A Traffic Jam Theory of Growth

Daria Finocchiaro[1] and Philippe Weil[2]

August 2022
EEA-ESEM, Milano

[1]Sveriges Riksbank, ECB, UU, CeMoF
[2]Université Libre de Bruxelles -SBSEM and ECARES, and CEPR

Growth, Innovation and Finance

- A long tradition in economics views innovation as the main driving force of long-term growth.
- Financial development has a nontrivial role: ▸ Arcand et al., (2015)
  - A two-way nexus.
  - A nonlinear relationship.
- Is there something hindering/reversing the contribution of finance to growth? ▸ Bloom et al., (2020)

Would a bridge across the straight of Messina improve traffic flow?

Lewis–Mogridge position

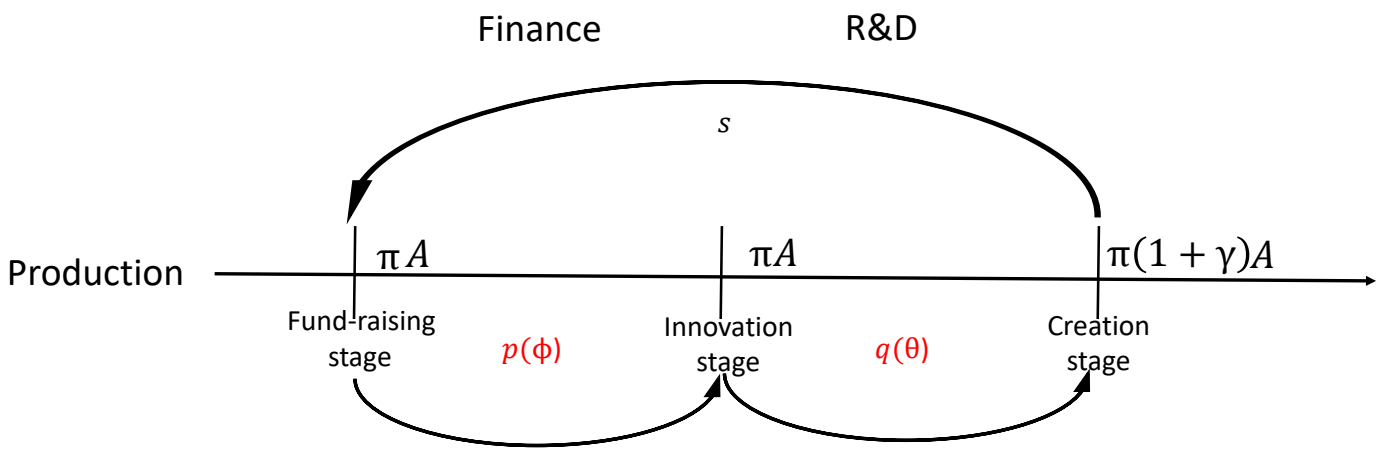
In this paper

- Investigate the finance-growth nexus, in an endogenous growth model with **search frictions** in both **innovation** *and* **credit markets**.
  - Negative (PE) relation between growth and tension in both innovation and credit markets.
  - Financial deepening has a **non-monotonic** effect on long-run growth since it might exacerbate congestion in the innovation market.
- Compare the competitive equilibrium of our model with the constrained efficient allocation (Modified Hosios condition).
  - Entry in financial and innovation markets is efficient if innovators and financiers are compensated for their contribution to growth.
  - The social planner takes into account the interaction between the two frictions.

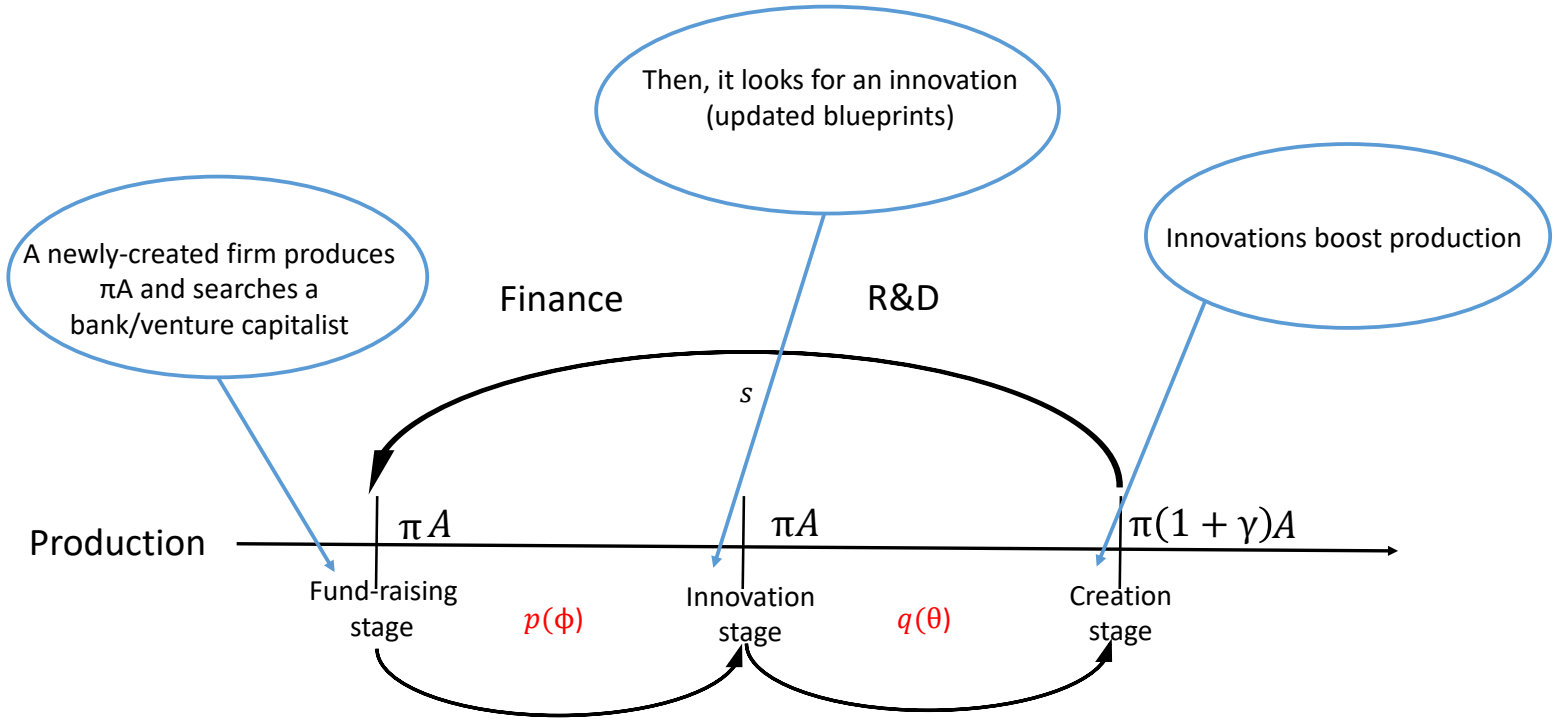
Literature review

1. **Growth and innovation**
   Romer (1990), Grossman and Helpman (1991), Aghion and Howitt (1992, 2006), Jones (1995, 2005, 2008), Jones (2005)....
2. **Growth and finance**
   - King and Levine (1993), Levine (1997), Rajan and Zingales (1998), Aghion, Howitt and Mayer-Foulkes (2004), Laeven, Levine and Michalopoulos (2014), Arcand, Berkes and Panizza (2015), Chiu, Meh and Wright (2017), Aghion et. al.(2018), Aghion, Howitt and Levin (2018b), Popov (2019).
3. **(Multi-layered) Search frictions**
   - Wasmer and Weil (2004), Silveira and Wright (2010), Petrosky-Nadeau and Wasmer (2015), Petrosky-Nadeau, Wasmer and Weil (2019), Berentsen et al. (2012).
4. **Customer market view of financial/innovation markets**
   - Petersen and Rajan (1994), Berger and Udell, (1995), Fenn et al. (1995), Cipollone and Giordani (2016, 2019).
5. **Efficiency in S&M models**
   - Petrosky-Nadeau and Wasmer (2017), Petrosky-Nadeau, Wasmer and Weil (2019), Mangin and Julien (2021).

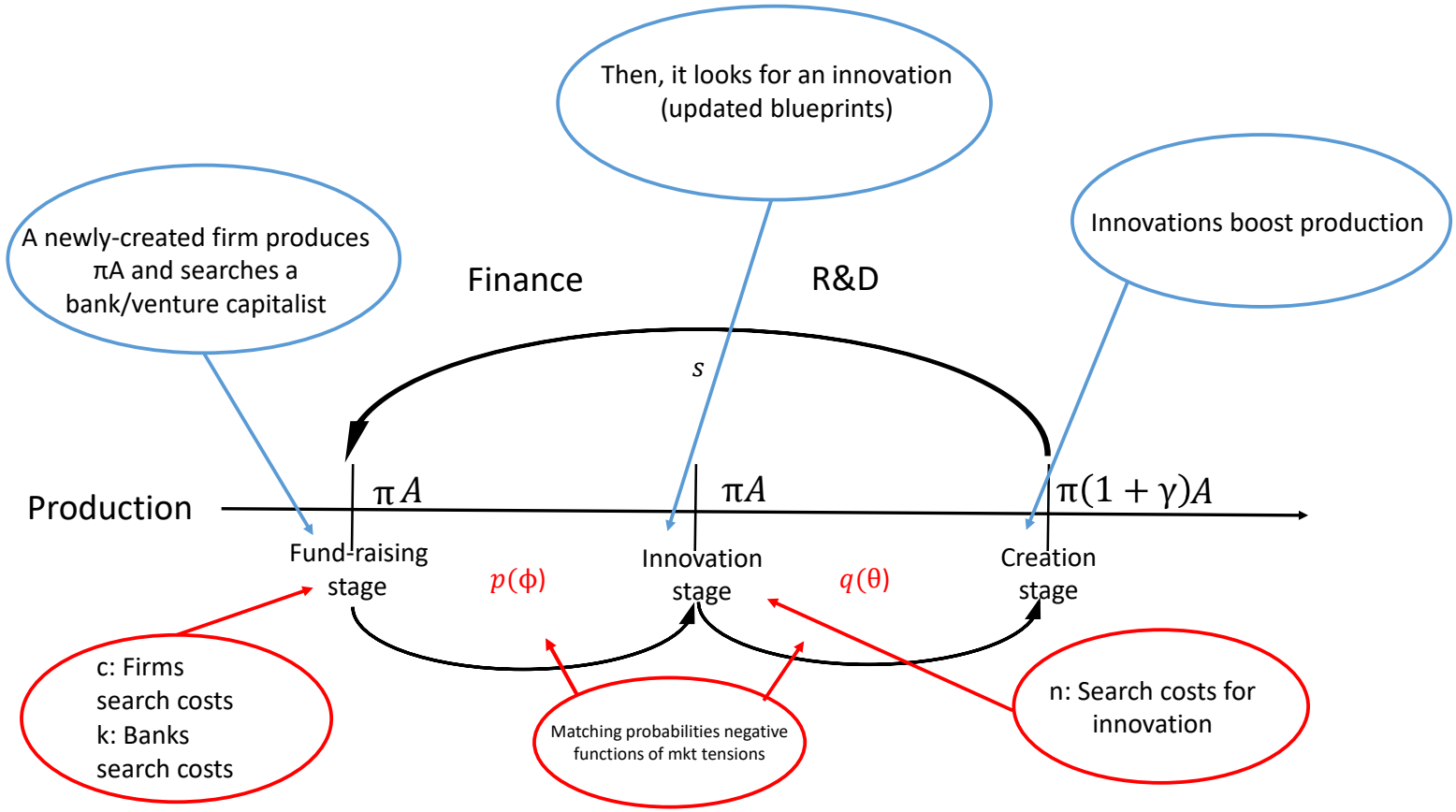
A snapshot of the model



A snapshot of the model



A snapshot of the model



Equilibrium

- **Growth rate**.

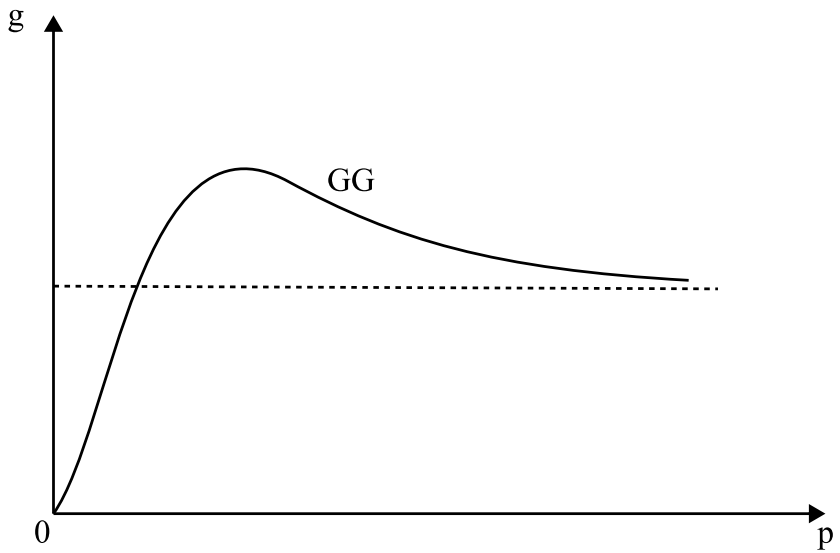
$$GG: g = \underbrace{\frac{1/s}{\left(\frac{1}{Q(p,g)} + \frac{1}{p} + \frac{1}{s}\right)}}_{\text{Fraction of lifetime spent at high productivity-Shares of firms}} \underbrace{\gamma}_{\text{Productivity jump}}$$

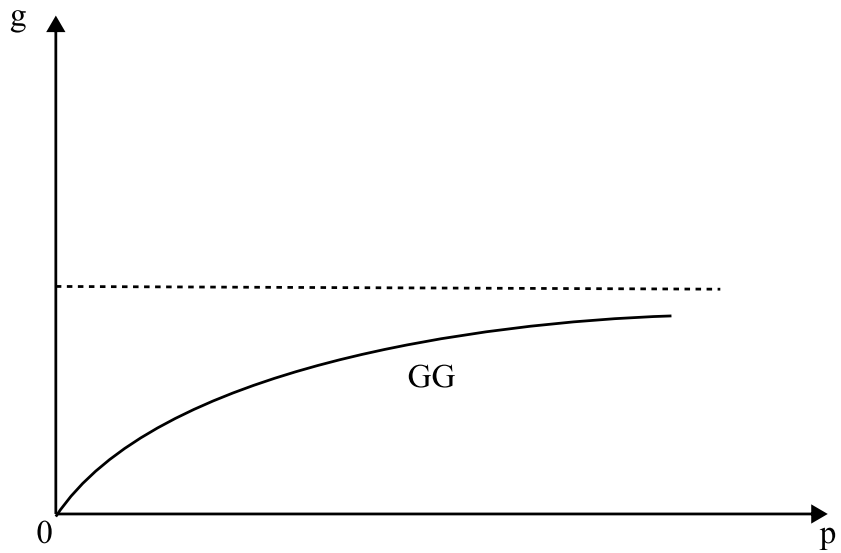
  - A firm spends $1/p$ units of time looking for a bank, $1/q$ units of time looking for an innovator and $1/s$ units of time producing at the upgraded profit level until it's destroyed.
  - What matters for growth is total search time, $T = 1/q + 1/p$.

- **Innovation and credit market tensions**. From firms' and banks free-entry conditions we can derive $Q(\cdot)$ and p.

  - *All else equal*, more finance ($p \uparrow$) closes the gap between g and γ.
  - If a firm finds a bank faster ($p \uparrow$) $Q \downarrow$, else profits would not be zero $\Rightarrow$Two contrasting effects of finance on T and hence growth.
  - Financial contract determined by Nash bargaining: equilibrium credit tension depends on the attractiveness of entry into the market.

GG curve





- When $p = 0$, it is impossible to meet a bank, and there is no growth.
- When the match with a bank occurs instantly ($p = \infty$), the difficulty of finding an innovator is the only brake to growth.
- Suppose the costs of looking for credit and innovators are equal, i.e. $c = \omega n$, then the **GG curve is hump-shaped**. The growth rate is maximal (the total expected search time is minimal) when expected credit and innovation search times are equal $1/p = 1/q$.

Finance and growth: a traffic jam explanation

- If the GG curve has a hump, the growth rate ($\sim T$), must be insensitive to a first order to a change in p.
  - For that to be the case, an infinitesimal increase (decrease) in the expected credit search time $1/p$ must be met by an exactly offsetting decrease (increase) in the expected innovation search time that leaves, therefore, T constant.
  - In the symmetric case $c = \omega n$, this occurs when $1/p = 1/q$, i.e., when credit and innovation expected search times are equal. Search costs matter as they affect firms profitability
- Driving from mainland Italy to Catania on Sicily involves confronting **congestions twice**
  - Will the **construction of a bridge** across the straight **reduce total travel time** to Catania? It all depends on relative congestion and bridge/road tolls!

Finance and growth: comparative statics

- **More finance (lower credit mkt tension)**
  - Lower search costs for banks have an **ambiguous** effect on growth, **positive direct** effect on p and **negative indirect** effect through q.
  - Lower search costs for firms have a **positive** impact on the innovation mkt and on growth.
- **Larger innovation**
  - **Positive direct** effect on g, **negative indirect** effects through innovation mkt tension.
- **US calibration.**
  - Improvements in credit mkt only moderate **negative** effects on growth. ▶ Table

Efficiency in credit and innovation market

A social planner maximize the present discounted value of output net of search cost. The matching frictions are a technological constraint.

- Two sources of externalities:
  1. **Matching externalities:** thick market and congestion externality.
  2. **Growth externality**: individual investment in R&D and more liquidity interact with each others and can boost aggregate productivity.
- **Generalized Hosios**: The decentralized solutions for credit and innovation tightness maximize net social welfare if:

$$\underbrace{1-\omega}_{\text{Banks surplus share}} = \underbrace{\eta}_{\text{Matching elasticity}} + \underbrace{f\left(g_{\mathcal{B}_0}\right)}_{\text{Banks contribution to growth}}$$

$$\underbrace{\alpha}_{\text{Innovators surplus share}} = \underbrace{\varepsilon}_{\text{Matching elasticity}} + \underbrace{f\left(g_{\mathcal{I}_1}\right)}_{\text{Innovators contribution to growth}}$$

Financiers and innovators are compensated for their contribution to growth.

Conclusions

- We study the finance-growth nexus in a parsimonious endogenous growth model with search frictions in credit *and* innovation markets.
- A two-way growth finance nexus:
  - Growth through innovation facilitated by the financial sector.
  - Financial deepening beyond a certain threshold is harmful for growth ($\sim$ bottlenecks...).
  - For a calibration close to US, modest negative effect of finance on growth.
- Entry in financial and innovation markets is efficient if innovators and financiers are compensated for their contribution to growth.
- Bottom line: to stimulate growth we should take into account that money is not the only hinder to innovation!

Further model extensions/robustness

- General, asymmetric case $(c \neq \omega n)$.
- Licensing costs in financial sector: growth prospects increase the size of the financial sector.
- Only one friction impeding innovation: finance always good for growth (as in PE).
- Multicountry version and convergence (work in progress).

Can there be too much of a good thing?

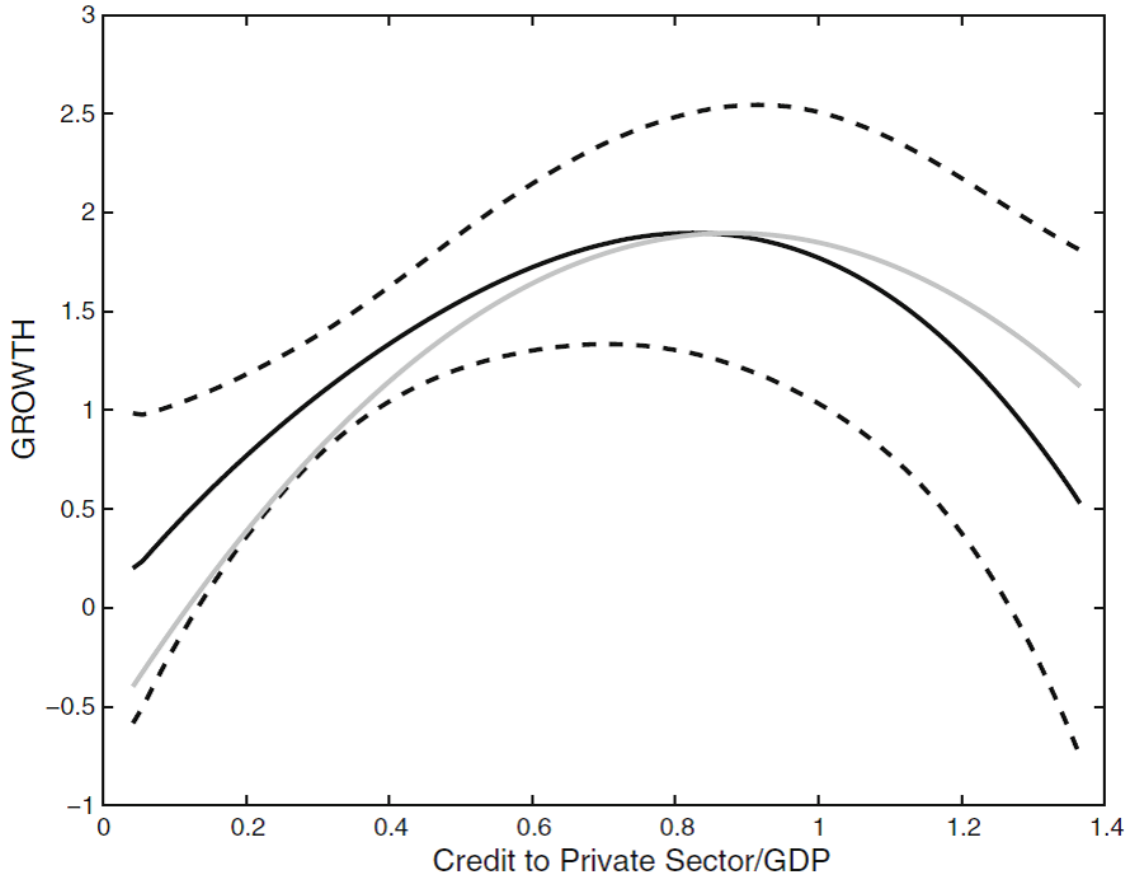


Fig. 2 Semi-parametric regressions. The *solid black line* plots the relationship between credit to the private sector obtained by allowing credit to the private to take a generic functional form. The *dotted lines* are 90 % confidence intervals and the *light solid line* plots the quadratic fit of columns 6, Table 1

▸ Which countries? ▸ Back

Source: Arcand, Berkes and Panizza (2015)

Can there be too much finance?

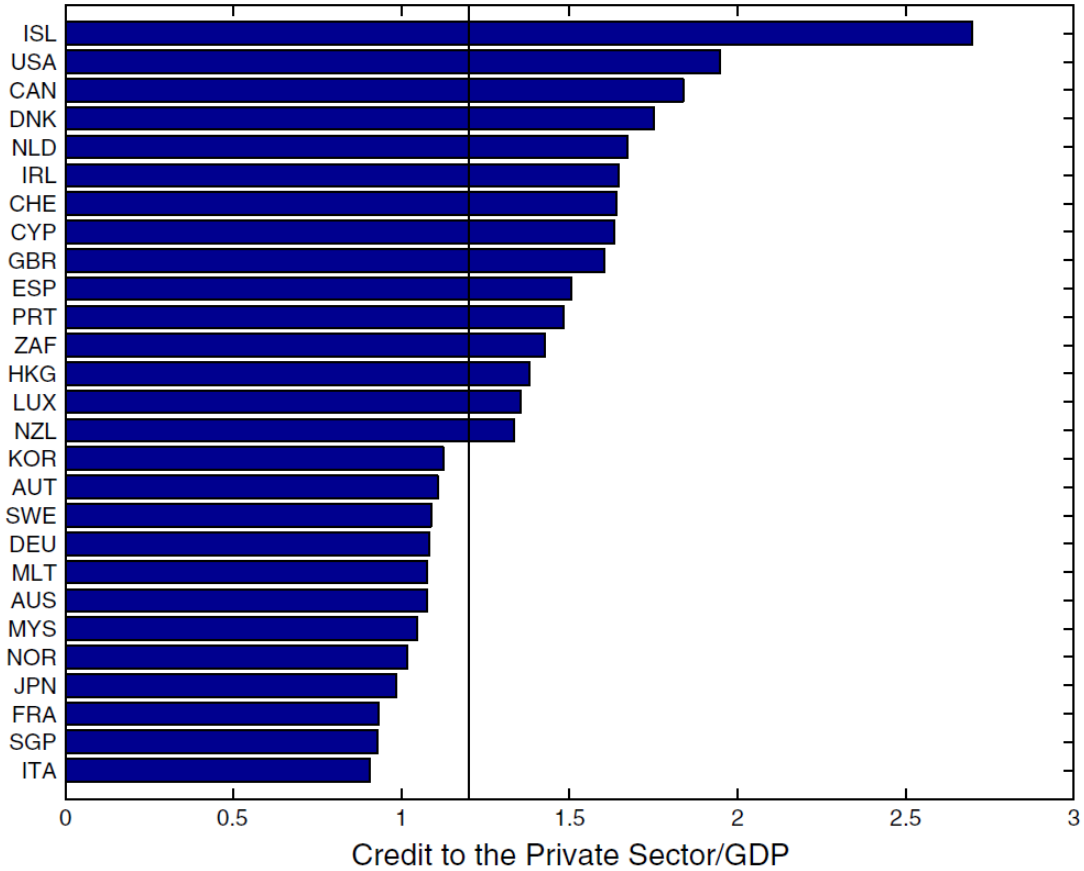


Fig. 6 Countries with large financial sectors (2006). This figure plots the 2006 level of credit to the private sector over GDP (PC) for all countries that in 2006 had values of PC $>$ 90 %. The *vertical line* is at PC $=$ 110 %

Back

Source: Arcand, Berkes and Panizza (2015)

"Are Ideas Getting Harder to Find?" (Bloom et al, 2020)

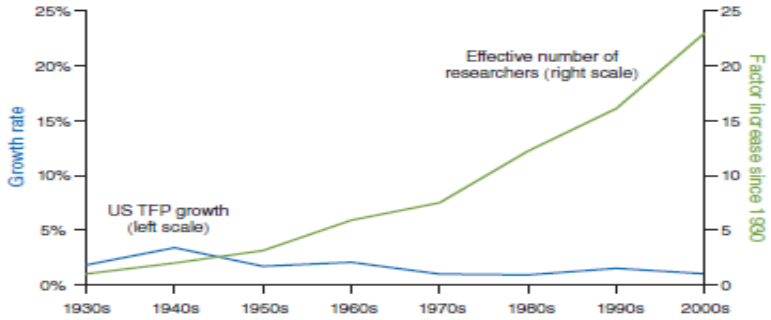


FIGURE 1. AGGREGATE DATA ON GROWTH AND RESEARCH EFFORT

Notes: The idea output measure is TFP growth, by decade (and for 2000–2014 for the latest observation). For the years since 1950, this measure is the Bureau of Labor Statistics (2017) Private Business Sector multifactor productivity growth series, adding back in the contributions from R&D and IPP. For the 1930s and 1940s, we use the measure from Gordon (2016). The idea input measure, *Effective number of researchers*, is gross domestic investment in intellectual property products from the National Income and Product Accounts (Bureau of Economic Analysis 2017), deflated by a measure of the nominal wage for high-skilled workers.

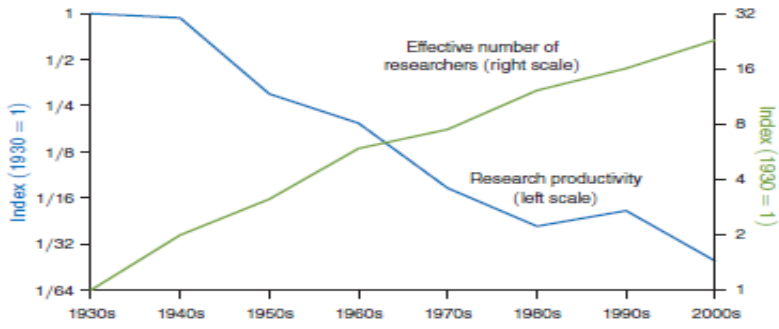


FIGURE 2. AGGREGATE EVIDENCE ON RESEARCH PRODUCTIVITY

Notes: Research productivity is the ratio of idea output, measured as TFP growth, to the effective number of researchers. See Notes to Figure 1 and the online Appendix. Both research productivity and research effort are normalized to the value of 1 in the 1930s.

Back

Table 2: Lower frictions in credit and innovation markets

	Benchmark	Low credit frictions	Low innovation frictions	Low frictions in both markets
g	2.00%	2.00%	2.07%	2.12%
$1/q$	2 yr	3.4 yr	1.03 yr	1.75 yr

Back

The value of a bank on the BGP

Funding stage

$$(r-g)\,\hat{B}_0 = -k + \phi p(\phi)\left[\hat{B}_1 - \hat{B}_0\right]$$

Innovating stage

$$(r-g)\,\hat{B}_1 = -n + q(\theta)\left[\hat{B}_2 - \hat{B}_1\right]$$

Creation Stage

$$(r-g)\,\hat{B}_2 = \rho + s\left[\hat{B}_3 - \hat{B}_2\right]$$

The value of a firm

Funding stage

$$(r-g)\,\hat{F}_0 = -c + p\,(\phi)\left[\hat{F}_1 - \hat{F}_0\right]$$

Innovating stage

$$(r-g)\,\hat{F}_1 = q(\theta)\left[\hat{F}_2 - \hat{F}_1\right]$$

Creation stage

$$(r-g)\,\hat{F}_2 = \pi\gamma - \rho + s\left[\hat{F}_3 - \hat{F}_2\right]$$

Note: in each stage, a firm produces πA *and* sustains costs πA

Equilibrium credit market tension under free entry

Equilibrium credit tension depends on the attractiveness of entry into the market. Nash-bargaining over the fee paid by the firm to its bank.

- **Surplus:** Expected PDV of profits generated by innovation net of loaned funds

$$S = \underbrace{\frac{q(\theta)}{r - g + q(\theta)}}_{\text{Discount factor from stage 2}} \left[\underbrace{\frac{\pi\gamma}{(r - g + s)}}_{\text{Output upgrade}} - \underbrace{\frac{n}{q(\theta)}}_{\text{Search costs}} \right]$$

- The costs to find a match must equal the share received of surplus

$$\frac{c}{p(\phi)} = \omega S$$

$$\frac{k}{\phi p(\phi)} = (1 - \omega) S$$

- Equilibrium tension

$$\phi^* = \frac{\omega}{1 - \omega} \frac{k}{c} \rightarrow p(\phi^*)$$