Optimal taxation and R&D policies

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  - ***Non-appropriability of innovation:*** Without Intellectual Property Rights (IPR), any firm could freely use another's idea. With IPR/patents, it creates monopoly distortions
  - ***Asymmetric information:*** Firms' underlying research productivity (turning R&D into innovation) is *private information* and some R&D inputs (like effort) are unobservable to policymakers

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  - ***Non-appropriability of innovation***
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- ▶ Dynamic mechanism design with spillovers, to study corporate taxation and R&D policy
- ▶ Contribution:
  - Mechanism design method/revelation principle extended to settings with spillovers and infinite-horizon dynamic firm heterogeneity
  - Characterize constrained efficient allocation when planner can't observe firm types or hidden R&D effort
  - Show an implementation with simple corporate tax and R&D subsidy schedules
  - Estimate the model using firm-level data matched to U.S. Patent Office Patent data

Model of Innovation with Asymmetric Information

- Firms produce differentiated goods and engage in R&D r to improve the quality q,
  $\Rightarrow \quad q = q_0 + \lambda$
- Endogenous quality improvement "step size" $\lambda = \lambda(r, \ell, \theta)$, with
  - R&D investment r: observable inputs spent (e.g. lab, material, scientists), with cost $M(r)$
  - R&D effort ℓ: unobservable actions that cannot be monitored, with cost $\phi(\ell)$
  - Firm type θ: Research productivity (e.g. efficiency of management/practices/ideas) with distribution $f(\theta)$ and $F(\theta)$

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  - Firm type θ: Research productivity (e.g. efficiency of management/practices/ideas) with distribution $f(\theta)$ and $F(\theta)$
- Quality spillovers: $\bar{q} = \mathbb{E}[q(\theta)] = \int_\Theta q(\theta)\, f(\theta)\, d\theta$
- Final goods production: $Y = \int_\Theta Y\big(q(\theta), k(\theta)\big)\, f(\theta) d\theta$
- Monopoly power and demand $p(q, k)$ and production decision for quantity k, and firms' problem $\pi(q(\theta), \bar{q}) = \max_k \; p(q(\theta), k)k - C(k, \bar{q})$

Model of Innovation: First-Best

- Consumer surplus: $Y\big(k(\theta), q(\theta)\big) - C\big(k(\theta), \bar{q}\big) - M\big(r(\theta)\big) - T(\theta)$
  for $T(\theta)$ transfer from HH to the firm of type θ, and consumption net of cost:
  $\mathcal{Y}(q(\theta), \bar{q}) = Y\Big(k^\star(q(\theta), \bar{q}), q(\theta)\Big) - C\Big(k^\star(q(\theta), \bar{q}), \bar{q}\Big)$
- Firm surplus $v(\theta) = T(\theta) - \phi\big(\ell(\theta)\big)$
- First Best:
  - Optimal R&D investment choice: $M'\big(r(\theta)\big) = \mathbb{E}\Big[\big(\frac{\partial \mathcal{Y}(q(\theta),\bar{q})}{\partial q} + \frac{\partial \mathcal{Y}(q(\theta),\bar{q})}{\partial \bar{q}}\big)\frac{\partial \lambda(\theta)}{\partial r(\theta)}\Big]$
  - Optimal effort: $\phi'\big(\ell(\theta)\big) = \mathbb{E}\Big[\big(\frac{\partial \mathcal{Y}(q(\theta),\bar{q})}{\partial q} + \frac{\partial \mathcal{Y}(q(\theta),\bar{q})}{\partial \bar{q}}\big)\frac{\partial \lambda(\theta)}{\partial \ell(\theta)}\Big]$

  $\Rightarrow$ Reward *R&D* and efforts for their positive externality using type θ-specific transfers $T(\theta) = \phi\big(\ell(\theta)\big)$
- Asymmetric information: cannot observe or condition policies on certain factors

Asymmetric Information and Mechanism Design setting

- Direct revelation mechanism
  - θ and ℓ are private information, government observe step size λ and quality q and efforts r
  - Firms report $\hat{\theta}$ and then goverment allocate transfers $T(\hat{\theta})$

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$$V(\theta) = T(\theta) - \phi(\ell(\theta)) \geq T(\hat{\theta}) - \phi\big(\ell(\lambda(\hat{\theta}), r(\hat{\theta}), \theta)\big) =: V(\theta, \hat{\theta}) \qquad \forall \theta, \hat{\theta}$$

    with $\ell(\lambda(\hat{\theta}), r(\hat{\theta}), \theta)\big)$ the effort provided by θ to "mimic" the type-$\hat{\theta}$ to still provide step $\lambda(\hat{\theta})$ (e.g. high type might pretend they are low type and provide less effort)
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  - Participation constraint $V(\theta) \geq 0$
- First order approach:
  - IC constraints are complicated to manipulate, have to do it for every $\theta, \hat{\theta}$
  - Replace them with their envelop conditions with $\frac{dV(\theta,\hat{\theta}())}{d\theta} = \frac{\partial V(\theta,\hat{\theta})}{\partial\theta} = \phi'(\ell(\theta))\frac{\partial\lambda/\partial\theta}{\partial\lambda/\partial\ell}$
  - Maximize the virtual surplus, net of the informational rent:

$$W(\bar{q}) = \mathbb{E}\Big[\mathcal{Y}(q(\theta), \bar{q}) - M(r(\theta)) - \phi(\ell(\theta)) - \frac{1-F(\theta)}{f(\theta)}\frac{\partial V(\theta,\hat{\theta})}{\partial(\theta)}\Big] \qquad \text{with} \qquad \bar{q} = \int q(\theta) f(\theta) d\theta$$

Optimal profit taxation and R&D subsidies

- The optimal (non-linear, type-specific!) profit wedge $\tau(\theta)$ and R&D subsidy wedge $s(\theta)$, s.t. $\tilde{\pi} = \pi(1-\tau(\cdot)) - (1-s(\cdot))M(r)$
- R&D subsidy wedge: $s(\theta)$

$$s(\theta) = \underbrace{\mathbb{E}\Big[\frac{\partial \mathcal{Y}}{\partial \bar{q}} \frac{\partial \lambda(\theta)}{\partial r}\Big]}_{\textit{Pigouvian correction}} + \underbrace{\mathbb{E}\Big[\Big(\frac{\partial \mathcal{Y}}{\partial q} - \frac{\partial \pi}{\partial q}\Big)\frac{\partial \lambda(\theta)}{\partial r}\Big]}_{\textit{Monopoly quality valuation correction}} + \overbrace{\underbrace{\frac{1-F(\theta)}{f(\theta)}}_{\substack{\textit{Type}\\ \textit{distribution}}} \phi'(\ell(\theta)) \frac{\lambda_\theta \lambda_r}{\lambda \lambda_\ell} \underbrace{(\rho_{\ell,r} - \rho_{\theta,r})}_{\substack{\textit{relative}\\ \textit{complementarity}}}}^{\textit{Screening and incentive term}}$$

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  - Similar for profit tax: $\tau(\theta)$

$$\tau(\theta) = -\underbrace{\mathbb{E}\left[\frac{\partial \mathcal{Y}}{\partial \bar{q}} \frac{\partial \lambda(\theta)}{\partial r}\right]}_{\textit{Pigouvian correction}} - \underbrace{\mathbb{E}\left[\left(\frac{\partial \mathcal{Y}}{\partial q} - \frac{\partial \pi}{\partial q}\right)\frac{\partial \lambda(\theta)}{\partial r}\right]}_{\textit{Monopoly quality valuation correction}} + \overbrace{\underbrace{\frac{1-F(\theta)}{f(\theta)}}_{\textit{distribution}} \underbrace{\frac{\phi'(\ell(\theta))\lambda_\theta}{\lambda(\theta)}\left[\frac{1}{\varepsilon_{\lambda,\ell}\,\varepsilon_{\ell,\tau}} + \rho_{\theta,\ell}\right]}_{\textit{elasticities}}}^{\textit{Screening and incentive term}}$$

Adding dynamics and Quantitative Investigation

- Contribution of this paper is to extend it to a dynamic setting
  - Markov process for θ^t, need to take all the terms in PDV, with a term I_t that controls how more persistent types confer more private information.
  - Make the taxes/subsidy $\tau(\theta^t)/s(\theta^t)$ increase/decrease over time depending on the sign of screening terms $\rho_{\ell,r} \lesseqgtr \rho_{\theta,r}$
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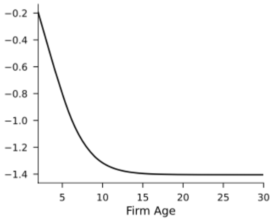
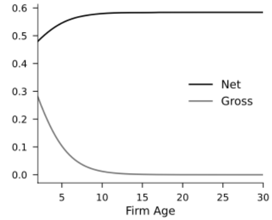
- Matching the model with data:
  - Functional forms: standard (CES/isoelastic/linear)
  - SMM / GMM with moments, e.g. (i) elasticity of patent quality to R&D spending, (ii) R&D intensity / sales, other about the firm distribution, etc.

Quantitative results – optimal R&D policies

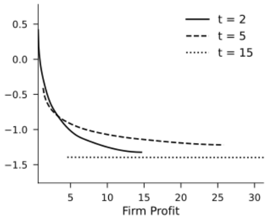
(a) Profit Wedge by Age



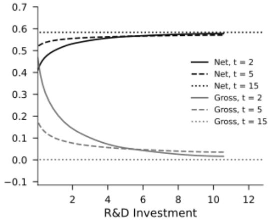
(b) R&D Wedges by Age



(c) Profit Wedge as Function of Profits



(d) R&D Wedges as Functions of R&D Investments



Quantitative results – simpler R&D policies

TABLE V

WELFARE FROM OPTIMAL SIMPLER POLICIES.

Policy Type		Welfare Achieved Relative to Full Optimum	
		Benchmark	No spillovers
A. Current US policy			
$T'(\pi) = 0.23$	$S'(M) = 0.19$	18%	31.1%
B. Optimal Linear			
$T'(\pi) = \tau_0$	$S'(M) = s_0$	89%	88.5%
C. Linear With Interaction Term			
$T'(\pi, M) = \tau_0 + \tau_1 M$	$S'(M) = s_0$	93.5%	93.7%
D. Heathcote–Storesletten–Violante (HSV)			
$T'(\pi) = \tau_0 - \tau_1 \pi^{\tau_2}$	$S'(M) = s_0 - s_1 M^{s_2}$	97.4%	98.2%
E. HSV Tax on Profits and Linear Subsidy			
$T'(\pi) = \tau_0$	$S'(M) = s_0 - s_1 M^{s_2}$	94.7%	95.6%
F. HSV Subsidy on R&D and Linear Profit Tax			
$T'(\pi) = \tau_0$	$S'(M) = s_0 - s_1 M^{s_2}$	97.3%	97.4%
G. HSV With Interaction Term			
$T'(\pi, M) = \tau_0 + \tau_3 M^{s_2} - \tau_1 \pi^{\tau_2}$	$S'(M) = s_0 - s_1 M^{s_2}$	97.4%	98.3 %

Note: The table shows the share of welfare from the full unrestricted optimum that is achieved by the optimal policy within each class. Each panel shows a different class. Column (1) shows the welfare relative to the benchmark optimum; Column (3) for the benchmark optimum but when there is no spillover ($\zeta = 0$).