Empirical studies of innovation
Lecture 2

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Jena Summer School
2012
Topics in this lecture

1. Using market value to measure returns to R&D
2. Measuring R&D spillovers using production functions
3. Intro to the use of innovation survey data
4. The CDM model
Market value model

• Assumes market efficiency

• Two versions
  – Theoretical - value function from firm’s dynamic program as a function of state variables (capital, R&D, etc.)
  – Hedonic - value of a set of goods that have a lower-dimensional vector of characteristics – yields a measure of current shadow value of the assets (conditional expectation, not stable over time)
Hedonic regression for market value

\[ V_{it}(A_{it}, K_{it}) = b_t [A_{it} + \gamma K_{it}] \]

Non linear: \[ \log(V_{it}/A_{it}) = \log Q_{it} = \log b_t + \log(1+\gamma_t K_{it}/A_{it}) \]

Linear approx.: \[ \log Q_{it} = \log b_t + \gamma_t K_{it}/A_{it} \]

Interpretation:

\( Q_{it} = V_{it}/A_{it} \) is Tobin’s \( q \) for firm \( i \) in year \( t \)

\( b_t = \) overall market level (approximately one).

\( \gamma_t = \) relative shadow value of \( K \) assets

(\( \gamma = \text{unity} \) if depreciation correct, investment strategy optimal, and no adjustment costs \( \Rightarrow \) no rents).
Summary of past results

• Market value positively related to R&D
• Range of estimates for shadow value
  – R&D expenditure coefficient: ~1.5 to 8 or 9
  – R&D stock coefficient: 0.2 to 2
• Wide variability over time and industry
• Substantial variability in specification, making comparisons difficult:
  – Intangibles, patents, trademarks
  – Leverage, sales growth, market share
Extracting depreciation rate

- Strong assumptions:
  - Equilibrium in R&D
  - Market efficiency
  - Negligible adjustment costs
  - Only mismeasurement in $K$ is using the wrong depreciation rate to construct it

$$\Rightarrow \hat{\delta}_{it} = \frac{(.15 + g_{it})}{\hat{\gamma}_t} - g_{it}$$
## Market value estimates – US manufacturing sector

<table>
<thead>
<tr>
<th>Period</th>
<th>K/A Coefficient</th>
<th>(s.e.)</th>
<th>Median depreciation</th>
<th>(s.e.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974-1978</td>
<td>0.398</td>
<td>0.028</td>
<td>42.8%</td>
<td>9.2%</td>
</tr>
<tr>
<td>1979-1983</td>
<td>0.573</td>
<td>0.028</td>
<td>30.3%</td>
<td>4.9%</td>
</tr>
<tr>
<td>1984-1988</td>
<td>0.362</td>
<td>0.029</td>
<td>54.0%</td>
<td>9.0%</td>
</tr>
<tr>
<td>1989-1993</td>
<td>0.352</td>
<td>0.033</td>
<td>55.3%</td>
<td>7.8%</td>
</tr>
<tr>
<td>1994-1998</td>
<td>0.507</td>
<td>0.040</td>
<td>37.8%</td>
<td>5.5%</td>
</tr>
<tr>
<td>1999-2003</td>
<td>0.745</td>
<td>0.044</td>
<td>21.8%</td>
<td>2.9%</td>
</tr>
</tbody>
</table>
Estimated depreciation of R&D for selected sectors

<table>
<thead>
<tr>
<th>Period</th>
<th>Drugs &amp; medical instruments</th>
<th>Computers &amp; electronics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974-1978</td>
<td>9.9% (4.2%)</td>
<td>31.9% (8.1%)</td>
</tr>
<tr>
<td>1979-1983</td>
<td>19.6% (7.9%)</td>
<td>50.1% (14.5%)</td>
</tr>
<tr>
<td>1984-1988</td>
<td>5.8% (3.1%)</td>
<td>88.1% (27.6%)</td>
</tr>
<tr>
<td>1989-1993</td>
<td>20.6% (6.6%)</td>
<td>51.3% (8.6%)</td>
</tr>
<tr>
<td>1994-1998</td>
<td>18.8% (5.6%)</td>
<td>51.2% (11.6%)</td>
</tr>
</tbody>
</table>

Differences across sectors are plausible, but there is high variability over time.
Returns to R&D

• Private
  – firms do R&D and improve their products and processes
  – have higher sales and/or lower costs
  – returns are amount of additional profit achieved per unit of R&D spending
  – Add up across firms, obtain net private returns

• Social
  – firms, universities, PROs in the economy do R&D
  – achieve higher profits and other improvements to health, defense, the environment
  – real output increases more than inputs of capital, labor, materials
  – returns are increase in welfare due to aggregate R&D

Why are these two measures different? Nonpecuniary spillovers
R&D Spillovers

• From firm to firm in the same or related industries.
  – Reverse engineering
  – Migration of scientists and engineers (e.g., within Silicon Valley)
  – Lower cost imitation of innovative products

• From firms to downstream customers
  – Improved capital equipment (e.g., computers in financial services)
  – Consumer electronics, healthcare (e.g., CT scanner)
  – Much of this welfare increase captured by pricing – flows to consumers
R&D Spillovers (cont.)

• From govt. and university research to firms
  – commercial product improvements from defense R&D
    (e.g., airframes, satellites)
  – scientific base for innovation (e.g., biotech)
• From govt. and university research to consumers
  – via new industrial products
  – directly (environment, healthcare, etc.)

Conclusion: some of the benefits to R&D go to individuals and firms that do not bear its cost.
R&D spillover schematic

Industry 1

Firm

User feedback

Basic science, defense R&D

Govt, Univ, PRO research

Related knowhow, scientific personnel

Industry 2

User feedback

Firm

Firm

Consumers

Lower prices, better products

Firm

Firm

Firm

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Some illustrative examples

• Internet
  – packet-switching technology funded by the U.S. Department of Defense.
  – protocols of the worldwide web conceptualized and developed by researchers on the payroll at CERN

• Technology underlying biotechnology
  – developed jointly by researchers at the UC San Francisco and Stanford University
  – based on earlier double helix work at Cambridge University

• Bell Labs – transistor, radio astronomy

*How do we measure the returns to these R&D efforts?*
Estimating spillover returns

• Usually estimate \( \text{social} = \text{private} + \text{spillover} \)
• Construct measures of flows from other sectors or countries based on trade, patent citations, inter-industry investments, etc.
• Weight external R&D measure using these flows
• Include in a productivity regression along with own R&D
## Industry estimates of returns

<table>
<thead>
<tr>
<th>Authors</th>
<th>Sample</th>
<th>Years</th>
<th>Private returns</th>
<th>Social returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Griliches-Lichtenberg (1984a)</td>
<td>US industries</td>
<td>1959-78</td>
<td>11% to 31%</td>
<td>50% to 90%</td>
</tr>
<tr>
<td>Odagiri (1985)</td>
<td>Japan industries</td>
<td>1960-77</td>
<td>157% to 315%</td>
<td>-606% to 734%</td>
</tr>
<tr>
<td>Sterlacchini (1989)</td>
<td>UK industries</td>
<td>1945-83</td>
<td>12% to 20%</td>
<td>15% to 35%</td>
</tr>
<tr>
<td>Goto-Suzuki (1989)</td>
<td>Japan industries</td>
<td>1978-83</td>
<td>26%</td>
<td>80%</td>
</tr>
<tr>
<td>Bernstein (1989)</td>
<td>Canada industries</td>
<td>1963-83</td>
<td>24% to 47%</td>
<td>29% to 94%</td>
</tr>
<tr>
<td>Bernstein-Nadiri (1989)</td>
<td>US industries</td>
<td>1965-78</td>
<td>7%</td>
<td>9% to 13%</td>
</tr>
<tr>
<td>Mohnen-Lepine (1991)</td>
<td>Canada industries</td>
<td>1975, 77, 79, 81-83</td>
<td>56% (5% to 275%)</td>
<td>30% (2% to 90%)</td>
</tr>
<tr>
<td>Wolff-Nadiri (1993)</td>
<td>US industries</td>
<td>1947, 58, 63, 67, 72,77</td>
<td>11%-19%</td>
<td>0%-14%</td>
</tr>
<tr>
<td>Bernstein-Yan (1997)</td>
<td>Canada industries</td>
<td>1964-82</td>
<td>17.2%</td>
<td>62% to 183%</td>
</tr>
<tr>
<td>Japan industries</td>
<td>1964-82</td>
<td>17.4%</td>
<td>9% to 56%</td>
<td></td>
</tr>
<tr>
<td>Bernstein (1998)</td>
<td>Canada industries</td>
<td>1962-89</td>
<td>12.8%</td>
<td>19% to 145%</td>
</tr>
<tr>
<td>US industries</td>
<td>1962-89</td>
<td>16.4%</td>
<td>28% to 167%</td>
<td></td>
</tr>
<tr>
<td>Bernstein-Mohnen (1998)</td>
<td>Canada industries</td>
<td>1962-86</td>
<td>44.0%</td>
<td>47%</td>
</tr>
<tr>
<td>Japan industries</td>
<td>1962-86</td>
<td>47%</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Griffith-Redding-van Reenen (2004)</td>
<td>12 OECD countries/11 industries</td>
<td>1974-90</td>
<td>47% to 67%</td>
<td>57% to 105%</td>
</tr>
</tbody>
</table>

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Conclusions from this literature

• In general, the social returns to most R&D investments are greater than the private returns.
  – Gap varies by industry and type of research
  – some R&D investments have high private returns and do not need to be subsidized.

• Some kinds of public research spending (academic science; advanced training) have very high social returns, some of them geographically concentrated.

• R&D process is highly uncertain; probability of success not sensitive to fine financial tuning; project choice is difficult, for firms or government agencies.
Some remaining questions

• Quality-adjusted price deflators and their effect on measured R&D contribution.
• How do we target the marginal project? If we are going to subsidize some (pre-)commercial projects, how should we choose and evaluate them?
• Possible conflicts between the goals of the firm (product differentiation) and the preferences of society.
• Short run response to R&D subsidies is an increase in the wage of R&D workers (elasticity ~0.2). How does the long run play out?
Measuring innovative activity

• Large literature using R&D (capital) as a proxy for innovation input
  – Hall, Mairesse, Mohnen 2010 survey, *inter alia*

• Smaller literature using patents as a proxy for intermediate innovation output

• Both measures have weaknesses, especially outside the manufacturing sector.

• Now we have more direct measures – do they help?
Innovation surveys contain.....

• Data on innovation:
  – Product or process new to firm/market (yes/no)
  – Share of sales during past 3 years from new products
  – Later surveys have expenditures on various kinds of innovation investments (answers can be missing or noisy)

• Data on productivity and employment:
  – Usually sales per worker (labor productivity)
  – Sometimes TFP (adjusted for changes in capital)
  – Issues arising from deflation and level of aggregation
    • of goods, and of enterprises
Share of firms with innovation new to the firm or market, 2006-2008

Share of firms in innovative sectors (see text)
Labor productivity levels 2009 and innovation 2006-2008

GDP per hour worked (thousands of euros)

Share of firms innovating (%)

- SMEs
- Large firms
- Linear (SMEs)
- Linear (Large firms)
CDM model

• Proposed originally by Crépon, Duguet and Mairesse (CDM, 1998)

• Relationship among
  – innovation input (mostly, but not limited to, R&D)
  – innovation output (process and product)
  – productivity levels

• Closer look at the black box of the innovation process at the firm level:
  – unpacks the relationship between innovation input and productivity by looking at the innovation output
The model

1. The determinants of R&D choice: whether to do it and how much to do.
2. A knowledge production function with product and/or process innovation as outcomes depending on predicted R&D intensity.
3. A conventional production function that includes the predicted innovation outcomes to measure their contribution to the firm’s productivity.
STEP 1 - R&D decision

Only a share of firms in the sample report positive R&D expenditures

**SELECTION MODEL**

Selection equation:

\[ RDI_i = \begin{cases} 
1 & \text{if } W_i \alpha + \varepsilon_i > 0 \\
0 & \text{if } W_i \alpha + \varepsilon_i \leq 0 
\end{cases} \]

Conditional on reporting R&D, regression equation for level of R&D:

\[ RD_i = \begin{cases} 
RD_i^* = Z_i \beta + e_i & \text{if } RDI_i = 1 \\
\text{notobserved} & \text{if } RDI_i = 0 
\end{cases} \]

Generalized Tobit, or Heckman selection model, estimated by ML.
STEP 2 - Knowledge production function (KPF)

Outputs of the KPF are product and/or process innovation - modeled as a bivariate probit ($\Phi$):

$$
\begin{pmatrix}
PROD_i \\
PROC_i
\end{pmatrix} = \Phi \left( \begin{pmatrix}
\hat{RD}_i \gamma + X_i \delta \\
\hat{RD}_i \gamma + X_i \delta
\end{pmatrix}, \rho \right)
$$

R&D input is the predicted value of R&D intensity from the model in STEP 1.

WHY?

Instruments the innovative effort in the KPF and accounts for that part of innovation activity that has not been formalized - especially important for SMEs.
STEP 3 - Production function

Conventional production function with three inputs: labor, capital and knowledge capital, where

\[ y_i = \pi_1 k_i + \pi_2 PROD_i + \pi_3 PROC_i + v_i \]

\( y_i \) = labor productivity (log sales per worker)

\( k_i \) = capital per worker (log investment or lagged capital per worker)

Knowledge input - predicted probabilities of product and process innovation from Step 2.

Triangular and somewhat nonlinear model

Estimated in three steps or by ML on three sets of equations
Production function data issues

Conventional setup:

\[ q_{it} = a_{it} + \alpha c_{it} + \beta l_{it} \quad i = \text{entity}, t = \text{time} \]

- \( q = \log \text{sales} \)
- \( c = \log \text{tangible capital} \)
- \( l = \log \text{employment} \)
- \( a_{it} = \text{TFP (total factor productivity)} \)

What about deflation of output/sales?
What happens when we add knowledge capital \( k \)?
Revenue productivity

If firms have market power and idiosyncratic prices, we observe real revenue $r$, not output $q$, with $r = p+q$ (all in logs)

Add a demand equation: $q_{it} = \eta p_{it}$, $\eta < 0$

Then the revenue productivity relationship is

$$r_{it} = \frac{\eta + 1}{\eta} (a_{it} + \alpha c_{it} + \beta l_{it})$$

Note that if demand is inelastic ($0 > \eta > -1$), revenue falls with increased output, although profit may rise.
Adding innovation

Add two terms involving knowledge stock:
process: $\gamma k_{it}$ in the production function, $\gamma > 0$
product: $\varphi k_{it}$ in the demand function, $\varphi > 0$

This yields the following revenue function:

$$r_{it} = \left( \frac{\eta + 1}{\eta} \right) (a_{it} + \alpha c_{it} + \beta l_{it}) + \left( \frac{\gamma(\eta + 1) - \varphi}{\eta} \right) k_{it}$$

Product improvement ($-\varphi/\eta$) always positive
Process improvement ($\gamma(\eta+1)/\eta$) can be negative
Conclusions

• Under the assumption of profit-maximizing firms facing downward sloping demand, the impact of product innovation on revenue productivity and on employment is positive.

• Under the same assumptions, the impact of process innovation on revenue productivity and on employment is positive unless demand is very inelastic.

(But recall that profit-maximizing firms normally operate in the elastic portion of the demand curve)
Example – Italian data

• 7 through 10th waves of the Mediocredito Centrale – Capitalia (now Unicredit) survey of more than 4,000 manufacturing firms.
  – each survey gathers information on the previous three years -> 1995-2006.
• Merging the 4 samples, adding capital investment, and cleaning
  – unbalanced sample of 13,724 obs
  – 9,387 firms
  – 4,753 obs with positive R&D
Estimation & Results

• First test for selection in the R&D decision
  – Estimate probability of observing R&D, save predicted prob & Mills’ ratio
  – OLS on sample with observed R&D intensity, including predicted prob, Mills’ ratio, squares and interactions in the regression
  – Test the joint significance of the probability terms

• Conclusion: Some selectivity in our data, selection equation is correlated with intensity equation
## Step 1: R&D Intensity

Dependent variable: R&D expenditure per employee (in logarithms)

<table>
<thead>
<tr>
<th></th>
<th>Selection</th>
<th>Regression</th>
</tr>
</thead>
<tbody>
<tr>
<td>D (Large firm competitors)</td>
<td>0.049 (0.025) **</td>
<td>0.047 (0.039)</td>
</tr>
<tr>
<td>D (Regional competitors)</td>
<td>0.034 (0.049)</td>
<td>-0.104 (0.085)</td>
</tr>
<tr>
<td>D (National competitors)</td>
<td>0.126 (0.043) ***</td>
<td>-0.104 (0.073)</td>
</tr>
<tr>
<td>D (European competitors)</td>
<td>0.411 (0.048) ***</td>
<td>0.230 (0.079) ***</td>
</tr>
<tr>
<td>D (International competitors)</td>
<td>0.444 (0.050) ***</td>
<td>0.339 (0.082) ***</td>
</tr>
<tr>
<td>D (Received subsidies)</td>
<td>0.290 (0.025) ***</td>
<td>0.404 (0.041) ***</td>
</tr>
<tr>
<td>D (Member of a group)</td>
<td>0.067 (0.030) **</td>
<td>0.252 (0.046) ***</td>
</tr>
<tr>
<td>Log employment</td>
<td>0.191 (0.013) ***</td>
<td>-0.115 (0.020) ***</td>
</tr>
<tr>
<td>Log age</td>
<td>0.033 (0.017) *</td>
<td>-0.045 (0.027) *</td>
</tr>
<tr>
<td>Standard error</td>
<td>1.318 (0.014) ***</td>
<td></td>
</tr>
<tr>
<td>Rho (correlation)</td>
<td>0.473 (0.023) ***</td>
<td></td>
</tr>
<tr>
<td>Number of observations</td>
<td>13,724</td>
<td>4,753</td>
</tr>
</tbody>
</table>

OLS estimates, industry, wave & time effects included. Robust s.e.s, clustered on firm.
Step 1 Summary

• International competition fosters R&D intensity
• Having a subsidy increases R&D, or the likelihood of reporting it
• Being part of a group increases R&D
• Older and larger firms have lower R&D intensities
Steps 2 & 3: Innovation and labor productivity

All firms - 13724 observations

<table>
<thead>
<tr>
<th></th>
<th>Prob of Process innovation</th>
<th>Prob of product innovation</th>
<th>Labor productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>P (proc inno)</td>
<td>-1.03 (0.21)***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P (prod inno)</td>
<td>0.45 (0.07)***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R&amp;D intensity</td>
<td>0.52 (0.15)***</td>
<td>0.72 (0.16)***</td>
<td></td>
</tr>
<tr>
<td>Inv intensity</td>
<td>0.11 (0.01)***</td>
<td></td>
<td>0.11 (0.01)***</td>
</tr>
<tr>
<td>Capital intensity</td>
<td></td>
<td>0.33 (0.04)***</td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td>0.17 (0.01)***</td>
<td>0.18 (0.01)***</td>
<td>0.25 (0.03)***</td>
</tr>
<tr>
<td>Age</td>
<td>0.01 (0.02)</td>
<td>0.09 (0.02)***</td>
<td>-0.04 (0.01)***</td>
</tr>
<tr>
<td>Correl (proc, prod)</td>
<td></td>
<td>0.461 (0.013)</td>
<td></td>
</tr>
<tr>
<td>Std error</td>
<td></td>
<td>0.62 (0.01)***</td>
<td></td>
</tr>
</tbody>
</table>

Method of estimation: ML on the system. Robust s.e.s clustered on firm.
Year and sector dummies included.
Steps 2&3 Summary

• Firm size negatively associated with R&D intensity, but positively with the likelihood of having product or process innovation
• R&D has a strong and sizeable impact on a firm’s ability to produce innovation, somewhat higher for product than process
• Investment in new equipment and machinery matters more for process innovation than for product innovation
• Product innovation has a positive impact on firms’ labor productivity...
• ....but process innovation exerts the largest effect, via the associated investment
• Older firms are less productive, ceteris paribus.
• Larger firms are less R&D-intensive but more productive
CDM model applied to CIS data

• Estimated for 15+ countries
• Confirmed high rates of return to R&D found in earlier studies
• Like patents, innovation output statistics are much more variable (“noisier”) than R&D, and R&D tends to predict productivity better, when it is available
• See Hall (2011), Nordic Economic Policy Review for a summary of the results of regressions of individual firm TFP on innovation
Brief summary

• TFP levels
  – Elasticity wrt innovative sales center on (0.09, 0.13)
    • higher for high tech and knowledge-intensive sectors
    • Lower on average for low tech and developing countries, but also more variable
  – With product innovation included, process innovation often negative or zero (= inelastic demand or measurement error)
  – Without product innovation, process innovation positive for productivity

• TFP growth rates
  – Similar results, somewhat lower and noisier
Employment effects
Employment impacts

• Assume capital $C$ and knowledge stock $K$ are predetermined. Can show optimal labor choice is

$$l_{it} = \left(1 - \frac{\eta + 1}{\eta} \beta\right)^{-1} \left[\left(\frac{\eta + 1}{\eta}\right)\alpha c_{it} + \left(\frac{\gamma(\eta + 1) - \phi}{\eta}\right)k_{it}\right] + \text{const}$$

• We have a similar conclusion for labor as for output (if demand is elastic or not very inelastic):
  – Product improvement $(-\phi/\eta)$ always positive
  – Process improvement $(\gamma(\eta+1)/\eta)$ can be negative
Accounting for employment change

Uses an equation in growth rates, allowing for price changes:

\[ l - (g_1 - \pi) = \alpha_{0i} + \alpha_1 D_{proc} + \frac{\beta}{(1 + \phi_2)} \frac{g_2}{(1 + \pi)} + \left[ u - \phi_1 (1 + \pi) \right] \]

\( l \) = employment growth (\( i \) = industry)
\( \pi \) = growth of sector price deflator
\( g_1, g_2 \) = growth in sales of old, new products
\( D_{proc} \) = dummy for process innovation
\( \beta \) = relative efficiency of producing new vs old products
\( \phi_1, \phi_2 \) = rel. change in price of old, new products
If \( \phi_2 > o \), the quality improvement of the new prod is passed to consumers via higher prices (lower employment impact, c.p.)
If \( \phi_2 < o \), quality improvement leads to lower “effective” prices
# Results for Europe

Manufacturing sector firms 1998-2000

<table>
<thead>
<tr>
<th></th>
<th>Italy</th>
<th>France</th>
<th>Spain</th>
<th>Germany</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth of sales of new products</td>
<td>0.94 (0.04)</td>
<td>0.98 (0.06)</td>
<td>1.02 (0.04)</td>
<td>1.01 (0.07)</td>
<td>0.98 (0.05)</td>
</tr>
<tr>
<td>D (process)</td>
<td>0.2 (0.9)</td>
<td>-0.3 (1.6)</td>
<td>2.5 (1.8)</td>
<td>-6.2 (2.9)</td>
<td>-3.9 (1.9)</td>
</tr>
<tr>
<td>N of firms</td>
<td>4618</td>
<td>4631</td>
<td>4548</td>
<td>1319</td>
<td>2493</td>
</tr>
</tbody>
</table>

- Labor efficiency of production of old and new products roughly the same (except possibly in Italy)
- Process innovation has no impact in Italy, France, and Spain, leads to reduced labor in Germany and UK (increased efficiency)

=> Suggests the importance of labor market regulation, although effects are fairly small.
Decomposition of employment growth

\[ \bar{l} = \hat{\alpha}_0 + \left( g_1 - \pi \right) + \hat{\alpha}_1 \bar{D}_{proc} + \frac{\beta}{(1+\varphi_2)(1+\pi)} g_2 \]

Manufacturing sector firms 1998-2000

<table>
<thead>
<tr>
<th>Average employment growth (%)</th>
<th>Italy</th>
<th>France</th>
<th>Spain</th>
<th>Germany</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.5</td>
<td>8.3</td>
<td>14.2</td>
<td>5.9</td>
<td>6.7</td>
</tr>
</tbody>
</table>

Due to.....

<table>
<thead>
<tr>
<th>Industry specific trend</th>
<th>Italy</th>
<th>France</th>
<th>Spain</th>
<th>Germany</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-5.6</td>
<td>-1.9</td>
<td>-5.7</td>
<td>-7.5</td>
<td>-5.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Output growth of old products (non-innov.)</th>
<th>Italy</th>
<th>France</th>
<th>Spain</th>
<th>Germany</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5.7</td>
<td>4.8</td>
<td>12.2</td>
<td>6.0</td>
<td>8.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Process innovation without product</th>
<th>Italy</th>
<th>France</th>
<th>Spain</th>
<th>Germany</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.1</td>
<td>-0.1</td>
<td>0.3</td>
<td>-0.6</td>
<td>-0.4</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Product innovation</th>
<th>Italy</th>
<th>France</th>
<th>Spain</th>
<th>Germany</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.4</td>
<td>5.5</td>
<td>7.4</td>
<td>8.0</td>
<td>3.9</td>
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</tbody>
</table>

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