Innovation, R&D spillovers, and the variety and concentration of local production structure

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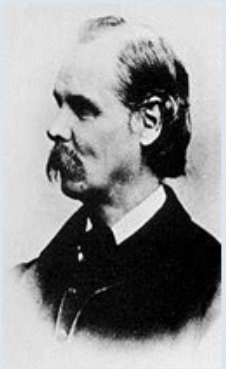
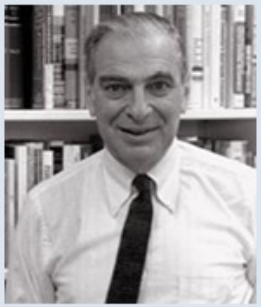
Introduction

- Stylised fact: Innovation is more geographically concentrated than production.
- Explanation: localised knowledge spillovers induce agglomeration and result to higher levels of innovation.
- Glaeser et al. (1992): Is this due to spillovers within or across industries? How does local production structure affect innovation?

Which local factors enhance innovation?

	Specialisation	Diversity
Concentration	   MAR externalities	X
Competition	 Porter externalities	 Jacobs externalities

What is the rationale behind these hypotheses?

- The theoretical foundation of the hypotheses is vague.
- Empirical results have been very mixed (Beaudry & Schiffauerova 2009, de Groot et al. 2009)
  - Model specification, measurement and methodological issues.
- Research questions:
  1. How does variety and concentration affect firms' innovation incentives and, subsequently, effective R&D and output?
  2. Under what conditions would we expect these hypotheses to hold?

A very concise literature review

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- Steurs (1995) seems to be the only paper that studies simultaneously both intra-industry and inter-industry spillovers between segmented markets
  - 2 industries that have 2 firms each
  - Inter-industry spillovers always increase effective R&D but they also reinforce the disincentive effect of intra-industry spillovers

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- Effective R&D,

$$X_{ij} = x_{ij} + \beta \sum_{k \neq i} x_{kj} + \sigma \sum \sum_{l \neq j} x_{il}, \ \beta, \sigma \in [0, 1],$$

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  decreases unit cost or increases demand.
- R&D cost is given by $\frac{1}{2}\gamma x_{ij}^2$, where γ is an inverse measure of R&D efficiency.
- $\pi_{ij} = (a - c + X_{ij} - Q_j)q_{ij} - \frac{1}{2}\gamma x_{ij}^2$, $i \in n, j \in m$.

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- Stage 1: Firms simultaneously choose their R&D outputs, x_{ij}, $i \in n, j \in m$.
- Stage 2: Firms simultaneously choose their final good outputs, q_{ij}, $i \in n, j \in m$ (Cournot competition).

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- Solve by backward induction for symmetric equilibria:

$$q_{ij}^* = \frac{a - c + X_{ij} - \sum_{k \neq i} X_{kj}}{n+1}, \; Q_j = \frac{n(a-c) + \sum_{i=1}^{n} X_{ij}}{n+1}.$$

$$x^* = \frac{2(a-c)(n-(n-1)\beta)}{\gamma(n+1)^2 - 2(n-(n-1)\beta)(n\sigma(m-1) + (n-1)\beta + 1)}.$$

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- Effective R&D: $X = (n\sigma(m-1) + (n-1)\beta + 1)x^*$.
- Equilibrium output levels: $q^* = \frac{a-c+X}{n+1}$ and $Q = nq^*$.

Comparative statics of effective R&D

Proposition

Effective R&D always increases with inter-industry spillover rate, σ, whereas the intra-industry spillover rate that maximises effective R&D is given by $\beta^* = \max\{\frac{1}{2}\frac{n-1-n\sigma(m-1)}{n-1}, 0\}$.

- Effective R&D is maximised for $\beta = 0, \sigma = 1$, but this may not be a likely situation.

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Proposition

If intra- and inter-industry spillover rates are equal, $\beta = \sigma = \phi$, then the common spillover rate that maximises effective R&D is given by $\phi^* = \frac{1}{2}\frac{n^2m-2n+1}{n^2m-nm-n+1} \in \left[\frac{1}{2}, 1\right)$, *with* $\frac{\partial\phi^*}{\partial m} > 0, \frac{\partial\phi^*}{\partial n} < 0$.

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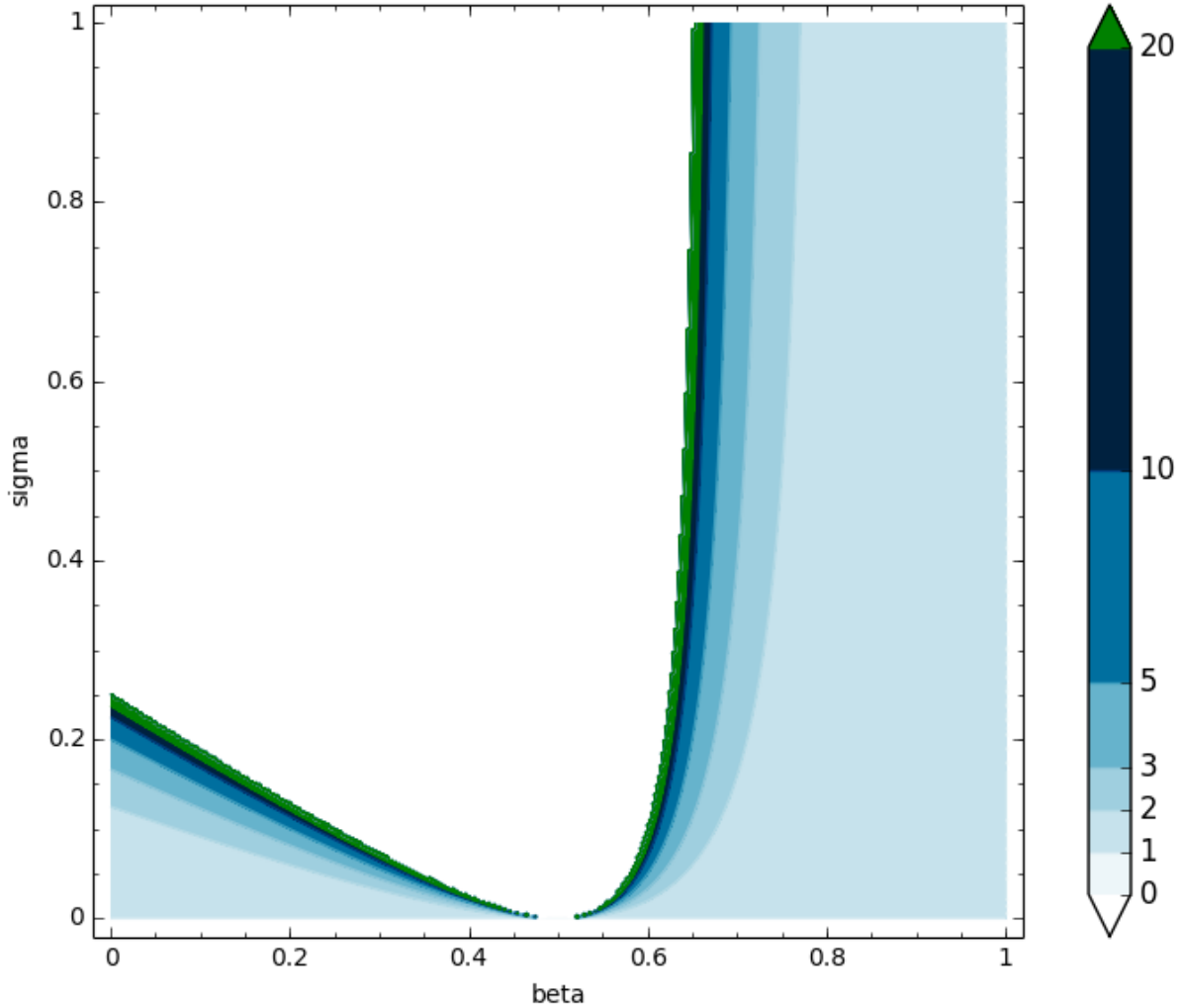
If $3\beta\sigma m + 4\beta^2 - 3\beta\sigma - 2\sigma m - 4\beta + 2\sigma + 1 \leq 0$, then effective R&D is always increasing in n. Otherwise, effective R&D is maximised for $n^* = \frac{\beta\sigma m + 4\beta^2 - \beta\sigma - 4\beta + 1}{3\beta\sigma m + 4\beta^2 - 3\beta\sigma - 2\sigma m - 4\beta + 2\sigma + 1}$ firms.

- The effect of n is conditional on β, σ and m.
- For example, a finite n^* if $\beta \geq 2/3$.

Optimal n

The number of firms that maximises X, when $m = 3$.



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- Conversely...(De Bondt et al. 1992)

Corollary

In the absence of inter-industry R&D spillovers or holding them constant, monopoly maximises effective R&D, expect when $\beta = \frac{1}{2}$*, in which case the number of firms has no effect.*

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- However, effective R&D may not always be the relevant performance measure.
- Typical measures: Economic growth (employment, wages), Productivity (output, value added), Innovation (patents, expenditures) (Beaudry & Schiffauerova 2009).

Comparative statics of total industry output

Proposition

Total industry output is increasing in m and σ, as well as in β when $\beta \leq \max\{\frac{1}{2}\frac{n-1-n\sigma(m-1)}{n-1}, 0\}$.

- This is simply because output is increasing in effective R&D.

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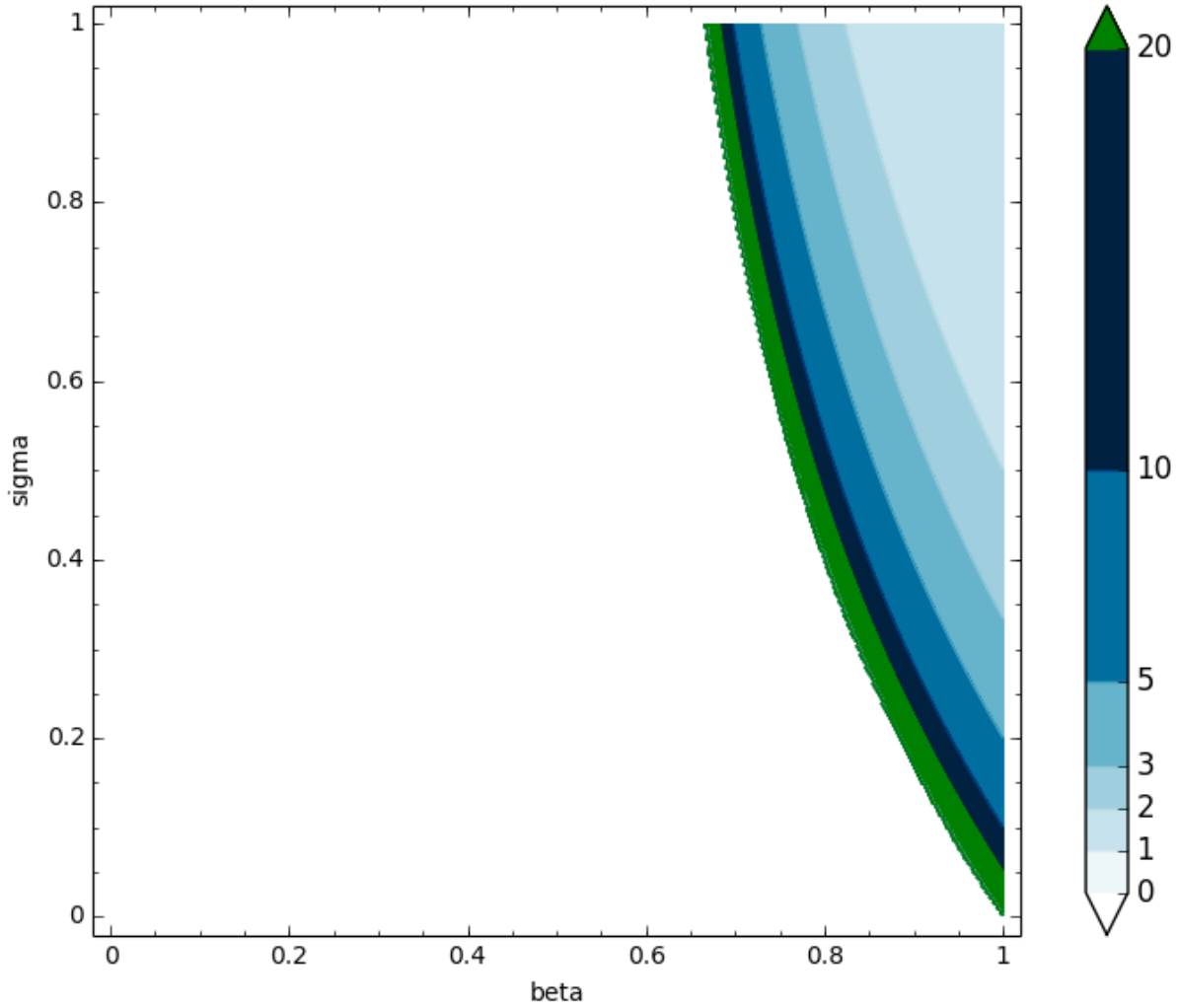
Proposition

Total industry output is increasing in n if $4\beta\sigma m + 6\beta^2 - 4\beta\sigma - 2\sigma m - 6\beta + 2\sigma + 2 - \gamma \leq 0$. *Otherwise, total industry output is maximised for* $n^* = \frac{2(2\beta^2-2\beta+\gamma)}{4\beta\sigma m+6\beta^2-4\beta\sigma-2\sigma m-6\beta+2\sigma+2-\gamma}$ *firms.*

- The effect of n is now also conditional γ.

Optimal n

The number of firms that maximises Q, when $m = 3, \gamma = 2$.



Comparative statics of total industry output

- Industry output can be increasing in n even when effective R&D is not.

Comparative statics of total industry output

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Corollary

In the absence of inter-industry R&D spillovers or holding them constant, total industry output is always increasing in n when $\gamma \geq 6\beta^2 - 6\beta + 2$ *and never maximised by monopoly.*

- The choice of the performance measure matters!

Conclusion

- Effective R&D and industry output are always increasing with variety (Jacobs externalities).
- However, the effect of competition depends on both spillover rates, variety, and, in the case of output, R&D efficiency.

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- Effective R&D and industry output are always increasing with variety (Jacobs externalities).
- However, the effect of competition depends on both spillover rates, variety, and, in the case of output, R&D efficiency.
- If variety is low, concentration typically increases effective R&D (MAR externalities).
- If variety is low, competition typically increases industry output (Porter externalities).

Conclusion

- The choice of dependent and independent variables matters.
- Dependent variable: Q and X, for example, may move in different directions.
- Independent variables: average local concentration vs. industry specific concentration.

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- The choice of dependent and independent variables matters.
- Dependent variable: Q and X, for example, may move in different directions.
- Independent variables: average local concentration vs. industry specific concentration.
- Which industries are related (Frenken et al. 2007)?
- The use of relative measures makes comparison difficult and has also affected the results (de Groot et al. 2009).
- A standard model, but does it capture the essence of these hypotheses (e.g. absorptive capacity, firm survival, creativity)?

Thank you!