Innovation and firm growth

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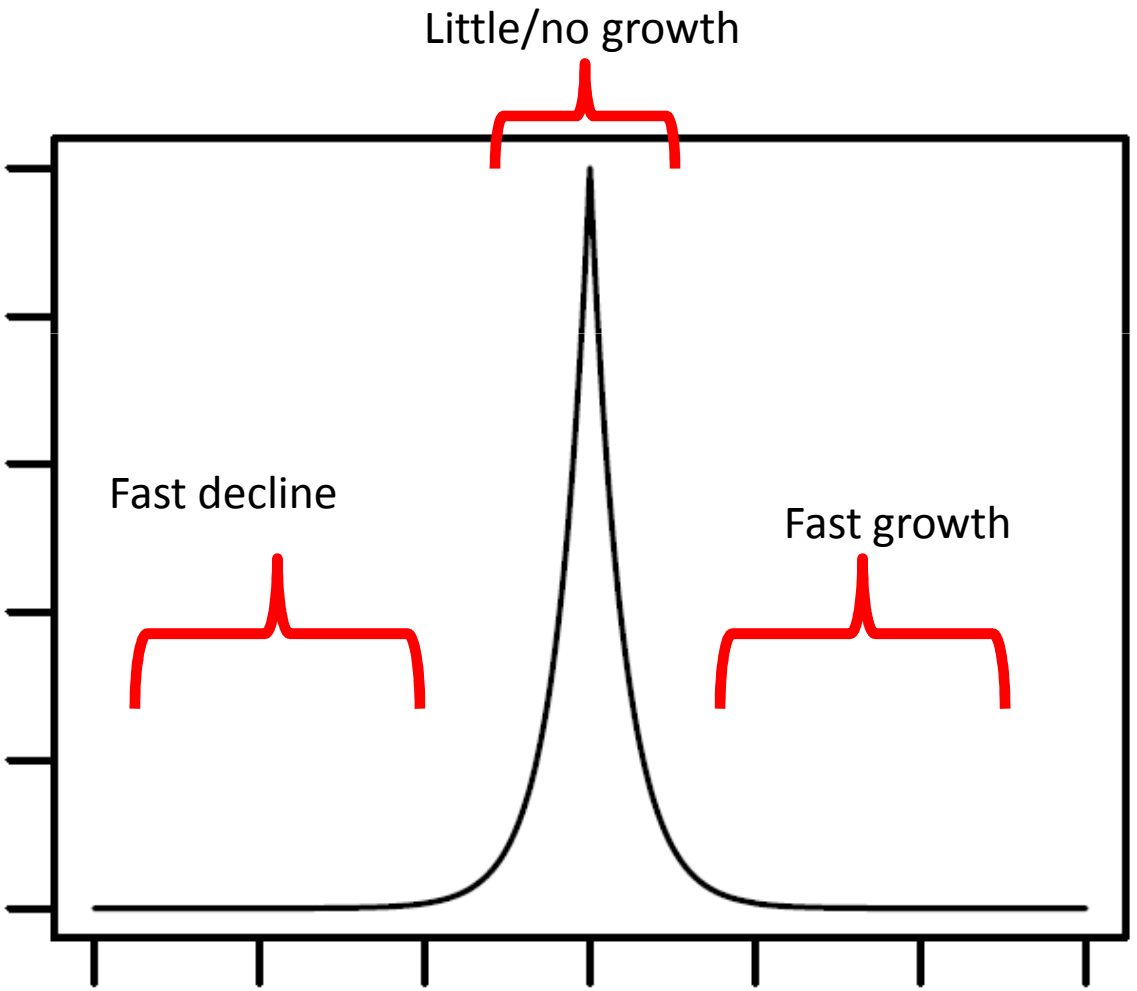
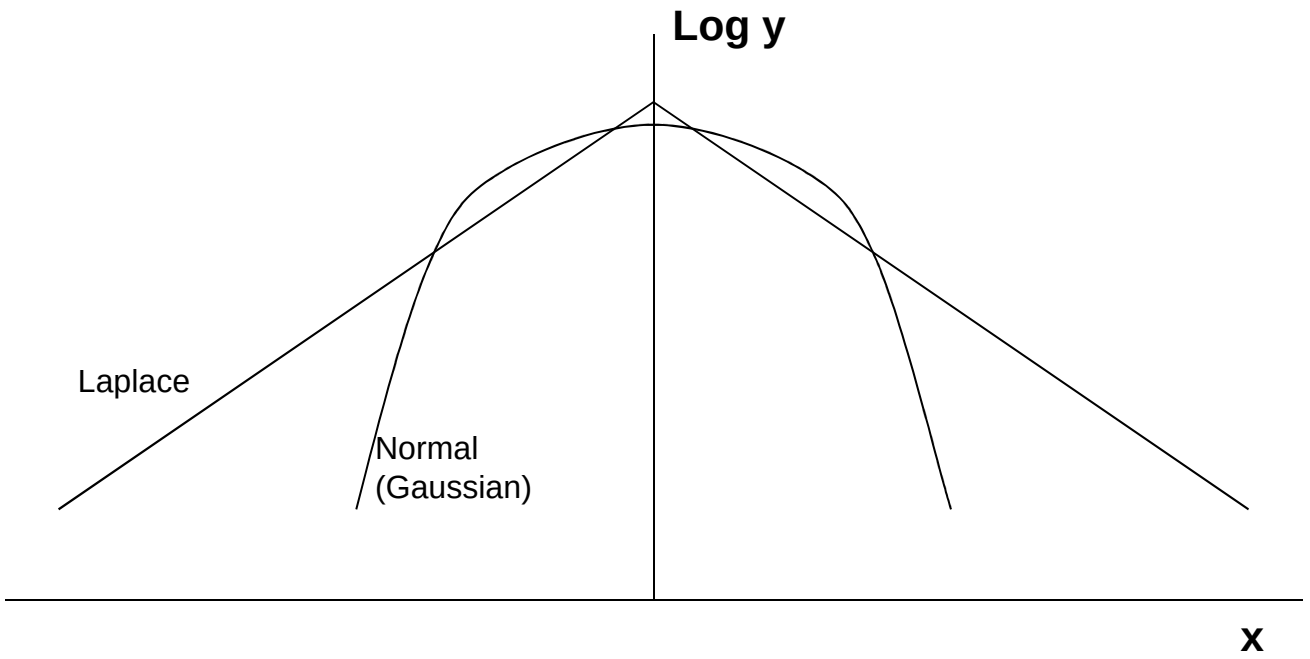
Part I

- What do we know about firm growth?

Growth rate distribution



Laplace Distribution
(aka symmetric exponential)



"a 6-sigma event has a chance of 10^{-9} of occurring in the Gaussian case, whereas with the exponential form the chance is 0.0025."

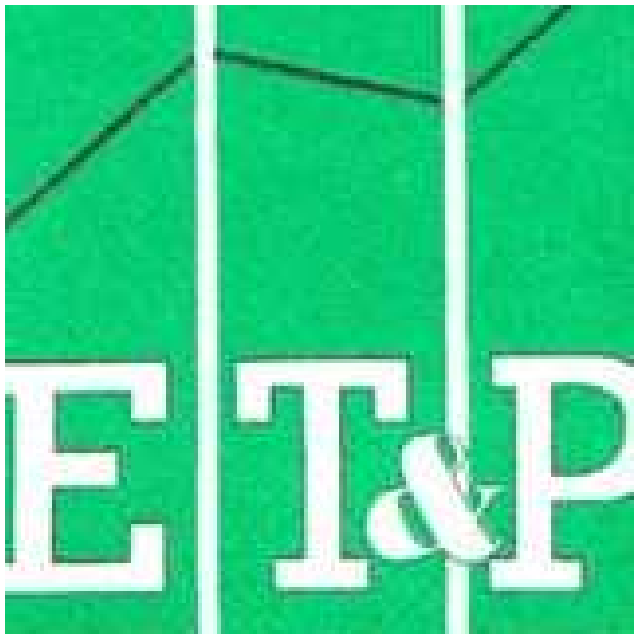
P88 in Goldenfeld N., Kadanoff L.P. (1999). Simple lessons from Complexity. Science, 284, 87-89.

Growth rate distribution

Stanley et al, 1996

FIG. 3 Scaled probability density $p_{scal} \equiv 2^{1/2}\sigma(s_0)p(r \mid s_0)$ as a function of the scaled growth rate $r_{scal} \equiv 2^{1/2}[r - \bar{r}(s_0)]/\sigma(s_0)$ of sales (circles). The values were rescaled using the measured values of $\bar{r}(s_0)$ and $\sigma(s_0)$. Also we show (triangles) the analogous scaled quantities for the number of employees. All the data collapse upon the universal curve $p_{scal} = \exp(-\mid r_{scal} \mid)$ (solid line) as predicted by equations (1) and (2).

Steady growth is the norm?



Growth is largely random

- “The most elementary ‘fact’ about corporate growth thrown up by econometric work on both large and small firms is that firm size follows a random walk.”

Geroski (2000: 169)

Growth paths?

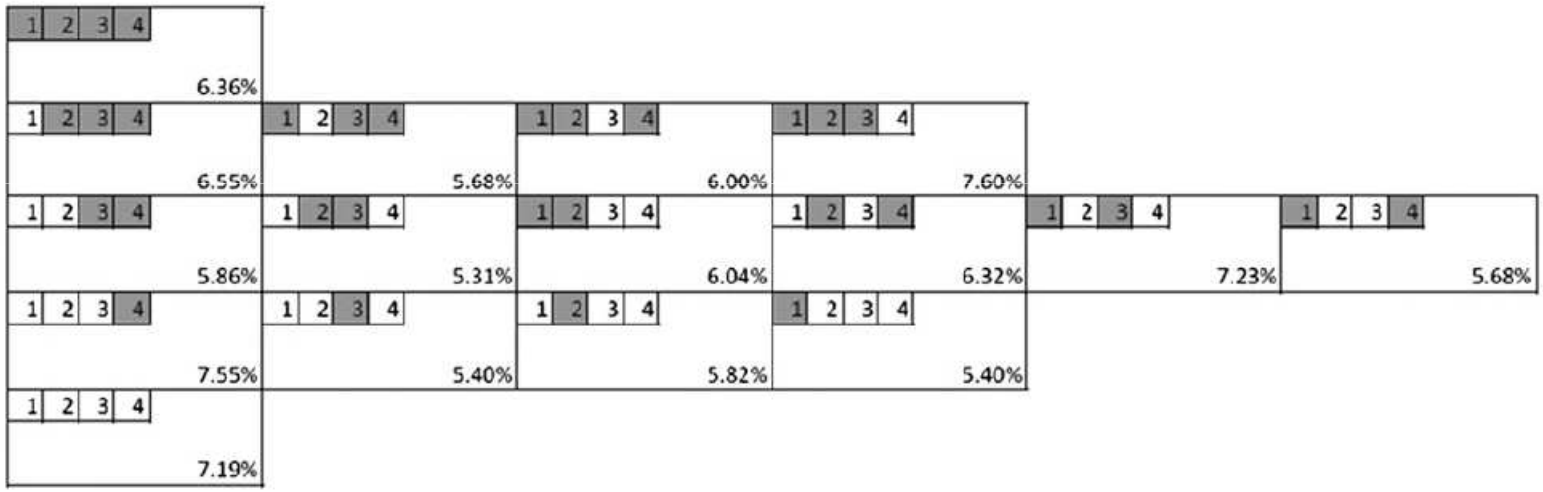


Fig. 2. Growth paths of firms surviving until the end of the fifth year. $N = 2184$. Legend: white squares correspond to growth years (above-median growth) while dark squares correspond to decline years (below-median growth), for the first four growth years of each business. Frequencies are shown in each box. If there is no structure in growth rates (i.e. a purely random process), each of the 16 growth paths should occur with probability $1/16 = 6.25\%$.

To explain growth, we need variables that change *within* firms over time

- "60% of the total variation in firm growth rates is within firms over time, while 40% of the total variability in firm [growth] is between firm variation."
  - Geroski, P., Gugler K., (2004, OEP, p604).

Part II

- What do we know about innovation?

Stylized facts on innovation

- The returns to innovation are very skewed…

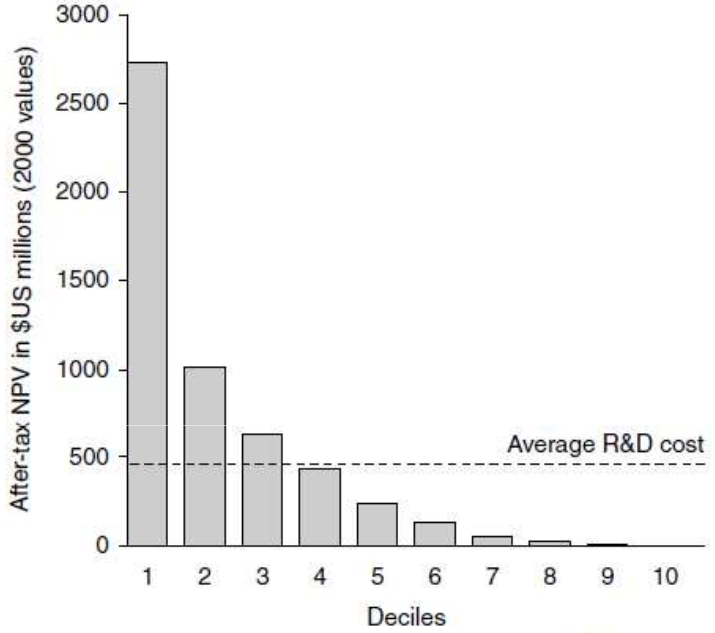


Fig. 7. Present values by decile for 1990 to 1994 new drug introductions. **NPV** = net present value; **R&D** = research and development.

Pharmacoeconomics 2002; 20 Suppl. 3

Stylized facts on innovation

- The returns to innovation are very skewed, with long payback times

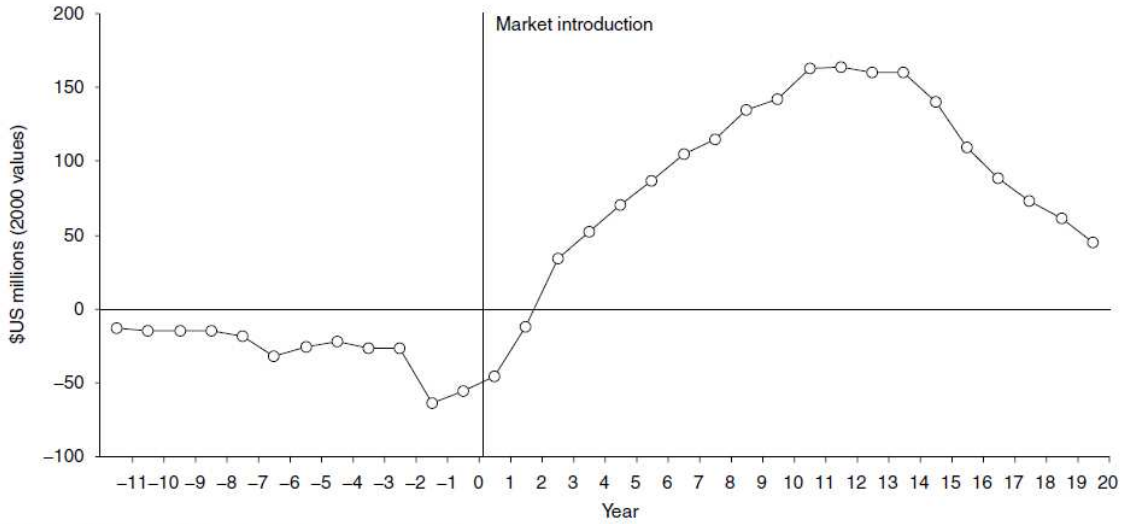


Fig. 5. Cash flows over the product life cycle: baseline case.

Models of R&D investment

- **Neoclassical:**
  - Firms are infinitely rational and find the value of R&D that optimizes revenue

- **Evolutionary:**
  - Rules of thumb: X% of sales (Thompson, 1999, SCED)
  - Inertia, bounded rationality
  - Firms have many projects, they fund their favourites, some R&D projects will not be funded (Hottenrott & Peters, 2012 RES)

Uncertainty at every stage

(Mansfield et al, 1977)

- 3 stages of innovation, 3 conditional probabilities of success:
- Probability that a project's technical goals will be met (x)
- Probability that, given technical success, the resulting product or process will be commercialized (y)
- Probability that, given commercialization, the project yields a satisfactory return on investment (z)

- Overall success: $x \times y \times z$

- If a firm fails at any of these stages: costs but no benefits

Ways to measure innovation

- R&D expenditure
  - Highly persistent (Hall, Jaffe, Trajtenberg 2005 RJE)
- Patents
  - Erratic time series
- Sales new to the market (CIS)
  - Subjectively perceived
- Sales new to the firm (CIS)
  - Same as diversification?
- Product or process innovations introduced (CIS)
  - Subjectively perceived
- 'Major innovations' – the SPRU dataset
  - Experts from science, industry and academia were asked to identify the successful commercial introduction of new or improved products and processes (e.g. Robson & Townsend 1984, Van Reenen 1997 JLE, Geroski et al, 1997 RP)

Part III

- Linking innovation and firm growth

Innovation and firm growth

- Theoretical work and questionaires emphasize the
- role of innovation for growth
    - Nelson and Winter (1982), Aghion & Howitt (1992), Geroski (2000, 2005)

- "Executives overwhelmingly say that innovation is what their companies need most for growth."
    - McKinsey Global Survey of Business Executives (Carden, 2005:25).

- Empirical work has had little success detecting the influence of innovation on firm growth

Early evidence

- **Positive effects:** Mansfield (1962 AER), Scherer (1965), Mowery (1983), Geroski & Machin (1992), Geroski & Toker (1996), Roper (1997), Del Monte & Papagni (2003 RP)

- **Mixed evidence:** Freel (2000): although it is not necessarily true that 'innovators are more likely to grow', nevertheless 'innovators are likely to grow more'

- **No effects:** Bottazzi et al., (2001 IJIO): no significant effect for their sample of the worldwide pharmaceutical sector

Cefis & Orsenigo, 2001 RP: p. 1157

- “Linking more explicitly the evidence on the patterns of innovation with what is known about firms growth and other aspects of corporate performance – both at the empirical and at the theoretical level – is a hard but urgent challenge for future research”

Recent evidence

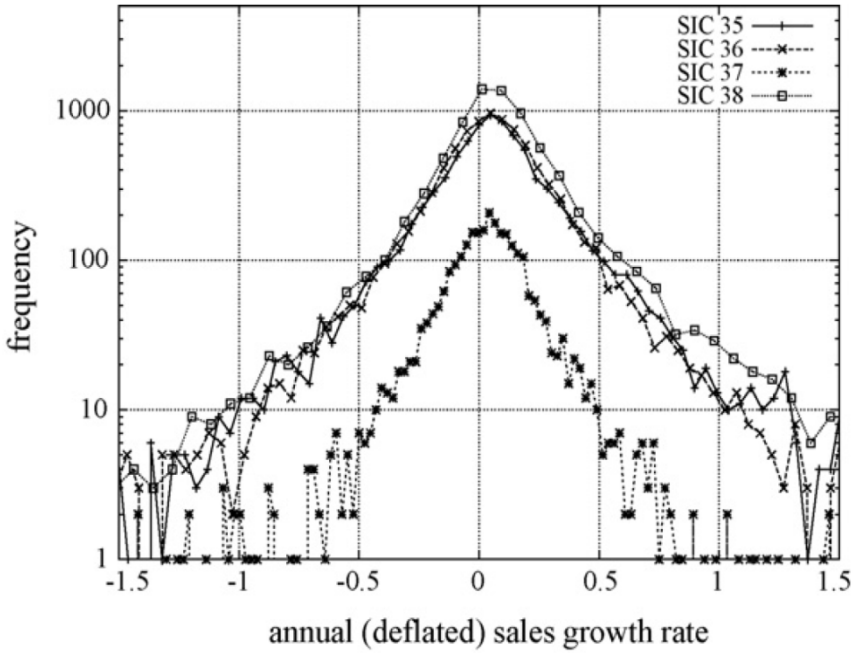
- Quantile regressions to identify heterogeneous effects of innovation along the growth rate distribution

- Coad & Rao 2008 RP; Stam & Wennberg, 2009 SBE; Goedhuys & Sleuwaegen, 2009 SBE; Holzl, 2009 SBE; Falk, 2012 SBE; Bartelsman, Dobbelaere & Peters 2014 ICC.

Innovation and growth

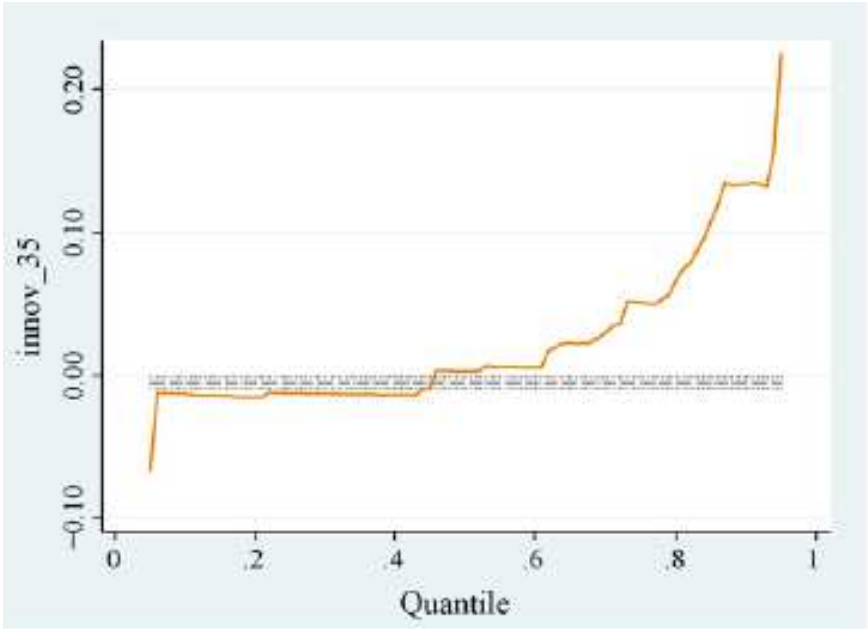
- The returns to innovation are very skewed

Growth rate distribution →



- Firm growth rates – most firms hardly grow at all, a handful of (innovative) firms experience fast growth

Quantile regression →



Coad Rao 2008 RP

Innovation and employment growth

- Are robots replacing humans?
- If anything, innovation is usually associated with employment growth at the firm-level

Innovation and employment: many substitution channels

(Spiezia & Vivarelli 2000, book chapter)

- Compensation via new machines;
- Compensation via decrease in prices;
- Compensation via new investments;
- Compensation via decrease in wages;
- Compensation via increase in incomes;
- Compensation via new products

Harrison, Jaumandreu, Mairesse & Peters (2014 IJIO)

Table 2
Firm-level employment effects of innovation.

		Displacement (prod. function)	Compensation (demand)		
R&D and innovation expenditures ⟹	Productivity trend / Process innovation	Productivity effect (<0): less labor for a given output (labor saving?)	Price effect (>0): cost reduction, passed on to price, expands demand	⟸	Depends on firm agents' behavior
	Product innovation	Productivity differences of the new product (>0 or <0)	Demand-enlargement effect (>0)	⟸	Depends on competition

- Process innovation reduces employment requirements for a given output
  - but the growth of demand for the old products tends to overcompensate these displacement effects
- New products do not reduce employment requirements
  - The growth of the demand for the new products is the strongest force behind employment creation
- Reallocation due to business stealing is estimated at a maximum of one third of the net employment created by product innovators
- The growth of employment originated from the market expansion induced by the new products can be as important as another third

R&D expenditure as part of the growth process

- R&D as a fixed % of sales?
- R&D workers as a share of employment?
- Profits reinvested into R&D?

- What are the causal relations?
- What is the lag structure?

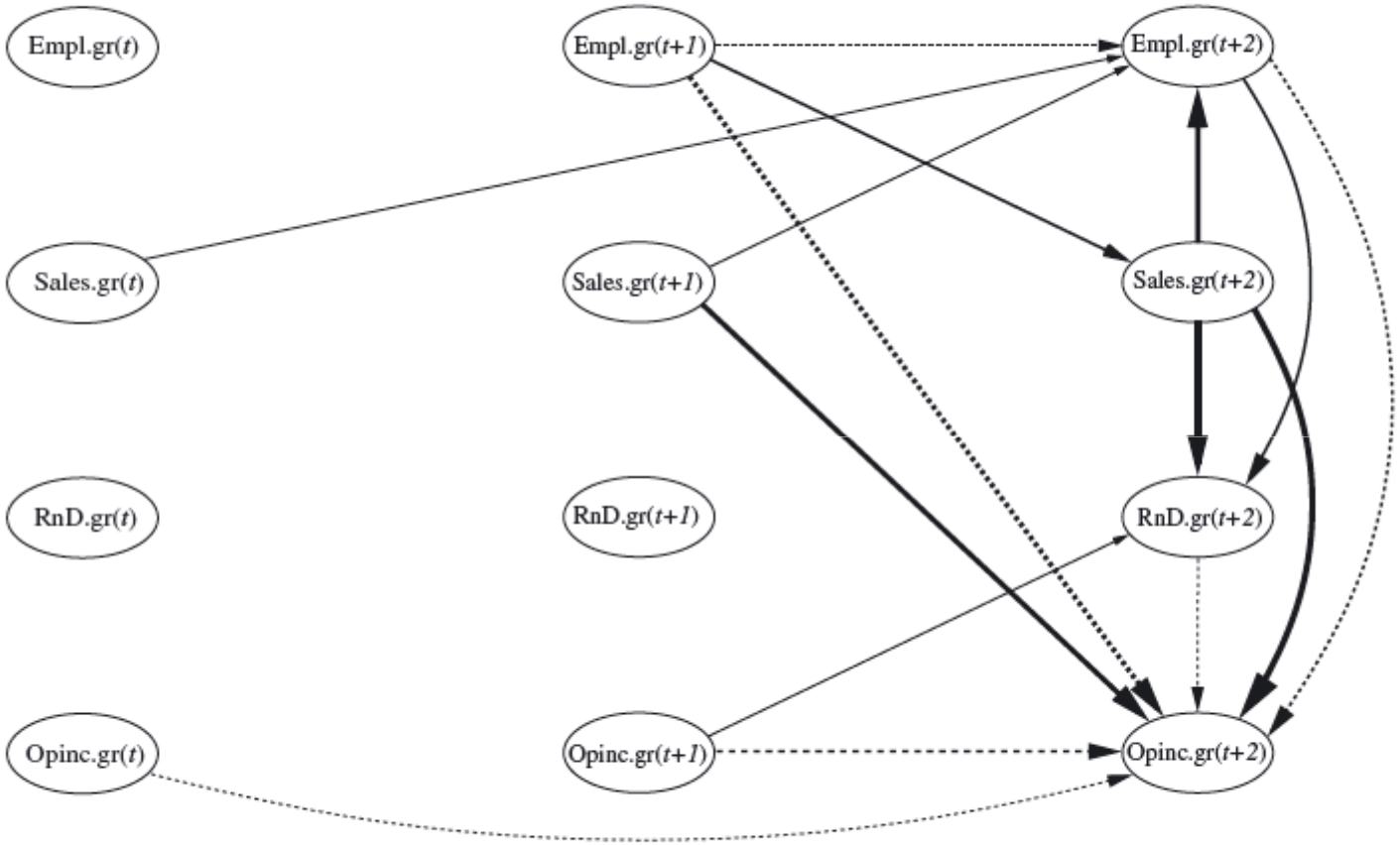


Figure 6. Plot of results from VAR-LiNGAM-estimates with two time lags. Solid arrows indicate positive effects, dashed arrows negative ones. Thick lines correspond to strong effects, thin ones to weak effects

- Moneta, Entner, Hoyer, Coad 2013 OBES

Yollies

(Veugelers & Cincera, 2010 BPB)

- ‘Yollies’ are Young Leading Innovators
- Young large firms (e.g. Amgen, Cisco, Google, Microsoft, Qualcomm and Sun)
- Page 5: “Almost all of the explanation for the lower R&D intensity of EU yollies can be found in a different sectoral composition”

‘True’ entrepreneurship

- Dennis (2011, JSBM, p99) defines entrepreneurship in terms of being innovative - **"entrepreneurship, by definition, is innovative."**
- Henreksson (2005: p439) and Reynolds et al (2005 p223) **define entrepreneurship in terms of subjective growth ambitions**
- Bottazzi & Da Rin (2002, EP, p235) and Avnimelech & Teubal (2006 RP; p1477) **confine 'start-ups' to high-tech industries**
- Audretsch (2007, p65) writes that **"entrepreneurship is the missing link between investments in new knowledge and economic growth."**

- The ideal-type or template for an entrepreneurial firm is to be innovative, more likely to be found in high-tech sectors, and also to grow fast

HGFs not over-represented in high-tech sectors

- Henrekson and Johansson (2010, SBE): HGFs are not over-represented in high-tech sectors.

- "A key assumption amongst policy-makers is that high growth firms (HGFs) are dominated by TBFs. [Technology Based Firms] ... The reality is that the representation of technology based firms in the population of HGFs is on a par with their proportion in the economy – and some studies suggest that they may even be under-represented."
    - Mason and Brown (2012, p2) Report on high-tech HGFs in Scotland

- Daunfeldt, Elert, Johansson (2014, this conference): Swedish HGFs are *less* frequent in high-R&D sectors

Innovation and HGFs: resolving the paradox

- Innovation is crucially important for HGFs
- HGFs slightly *under*-represented in high-tech sectors

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- More innovative within sectors?
  - IKEA, Walmart, Starbucks, etc. in low-tech sectors

Walmart

(Basker, 2007 JEP)

- p179: “By all accounts, technology and scale are at the core of Wal-Mart's advantage over its rivals. ... Wal-Mart's technological edge is in its logistics, distribution, and inventory control.”
- p191: “other chain retailers have either explicitly emulated Wal-Mart or, more broadly, changed their practices in ways that reflect Wal-Mart's influence: Target's vice chairman is quoted as saying that Target is ‘the world's premier student of Wal-Mart’”

Future research

- Growth trigger points? (E.g. diversification, internationalization)
- What is the most effective policy target: HGFs, declining firms, 'trundlers', or "sleeping gazelles" (Bornhall, Daunfeldt & Rudholm 2013)?
- Seek variables that vary *within* firms over time
- Test whether growing firms follow rules of thumb (e.g. R&D as X% of sales)