

# CLOSING THE INNOVATION GAP: DESIGNING OPTIMAL POLICY IN EUROPE

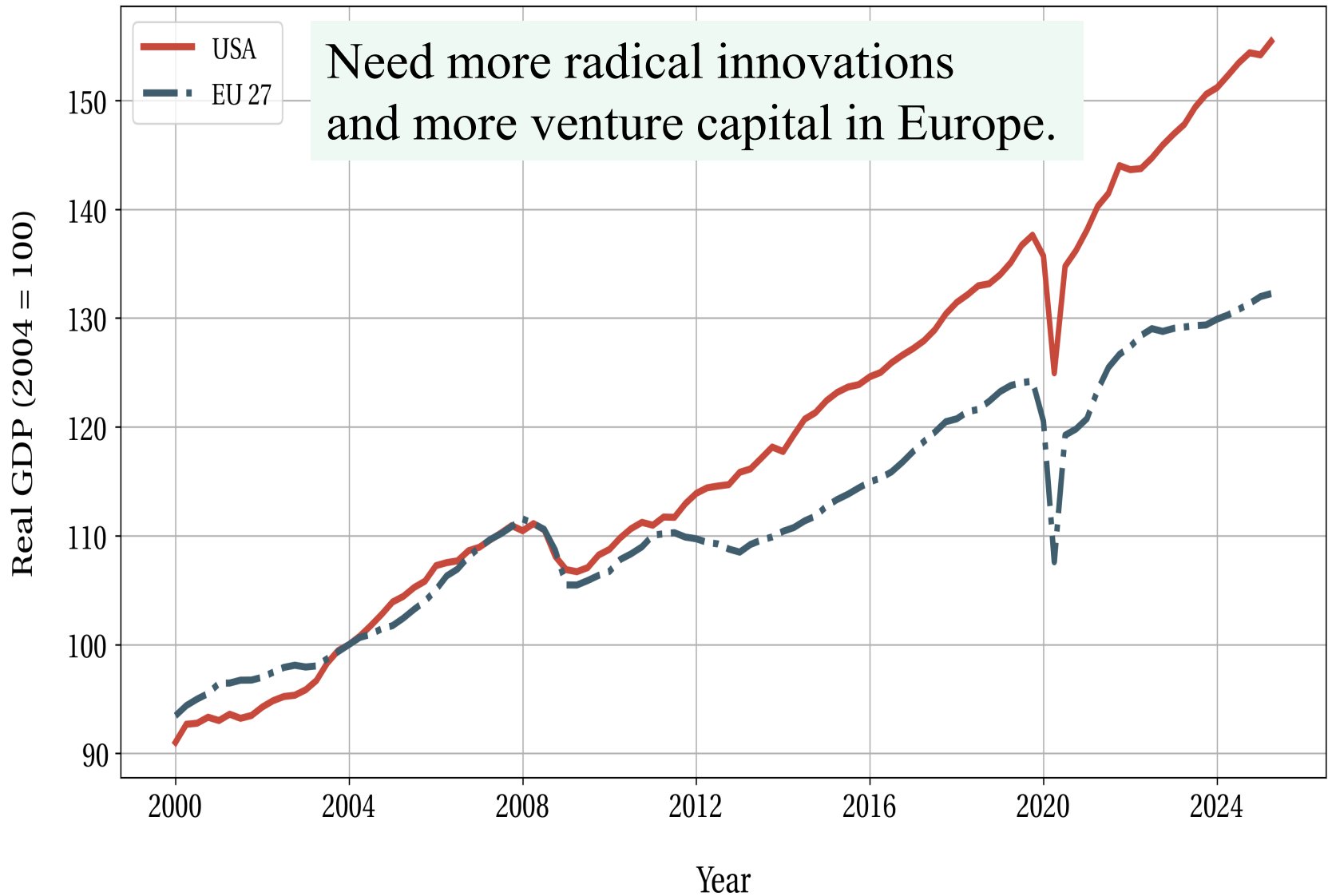
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- **Innovation Gap:** Draghi report (2025)
  - Europe good at incremental innovation
  - lags behind in high-tech industries, frontier innovation
  - less basic research, less early stage financing, insufficient scale up
  - in consequence: diverging productivity trend Europe - US, **Figure 1**
- **Policy priorities:**
  - should R&D subsidies differentiate across high-/low-tech start-ups?
  - what is the right policy to expand venture capital financing?
  - how can policy emphasize more disruptive innovation?

# Figure 1: Divergent Growth Europe US

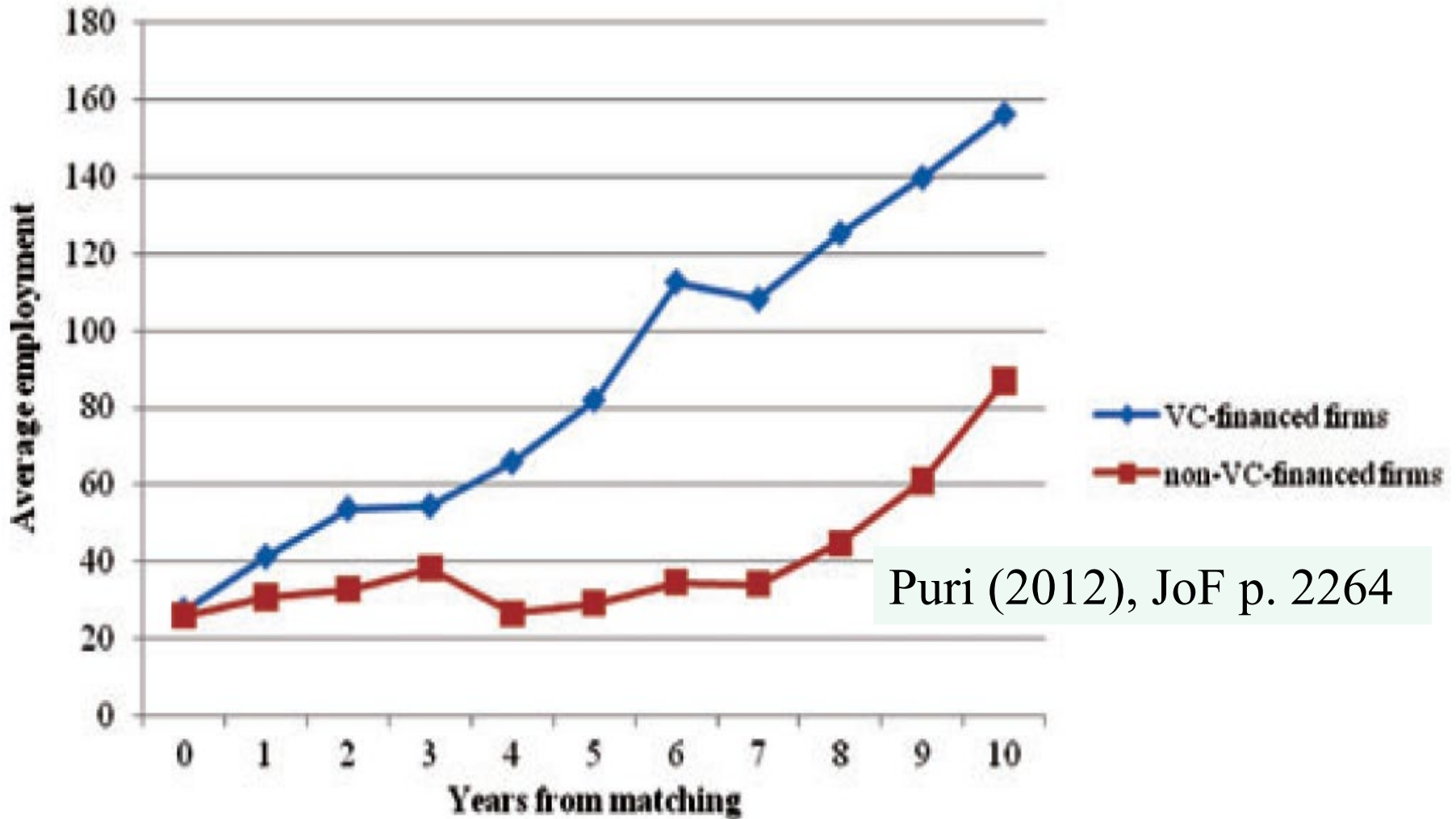


# I. Introduction: Research Questions

- **Growth theory:** rests on
  - investment to build plants with unique products
  - innovation of mature firms by knowledge accumulation
  - innovative start-ups generate new technology
- **Research questions:**
  - how can policy shift innovation into a more radical direction?
  - what is contribution of venture capital to innovation?
  - how is heterogeneous start-up R&D linked to mature firms?
- **Research gaps:**
  - venture capital (VC) literature mostly partial equilibrium
  - little integration of VC and start-up heterogeneity in growth models
  - narrow policy focus on R&D subsidies, maybe too narrow?
- **Literature:** see paper, we integrate VC into macro growth model

# Figure 2: Scaling Up With Venture Capital

(a) Average employment in matched sample



Puri (2012), JoF p. 2264

# I. Introduction: Novel Contributions

- **Start-up R&D:**

- early stage, experimental R&D yields high-/low-tech start-ups
- **high-tech:** more innovative, **venture capital** & bank financing
- **low-tech:** less profitable, **exclusive bank financing**

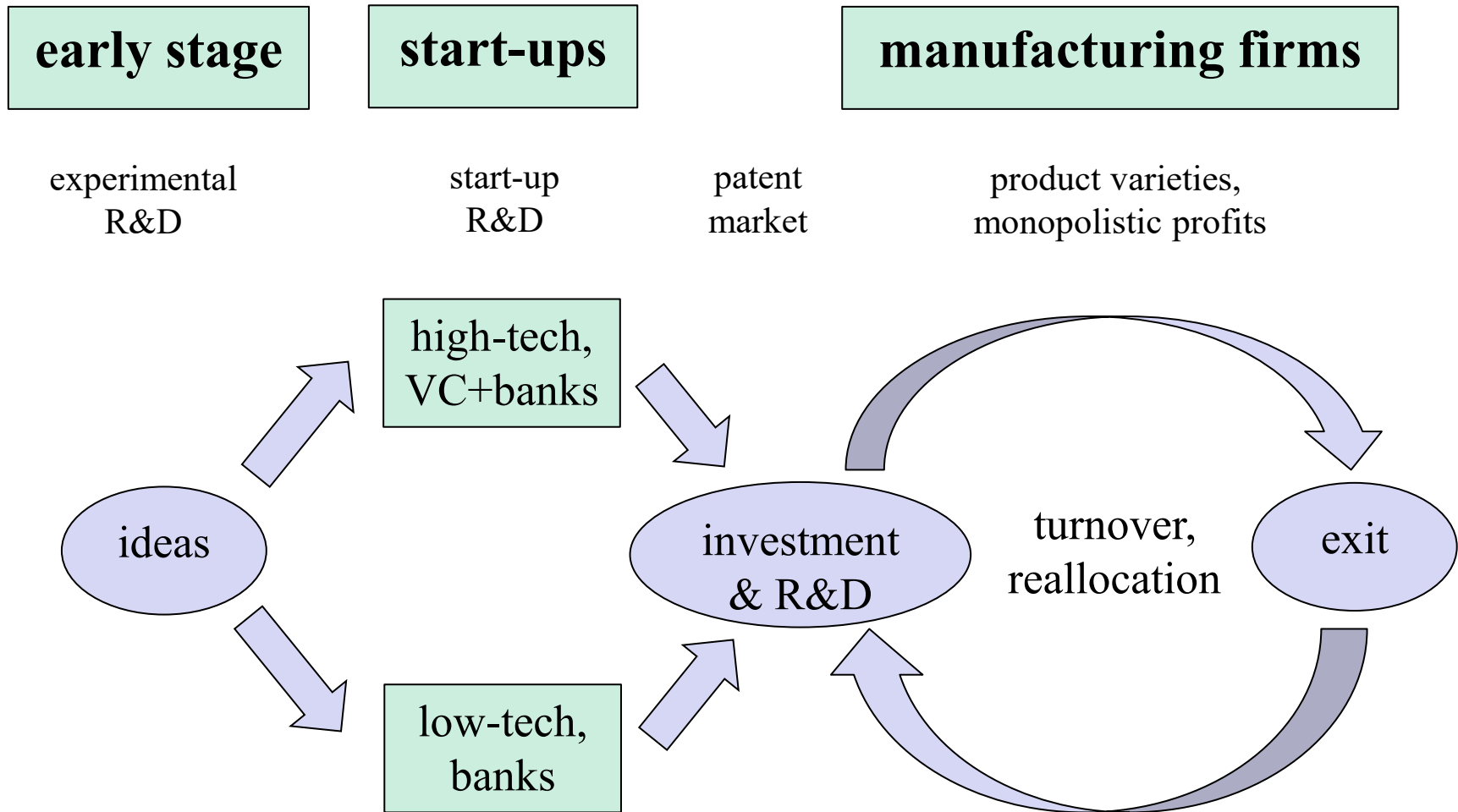
- **Role of venture capital (VC):**

- VC adds value, but more expensive, only for the best
- VC scales up start-up R&D on **intensive + extensive margins**

- **Innovation policy:** based on explicit **welfare analysis**

- investment/**R&D subsidy + rent tax** for mature firms  
=> compensate for *spillovers* and extract *rents* from market power
- **differential R&D subsidies** to start-ups: *learning from the best*
- **basic research** favors *radical innovations* of high-tech start-ups
- **VC is efficient:** magnifies *radical innovation*

# Figure 3: A Snapshot of the Model



## II. Model: Start-up Innovation

- **Start-up innovation:** high- / low-tech  $j \in \{h, l\}$ 
  - R&D yields 'patents'  $n_t^j$  **sold to mature firms**
  - $z_t^h > z^l$ : high-tech more profitable, more R&D, larger
  - $z_t^h = z(B_t)$ ,  $z^l > 0$ : only high-techs benefit from **basic research**
  - R&D productivity gains  $a_t$  from knowledge **spillovers**

$$n_t^j = p^j z_t^j a_t f(R_t^j)$$

- **Innovation finance:** start-ups with little own money
  - *discrete financing choice:* **only high-techs opt for VC**
  - **VC contract:** VC return  $r_t^v$  & VC financing  $x_t$ , banks fund  $R_t^h - x_t$
  - **VC advice**  $p^h > p^l$ : *scale up R&D, add value, more high-tech firms*

## II. Model: Start-up Innovation

- **Expected profits:** low-tech  $\Pi_{t+1}^l$ , high-tech  $\Pi_{t+1}^h$ , VCs  $\Pi_{t+1}^v$ 
  - patent price  $v_t$ , differentiated R&D subsidy  $s_t^l$

$$\Pi_{t+1}^l = p^l (1 + s_t^l) v_t \cdot z^l a_t f(R_t^l) - (1 + i_t) R_t^l$$

$$\Pi_{t+1}^h = p^h \left[ (1 + s_t^h) v_t \cdot z^h a_t f(R_t^h) - r_t^v x_t \right] - (1 + i_t) (R_t^h - x_t)$$

$$\Pi_{t+1}^v = \left[ p^h r_t^v - (1 + r_t) \right] x_t - \xi \geq 0$$

- **Intensive R&D:** VC advice scales up high-tech R&D  $R_t^h$
- **Extensive R&D:** by early stage experimentation (prob.  $E_t$ )
  - max. exp. profit  $\chi_{t+1}^E = \max_{E_t} E_t \cdot \Pi_{t+1}^h + (1 - E_t) \cdot \Pi_{t+1}^l - \kappa(E_t)$
- **Role of VC:** encourages *more radical start-up innovation*
  - **more** and **larger** high-tech start-ups (*extensive & intensive*)
- **Learning from the best:** high-techs yield larger spillovers

## II. Model: Mature Firms

- **Production:** final output  $Y_t$  with inputs from  $i \in N_t$  plants
  - *knowledge spillovers*  $A(N_{t-1})$ : investment is equipment + R&D
  - *market power*: monopolistic profits = return on capital + rent

$$Y_t = CES [A(N_{t-1}) \cdot y_{i,t}], \quad N_t = n_{t-1} + \phi N_{t-1}$$

- **Final goods firms:** operate  $N_t$  plants with monopolistic profits  $\pi_t$ 
  - max. PV of payouts  $\chi_t = (1 - \tau_t) \pi_t N_t + s_t^N N_{t-1} - v_{t-1} g n_{t-1} - k n_t$
  - build  $n_t$  plants: invest equipment  $k$  and  $g$  patents with price  $v_t$
- **Distortions:** knowledge spillovers and market power
  - extract rents with tax  $\tau_t$ , reward spillovers with subsidy  $s_t^N$

## II. Model: Intertemporal Equilibrium

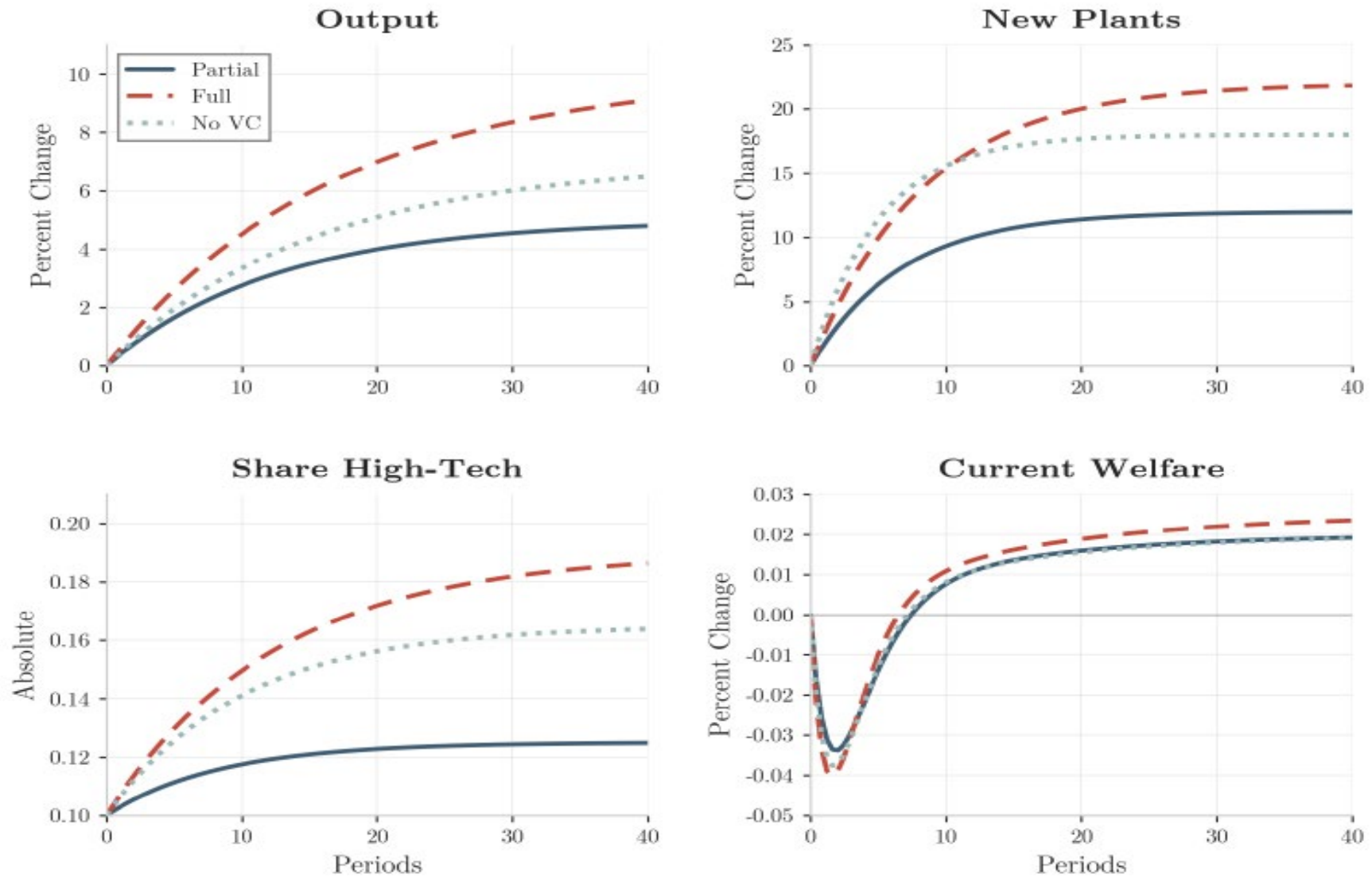
- **Welfare:**  $U_t = u_t + \beta U_{t+1}$ , from consumption and
  - effort costs of entrepreneurs, VCs, investors
- **Efficiency:** market equilibrium is distorted
  - compute Pareto optimal allocation and show how policy helps markets to generate better results (achieve a Pareto optimum)
- **Optimal policy:** venture capital is efficient, but need
  - 1 basic research as an R&D input to high-tech start-ups:  $B_t$
  - 2 differentiated start-up R&D subsidies:  $s_t^h > s_t^l$
  - 3 investment/R&D subsidy to established firms:  $s_t^N$
  - 4 rent tax to offset market power:  $\tau_t$

### III. Results: Implementing Optimal Policy, SS Effects

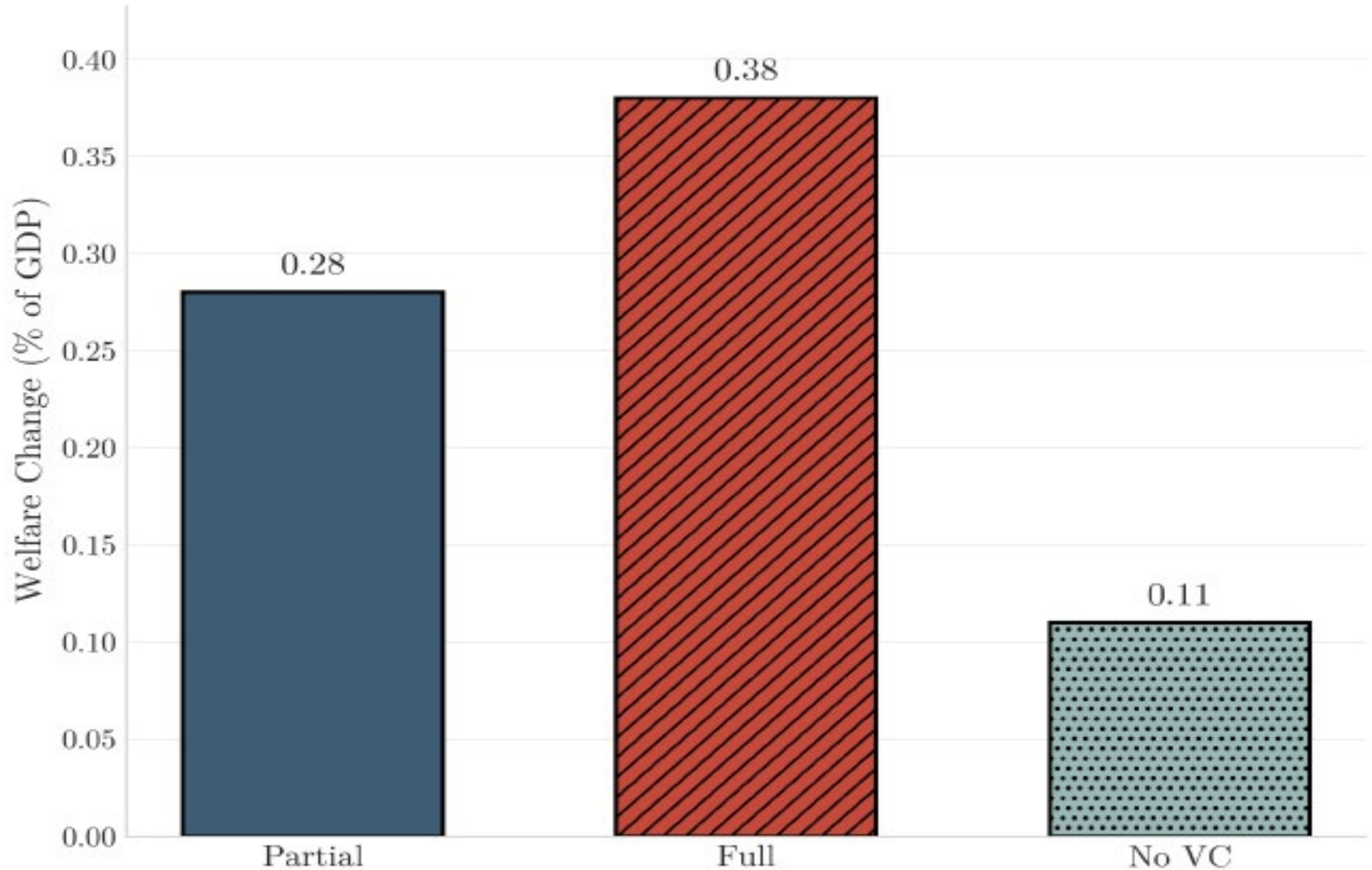
- **Optimal policy:** introduce from scratch, start w/o basic research
  - **Partial:** target mature firms with R&D/inv.subsidy  $s^N$  + rent tax  $\tau$
  - **Full:** add differentiated R&D subsidies to start-ups
  - **NoVC:** shut off the venture capital sector

		Partial	Full	NoVC
$T/Y$	Tax cost in % of GDP	3.5	4.62	4.7
$v$	Patent price	<b>1.67</b>	<b>-16.52</b>	-8.64
$n^h$	High-tech R&D output	8.55	<b>16.1</b>	-2.62
$n^l$	Low-tech R&D output	8.55	<b>0.66</b>	12.29
$E$	Share of high-tech start-ups	<b>0.13</b>	<b>0.19</b>	0.17
$Y$	GDP (final output)	5.25	<b>8.7</b>	<b>7.17</b>

# Figure 5: Dynamic Effects of Optimal Policy



# Figure 6: Welfare Gains of Optimal Policy



### III. Results: Closing the Innovation Gap

- **Basic research:** is a public good (input) for private R&D
  - mostly benefits firms close to the technology frontier
  - *intensive R&D*: scales up high-tech start-ups
  - *extensive R&D*: raises share  $E_t$  of high-tech start-ups
  - thereby boosts demand for venture capital

		Full	with BR
$T/Y$	Tax cost, % of GDP	4.619	4.874
$v$	Patent price	-16.521	-35.732
$n^h$	High-tech R&D output	<b>16.096</b>	<b>48.337</b>
$n^l$	Low-tech R&D output	0.662	-27.928
$E$	Share of high-tech start-ups	<b>0.187</b>	<b>0.237</b>
$X^v/Y$	Venture capital, % of GDP	<b>0.746</b>	<b>0.91</b>
$Y$	Output	8.695	<b>12.647</b>
$\tilde{u}$	Welfare change, % of GDP	0.377	0.855

# VI. Summing up

- **New Technology:**
  - **Start-ups:** innovation on intensive and extensive margins
    - expand high- and low-tech firms + larger share of high-tech
    - basic research and VC: scaling up the best, **more radical innovation**
  - **Mature firms:** introduce new product lines, exploit market power
    - investment & own R&D + patents from start-ups
- **Optimal innovation policy:** VC (for high-techs only) is efficient
  - ① basic research as an R&D input to high-tech start-ups:  $B_t$
  - ② differentiated start-up R&D subsidies:  $s_t^h > s_t^l$  (learning from the best)
  - ③ investment/R&D subsidy to established firms:  $s_t^N$
  - ④ rent tax to offset market power:  $\tau_t$
- **Closing innovation gap:** optimal policy from scratch
  - GDP gains of up to 12.6%, GDP share of VC from .43 to .91
  - more disruptive innovation: share of high-techs more than double, but share high-tech R&D output 5 x larger!

### III. Quantitative Results: Calibration (Preliminary)

- **Calibration:** replicate (stationary) data, for example,

$E$	share of high-tech start-ups	0.1
$n^h E / n^s$	share of high-tech in total R&D output	0.25
$x / R^h$	share of VC funding per high-tech start-up	0.4
$X^v / Y$	share of VC funding in GDP	0.43
$r, r^v$	return on equity & venture returns	0.08 & 0.35
$p^h, p^l$	success probabilities high- & low-tech	0.9 & 0.8
$\varepsilon$	ratio of low- and high-tech spillovers	0.5

- **Key behavioral elasticities:** determine magnitude of results

Elasticity of start-up R&D	$\epsilon^n = \frac{d \log(n^j)}{d \log(v)}$	1.5
Semi-elasticity of early-stage R&D	$\epsilon^E = \frac{dE}{d \log(\lambda^E)}$	0.2
Elasticity of basic research	$\epsilon^B = \frac{d \log(n^h E)}{d \log(B)}$	0.35