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MARKET INCENTIVES TO INNOVATION MICRODATA ANALYSIS

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MARKET INCENTIVES TO INNOVATION – MICRODATA ANALYSIS

An OECD proposal to WPIA

1. Background

1. Government policies targeting business innovation can take two main routes: they can either directly trigger innovation, by granting subsidies or by public procurement; or they can affect the framework conditions in which firms operate, aiming to make them more favourable to innovation. Among the latter, the intensity and type of competition are major factors. Market competition results from a complex process involving technological conditions, trade policy, competition policy *per se*, and innovation and structural policies in general.

2. Economic analysis of the impact of competition on innovation provides ambiguous messages, in line with Schumpeter's changing views. On the one hand competition might encourage innovation, as it forces incumbents to innovate just to keep their position ahead of established competitors or the threat of new entrants; on the other hand competition reduces the reward from innovation (rent dissipation). Which of these effects dominates is an open question, which might depend on the particular circumstances of each market. Recent theory for instance focuses on the distance to the technological frontier as a key determinant of the connection between competition and innovation, seen as positive close to the frontier, but negative far from the frontier (Aghion *et al.,* 2005).

3. It is also important to mention difficulties regarding the definition and measurement of competition. In a market situation, it is not only the perceived competitive pressure, but also some other characteristics of competition which could matter: two firms competing neck and neck might feel as much threatened by each other as start ups faced with dozens of competitors (including many potential, unknown ones) could feel, but due to the information structure etc. the effect on the innovation behaviour of firms might differ. Hence, competition is not necessarily fully captured (in the context of innovation) by a single "intensity" indicator.

4. Empirical studies have not been conclusive either. Empirical evidence remains quite scarce, limited to a few countries (mainly US or UK firms), a few industries, or specific periods of time. In addition, major issues like the measurement of competition or the treatment of reverse causality from innovation to competition are still open.

5. Another area studies have investigated is the impact of co-operation and spillovers on inventive performance of the firm. The two issues of competition and co-operation are obviously related: they can sometimes exclude each other, as firms don't want to help their competitors, but can also reinforce each other as competitors can share (voluntarily or not) some R&D (joint R&D) or some knowledge (spillovers). Upstream co-operation can enhance or reduce competition, depending on the way it is done and on particular circumstances. Although they are closely related, the two aspects have not been investigated in an integrated way to date.

2. Content of the project

6. This project will consist in estimating a model linking competition to innovation and to productivity, estimated on microdata. The same model will be estimated separately in a range of countries. The model will control for other factors affecting innovation and productivity, notably human capital and the distance to the technology frontier firms[1].

7. What is new with this project compared to the available studies:

- Estimating the same model across countries will allow results obtained under various conditions to be compared, possibly identifying robust links between competition and innovation, or patterns which generate such links.
- The proposed project will attempt to control for the converse effect of innovation on competition thanks to an appropriate empirical setting.
- The analysis will investigate whether the various kinds of competitive pressures faced by firms (beyond their overall intensity) have the same impact on their innovative effort, both in terms of intensity and in terms of direction of this effort: domestic v. foreign competition, market v. technological competition, various market structures (*e.g.* number of competitors).
- The analysis will take into account identified co-operative relationships between firms in the field of innovation (joint R&D) and knowledge spillovers.

8. This draft proposal aims at providing a harmonised core regarding the topics covered by countries. However, certain countries have access to much richer data sources than those required for this core: it could therefore be envisaged that, in addition to the harmonised project, a series of country-specific studies be conducted (or projects involving a small number of countries which have similar data available). Countries will be encouraged to share the methodologies and results: this exchange of experience will allow participating countries to benefit from each others' progress.

3. Modelling and data aspects

9. A possible model is given in the appendix. This model has two equations: a first equation explaining innovation by competition (several measures), various types of co-operation and spillovers, distance to frontier and various controls (size, skills, capital intensity, etc.). Additional factors could be added, reflecting *e.g.* spillovers, linkages (in particular group ownership) or industry-level controls. A second equation would explain productivity growth by the innovation performance of the firm.

10. In addition, with a view to controlling for the effect of innovation on competition (endogeneity issues), a preliminary first stage equation could be estimated that explains competition by more "exogenous" variables like institutional shocks affecting markets (*e.g.* the product market regulation index of OECD).

11. The proper modelling and measurement of competition remains an open question: which dimensions of the competitive process are relevant to innovation? How can they be measured? How should we deal with the potential reverse causality issues between innovation and competition?

The appendix includes preliminary suggestions to be discussed.

[1] Countries may also want to extend the analysis to ICT if the information is available.

12. Data needed for such an exercise will depend on the selected model. An indicative list would include:

- Balance sheet data (for compiling productivity and various competition indicators) – could come from business registers.
- R&D data – from R&D surveys or SBS.
- Patent data: Applications to the national patent office when available[2], otherwise information available in the PATSTAT database; the OECD could provide PCT, EPO, JPO and USPTO data, with harmonised names of patent holders.
- Skills of the labour force (optional).

13. Notes:

- Due to the data required (in particular TFP, R&D and patents), the analysis will mainly focus on manufacturing industries**.**
- Some information is available from the OECD, either at a micro level (patents, see above) or at aggregate level (patents, R&D and accounting data as available in the STAN and ANBERD databases).

Questions:

- Is the general approach to the issue relevant?

- What model(s) would best address the question?
  Is the proposed model relevant? How could the proposed model be improved (*e.g.* supplementary explanatory variables)? What measures of competition are preferable in this context?
  Please provide comments on each section of the Appendix: A.1, A.2 and A.3.

- Are all the required data sources available in your country (for manufacturing industries)?
  If yes:
  - Over which time period? (see also the mini survey about micro-data)
  - Do you have direct access to them or is there a delay?
  - Which additional information do you think would be useful?

  If not:
  - Are there alternatives?
  - Do you think sub-parts of the model could be estimated?

[2] This would enable to analysis of the innovation behaviour of small firms more precisely.

APPENDIX: TECHNICAL DOCUMENTATION

A.1 Motivation for the Empirical Strategy

14. Previous literature on the topic shows that there are two main possible empirical approaches to study the link between innovation and competition[3]:

A - Studies that use proxies for product market competition (concentration indices, mark-up estimates, measures of trade openness) to study their correlations with alternative measures of the firms' (innovative) performance. *E.g.* Nickell (1996), Bloom, Schankerman and Van Reenen (2007), Boone (2000, 2001, 2008 in a theoretical perspective), etc.

The main advantage of these approaches is that they are easily replicable in different countries, so that the methodologies may be highly comparable among participating countries.

The main *drawback* of this kind of approach is their lack of "internal validity", since the competition indicators are highly endogenous with respect to innovation, in particular the firm level indicators (such as mark-ups). In other words, identification of the true economic impact of competition on innovation is not always possible or credible[4], so that the obtained correlations are difficult to interpret.

B - Studies that look at policies / events that affect competition rather than attempting to measure market pressures directly; *e.g.* Nicoletti & Scarpetta (2004), Griffith *et al*. (2006), Aghion *et al.* (2005).

The main advantage of this kind of approach is its high level of "internal validity": conditional on the fact that the event effectively affected the competitive pressure faced by (at least some) firms, these "natural experiments" provide credible (local) estimates of the impact of competition on various aspects of firms' behaviours.

The main drawback is the lack of external validity, due to the fact that these events did not necessarily affect all OECD countries or all the industries or firm sub-populations the same way.

15. Defining a harmonised framework unavoidably leads to the first kind of approach, but an attempt will be made to enrich the proposal so as to improve identification, and therefore the quality of the economic analysis that will follow.

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3 Note that the REFBARIN project (BFP, Ghendt and Delft Universities) is an example of the second type of approach. It deals partially with the link between PMRs and innovative activity (the other explanatory variable of innovation being labour bargaining). In this framework a competition needs to be instrumented by PMR variables.

4 See the Manski reflexion problem (1991).

A.2. Proposed Set-Up

16. Our basic set-up is a simple model relating competition intensity to firms' innovation (effort or performance). It is a transposition of the (originally industry level) model of Griffith *et al.* (2006) at the firm level, and it shares the same features as the empirical analysis in Aghion *et al*. (2005) although in a simplified, linear framework[5].

A.2.1 Baseline Model

17. The equations of interest are the following (a precise definition of the various indicators is suggested below):

- First, a knowledge production function relating competition to innovation:

$$Innov_{ijt} = \alpha_1^{(1)}.COMP_{(i)jt} + \alpha_2^{(1)}.DTF_{ijt-1} + \alpha_3^{(1)}.COMP_{(i)jt}.DTF_{ijt-1} + \beta^{(1)}.\ln(L)_{ijt-1} + \gamma^{(1)}.\ln\left(\frac{K}{L}\right)_{ijt-1} + \left(\theta^{(1)}.\ln\left(\frac{Skills}{L}\right)_{ijt-1}\right) + \lambda^{(1)}GP_{ijt} + \delta_t^{(1)} + \delta_j^{(1)} + \eta_i^{(1)} + \varepsilon_{ijt}^{(1)}$$

Where $Innov_{ijt}$ is an indicator of innovation (R&D expenditures or patents[6]), $COMP_{(i)jt}$ is an indicator of competition, GP_{ijt} is a dummy variable indicating whether the considered firm is part of a larger group, and $DTF_{ijt} = \ln\left(TFP_{Fjt}\right) - \ln\left(TFP_{ijt}\right)$stands for the firm's distance to technology frontier (and TFP stands for "Total Factor Productivity"). Lastly, L denotes labour, $Skills$ the skilled workforce and K the capital stock.

18. This equation could be complemented with additional indicators of technology spillovers or / and industry level controls.

- Second, an equation describing firms' growth, under the assumption that TFP growth is explained by firms' innovative behaviour:

$$\Delta\ln(TFP)_{ijt} = \alpha^{(2)}.Innov_{ijt-1} + \beta^{(2)}.\ln(TFP)_{ijt-1} + \delta_{t-1}^{(2)} + \delta_j^{(2)} + \eta_i^{(2)} + \varepsilon_{ijt-1}^{(2)}$$

In the previous equation, the $Innov_{ijt-1}$ indicator could be instrumented by the indicators of competition, which were excluded from the previous equation (see also below).

19. In a reduced form (*i.e*. replacing the indicator of innovation by its excluded predictors), we simply get:

$$\Delta\ln(TFP)_{ijt} = \alpha_1^{(2)}.COMP_{(i)jt-1} + \alpha_2^{(2)}.DTF_{ijt-2} + \alpha_3^{(2)}.COMP_{(i)jt-1}.DTF_{ijt-2} + \alpha_4^{(2)}.GP_{ijt-1}\left(+\beta^{(2)}.\ln(TFP)_{ijt-1}\right) + \delta_{t-1}^{(2)} + \delta_j^{(2)} + \eta_i^{(2)} + \varepsilon_{ijt-1}^{(2)}$$

5 Few papers using micro data take the potential endogeneity of competition in the performance equations into account (this is *not* the case in Nickell, 1996).

6 The econometric treatment of patents (count data) is more difficult, especially when taking endogeneity issues into account. See *e.g.* Blundell, Griffith and Van Reenen (1999), and Blundell and Powell (2004).

Note: The terms $\ln(L)_{ijt-2}$, $\ln\left(\frac{K}{L}\right)_{ijt-2}$, $\ln\left(\frac{Skills}{L}\right)_{ijt-2}$ have been removed from the equation due to their likely colinearity with $\ln(TFP)_{ijt-1}$ (to be checked empirically).

A.2.2 Towards Causality: a More Relevant Empirical Treatment of Competition

Instrumental Variables (IV) Evidence

20. The main concern with the previous approach is that it is plagued by reverse causality issues, since competition may be a determinant of firms' innovative behaviour, but the innovative performance of firms may conversely affect the competitive pressure they face. In more technical terms, competition is highly endogenous in the innovation equation, and therefore also in the growth equation.

21. It is therefore useful to introduce a first stage equation explaining competition by additional "exogenous" variables related to (policy related) shocks that may have exogenously affected the competitive pressure faced by firms. We denote these shocks by $PMR_{(j)t}$; they are either defined at the industry or at the country level (but to be transposed at the industry level in this latter case). They most of the time take the form of dummy variables indicating that specific sectors j were affected by a policy change after date $\bar{T}$:

$$PMR_{(j)t} = \mathbb{I}_{(t>\bar{T})}.\mathbb{I}_{(j\in J)}$$

where $\mathbb{I}$ stands for a dummy variable.

22. The first stage equation is therefore defined as:

$$COMP_{(i)jt} = \alpha^{(1)}.PMR_{(j)t}\left(+\beta^{(1)}.X_{ijt}\right) + \delta_t^{(1)} + \delta_j^{(1)} + \eta_i^{(1)} + \varepsilon_{(i)jt}^{(1)}$$

Interactions terms between PMR and distance to technology frontier $PMR_{(j)t}.DTF_{ijt}$ could be used as IVs for interactions between competition indicators and distance to technology frontier $COMP_{(i)jt}.DTF_{ijt}$.

23. Special care should also be devoted to the necessary time trends to be introduced in the regression analysis, and to the adequate level of clustering for standard deviations (see Bertrand, Duflo, Mullainathan, 2002 on this aspect).

24. If several IVs are available, it may be technically possible to estimate a specification in which both competition and innovation indicators are introduced in the TFP growth equation, as in Griffith, Harrison and Simpson (2006):

$$\Delta\ln(TFP)_{ijt} = \alpha^{(2A)}.Innov_{ijt-1} + \alpha^{(2B)}.COMP_{(i)jt} + \beta^{(2)}.\ln(TFP)_{ijt-1} + \delta_{t-1}^{(2)} + \delta_j^{(2)} + \eta_i^{(2)} + \varepsilon_{ijt-1}^{(2)}$$

A.3. Measurement Issues

A.3.1. Innovation Indicators

25. The main indicator of innovation will be based on the firms' R&D activity:

- R&D expenditures (ev. as a share of the firm's value added).
- R&D personnel (ev. as a share of total employment).

OPTIONAL (*since this kind of count data renders the analysis much more complex****):***

- *Patent applications.*
- *Citation-weighted patent applications.*

A.3.2. Competition Indicators

26. It would be interesting to perform the analysis with various kinds of indicators describing various types of competition, *e.g.* (to be discussed):

- Synthetic indicator of the intensity of competition:

  Mark-up (Lerner) index

  $$LI_{ijt} = \frac{\text{Operating Profit}_{ijt} - \text{Financial Cost}_{ijt}}{\text{Sales}_{ijt}}$$

- Indicators related to the *domestic* market structure:
  - Concentration (Herfindahl) Index: $HHI_{(i)jt} = \sum_{i \in j} \left(\frac{\text{Sales}_{ijt}}{\text{Sales}_{jt}} \right)^2$

    Alternatively: market share of the largest firm / of the three largest firms
  - (Firm level market share).
  - Indicators of the contestability of the market: dummy variables indicating whether the identity of the leading firm(s) changes from period to period.
  - Capital intensity, industry level entry rates (as measures of entry – sunk or fixed – costs[7]).
  - Relative profits (Boone, 2000 and 2008): seems a promising way to model interaction among competitors[8]?
  - Others?

- Indicators related to international / foreign competition:
  - Intensity of foreign trade (*e.g.* penetration indices), which provides a measure of the competition from abroad (more relevant for manufacturing than for service industries?)
  - For firms which are active on international markets (especially in the case of "small" countries): market share, where the market is defined by the aggregate of all trading partners (use of the OECD bilateral trade database?)

…

7 Capital intensity may be a useful control if no measure of TFP is available (i.e. when the equations are specified with labour productivity).

8 In the Boone, van Ours, van der Wiel (2007), *"How (not) to measure competition"* CEPR DP No.6275, there is indeed the affirmation that PE (profit elasticity) measures better competition than PCM and the Herfindahl index, but it is yet to be proved its usefulness modelling innovation in relation to competition.

OPTIONAL:

- ***Indicators of technological competition (and related):***

  - *Strength of IPRs (weighted by industry-level patent propensities?)*
  - *Indicators "à la" Bloom, Schankerman and Van Reenen (2007) following Jaffe (1986)*

  R&D of "close" firms in terms of technology:

  $SPILLTECH_{it} = \sum_{j \neq i} \frac{(T_{it}T'_{jt})}{(T_{it}T'_{it})^{1/2}(T_{jt}T'_{jt})^{1/2}} R\&D_{jt}$. *where* T_{it} *stands for the vector of shares of patents of firm* i *across technology classes (drawback: for patenting firms only).*

  R&D of product market competitors:

  $SPILLSIC_{it} = \sum_{j \neq i} \frac{(S_{it}S'_{jt})}{(S_{it}S'_{it})^{1/2}(S_{jt}S'_{jt})^{1/2}} R\&D_{jt}$. *where* S_{it} *stands for the vector of shares of sales of firm* i *across product classes (if this information is available).*

A.3.3. PMR Indicators (IVs for competition indicators)

27. OECD PMR Indicators[9] (**www.oecd.org/eco/pmr** to be updated by the end of 2008)

See Nicoletti and Scarpetta (2003), among others, for an analysis using this kind of indicators.

The limits of these various indicators are that:

- Few have simultaneously a country*industry*panel dimension.
- Even if we use their underlying components (*e.g.* privatisation, etc.) instead of the final synthetic index, they are a little bit like "black boxes".

28. Four sets of regulatory indicators are available:

- **OECD indicators of Economy-wide regulation:** covers different regulatory areas (state control, barriers to entrepreneurship, administrative regulation) and summarises general-purpose and industry-specific regulations into a single indicator in each country **in 1998 and 2003.**
- **OECD Indicators of Regulation Impact:** these indicators measure the potential costs of anti-competitive regulation in selected non-manufacturing sectors on sectors of the economy that use the output of non-manufacturing sectors as intermediate inputs in the production process. **Country*industry*panel dimension**.

[9] Cincera, Galgau, (2005), *"Impact of market entry and exit on EU productivity and growth performance"*, European Economy, Economic Papers, use a set of PMR indicators based on various data sources, namely, the OECD database on regulatory reforms, the Fraser Institute composite indicators, the ENSR surveys by the Observatory of European SMEs, the structural indicators of EUROSTAT and, information provided by the European Centre of Enterprises with Public Participation.

- Indicators of Regulation in Retail Trade: 1998 and 2003.
- Indicators of Regulation in Energy, Transport and Communication: 7 sectors, but available yearly from 1975 to 2003.

OPTIONAL / NOT HARMONISED: Alternative Experiments

*C**ountry specific events** may also provide an interesting source of ("exogenous") variation in the intensity of competition, thus providing powerful IVs for the causal analysis…*

Examples used in the empirical literature:

- ***European Single Market Program (1988-1992)***

See Griffith, Harrison and Simpson (2006) and Aghion, Bloom, Blundell, Griffith and Howitt (2005) as example of articles relying on this shock.
*A major drawback is that it is a **quite old** reform…*

The SMP reforms were undertaken at around the same time across European countries, i.e. between 1988 and 1992. The data used in the previously mentioned papers come from a European Commission Report by Buigues et al. (1990). The report identifies 3-digit industries that were expected ex-ante to be highly and moderately (4 main groups) affected by the SMP and the share of each of these industries in each country's manufacturing employment over 1985-1987.

Four sets of PMR variables can be constructed following Griffith, Harrison and Simpson (2006) and taking the form of a step-function that is equal to zero in all years prior to 1992 (ev. 1988), and that is equal to one from 1992 and all subsequent years if the firm belongs to an industry that was highly (resp. moderately) affected by the reform.

- ***Shocks in International Trade***

- ***Additional Country(and / or Industry) Specific Policy Changes***

Aghion et al. (2005, p. 709) also use additional IVs related to UK specific events: the Thatcher era privatisations, the Monopoly and Merger Commission (MMC) investigations that resulted in structural or behavioural remedies being imposed on particular industries.

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