Heterogeneous Innovation and Intertemporal Productivity Choice

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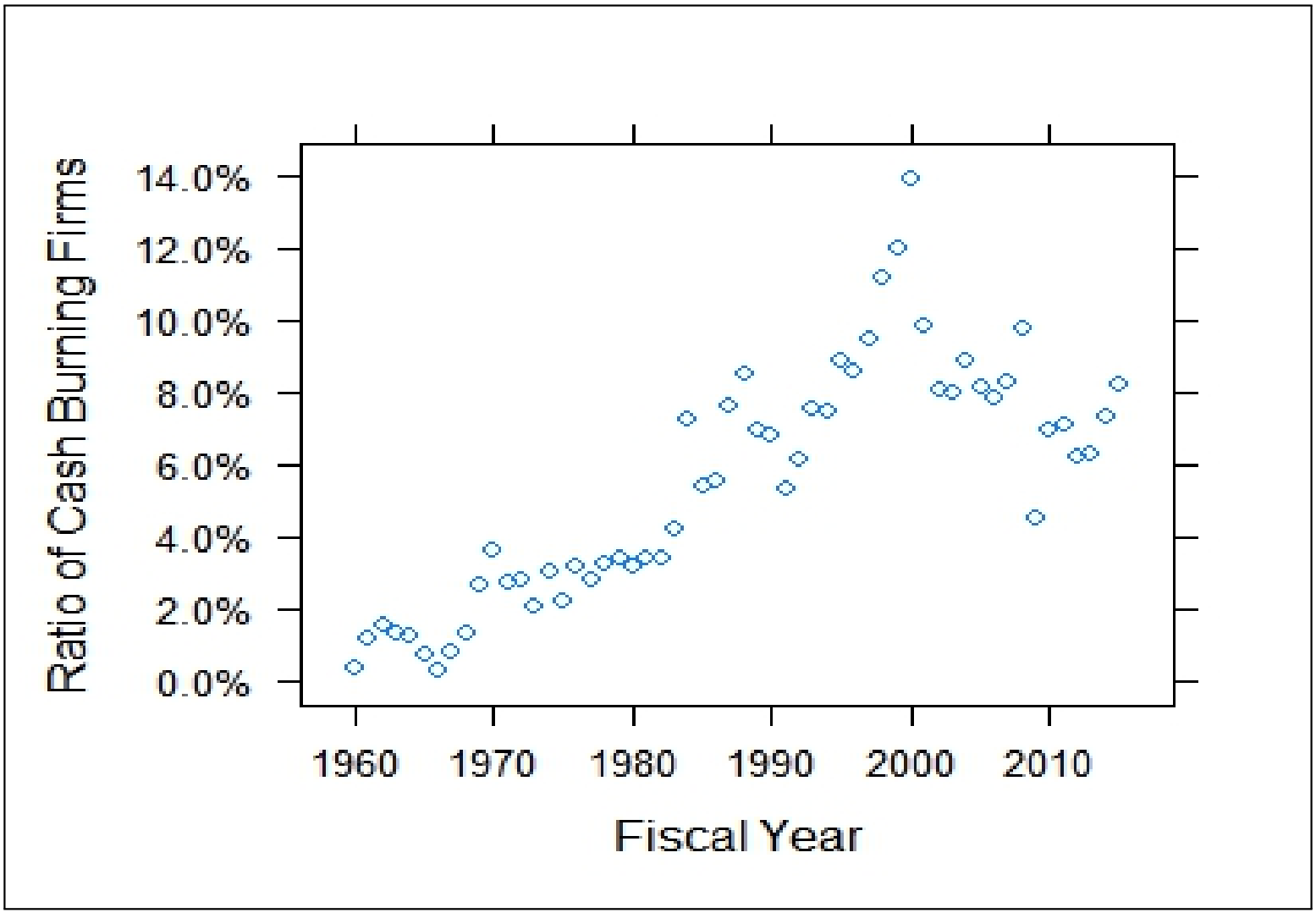
Research Motivation

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...

Research Motivation



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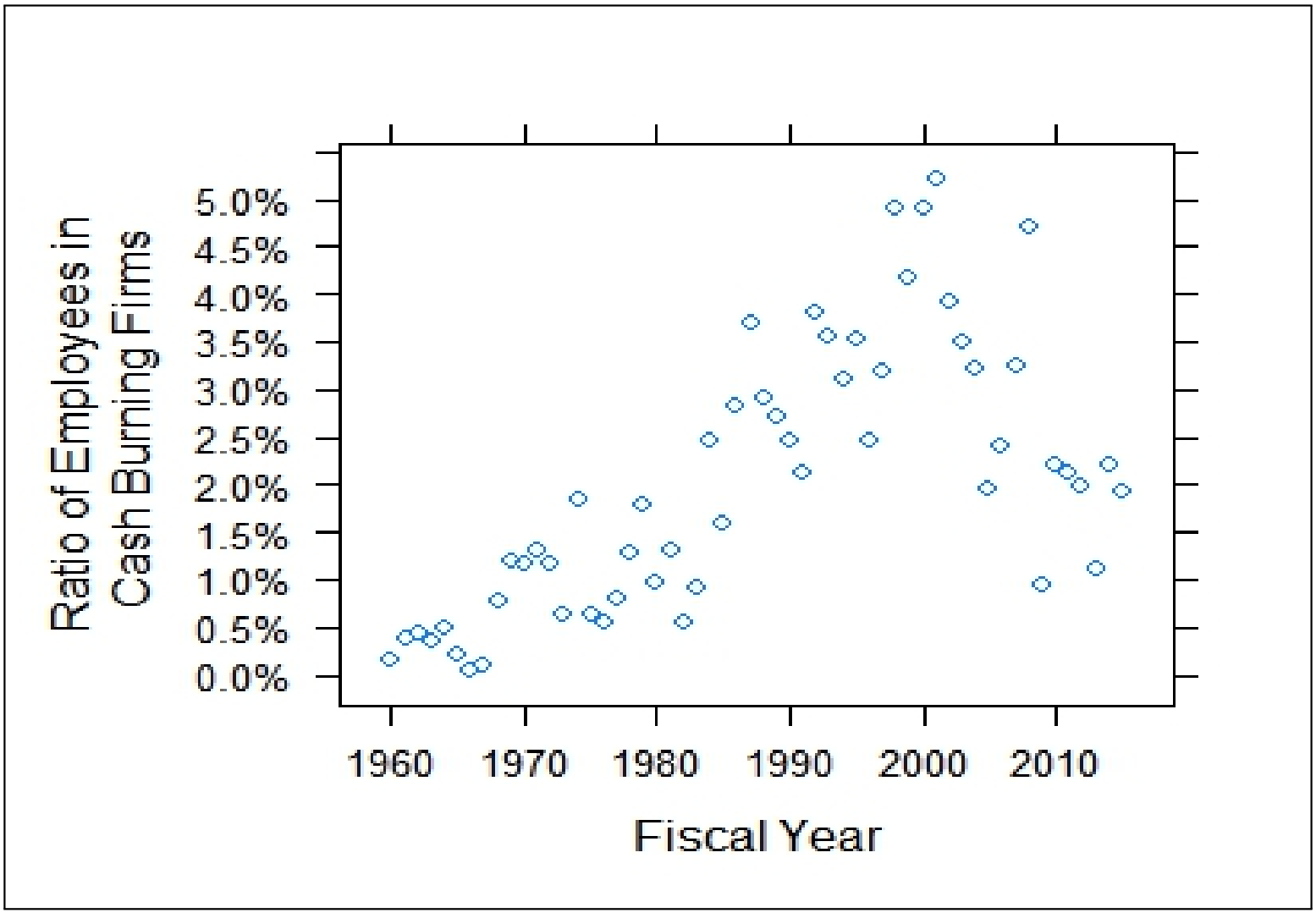


Research Motivation

Questions:

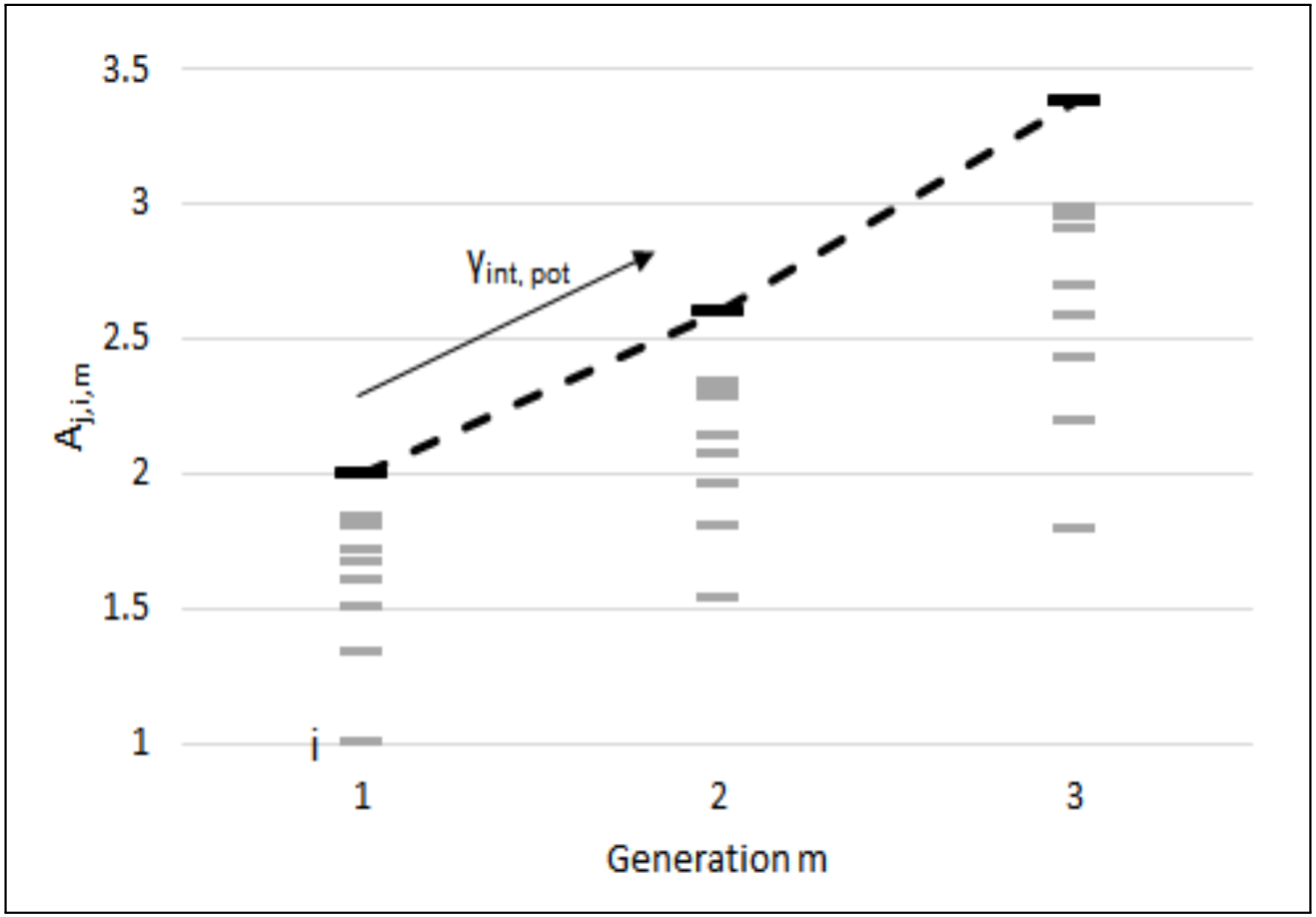
- What's the impact of intertemporal TFP choice on aggregate TFP?
- What are the implications to the innovation strategy of firms?
- How long does it take to "get TFP back"?

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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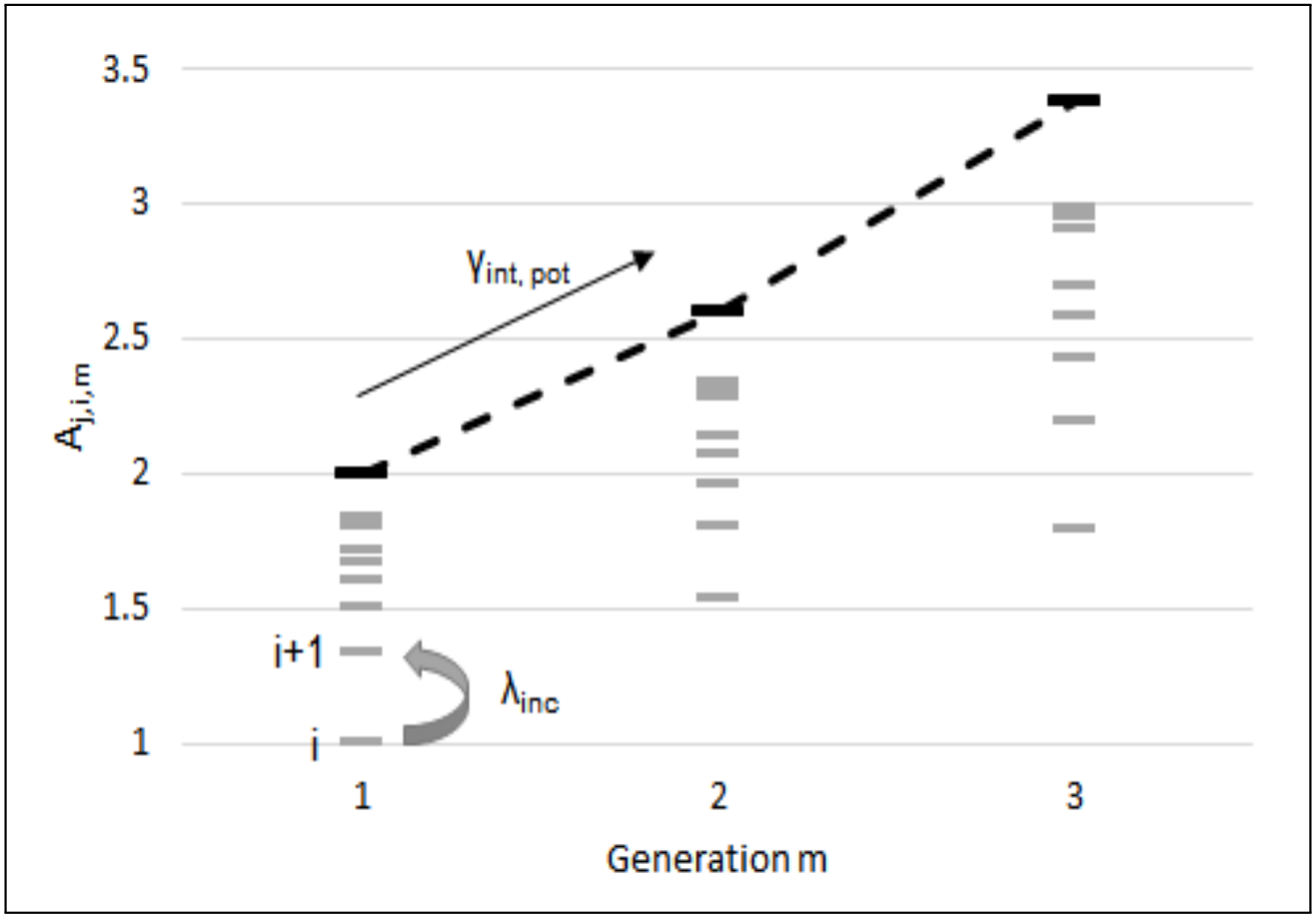

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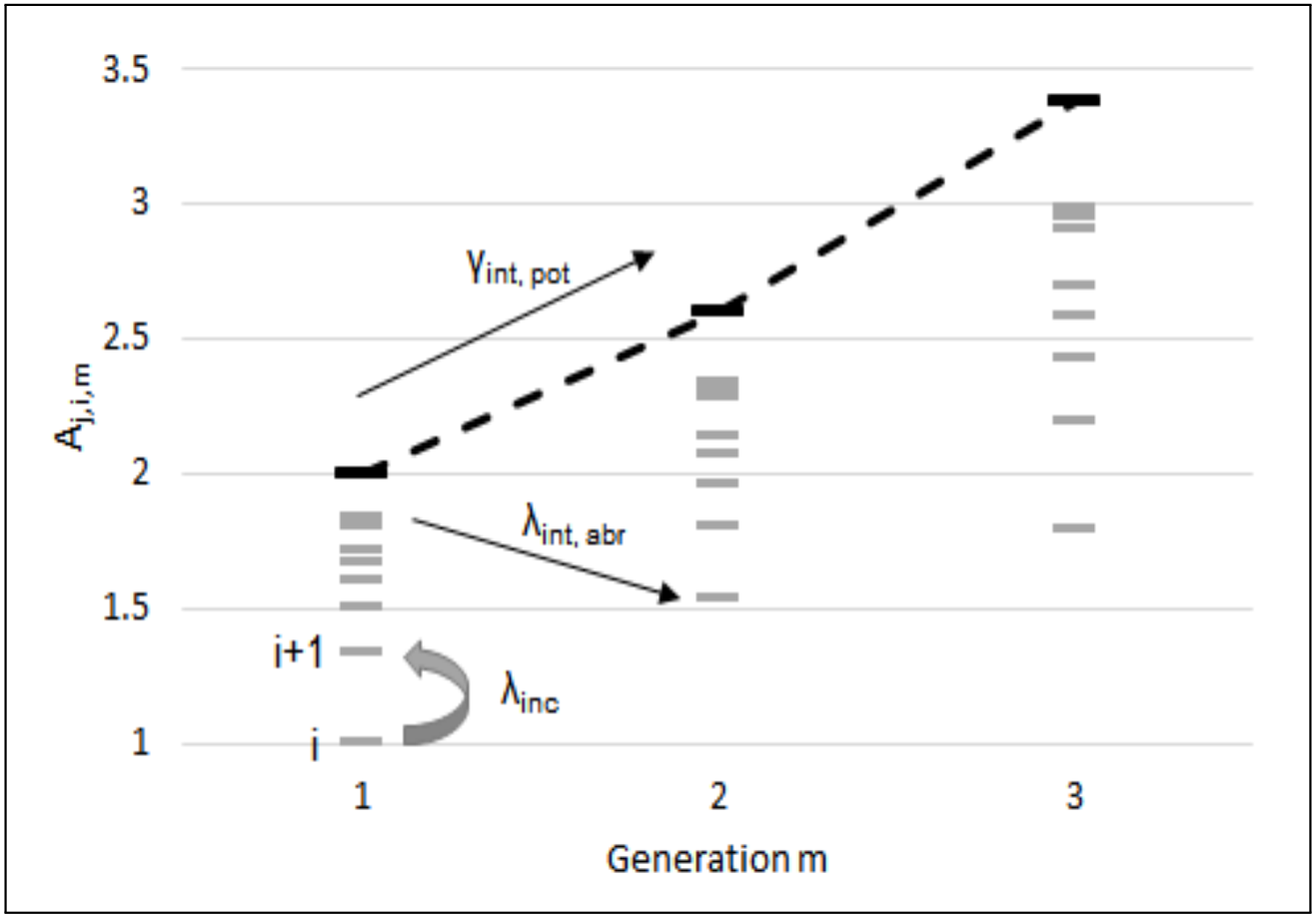

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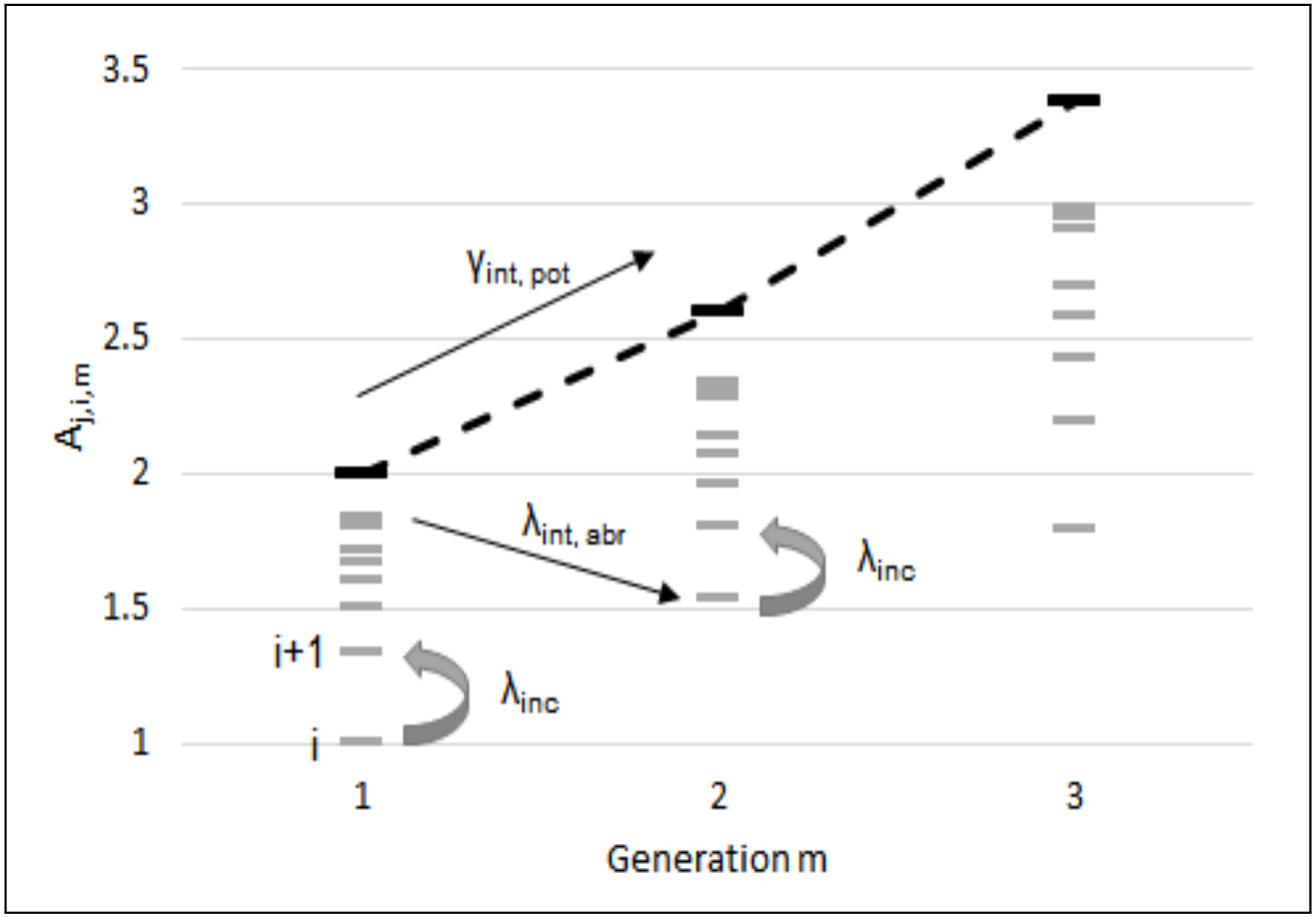

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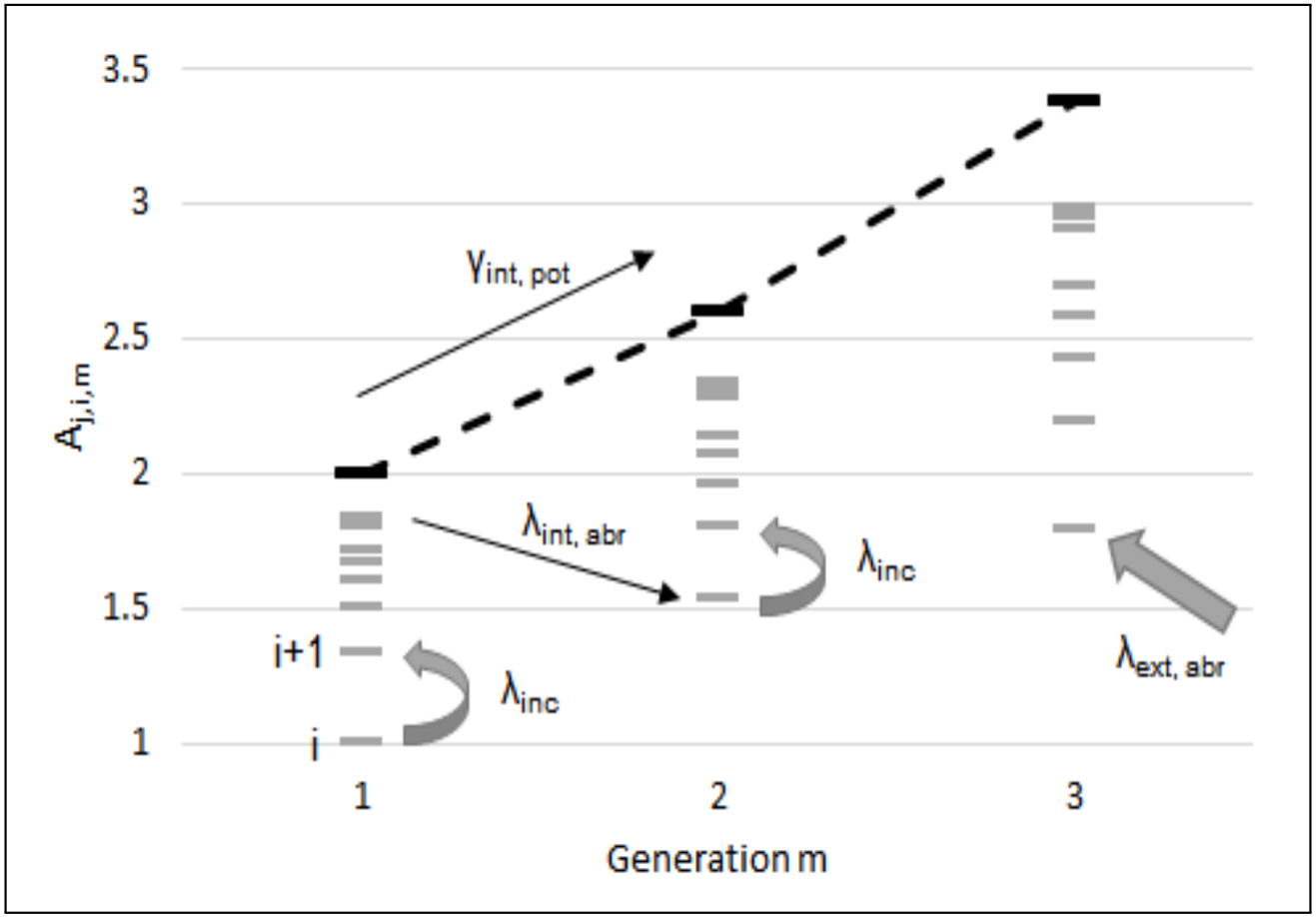

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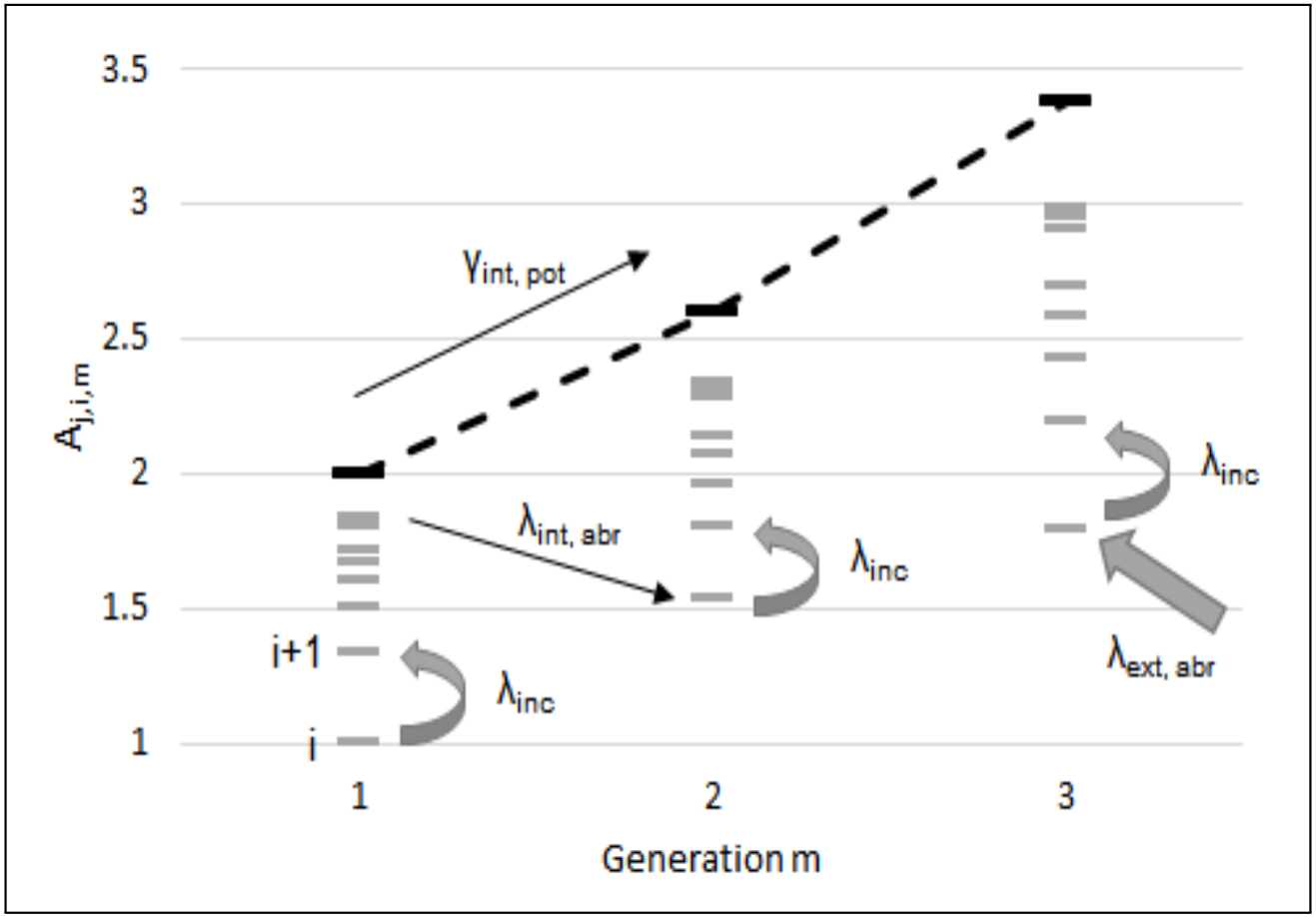

Framework - Innovation

- 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

Estimation strategy:

- Patent and citation distribution: invariant (at SS);
- Need to discipline patent arrival and quality ladder;
- Find the "decay rate" of patent quality;
- Distinguish external vs. internal (patent classification or type of citation, could do robustness), abrupt vs. incremental (# of citations);
- Generational productivity step: impose the same shape and compare absolute levels ("envelope").

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;