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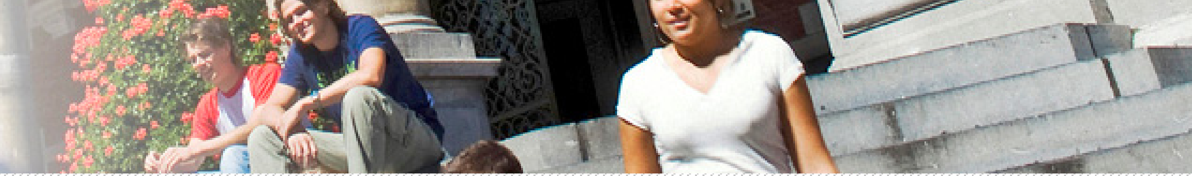

Addressing Keller's Critique: More on the Identification of Productive Technology Spillovers

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WIIW, March 25, 2010

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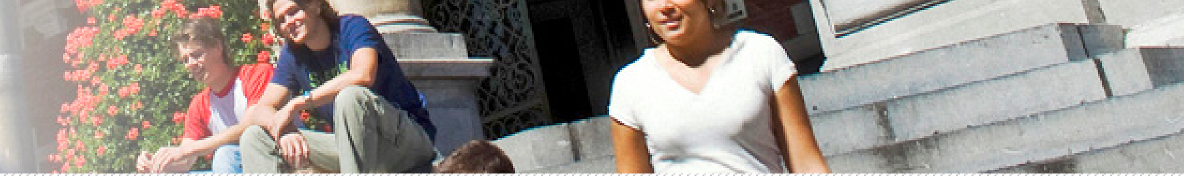
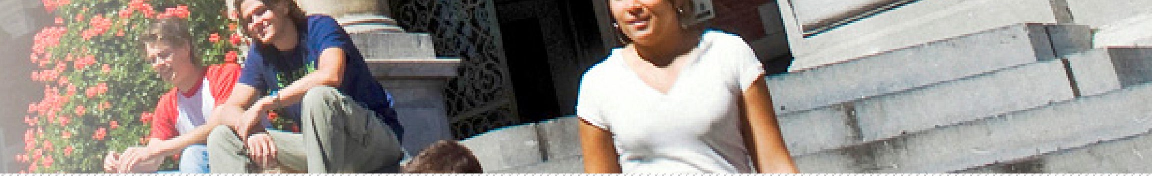


Objective

› Main question:
  - To what extent does innovative activity in an industry affect productivity growth in other industries?

› Academic challenge
  - Current estimation procedures indicate that productivity effects of technology spillovers are sizeable (see Hall, Mairesse and Mohnen, 2010), but main contributors and channels cannot be identified

› Contribution
  - alternative estimation approach (entropy econometrics) to provide more insights



Literature (I): Two Types of Spillovers

› Griliches (1979, *Bell Journal of Economics*):

1) "Rent spillovers":

   Product innovations lead to improved intermediate inputs and capital inputs. If deflation procedures do not fully capture the change in quality, part of the productivity effects will not be attributed to the innovating industry, but to downstream industries

2) "Knowledge spillovers":

   Knowledge has characteristics of a public good. Imitation can lead to positive productivity effects elsewhere, but idea-generation processes can also be enhanced by knowledge flows

Literature (II): Estimated Equations

- Extended Cobb-Douglas Production Function

$$Q_{it} = A(IR)_{it}^{\eta} K_{it}^{\alpha} L_{it}^{\beta} R_{it}^{\gamma}$$

- Output elasticities with regard to “own” R&D and “indirect” R&D can be estimated, as well as rates of return to these investments
- If zero depreciation is assumed, productivity growth can be related to current R&D intensities to estimate rates of return
- Bernstein and Nadiri (1988, *American Economic Review P&P*)
  - Include R&D intensities for each and every industry (in the right hand side of the equation) and estimate separate rates of return. Severe multicollinearity problems…

Literature (III): Weighting Schemes

- One spillover variable:

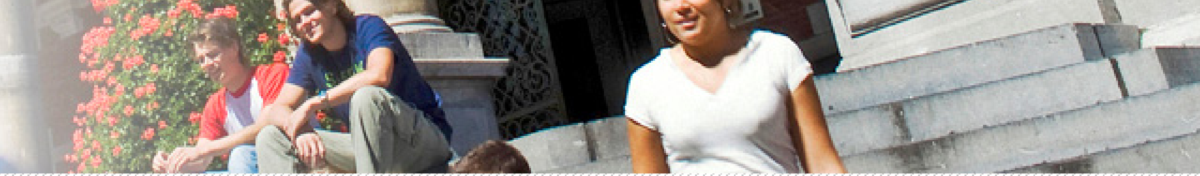
$$IRE_j = \sum_i \omega_{ij} RE_i$$

- Weights can be determined in several ways, emphasizing rent spillovers or knowledge spillovers through specific channels
  - Unit weights
  - Transaction input or output shares (Wolff, 1997)
  - Innovation shares (Scherer, 1982; DeBresson, 1994)
  - Patent information shares (Verspagen, 1997)
  - Technological proximity (Jaffe, 1986; Goto and Suzuki, 1989; Los, 2000)

Wolfgang Keller (*ESR*, 1997; *EER*, 1998):

"Weighting Schemes

Do not Matter!"

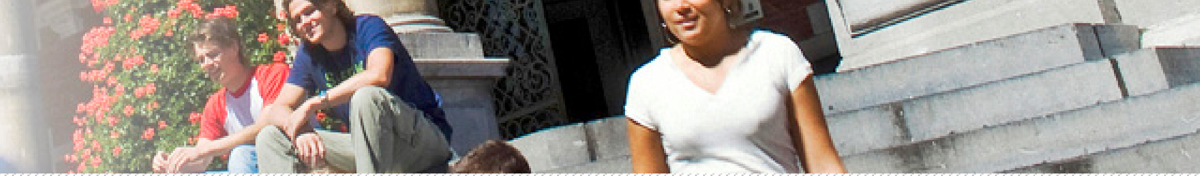


Alternative Approach (Intuition)

- Idea behind minimum cross entropy econometrics (Golan, Judge & Miller, 1996, Wiley):
  - Prior distribution for parameter values is fed into estimation procedure (based on theory, other empirical research, beliefs)
  - Estimates as close as possible to prior distribution, but in line with observations, and
  - Very general distribution for the error terms
  - Appropriate method for ill-behaved data (e.g. multicollinearity, few observations)

Minimum Cross Entropy Approach (I)

- $y_i = \beta x_i + \varepsilon_i$ (can be generalized to multivariate case)
- The estimator β^* can take on K values $(b_1,\ldots,b_K)$, with unknown probabilities $\mathbf{p}=(p_1,\ldots, p_K)$. Non-sample information about $\mathbf{p}$ in prior distribution $\mathbf{q}=(q_1,\ldots, q_K)$.
- The random disturbances ε_i can take on R values $(e_1,\ldots,e_R)$ with unknown probabilities $\mathbf{w}=(w_1,\ldots, w_Q)$. Prior for $\mathbf{w}$ is called $\mathbf{u}$
- Linear model becomes $\mathbf{y}=\mathbf{xb'p} + \mathbf{Ew}$



Minimum Cross Entropy (II)

Minimize (over **p** and **w**):

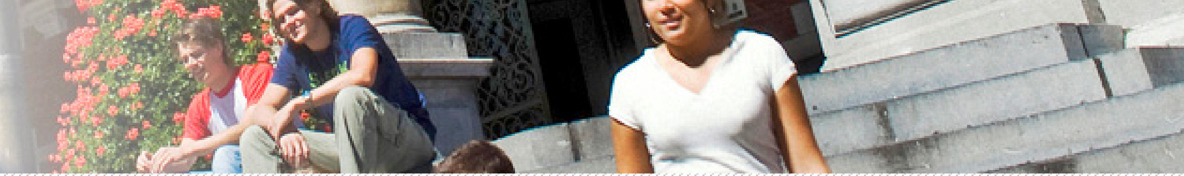
$$I = \sum_k p_k \ln(p_k/q_k) + \sum_r w_r \ln(w_r/u_r)$$

subject to:

(1) $\sum_k x_i b_k p_k + \sum_r e_{ir} w_{ir} = y_i$ (for i = 1, ..., N)

(2) $\sum_k p_k = 1$

(3) $\sum_r w_{ir} = 1$ (for i = 1, ..., N)



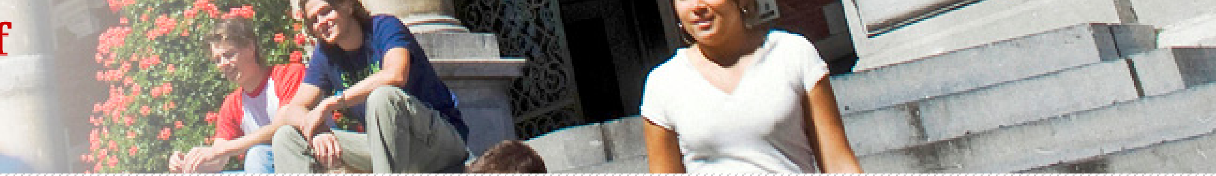
Minimum Cross Entropy (III)

Result of non-linear minimization problem:

$\beta^* = \sum_k b_k p^*_k$

If observations do not contain information, estimate will be identical to expected value implied by prior: $p^*_k = q_k$

Estimated value is bound by minimum and maximum values of prior distribution. Quite often: estimates not sensitive to wide bounds.



Minimum Cross Entropy (IV)

Issue: how to set prior distribution of disturbance terms? Common approach: symmetrical around 0, bounds equal to $-3\sigma_y$ and $+3\sigma_y$

Hypothesis testing possible (Golan, 2001, *J of Ectrics*):

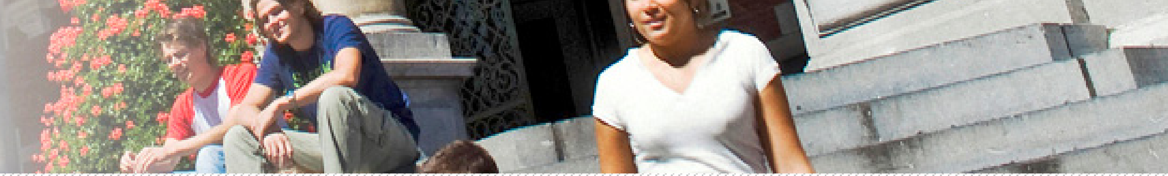
H_0: $\beta=\sum_k b_k q_k$ Test statistic: $\sum_k (p^*_k - q_k)^2/q_k \sim \chi_1^2$

Appropriate method for ill-behaved data (e.g. multicollinearity, few observations)

Regression Equation and Data

$$\left(\frac{\hat{Q}}{L}\right)_{ict} = \sum_{j=1}^{18} \beta_{ij}^{D} \frac{RE_{jct}}{Q_{ict}} + \varepsilon_{ict} \qquad \text{for i=1, ..., 18}$$

- Three subperiods: 1976-1983, 1984-1991, 1992-1999
- Data for Denmark, Finland, France, Germany, Ireland, Italy, Japan, The Netherlands, Spain, Sweden, the UK and the US
- 18 manufacturing industries, limited by availability of OECD R&D data (STAN ANBERD, in current prices)
- Labor productivity growth rates (in real terms) and value added figures (in current values) taken from EUKLEMS dataset
- Regressions run by industry!



Reference: OLS Estimates

- Condition numbers: in range 46 – 125 (>30 critical)
- R^2 in the range [0.42, 0.78]
- Sometimes very high and low point estimates. Rates of return to R&D in other industries of more than 3800% and less than minus 2300%
- Own R&D significant (at 10%) only for “rubber and plastics”, “office and computing machinery”, and “radio, TV and communication equipment”; Estimated rate of return to own R&D in “pulp, paper and printing” -137%

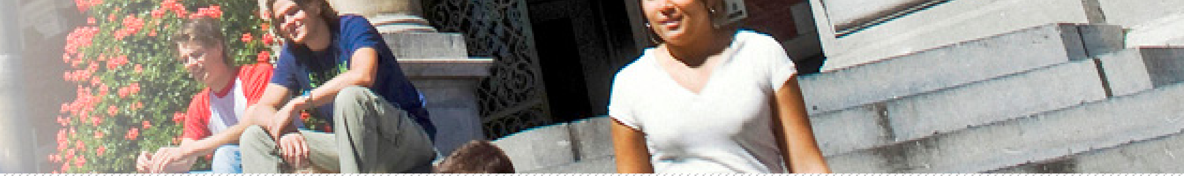
Minimum Cross Entropy: Setup

- Support vector for ALL rates of return: [0, 0.5, 1]
- Prior distribution [0.999, 0.0005, 0.0005]
- Expected rate of return under prior: 0.075%

- No constant term or time dummies included, i.e. all labor productivity growth is assumed to be driven by R&D activity
- Correlation coefficients used as goodness of fit indicators

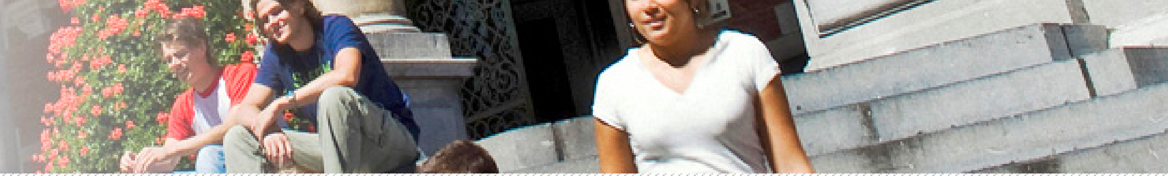
Structure of Results

Sending Industries ↓					
Receiving Industries →	1	2	3	4	5 Rate of return on “own” R&D
1					
2					
3					
4					
5					



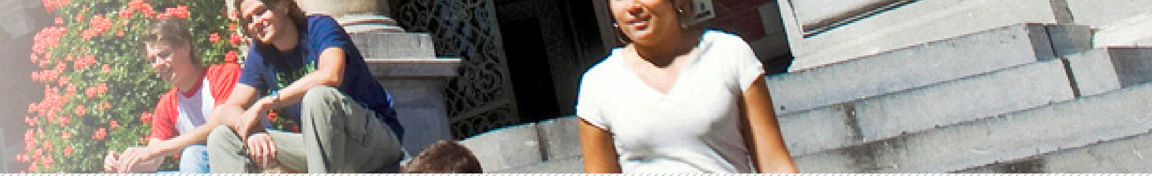
Minimum Cross Entropy: Results

- Own R&D significantly positive for 5 out of 18 industries. Range: 8% - 72%. Highest returns for “electronics” and “computers”
- 6% of off-diagonal cells significantly positive, 10% for spillovers generated by medium-tech and high-tech industries
- Most general generator: “chemicals”, with positive spillovers to “food products”, “plastics”, “basic metals”, “computers” and “electronics”
- Most general receiver: “computers”
- High values for “chemicals to computers” (58%), “instruments to computers” (59%), “electronics to paper” (66%), “food to instruments” (83%)



Sensitivity Analyses (I)

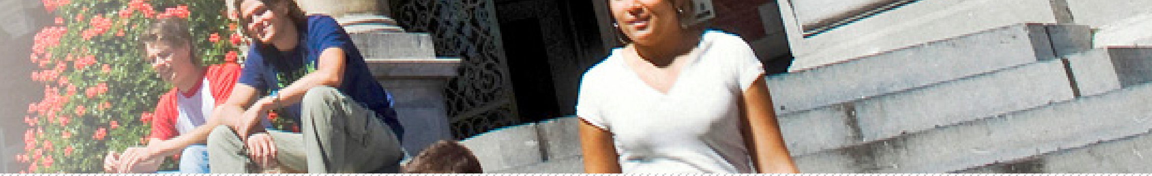
- Wider support vector: [0, 1.0, 2.0]
  - No qualitative changes. Rate of return to “own” R&D in “computers” goes up from 65% to 85%
- Inclusion of intra-industry spillovers from abroad
  - Support [-1.0, 0, 1.0]; Negative effects, although insignificant, found for “computers”, “electronics” and “cars”;
  - Explanatory power increases considerably
  - Rate of return on “own” R&D in “chemicals” drops from 27% to 14%.
  - Implausibly strong spillovers from baseline regression disappear



Sensitivity Analyses (II)

› Inclusion of capital intensity growth (some industries had to be aggregated)

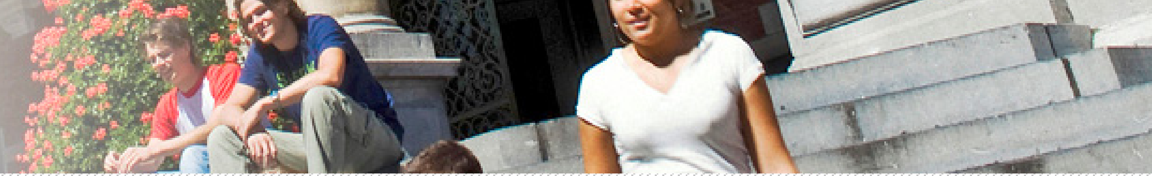
- Prior distributed uniformly [0, capital share, 2*capital share]
- Goodness-of-fit superior to baseline
- Estimates for capital elasticity often very different from shares in value added
- "Own" R&D less productivity-enhancing in "chemicals" (9% vs. 27%)
- Most rates of return are somewhat lower
- High-tech equipment: high rate of return to "electronics" R&D
- Qualitatively, results are similar



Sensitivity Analysis (III)

› Correcting labor productivity growth for changes in the skill composition of the labor force
  - Left-hand side variable changed
  - No substantial changes
  - In comparison to baseline estimates, some implausible estimates disappear (could be related to smaller sample)

› All in all: results are rather robust, but omitted variables problem cannot solved by Minimum Cross Entropy econometrics



To Be Done...

- Dynamic specification, using full panel dataset (along the lines of Kao et al., 1999, taking cointegration into account)
- Thinking about specification in terms of elasticities (first results available), theoretical justification maybe weak
- Identification of productive spillovers to services industries