Research and Development: The search for prices

Discussion remarks

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Outline of Discussion

- Papers on turnover and prices – discussion points
  - Comparison of turnover and price statistics
  - Treatment in the national accounts
  - Classification issues
  - Scope of who produces R&D
  - Own/purchased, internal/external R&D
  - Turnover and R&D surveys
- Conclusions:
  - Using purchased R&D to proxy own R&D is risky
  - Other second best alternatives
- Starting from scratch – an alternative approach to measurement and data collection

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Papers on turnover and prices

- Classification systems
  - NACE Rev 2 – 72
    - Norway, Netherlands, Germany, Hungary
  - NAICS 5417
    - United States

Comparison of turnover statistics

Concept	Norway	Netherlands	Germany	Hungary	US
% of total turnover	7.2 billion Euro	1.8% - 1.9%	0.4%	< 0.2%	2.8%
R&D by type					
Nat Sci/Eng (72.190)	81.1%		93%	72%	95% NAICS 54171
Social Sci (72.200)	18.7%		7%	16%	5% NAICS 54172
Biotech (72.110)	0.2%			12%	

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Comparison of turnover statistics

Concept	Norway	Netherlands	Germany	Hungary	US
% of R&D by firm size					
Small	10% (0-9)			~ 20% (0-9)	
Medium	18% (10-49)				
Large	72% (50+)		67.4% (> 10 million euro)		
Ratio of own to total R&D	75%	59.4% (table 7)	80%		66%

Comparison of turnover statistics

Concept	Norway	Netherlands	Germany	Hungary	US
Source of R&D	> 10 employees				
Business	43.0%	53%	70%	48.3%	74.7%
Manuf		38.8%			
Services		12.4%			
Governmt				41.8%	
Academic/ Universities	21.6%	34.7%	30%		25.3%
Non-profit				0.6%	
Foreign	35.4%			9.3%	
Research Institutions		12.1%			

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Public funding of R&D

Country	Concept	Statistic
Norway	Public subsidies in NACE 72 as a percent of total operational income in that sector	25%
Germany	Public Subsidies as share of total receipts (turnover + other income + subsidies) – NACE 73	14.5%

Treatment in the national accounts

- Is there an explicit goal of treating R&D as an investment expense in the national accounts?

Classification issues

- The NACE and NAICS codes are broadly similar but there are underlying differences in terms of what is viewed as being included in these industries;
  - Norway notes that NACE 72.200 includes Business and Management Consulting, which is not viewed as R&D in the U.S.

- Another problem is a lack of product line data although a product line classification system exists in NACE Rev 2 - Germany

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Scope issues

- The providers of R&D, who influence market supply/demand and hence prices, are often outside the scope of traditional PPIs.
  - Purchases of R&D from foreign companies, academic centers, not-for-profit companies.

- There exists significant public subsidization of the industry, which may distort private sector pricing

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Scope issues

- Turnover surveys do not capture transactions received by firms producing R&D as a secondary output, that is firms outside of NACE 2 or NAICS 5417
- Question: Do we know the size of R&D that is produced outside of NACE 72 or NAICS 5417?
- Own R&D is large relative to purchased R&D

Pricing methodology

- R&D is a unique, non-repeatable activity
  - U.S. similar to pricing challenges in accounting and financial management
  - U.S. national accounts uses margin pricing for R&D, inconsistent with the non-repeatable nature of R&D
  - Germany notes the need to conduct a pilot to see if there are homogeneous and/or repeatable R&D activities as a precursor to the development of a price index.

- Purchased R&D measurement
  - Hungary pilot / Will they find repeatable R&D? / Also, pilot may inform product lines that all papers say is missing

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Conclusions: Caution

- Own R&D
  - non-marketed, no observed prices
  - Using purchased R&D as a proxy for own R&D is problematic
  - Supply/demand, labor skill, type of R&D may differ significantly between OWN and purchased R&D

- Indirect measures related to labor costs and returns to investment may be second best
  - Germany - Price indexes for labor costs and price indexes for investment in buildings and in machinery.

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Starting from scratch

An Alternative approach to
developing a price index for R&D

Starting from scratch – an alternative approach to measurement and data collection

- View own/internal R&D as productivity enhancing in a multi-factor productivity approach

- Use the traditional growth accounting model in productivity to calculate rate of change of multi-factor productivity in real terms as the residual between rate of change of real output and the rate of change of factor inputs weighted by factor shares.

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Starting from scratch – an alternative approach to measurement and data collection

- Adopt the multi-factor productivity approach just described at the establishment level and aggregate up to the sector level
- At each firm, recover the price index for productivity enhancing activities as an implicit price deflator.
- Isolate the portion of this implied price index attributable to R&D.

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Starting from scratch – an alternative approach to measurement and data collection

- Examine the data collection requirements of this approach:
  - Need for repeat observations of prices and quantities for both output and factor input **at the establishment level.**
- Assertion: This data collection approach permits an alternative way to calculate labor and multi-factor productivity that permits use of definitions of service output in SPPIs.

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Start with a simple model to fix concepts

Output equation – Cobb Douglas form:

$$Q = A\,K^{\alpha 1}\,L^{\alpha 2}\,M^{\alpha 3}$$

Profit maximization condition:

$$\pi = P\,A\,K^{\alpha 1}\,L^{\alpha 2}\,M^{\alpha 3} - P_K K - P_L L - P_M M$$

$$\frac{\partial \pi}{\partial L} = \alpha_2 P\,A\,K^{\alpha 1}\,L^{\alpha 2 - 1}\,M^{\alpha 3} - P_L = 0$$

Profit maximization condition: Similar results for K, M

$$MP_L = \alpha_2 \, A \, K^{\alpha 1} \, L^{\alpha 2 - 1} \, M^{\alpha 3} = P_L / P$$

$$\alpha_2 \, Q/L = P_L / P$$

$$\alpha_2 = \frac{(LP_L)}{PQ} = Labor\ Share\ S_L$$

Multi-factor Productivity growth accounting framework

$$Q = A\, K^{\alpha 1}\, L^{\alpha 2}\, M^{\alpha 3}$$

$$\ln Q = \ln A + \alpha 1 \ln K + \alpha 2 \ln L + \alpha 3 \ln M$$

$$\partial \ln Q = \partial \ln A + \alpha 1\, \partial \ln K + \alpha 2\, \partial \ln L + \alpha 3\, \partial \ln M$$

$$\partial \ln \mathrm{A} = \partial \ln Q - \left(\alpha 1\, \partial \ln K + \alpha 2\, \partial \ln L + \alpha 3\, \partial \ln M\right)$$

$$\alpha_1 = \frac{(KP_K)}{PQ} \qquad \alpha_2 = \frac{(LP_L)}{PQ} \qquad \alpha_3 = \frac{(MP_M)}{PQ}$$

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Full Model with internal R&D and purchased business services included:

$$Q = f(K(1), L(1), M(1), BS(1), RD)$$

$$RD = g(K(2), L(2), M(2), BS(2))$$

$$Q = A(1)\, K(1)^{\alpha 1}\, L(1)^{\alpha 2}\, M(1)^{\alpha 3} BS(1)^{\alpha 4}$$

$$A(2)\, K(2)^{\alpha 5}\, L(2)^{\alpha 6}\, M(2)^{\alpha 7} BS(2)^{\alpha 8}$$

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Using R&D Labor as an example, Profit Maximization requires:

$$\alpha_6 = \frac{(L(2)P_{L2})}{PQ} = Labor\ Share\ S_{L2}$$

Multi factor productivity

$$\begin{aligned}\partial\, ln\, A(1) + \partial \ln A(2) = \partial \ln Q \\ -(\alpha 1\, \partial \ln K(1) + \alpha 2\, \partial \ln L(1) + \alpha 3\, \partial \ln M(1) + \alpha 4\, \partial \ln BS(1) \\ + \alpha 5\, \partial \ln K(2) + \alpha 6\, \partial \ln L(3) + \alpha 7 \ln M(2) + \alpha 8) \ln BS(2))\end{aligned}$$

What is relationship between multi-factor productivity and calculating a price index for R&D?

- $\partial \ln A(1) + \partial \ln A(2)$ is the overall impact on real output of all productivity enhancing activities.
- What is needed is the price index associated with the term $\partial \ln A(2)$
- Method
  - Look at the data needed to calculate this term, derive an associated nominal value, and an implicit price index.
  - Use regression methods to isolate the R&D price index

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Discrete approximations

$$\partial \ln Q = \frac{Q_{t+1} - Q_t}{Q_t}$$

$$\partial \ln Q = \frac{\dfrac{P_{t+1}Q_{t+1}}{P_{t+1}/P_t} - P_tQ_t}{P_tQ_t}$$

$$\partial \ln K(2) = \frac{K(2)_{t+1} - K(2)_t}{K(2)_t}$$

$$\partial \ln K(2) = \frac{\dfrac{P_{k2,t+1}K(2)_{k2,t+1}}{P_{k2,t+1}/P_{k2,t}} - P_{k2,t}K(2)_t}{P_{k2,t}K(2)_t}$$

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Data collection, estimating the R&D price index and productivity

- Data collection requirements – turnover perspective: At the sector level, for each product/service line or across all products/services, collect:
  - Total revenue at two points in time
  - Price relative (price index at the two points in time)
  - For each input, total input costs and input price relatives at two points in time
    - Labor, capital , business services related and not related to R&D

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Data collection, estimating the R&D price index and productivity

- Data collection requirements – Producer price perspective
  - At initiation
    - Collect revenue by product/service line and base price
    - Collect costs of the inputs used in the production of the products/lines of service
  - Visit the establishment a second time
    - Collect revenue by product/service line and reprice
    - Collect updated costs of the inputs used in production and the price relatives of the inputs

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Data collection, estimating the R&D price index and productivity

- How do you estimate the price index for R&D?
  - Left hand side of the equation is the change in the real value of output resulting from R&D and other productivity enhancing activities: $\partial \ln A(1) + \partial \ln A(2)$
  - By construction the previous equations for the right hand side can be easily converted to derive the value of nominal change.
  - One can use these two values to calculate the implicit price deflator associated with the change in output resulting from all productivity enhancing activities

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Data collection, estimating the R&D price index and productivity

- Can you isolate the implied price deflator for R&D activities – that is, the implicit price deflator associated with $\partial \ln A(2)$?

- Idea: Regress the implied price deflators across establishments on the values of labor, capital, materials and business services

Data collection, estimating the R&D price index and productivity

- $$Define\,IPI_i = \frac{Nominal\,(\partial \ln A(1) + \partial \ln A\,(2))}{Real\,(\partial \ln A(1) + \partial \ln A(2))}$$

$$Regress\,IPI_i = \beta_0 + \beta_1 K_i(1) + \beta_2 L_i(1) + \beta_3 M_i(1) + \beta_4 BS_i(1)$$

$$+ \beta_5 K_i(2) + \beta_6 L_i(2) + \beta_7 M_i(1) + \beta_8 BS_i(2)$$

Data collection, estimating the R&D price index and productivity

- Estimate the impact of a change in R&D capital, labor, materials, or purchased business services on the change in the Implicit Price deflator as the sum of:

$$\beta_5 + \beta_6 + \beta_7 + \beta_8$$

- Starting a base period value of 100, the value of the IPI for R&D in subsequent periods will be the sum of these regression parameters that are updated each period.

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What are the implications for measuring productivity?

- Use the products/lines of service drawn at sample initiation of each establishment
  - That is, define service output using PPI methods
- Collect repeated observations at those establishments on revenue by product/service line and input costs
- Estimate labor and multi-factor productivity at each establishment – for example, the ratio of output to labor.

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What are the implications for measuring productivity?

- Calculate sectoral productivity as the rolled up average of the productivity estimates across establishments.
- Essentially this is defining sectoral productivity as the average of weighted ratios rather than the ratio of averages as it is currently done in traditional productivity estimates.
- This allows you to use the definition of of output in SPPIs to calculate productivity directly.

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