Innovation Union: Costs and Benefits of Innovation Policy Coordination

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Roadmap

Question

- What are the growth and welfare effects of innovation policy coordination across regions?

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  - Subsidy to cost of hiring scientists for R&D.

Motivation

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  - Brexit.

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- Policy coordination:
  - Ever closer union,
  - Brexit.
- Innovation policy: Horizon Europe (2021–2027)
  - Funding of €95.5b for R&D grants across the union.
  - Single innovation market.
  - Builds-off Horizon 2020 (2014–2020): budget €80b.

What We Do

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- Firms compete in quality for market leadership.

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(i) Document empirical facts on asymmetries in innovation performance and policy across the E.U.

(ii) Develop a general two-country Schumpeterian growth model:

- West (W, old E.U. members) and East (E, new E.U. members).
- Firms compete in quality for market leadership.

(iii) Calibrate to E.U. data and run policy experiments.

- Observed subsidy rates v.s. coordinated.
- Uncoordinated subsidy rates v.s. coordinated.
- Steady state and transition dynamics exercises.

What We Do

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  (a) Baseline: semi-endogenous (Jones 1995 JPE) growth.

  - Policy has only transitional effects on growth.

  (b) Add FDI and knowledge spillovers through multinational activity.

Qualitative Channels

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- Four key externalities

  a. Strategic motive: business-stealing gives over-investment in R&D.

  b. Inter-temporal effect: under-investment.

  c. Diversification: decreasing returns at country-level.

  d. Consumer surplus: price *level* effects from innovation.

Preview of Results

- Baseline: internalising strategic and diversification dominates inter-temporal effect.
  - Gains to coordination are large.
  - Optimal coordinated rates -39% and 59% for W and E respectively.
  - Rates are 12% and 10% in the data.

Preview of Results

- FDI extension: transfer of knowledge reverses the result.
  - Inter-temporal effect dominates.
  - Optimal coordinated rates 33% and -99%.
  - 7.5% welfare gains in consumption equivalents.

Preview of Results

- Model variants highlight the important role of knowledge spillovers in shaping coordination gains and key externalities.

Roadmap

World

- World with two countries: W and E.
- Continuous time.
- Trade in goods.
- Set of consumed good same across countries.
- Representative households; populations grow at rate n. Details

World

- Horizontal differentiation: continuum of varieties (denoted $\omega \in [0, 1]$).
- Vertical differentiation: vintages of each variety.
- Only the top quality vintage consumed in each variety.
  - Production controlled by firm from either W or E.
- Innovation arrival gives $\lambda > 1$ jump in quality.

Innovation

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  - Creative destruction

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- Arrival rate production function

$$\underbrace{I_i^K}_{\text{Arrival rate firm } i} = \overbrace{(A^K)^{1-\alpha}}^{\text{Productivity for } K} \underbrace{\ell_i^K}_{\text{Resarch emp. firm } i} \overbrace{(L^K)^{-\alpha}}^{\text{Research emp. in } K}$$

for country $K \in \{W, E\}$.

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  for country $K \in \{W, E\}$.

- Decreasing returns in research employment L^K: $\alpha \in (0, 1)$

Innovation

- Productivity country $K \in \{W, E\}$

$$\underbrace{A^K}_{\text{Innov. productivity}} = \overbrace{\gamma^K}^{\text{Exogenous prod.}} \underbrace{(\widehat{Q}^K)^{\phi}}_{\text{Knowledge spillovers}} \overbrace{q^{-1}}^{\text{Quality of variety leader}}$$

- $\widehat{Q}^K$ is country-specific average of aggregate quality from each K.

Innovation

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- $\widehat{Q}^K$ is country-specific average of aggregate quality from each K.

- $\phi < 1$: semi-endogenous growth
  - Decreasing returns to knowledge spillovers

Innovation

- Knowledge spillovers affecting R&D productivity:

$$\underbrace{\widehat{Q}^K(t)}_{\text{Knowledge spillovers}} = \underbrace{Q^K(t)^{\beta}}_{\text{Local quality aggregate}} \overbrace{Q(t)^{(1-\beta)}}^{\text{Global quality aggregate}}$$

where

$$Q(t) = \int_0^1 q(\omega, t) d\omega$$

$$Q^K(t) = \int_{\omega \in \omega^K} q(\omega, t) d\omega.$$

- Parameter $\beta \in [0.5, 1]$ captures local bias.

Subsidy Instruments

- Subsidy to wage bill of hiring scientists $s^K \in [0, 1]$.

- Scientist wage bill post-subsidy:

$$(1 - s^K) \underbrace{\ell_i^K w^K}_{\text{Scientist wage bill firm } i}$$

Equilibrium Innovation

- Potential entrants maximise expected profits

$$\max_{I_i^K} \overbrace{I_i^K}^{\text{Arrival rate firm } i} \underbrace{v}_{\text{Present value of incumbency}} - (1 - s^K)\ell_i^K w^K$$

subject to arrival rate production function.

Incumbent value

Equilibrium Definition

- Equilibrium is a set of endogenous aggregate objects such that
  - Households optimise in each country Show,
  - Potential entrants make zero expected profits in each country Show,
  - Labour markets clear in each country Show,
  - Aggregate growth determined by innovation intensity in each K and quality improvement λ Show.

Roadmap

Exercise Design

- Observed scenario
  - Equilibrium with subsidies fixed at rates in the data.

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  - Equilibrium with subsidies fixed at rates in the data.
- Coordinated scenario:
  - Choose 2 subsidy rates to maximise total E.U. welfare.

Moments | Parameters

Exercise Design

a. Steady state exercises.

b. Transition exercises:

- Initial steady state at observed subsidy rates.
- Set alternative counterfactual rate once and for all at $t = 0$.
- Map transition path to counterfactual steady state.
- Account for transition path in welfare computations.

Optimal R&D Subsidy Rates

	Transition		Steady State	
	s^W	s^E	s^W	s^E
Observed	0.12	0.10	0.12	0.10
Coordinated	-0.39	0.59	-0.99	0.55

Gains from Coordination

	Transition			Steady State		
	W	*E*	*EU*	*W*	*E*	*EU*
Coordinated vs observed	-0.07	0.23	0.16	-0.09	0.41	0.32

Gains from Coordination

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	W	*E*	*EU*	*W*	*E*	*EU*
Coordinated vs observed	-0.07	0.23	0.16	-0.09	0.41	0.32
Strategic motive	0.02	0.32	0.34	0.02	0.51	0.53

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Coordinated vs observed	-0.07	0.23	0.16	-0.09	0.41	0.32
Strategic motive	0.02	0.32	0.34	0.02	0.51	0.53
Consumer surplus effect	-0.06	-0.06	-0.12	-0.11	-0.11	-0.22

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Strategic motive	0.02	0.32	0.34	0.02	0.51	0.53
Consumer surplus effect	-0.06	-0.06	-0.12	-0.11	-0.11	-0.22
Intertemporal spillovers	-0.03	-0.03	-0.06	0.00	0.00	0.00

Roadmap

Model Variants and Other Exercises

1. FDI: include multinationals. Show

2. Policy Horizons. Show

Roadmap

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- What are the gains to innovation policy coordination?
- Develop a quantitative framework:
  - Can study steady states and the transition.
  - Extended to include knowledge transfer through multinationals.
- Gains are lower when accounting for the transition.
- Takeaways:
  - Spillovers matter!
  - Gains are large: 7% in FDI variant.

Addition of FDI: Model

- W leaders can offshore production to save on manufacturing costs.

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- Product cycles
  - Ideas start in W ($\omega \in \omega^W$),
  - W firms choose to offshore as multinationals ($\omega \in \omega^M$),
  - Once offshored, E can start innovating on that variety,
  - E leadership ($\omega \in \omega^E$),
  - W leadership.

Addition of FDI: Model

- Innovation productivity terms for sector $K \in \{W, M, E\}$

$$A^W = \gamma^W \, \widehat{Q}^W(t)^\phi \, q^{-1}$$
$$A^M = \gamma^M \, \widehat{Q}^W(t)^\phi \, q^{-1}$$
$$A^E = \gamma^E \, \widehat{Q}^E(t)^\phi \, q^{-1}$$

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where

$$\widehat{Q}^W(t) = Q^W(t)^\beta \, Q(t)^{1-\beta}$$
$$\widehat{Q}^E(t) = Q^{E+M}(t)^\beta \, Q(t)^{1-\beta}$$

and

$$Q^{E+M}(t) = \int_{\omega \in \omega^M \cup \omega^E} q(\omega, t) d\omega.$$

Addition of FDI: Results

	Baseline			With FDI		
	s^W	s^E		s^W	s^E	
Observed	0.12	0.10				
Coordinated	-0.39	0.59				
Welfare gains	W	E	W+E	W	E	W+E
Coordinated vs observed (CEV)	-0.07	0.23	0.16			
Strategic motive	0.02	0.32	0.34			
Consumer surplus	-0.06	-0.06	-0.12			
Intertemporal spillovers	-0.03	-0.03	-0.06			

All inclusive of transition

Back to **extensions**

Addition of FDI: Results

	Baseline			With FDI		
	s^W	s^E		s^W	s^E	
Observed	0.12	0.10		0.12	0.10	
Coordinated	-0.39	0.59		0.33	-0.99	
Welfare gains	W	E	W+E	W	E	W+E
Coordinated vs observed (CEV)	-0.07	0.23	0.16	0.05	0.02	0.07
Strategic motive	0.02	0.32	0.34	-0.01	-0.04	-0.05
Consumer surplus	-0.06	-0.06	-0.12	0.00	0.00	0.00
Intertemporal spillovers	-0.03	-0.03	-0.06	0.06	0.06	0.13

All inclusive of transition

Back to **extensions**

Fully Endogenous Variant: Model

- Remove decreasing returns to knowledge spillovers:

$$A^K = \overbrace{\gamma^K}^{\text{Exogenous prod.}} \underbrace{(\widehat{Q}^K)^{\phi}}_{\text{Knowledge spillovers}} \overbrace{q^{-1}}^{\text{Quality of variety leader}}$$

  with $\phi = 1$.

- Also some adjustment to arrival rate production function.

Fully Endogenous Variant: Results

	Baseline			Fully endogenous		
	s^W	s^E		s^W	s^E	
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Coordinated	-0.39	0.59				
Welfare gains	W	E	W+E	W	E	W+E
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Strategic motive	0.02	0.32	0.34			
Consumer surplus	-0.06	-0.06	-0.12			
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Observed	0.12	0.10		0.12	0.10	
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Welfare gains	W	E	W+E	W	E	W+E
Coordinated vs observed (CEV)	-0.07	0.23	0.16	0.07	0.07	0.14
Strategic motive	0.02	0.32	0.34	-0.15	-0.15	-0.30
Consumer surplus	-0.06	-0.06	-0.12	0.00	0.00	0.00
Intertemporal spillovers	-0.03	-0.03	-0.06	0.22	0.22	0.44

All inclusive of transition

Back to **extensions**

Zero Profit Condition

$$\underbrace{\overbrace{v^K(\omega,t)}^{\text{Gain in success}}\ \overbrace{A^K(\omega,t)I^K(\omega,t)^{\frac{\alpha}{\alpha-1}}}^{\text{Rate of success}}}_{\text{Expected gain to innovation}} = \underbrace{(1-s^K)w^K(t)}_{\text{Cost of innovation}}$$

Back to **equilibrium definition**

Labour Market Clearing Conditions

$$\underbrace{\ell^W}_{\text{Labour supply in W}} = \overbrace{\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma} a^{W(1-\sigma)} q^W \left(\frac{c^W \ell^W}{\bar{P}^{W(1-\sigma)}} + \frac{c^E(1-\ell^W)}{\bar{P}^{E(1-\sigma)}}\tau^{W(1-\sigma)}\right)}^{\text{Manufacturing labour demand in W}} + \underbrace{\frac{I^{W\frac{1}{1-\alpha}}}{\gamma^W} \frac{Q(t)}{\widehat{Q}^W(t)^\phi L(t)}}_{\text{Innovation labour demand in W}}$$

Back to **equilibrium definition**

Additional Terms in Household Budget Constraint

- Government budget constraint

$$T^K(t) = \underbrace{s^K w^K(t) \int_0^1 L_R^K(\omega, t)}_{\text{Total expenditure on R\&D by firms from } K}$$

- Asset holdings:

$$A^K(t) = \int_{\omega^K} \frac{v^K(\omega, t)}{L^K(t)} d\omega$$

Back to **household**

Innovation

- Present value of incumbency

$$v^K(\omega,t) = \frac{\overbrace{\pi^K(\omega,t)}^{\text{Period profits}}}{r(t) + \underbrace{I^W(\omega,t) + I^E(\omega,t)}_{\text{Schumpeterian creative destruction}} - \frac{\dot{v}^K(\omega,t)}{v^K(\omega,t)}}$$

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where

$$I^K(\omega,t) = \underbrace{\sum_i}_{\text{Over firms } i \text{ in sector}} I_i^K(\omega,t) \overbrace{= I^K(t)}^{\text{By symmetry}}$$

Profits

$$\pi^K(\omega,t) = \overbrace{\frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}(a^K w^K(t))^{1-\sigma}}^{\text{Preference, production parameters \& labour cost}} \underbrace{q(\omega,t)}_{\text{Incumbent's quality}}$$

$$\left(\underbrace{\frac{c^K(t)L^K(t)}{P^K(t)^{1-\sigma}}}_{\text{Demand from market } K} + \underbrace{\frac{c^{K*}(t)L^{K*}(t)}{P^{K*}(t)^{1-\sigma}}\tau^{1-\sigma}}_{\text{Demand from market } K*} \right)$$

Back to **equilibrium innovation**

Household

- Lifetime utility

$$U = \int_0^{\infty} \underbrace{L_0}_{\text{Starting population}} \overbrace{e^{-(\rho-n)t}}^{\rho \text{ discount rate; } n \text{ population growth}} \underbrace{\log[u(t)]}_{\text{Instantaneous utility}} \; dt$$

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with

$$u(t) = \left(\int_0^1 \left[\overbrace{\sum_{j=0}^{j^{max}(\omega,t)}}^{\text{Top quality vintage}} \underbrace{\lambda^{j(\omega,t)}}_{\lambda > 1 \text{ quality jump}} \overbrace{d(j,\omega,t)}^{\text{Per capita consumption}} \right]^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}$$

where $\sigma > 0$ elasticity of substitution.

Household

- Supply unit labour endowment inelastically.

- Budget constraint

$$\dot{A}(t) = \underbrace{w(t)}_{\text{Labour income}} + \overbrace{r(t)A(t)}^{A(t)\text{ assets per capita, }r(t)\text{ return}} - \underbrace{c(t)}_{\text{Nominal expenditure per capita}} - \overbrace{nA(t)}^{\text{Pop. growth } n} - \underbrace{T(t)}_{\text{Taxes}}$$

Setup

Households

- Choose vintage with lowest price per unit of quality: $j^{max}(\omega, t)$.

- Love of variety demand curves

$$d(\omega, t) = \underbrace{q(\omega, t)}_{\text{Quality of } j^{max}(\omega,t)} \overbrace{p(\omega, t)^{-\sigma}}^{\text{Price of } j^{max}(\omega,t)} \underbrace{\frac{c(t)}{P(t)^{1-\sigma}}}_{\text{CPI}}$$

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- Consumption Euler equation

$$\frac{\dot{c}(t)}{c(t)} = r(t) - \rho$$

Equilibrium definition

Growth rate

- Aggregate growth

$$\frac{\dot{Q}(t)}{Q(t)} = (\lambda^{\sigma-1} - 1)(I^W(t) + I^E(t))$$

- Semi-endogenous structure implies steady state growth:

$$\frac{\dot{Q}(t)}{Q(t)} = \frac{n}{1-\phi}$$

Equilibrium definition

Moments

Moments	Data (Model)	Source
East relative wage (w^E)	0.60 (0.61)	Eurostat, 2005-2016
MFP growth rate	0.66% (0.66%)	OECD 2005-2016
Share of sectors, West leadership (ω^W)	91% (91%)	OECD*, 2005-2016
West R&D expenditure/GDP	3.87% (3.04%)	Eurostat, 2015
East R&D expenditure/GDP	2.12% (1.85%)	Eurostat, 2015
West share of labour in R&D	3.13% (3.71%)	Eurostat, 2015
East share of labour in R&D	2.22% (4.33%)	Eurostat, 2015
West innovation elasticity to subsidy	[0.7, 3.5] (1.23)	Akcigit et al. (2018)
East innovation elasticity to subsidy	[0.7, 3.5] (1.60)	Akcigit et al. (2018)

* Analytical Activity of Multinational Enterprises database. Gives output of countries by ownership of firms.

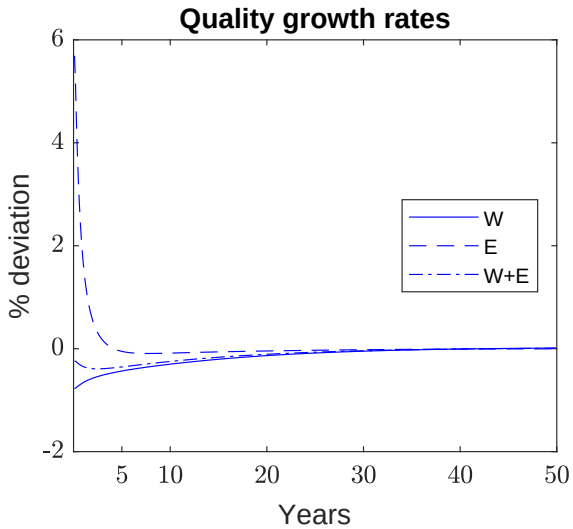
Back to Quantitative

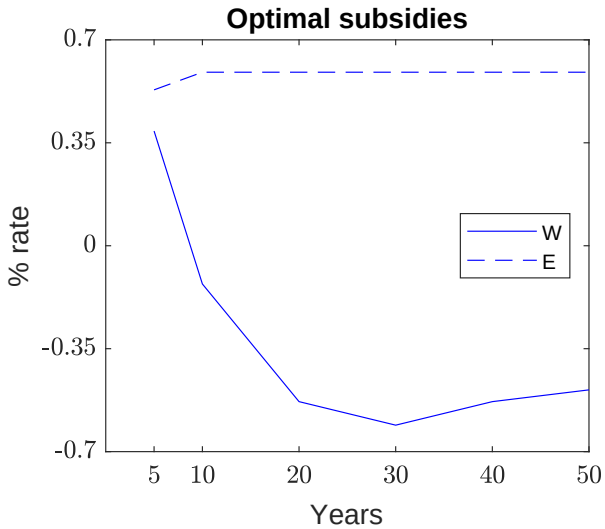
Some Parameters

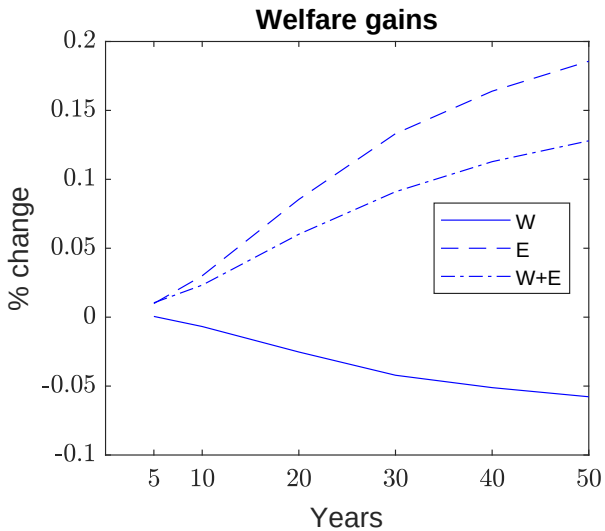
Calibrated parameters	Value
Innovative R&D productivity parameter, West (γ^W)	0.20
Innovative R&D productivity parameter, East (γ^E)	0.10
Spillover parameter (β)	0.60
Quality jump size (λ)	1.80
Decreasing returns (α)	0.20
Spillovers curvature (ϕ)	0.70

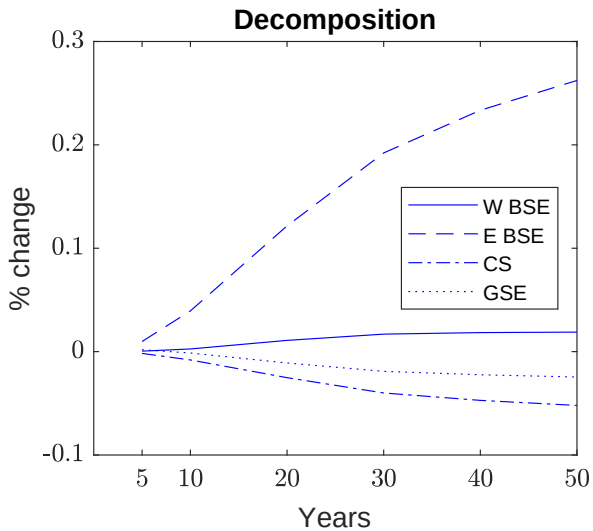
Back to Quantitative

Gains from Coordination: Dynamics









Back to **extensions**