Heterogeneous Innovation and Intertemporal Productivity Choice

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Research Motivation

Since the rebirth of endogenous growth in mid-2000s, literature became richer:

- Classics: Romer (1990), Grossman and Helpman (1991), Aghion and Howitt (1992);
- Micro-data renewal: Klette and Kortum (2004), Lentz and Mortensen (2008);
- Current state of the art: Acemoglu et al. (2013), Akcigit and Kerr (2016).

$\Rightarrow$ We now account for creative destruction/turnover, R&D spillover, imitation, incumbents' innovation, firm heterogeneity...but...

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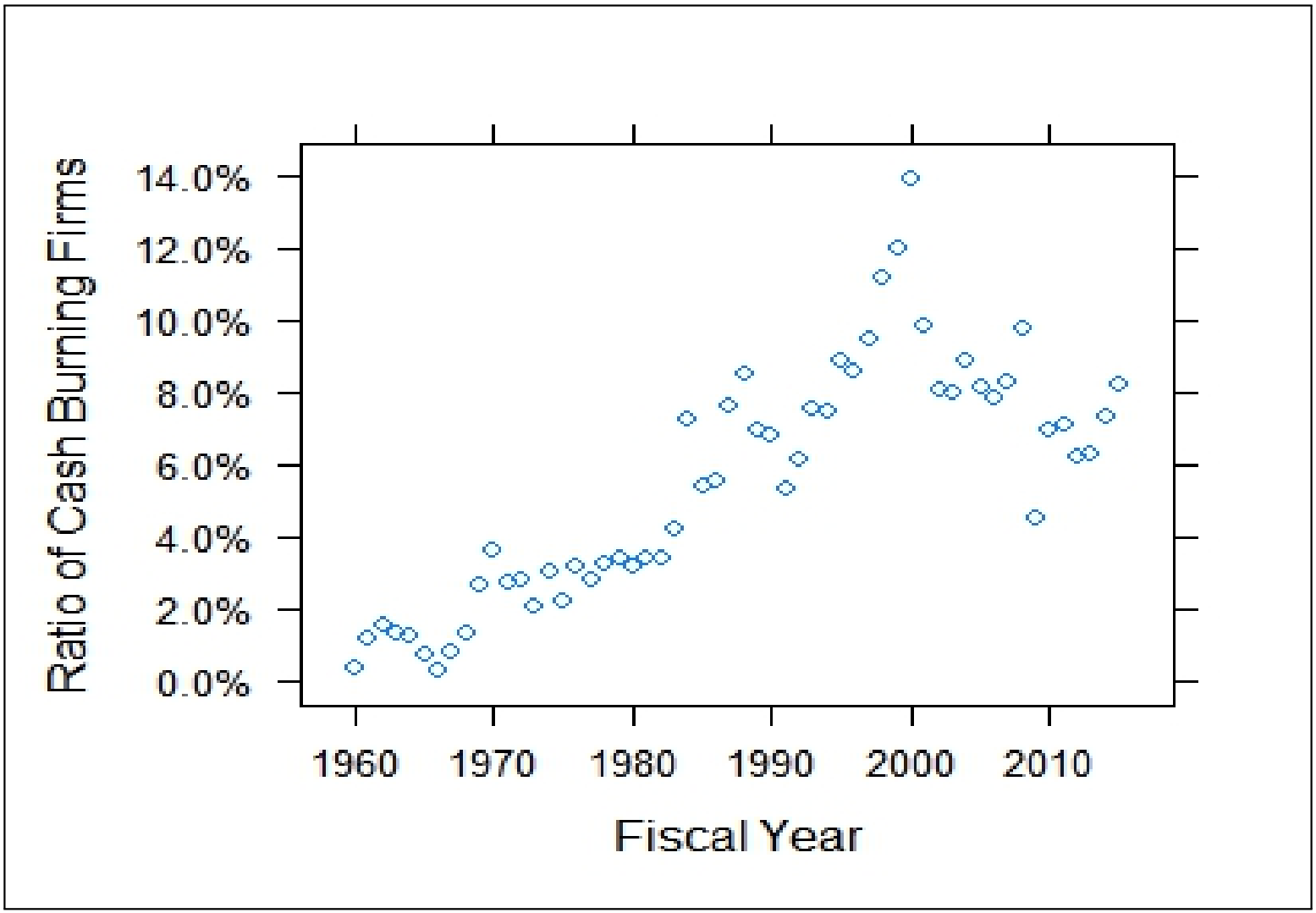

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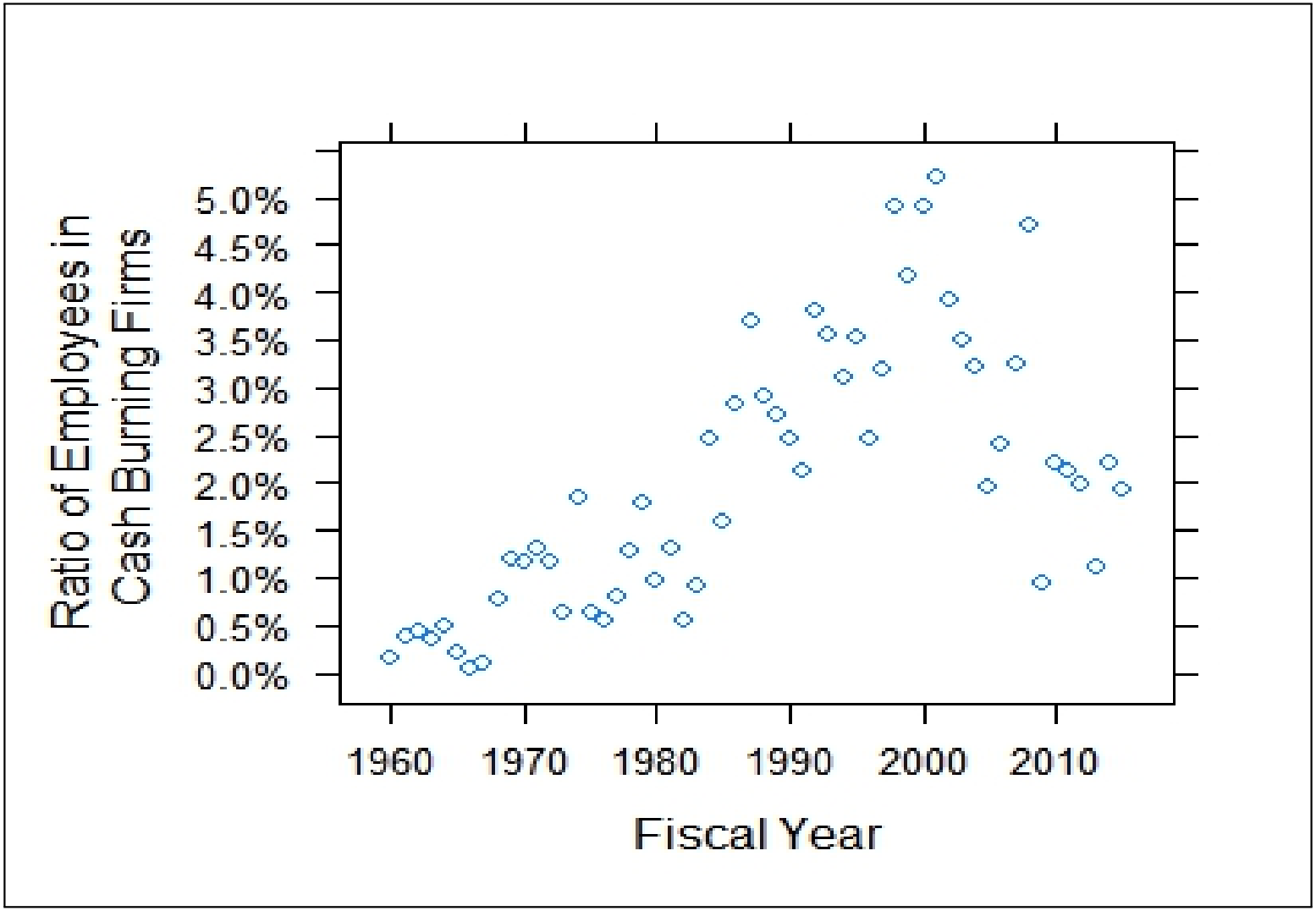


Research Motivation

Questions:

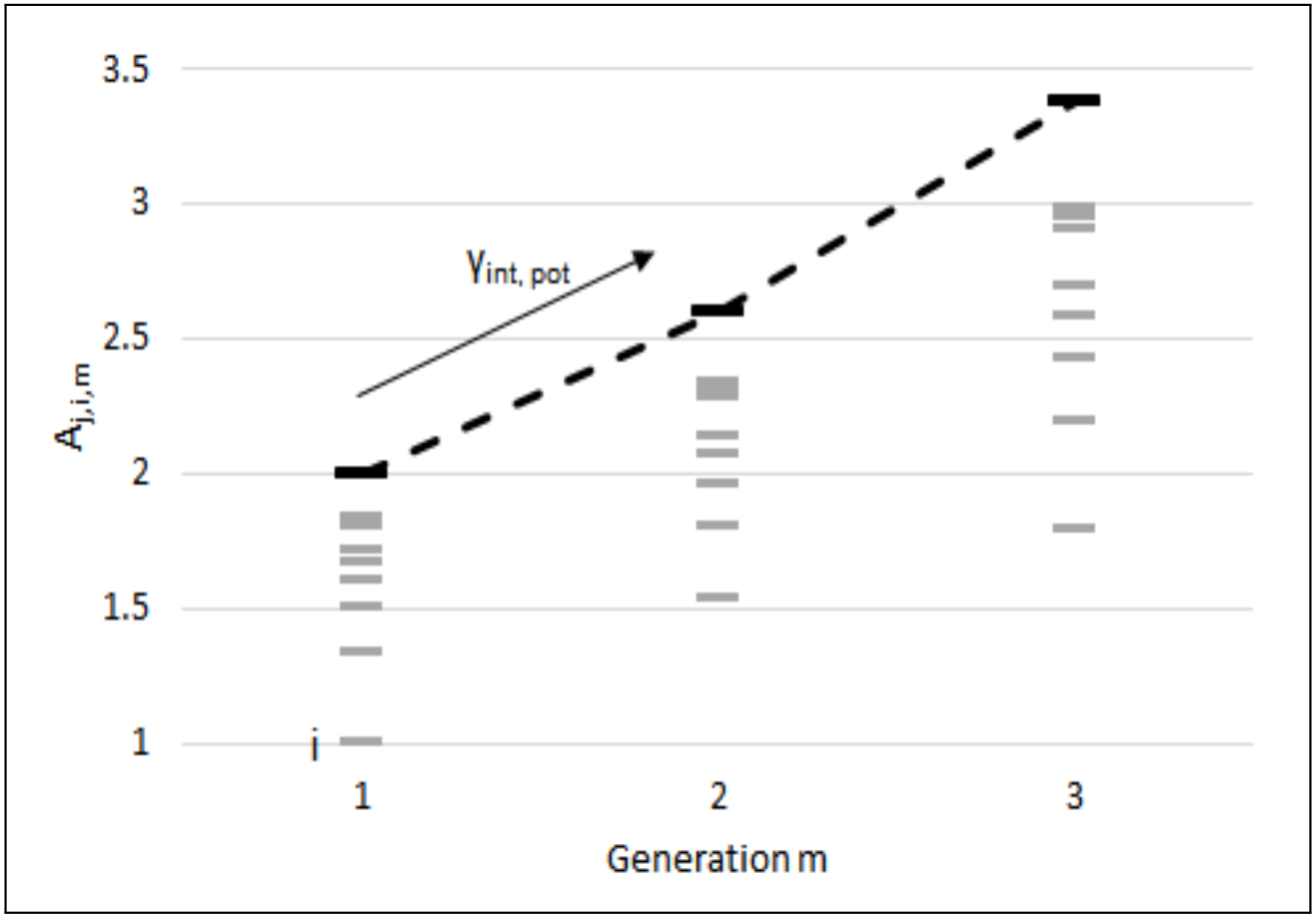
- What's the impact of intertemporal TFP choice on aggregate TFP?
- What are the implications to the innovation strategy of firms?
- How long does it take to "get TFP back"?

Why is it interesting?

- Having Bluetooth in your car $\neq$ Tesla, or innovation heterogeneity sparks different firm behavior;
- Less TFP now for more TFP latter could impact aggregate measurement;
- Finance has a role in "footing the bill" and reallocation;
- Normative: how to spur abrupt innovation?

Framework - Innovation

Focus: Innovation: internal (incremental or abrupt), external, and entrants (the last two only abrupt).



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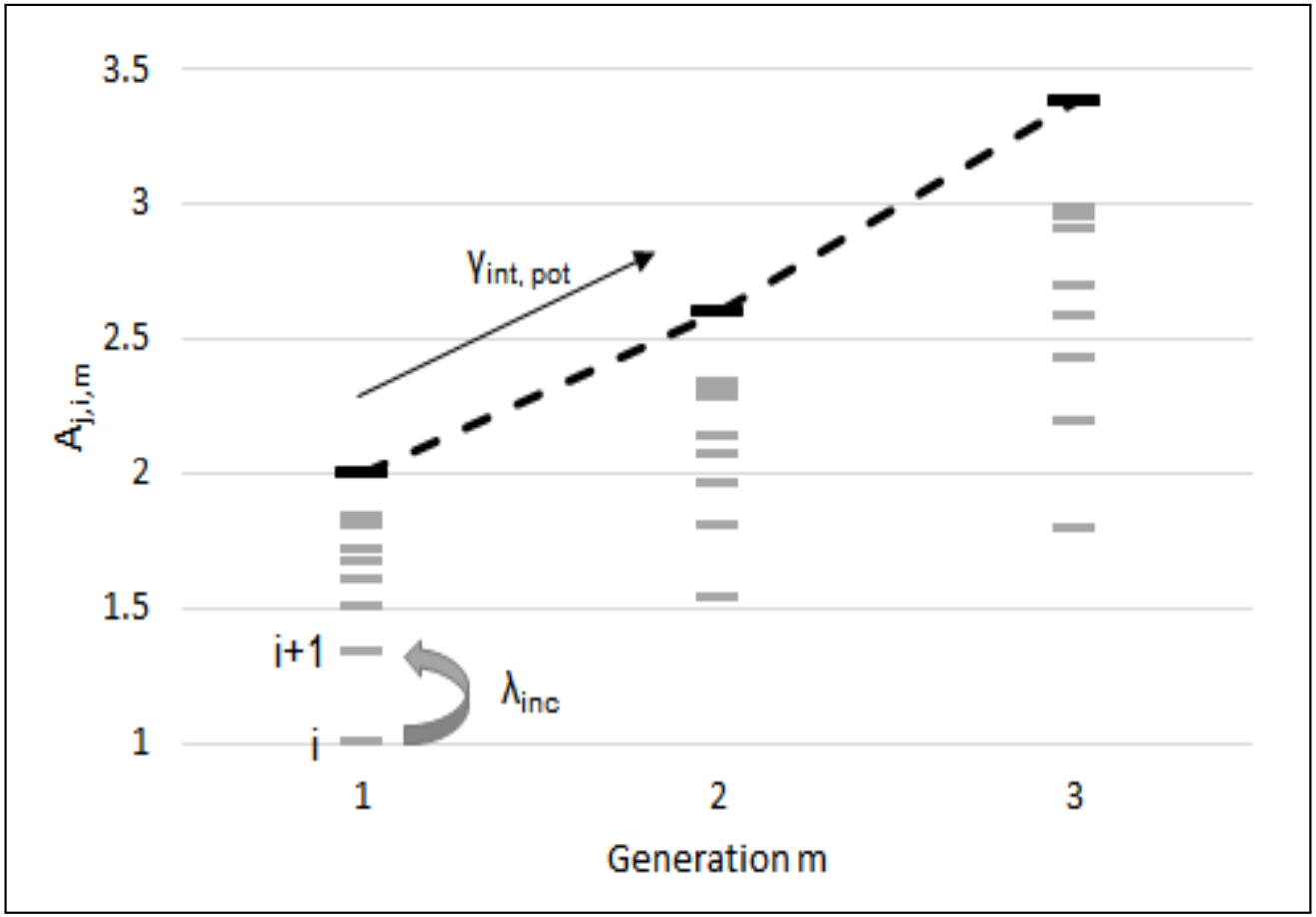

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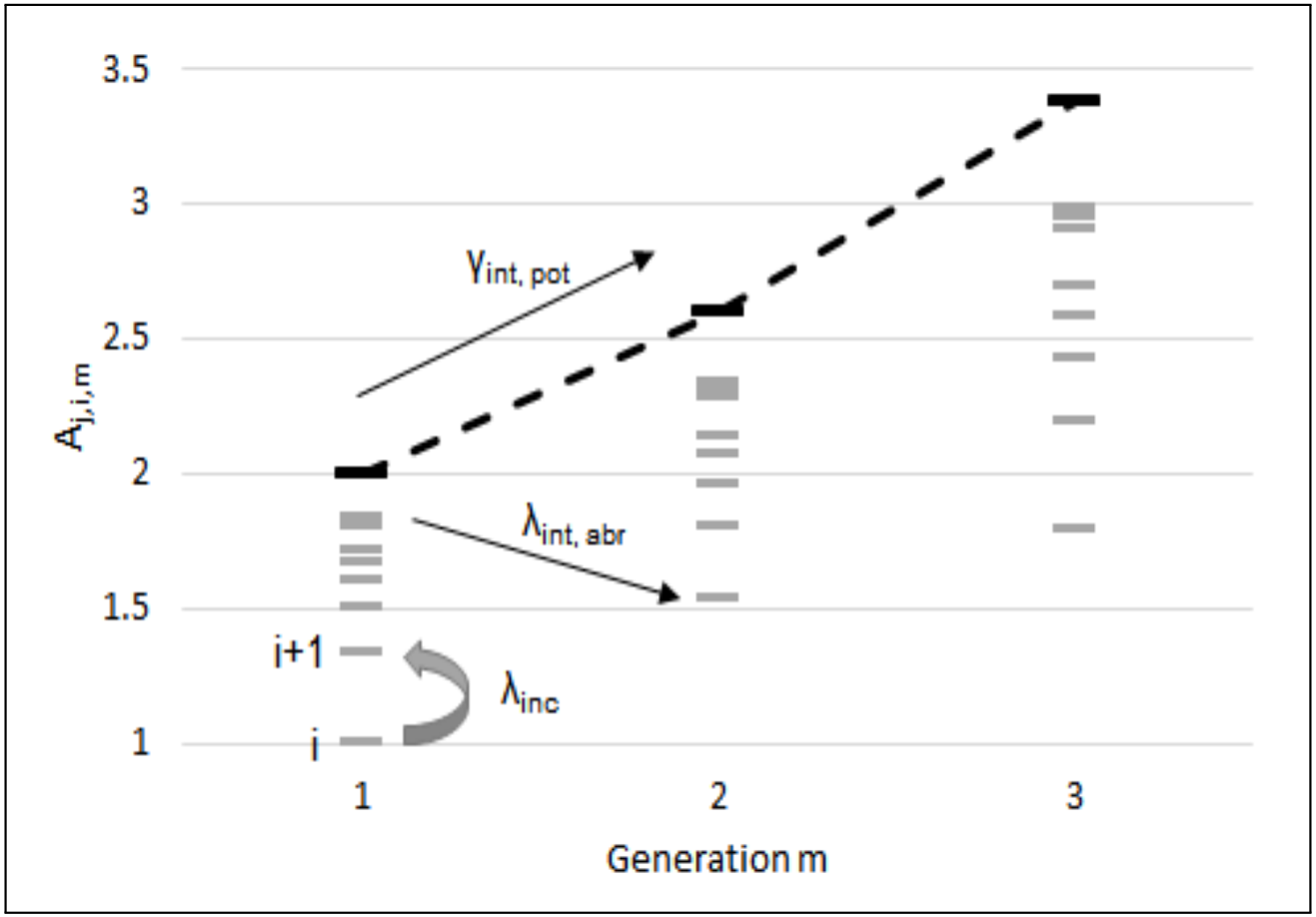

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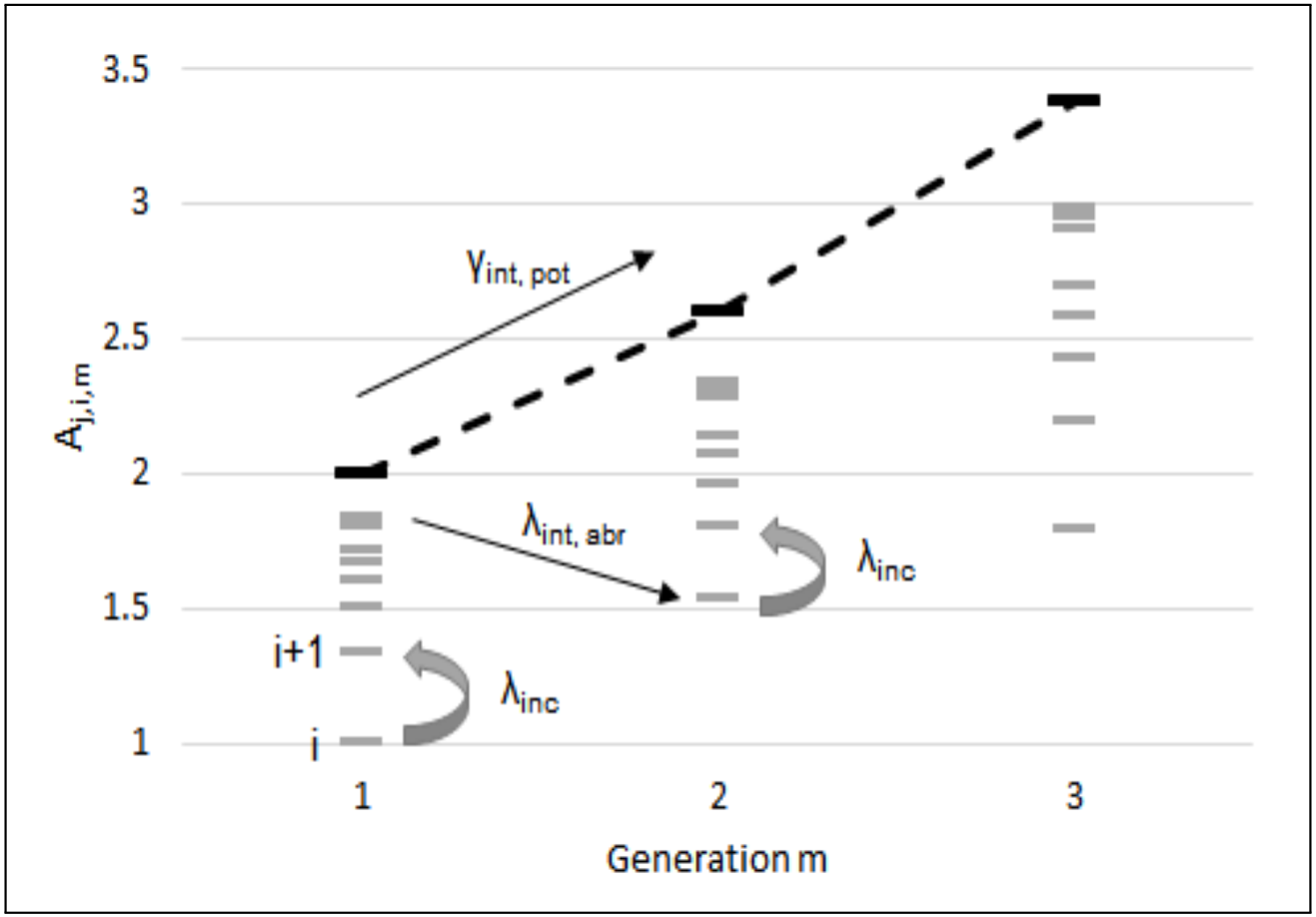

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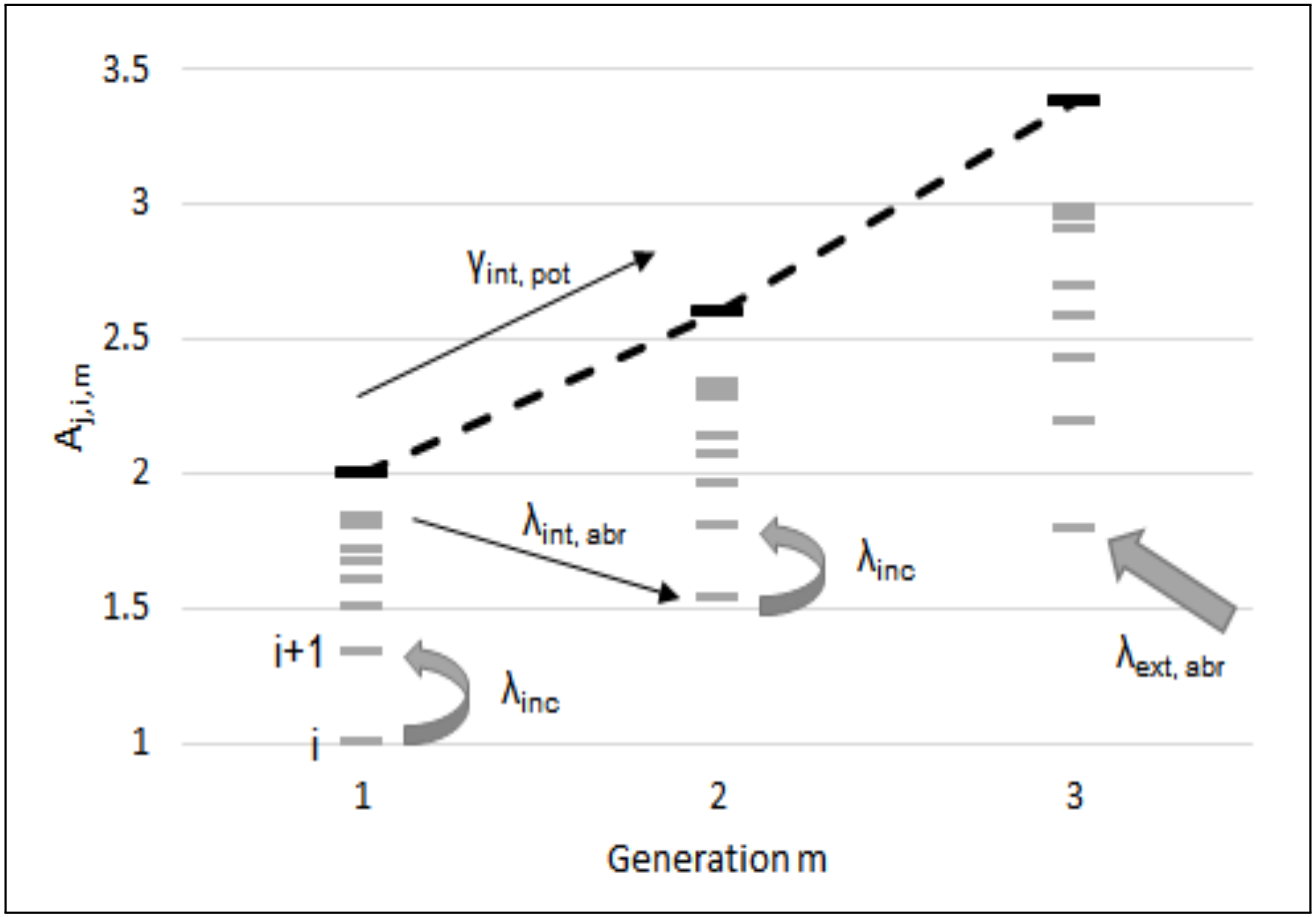

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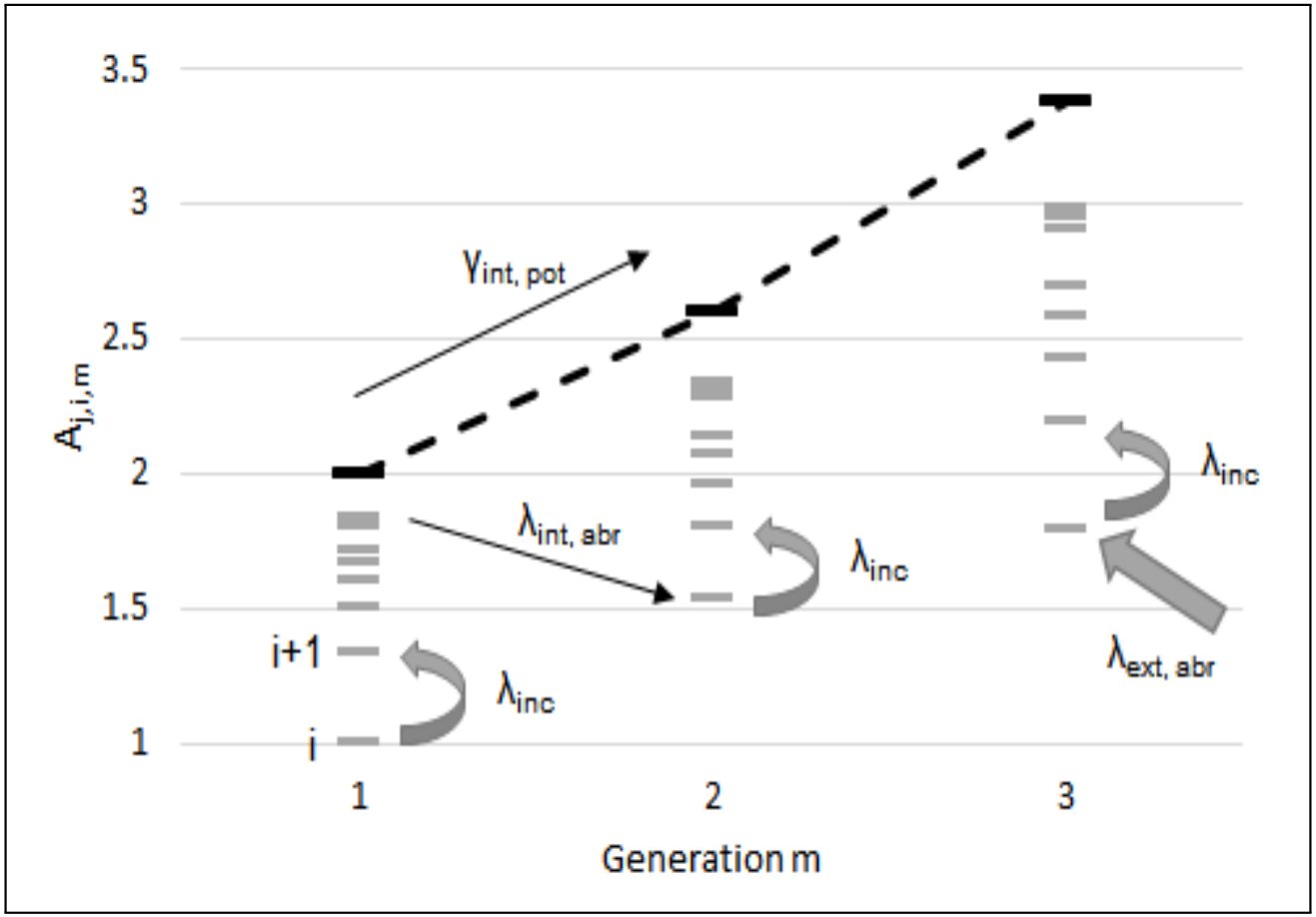


Framework - Innovation

- Law of motion ($A_{m+1} = A_m \gamma_{int,pot}$):

$$A_{t+\Delta t} = \begin{cases} A_m(1-\alpha^s)\ ,\ \lambda_{inc}\Delta t\ ,\ \alpha \in (0,1)\ ,\ \ s \in \{1,2,...\} \\ A_t \gamma_{int,abr}\ ,\ \lambda_{int,abr}\Delta t \\ A_t\ ,\ \left[1-\lambda_{inc}\Delta t; 1-\lambda_{int,abr}\Delta t\right] \end{cases}$$

- Incremental R&D cost: $\psi_{inc}(\lambda_{inc}, A_t) = \xi_j A_t \lambda_{inc}^{\eta}$
- Catching-up: laggards pay $\psi_{inc}(\lambda_{inc}, A_t)$ and get an arrival $\lambda_{inc} + h$;
- Abrupt R&D cost (for $n_p > 0$): $\psi_{abr}(\lambda_{ext,abr}, \bar{A}_t) = \xi_j \bar{A}_t \lambda_{ext,abr}^{\eta}$, $\bar{A}_t$ sector average;
- Cournot competition: profits π_t scale with $\frac{A_{j,i,m}}{\sum_j A_{j,i,m}}$ within an industry.

Empirical Work - Patents

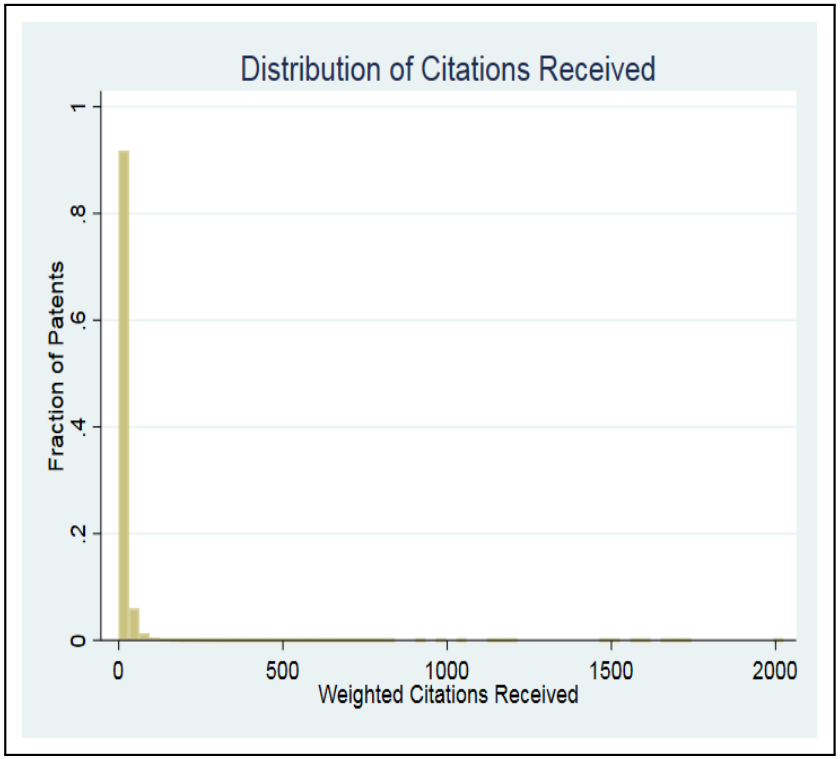
How to discipline $\{\alpha, \gamma_{int,abr}, \gamma_{ext,abr}, \gamma_{int,pot}\}$?

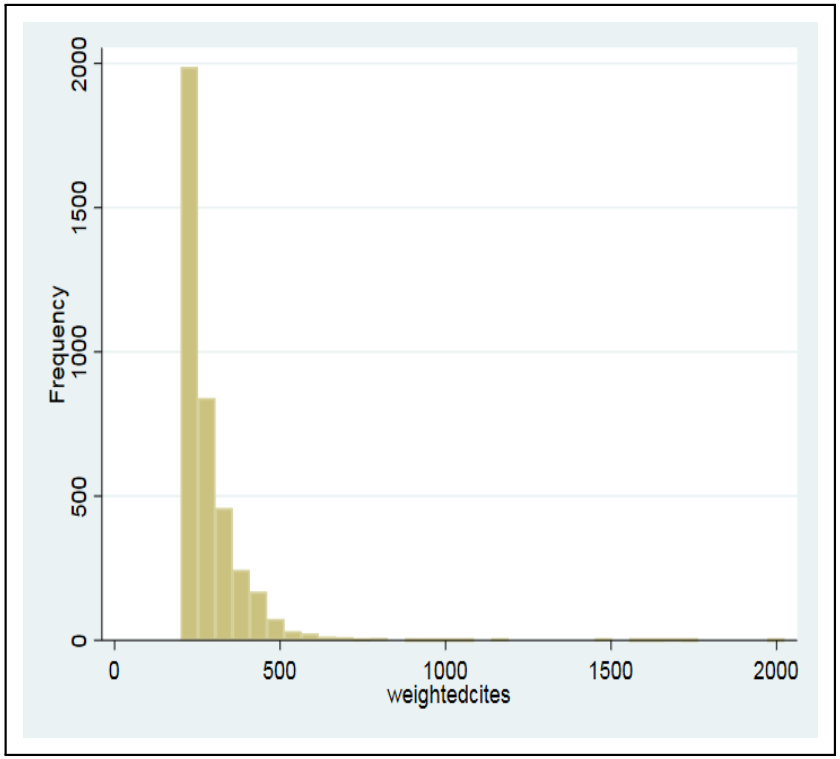
- USPTO patent data (e.g. # patents, # patent citations, if it's self-citation or external...).

Model (complete):

- Endogenous: R&D, productivity (all parameters);
- Exogenous: labor market (wages, supply), consumers (discounting), mass of entrants;
- Estimated (for Patents): $\{\alpha, \gamma_{int,abr}, \gamma_{ext,abr}, \gamma_{int,pot}\}$;
- Calibrated (for Complete version): discounting, curvature of the R&D cost function (η).

Empirical Work - Patents





Summary: # obs = 3,278,174; Mean = 11.76; Std. Dev. = 20.00

Empirical Work - Patents

GMM strategy:

- Each patent in the data set can be classified as internal or external (based on whether the company has previous patents within that classification) and incremental versus abrupt (based on the number of citations that the patent has);
- Given a guess of parameter values $\{\alpha, \gamma_{int,abr}, \gamma_{ext,abr}, \gamma_{int,pot}\}$, we can calculate the moments;
- Potential moments to use: average rate of internal, abrupt patents; average rate of external, abrupt patents; average rate of internal, incremental patents; correlation between abrupt and incremental patent rates.

Conclusion

- Goal: estimate the R&D part of an endogenous growth model with heterogeneous innovation;
- Possibilities:
  - Add firm-level financials and estimate the parameters of the Partial Equilibrium (indirect inference);
  - Solve the SS;
  - Cure cancer...
- Caveats: lots of firms don't innovate, patents do not represent innovation (nor products, ideally we would have product-level data).

References

[1] Aghion, P., and Howitt, P. A Model of Growth through Creative Destruction. *Econometrica 60*, 2 (1992), 323–351.

[2] Akcigit, U., and Kerr, W. R. Growth through heterogeneous innovations. forthcoming, 2016.

[3] Grossman, G. M., and Helpman, E. Quality ladders in the theory of growth. *Review of Economic Studies 58*, 1 (1991), 43–61.

[4] Klette, T. J., and Kortum, S. Innovating firms and aggregate innovation. *Journal of Political Economy 112*, 5 (2004), 986–1018.

[5] Philippe Aghion, C. H. P. H., and Vickers, J. Competition, imitation and growth with step-by-step innovation. *Review of Economic Studies 68*, 3 (2001), 467–492.

[6] Romer, P. Endogenous technological change. *Journal of Political Economy 98*, 5 (1990), S71–102.

Appendix: Framework - Innovation

Outside entrepreneur:

- Value function:
  $rV_0 - \dot{V}_0 = \max_{\lambda_{ext,abr}} \left[\lambda_{ext,abr}\left[E_j\left[V(A_{t,m+1})\right] - V_0\right] - v\bar{A}_t\lambda_{ext,abr}\right]$
- Cost: $C_E(\lambda_{ext,abr}, \bar{A}_t) = v\bar{A}_t\lambda_{ext,abr}$, v a constant;
- Free entry condition: $E_j\left[V(A_{t,m+1})\right] = v\bar{A}_t$
- $\Rightarrow$ Each firm faces an aggregate endogenous creative destruction (CD) of rate τ_{CE} and internal competition rate τ_I.

Appendix: Framework - Innovation

Incumbents:

- Value function: $rV(A_t) - \dot{V}(A_t) =$

$$\max_{\substack{\lambda_{inc},\, \lambda_{int,abr} \\ \lambda_{ext,abr}}} \left[\sum_{k}^{n_{j,p}} \left[\begin{array}{c} \pi_t n_{j,p} - \{\xi_j \lambda_{inc}^{\eta} A_{t,m}; \xi_j \bar{A}_t \lambda_{int,abr}^{\eta}\} \\ + \{\lambda_{inc}\left[V(A_{t,m}^{k-} \cup A_{t+\Delta t,m}^{k}) - V(A_{t,m})\right]; \\ \lambda_{int,abr}\left[E_j\left[V(A_{t,m}^{k-} \cup A_{t+\Delta t,m+1}^{k}\right] - V(A_{t,m})\right]\} \\ - \tau_I\left[V(A_{t,m} \setminus \bar{A}_{t+\Delta t,m}^{k}) - V(A_{t,m})\right] \\ - \tau_{CE}\left[V(A_{t,m} \setminus \bar{A}_{t+\Delta t,m+1}^{k}) - V(A_{t,m})\right] \end{array} \right] \right.$$
$$\left. + \lambda_{ext,abr}\left[E_j\left[V(A_{t,m}^{k} \cup A_{t+\Delta t,m+1}^{k'}\right] - V(A_{t,m})\right] - \xi_j \bar{A}_t \lambda_{int,abr}^{\eta} - \Phi \bar{A}_t \right]$$

- 1st: instant returns - costs;
- 2nd, 3rd: return from int. R&D;
- 4th: internal competition;
- 5th: external CE;
- 6th: return from abr. R&D;
- 7th: Abr. R&D and fixed costs;