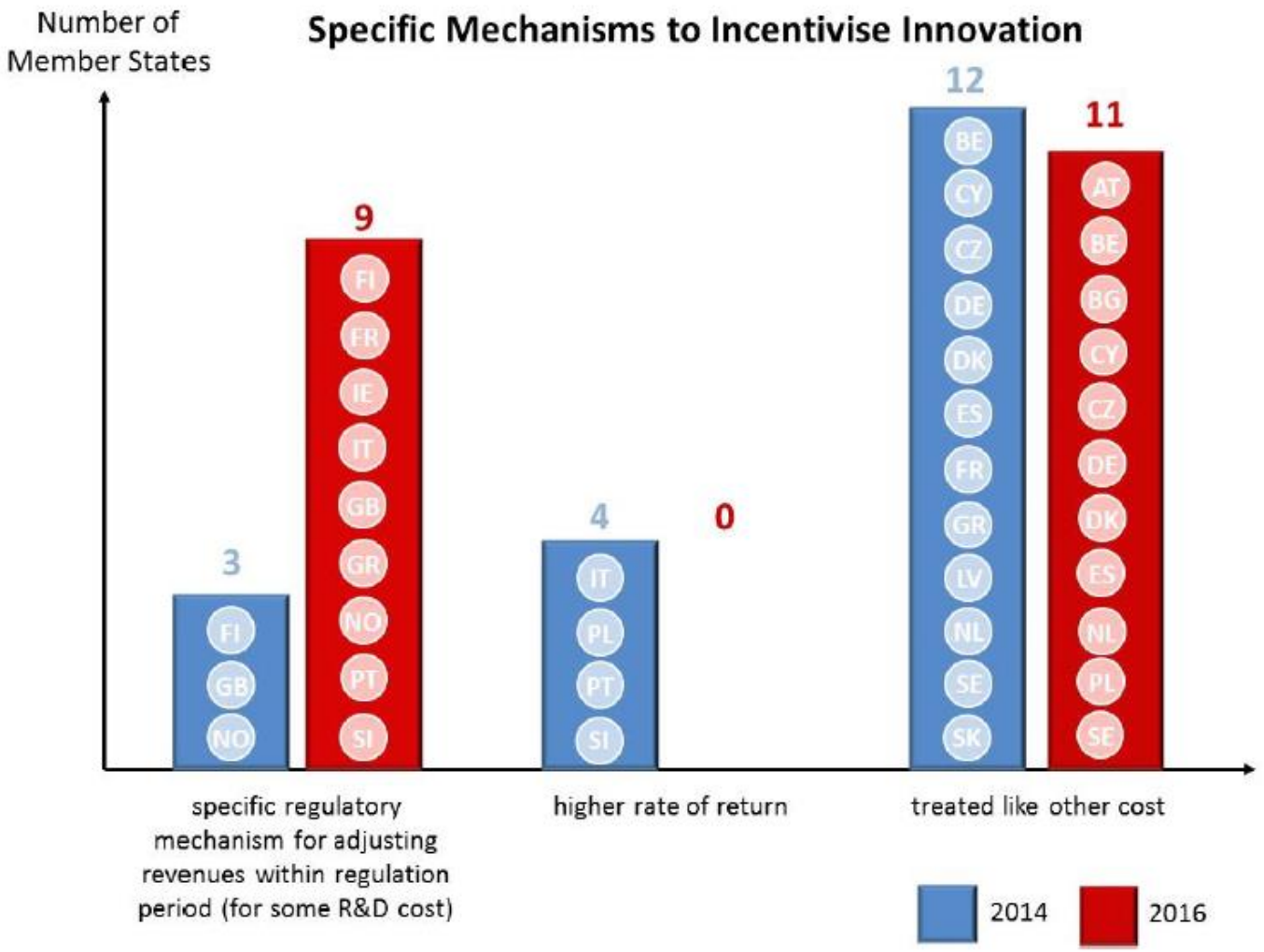


Figure 4: the effect of increase in uncertainties of innovation on the optimal share of firm and its effort (synergy between tasks and higher level of random effect correlation)

- Innovation activities are riskier compared with normal cost reduction activities.
- It is very likely that treating innovation cost like other costs leads to diversion of firms effort from innovation activities to normal efficiency gain.
- Thus regulator requires to design explicit innovation schemes in which the risk profile of innovation efforts are considered.

Regulatory treatment of innovation costs in Europe



Source: EURELECTRIC (2016)

Risk sharing

- Let's assume that regulator compensates the firm for innovation effort based on the following model:

$$z = \beta + \alpha x$$

  - β is a fixed payment transferred to the consumers
  - α is a performance based compensation
  - $x = e + \varepsilon$ where $\varepsilon \sim N(0, \sigma^2)$
  - The cost of firm for innovation is: $c(e) = \frac{1}{2}\rho e^2$
  - The risk preference of firm follows: $u(z, e) = -\exp[-r\left(z - \frac{1}{2}\rho e^2\right)]$
- When regulator observes the effort of firm the optimum contract requires $\alpha^* = 0$ (full insurance).
- When there is information asymmetry the optimum contract requires:

$$\alpha^* = \frac{1}{1+r\rho\sigma^2} \quad \text{and} \quad e^* = \frac{\alpha}{\rho}$$

Thus, there is a trade-off between insurance and incentive

Competitive innovation funds

- Suppose two firms compete for innovatin fund w which will be allocated to the project with higher potential value.
- The value of project is a linear function of firm's effort and its characteristics (λ_i) (coefficient of value potential)

$$f_i(e_i) = \lambda_i e_i \quad i \in \{1,2\}$$

- The probability of wining the competition is $p_i = \frac{f_i(e_i)}{f_1(e_1)+f_2(e_2)} \quad i \in \{1,2\}$
  - when $e_1 = e_2 = 0$ $p_i = \frac{1}{2}$.
- Firm risk preference is: $u_i(z_i) = -\exp(-r_i z_i)$ where $z_i = I_i + w_i - e_i$

$$\frac{p_2}{p_1} = \sqrt{\frac{\lambda_2 s(r_1) e^{-r_1 w}}{\lambda_1 s(r_2) e^{-r_2 w}} + \left(\frac{\lambda_1 s(r_2) - \lambda_2 s(r_1)}{2 s(r_2) e^{-r_2 w}}\right)^2} - \left(\frac{\lambda_1 s(r_2) - \lambda_2 s(r_1)}{2\lambda_1 s(r_2) e^{-r_2 w}}\right)$$

  - where $s(r_i) = \frac{r_i}{1 - e^{-r_i w}}$

Competitive innovation funds

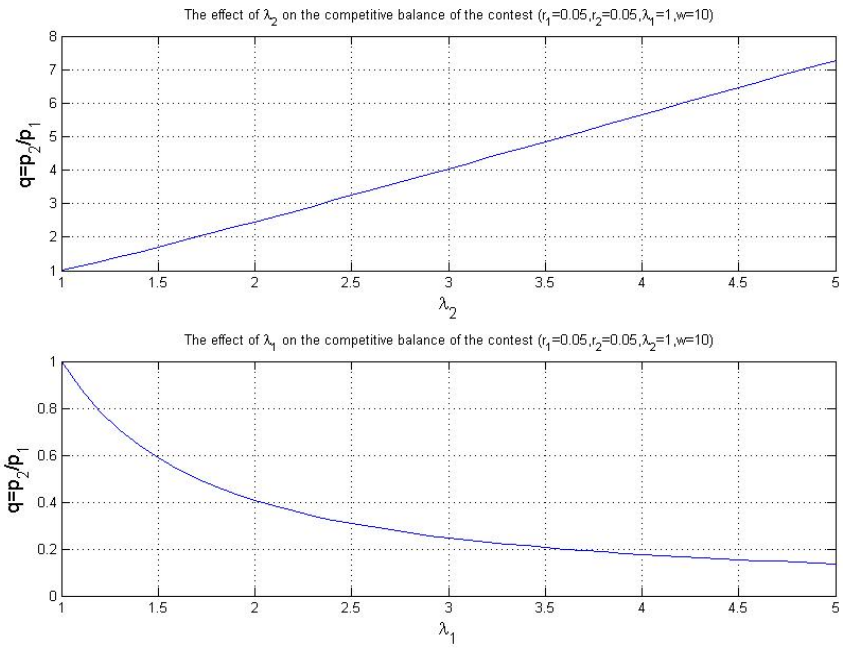


Figure 7: The effect of coefficient of value potential (λ) on the competitive balance of the contest (two parties have the same level of risk aversion)

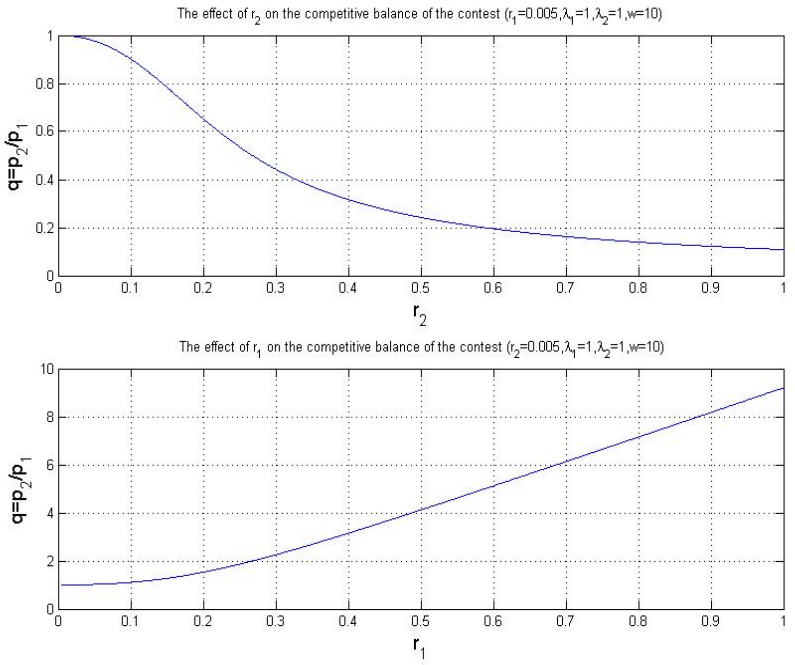


Figure 8: The effect of risk aversion of parties (r) on the competitive balance of the contest (two projects have the same potential value coefficient)

Competitive innovation funds

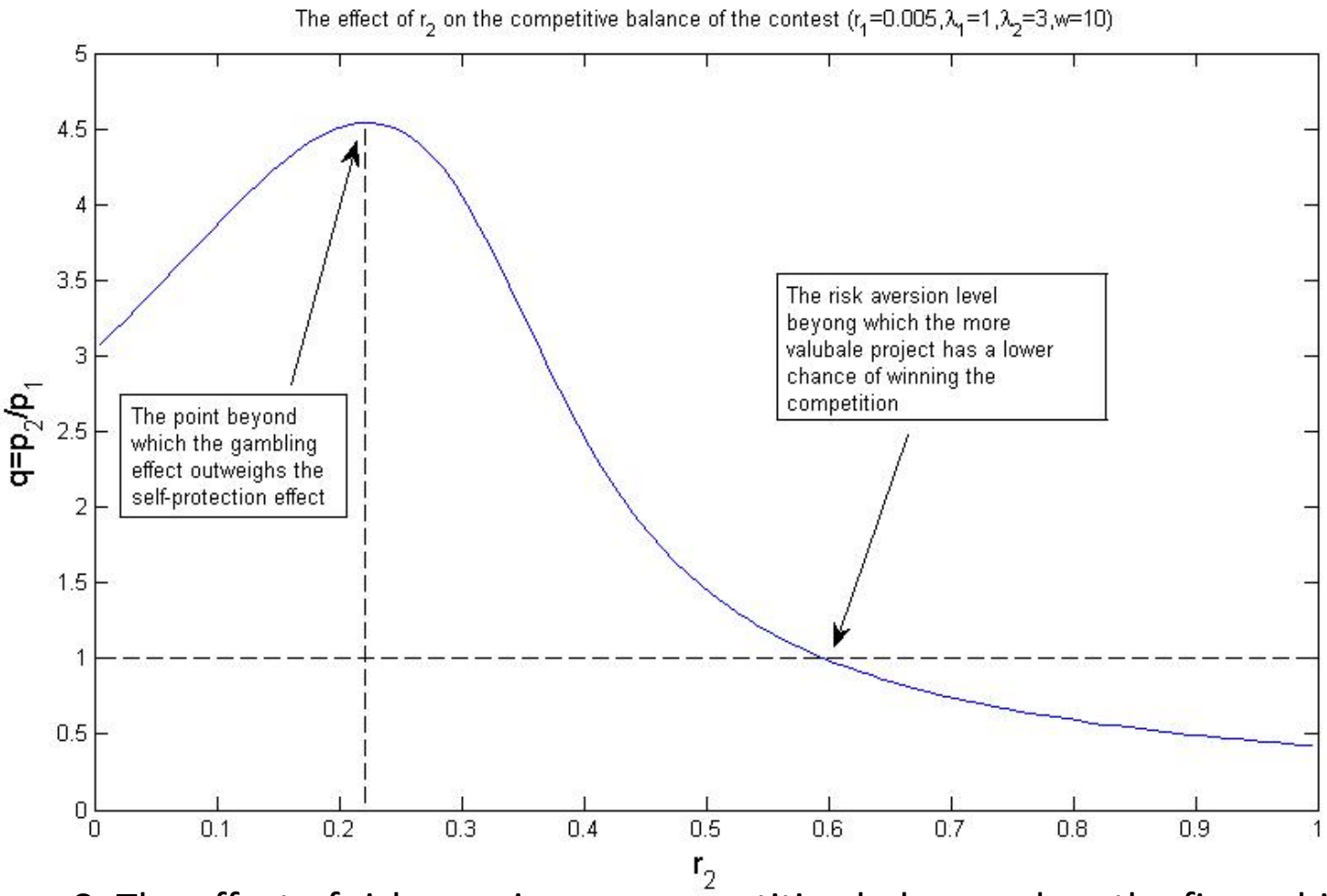


Figure 8: The effect of risk aversion on competitive balance when the firm which has the project with higher potential value is also more risk averse

Competitive innovation funds

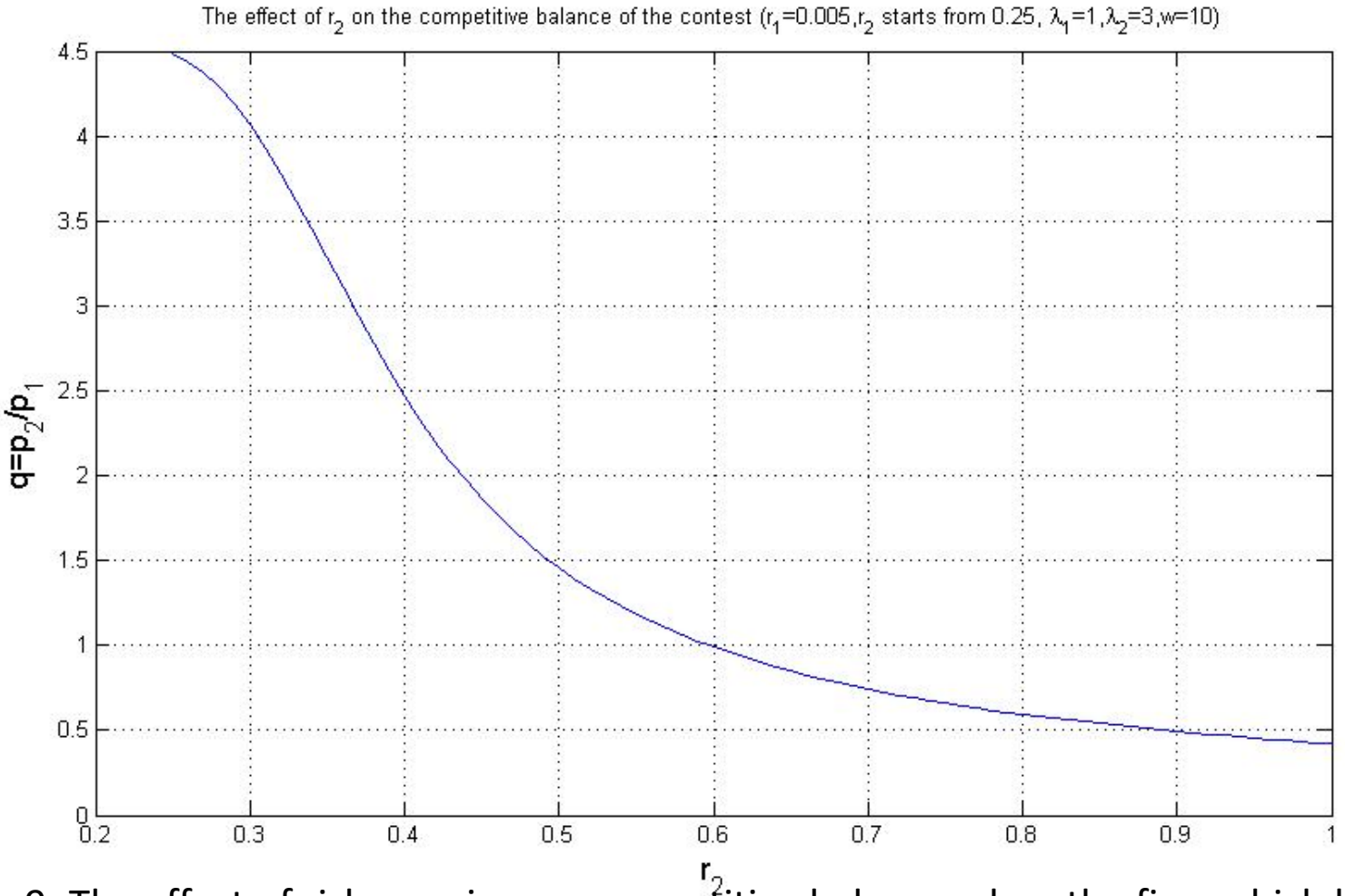


Figure 9: The effect of risk aversion on competitive balance when the firm which has the project with higher potential value is much more risk averse compare to its rival

Conclusions

- Innovations activities are not only costly but also risky - traditionally regulatory framework of network companies deterred them form risky activities.
- An important question is how to incentivise innovation under regulation?
- Treating innovation cost like any other cost leads to reduction of innovation efforts.
- Information asymmetry and risk averse attitude of firm prevents giving the firm full insurance for innovation costs.
- Competitive innovation funds do not necessarily lead to selection of the project with highest potential value.

Thank you for your attention