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Industry structure dynamics and productivity growth

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Abstract

Economic theory typically predicts that productivity should increase when a firm's market is expanding since the benefits of reducing costs are higher when spread across a larger market. On the other hand there is a strong line of research stressing the positive impact of increasing competition and claiming that productivity should jump when a firm's market is being squeezed by new competitors. This paper investigates the effects of industry structure dynamics on productivity growth on panel data from industries of ten European countries. The econometric results provide empirical support for positive impact of less fragmented market structures on productivity, however results also point out the important role which dynamics of firms turnover play in industry performance.

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1. Introduction

The term "industry structure" refers to the number and size distribution of firms in an industry. The number of firms in an industry may go into hundreds or thousands. The existence of a large number of firms in an industry reduces opportunities for coordination among firms in the industry. Therefore, generally speaking, the level of competition in an industry increases with the number of firms in the industry. The size distribution of firms in an industry is important from the view of both business policy and economic policy. If all firms in an industry are small in size, relative to the size of the industry, it is a fragmented industry. If a small number of firms controls a large share of the industry's output or sales, it is a consolidated industry. The type of competition in fragmented industries is generally very different from that in consolidated (or concentrated) industries.

Economic theory typically predicts that productivity should increase when a firm's market is expanding since the benefits of reducing costs are higher when spread across a larger market. There are many theoretical models and few empirical studies that tend to conclude that competition reduces innovation (see for example, Aghion et al. (2006), Desmet & Parente (2010), Vives (2008) and Bai & Herrendorf (2008)). On the other hand there is a strong line of research stressing the positive impact of increasing competition and claiming that productivity should jump when a firm's market is being squeezed by new competitors, mainly by larger pressure and incentives to innovate. Furthermore, few available empirical evidence is favorable to the positive effect of competition on innovation. Nickell (1996), Blundell, Griffith, and Van Reenen (1999).

Productivity growth is by far the most important determinant of increased living standards throughout history (Griliches 1996). Sustained economic growth occurs only when the amount of output produced by the firms increases steadily. The approach taken in much of the empirical literature is to use accounting decompositions that decompose aggregate growth into components that reflect

the contributions of productivity growth within industry and the reallocation of resources between industries (Haltiwanger, Bertelsmann, Scarpetta 2001). At this basic level a lot of studies show (van Ark B. et al. (2010)) that within-industry productivity growth is more important process for rapid economic growth. Moreover, F.Caselli et al. (2005) quantitatively assessed initial income gap between European countries through 1950 to 2005, having in regard convergence processes that occurred among those countries . Authors analyzed within-industry and between industry productivity level gap, capital deepening gap, labor and human capital gap. They found important differences in sources in covering these gaps. The most important observation is that, although productivity convergence process is much harder to accomplish than convergence process based on capital and labor accumulation, within-industry productivity growth was key factor for most successful convergence episodes of some countries. Hence, in a way, the developing countries, specifically post-communist countries must pay special attention to within-industry productivity which is most unused margin to exploit in their quest for convergence.

There are of course large differences between countries in intra industry productivity dynamics. These differences can be due to macroeconomic level causes or/and industry specific causes**.** An open question is whether the observed differences across countries are accounted for by differences in market institutions and policies, however these important questions are beyond the scope of this paper.

This paper investigates the impact of industry structure dynamics on productivity growth on a panel data from 57 industries of ten European countries. We will infer the degree of competition faced by firms from observations on concentration statistics and market dynamics intensity.

2. Theoretical background

The lack of agreement between theory and empirics which analyze the impact of changes in industry market structure on productivity growth rests on basic question: what market structure is most prone to greater productivity dynamics?
Broadly speaking, there are two types of market structures. We can name monopolistic or consolidated market structure when each firm is in fact price setter, choosing the price of its product, rather than a price taker. In standard theory, firm's profit maximization function results in existence of price mark-up over the cost of production of one unit of goods. But profit maximization function leads to higher average costs of production of one unit of goods than in non-monopolistic or non-consolidated market. Firm's productivity level of each firm is determined by average cost. The lower the average costs, the higher is productivity and vice versa. Therefore, in theory, we should find lower level of productivity in monopolistic market structures. However, in fragmented or competitive market structure, with fixed costs of production, the more firms there are, the lower the output or total sales of each firm, and the higher each firm's cost per unit of output (average costs). That implies that very fragmented market structure likewise monopolistic (consolidated) market structure may lead to higher average costs of production of each firm, thus lower level of productivity. The expansion of market share of firms on fragmented, competitive market results in lower average costs and productivity gains from economies of scale in production process. Thus changes in market structure enhance productivity growth i.e. increasing competition on monopolistic (consolidated) markets leads to productivity growth and that consolidation on competitive (fragmented) markets also results in productivity growth. Fragmented industries generally exhibit low entry barriers. Low entry barriers in an industry encourage the entry of new rivals into the industry whenever profits are high. These entries lead to excess capacity in the industry and price competition to utilize their capacity and to sustain their market shares. In this type of market, productivity growth results to the greatest extent from firm turnover intensity (Scherer, F.M 1996). A consolidated (monopolistic) industry typically has different industry

structure. Such industries typically exhibit high entry barriers, differentiated products, established brand preferences, and often high profitability. In some consolidated industries, firms rivalry is based on non-price factors and tend to maintain or extent their market shares through changes in processes and products and launching new. In this type of market, productivity growth results mainly from investment processes.

Generally, first line of market structure studies, emphasizes that increased competition leads to productivity gains at surviving firms – what we could call gains in X-efficiency, or what the literature calls within firm gains or innovation. When firms are faced with increased competition, they made substantial investments to raise productivity. What is important, in most of these studies, there was discovered that in the increasing competitive environment, the scale of the firm's market was not increasing but was, if anything, decreasing.
But if not gaining from economies of scale, then what drove investment and productivity growth on more competitive markets? One could argue that likely it may be that the cost of investment fell as competition increased because of rise of the opportunity cost of investment (Arrow (1962)).

Secondly, this line of research points out to role of market dynamics intensity. Basic mechanism is rate of firm turnover, i.e. firm entry and firm exit rate. High values of these measures imply high level of creative destruction process, low values implies existence of barriers entry and specific policies that protect existing weak firms, overall hampering within-industry dynamic process. Also Some of studies (Melitz 2003) analyze the impact of trade and market liberalization reforms on within-industry productivity and have shown that productivity growth is strongly correlated with the establishment's export status: relatively more productive establishments are much more likely to export (even within so-called "export sectors," a substantial portion of establishments do not export). In that hypothesis, exposure to trade or new markets induces only the more productive firms to export while simultaneously forcing the least productive firms to exit.

However, second line of research, following Schumpeter (1943) tradition, found that in fact there is an inverted-U relationship (Aghion et al.(2005)) between competition and industry productivity growth. It has been argued that more monopolistic firms can more easily fund R&D expenditure because they face less market uncertainty. Firms have little incentive to innovate if they are not stimulated by competition, but too much competition may discourage innovation because firms are not able to reap the benefits of their efforts. There is, therefore, an optimal degree of competition. Finally, it may be argued that in oligopolistic industries, resources may be spent on deterring rivals, and this can lead directly to production inefficiency. It is generally the case that cost-reducing improvements in productivity will generate larger increases in profit in a more competitive environment, thereby raising the incentives for R & D expenditure. Importantly, the costs of weak market competition rise as an economy moves closer to the technological frontier. Aghion et al. (2006) draw on a panel of manufacturing firms in the United Kingdom over 1973–92 to prove this empirically. If we restrict the set of industries to those that are closer to the world technological frontier, the upward sloping part of the inverted-U relationship between competition and innovation is steeper than the shape for the whole sample. Thus, the cost of (in terms of productivity growth) too little competition grows as the economy develops and moves closer to the frontier.
In that view innovation are very costly and existence of monopoly profits can facilitate opportunities to engage in innovation activities. Worth adding, is fact that the same logic applies to process of imitation. For example, Levin et al (1987) and Mansfield et al (1981), using survey evidence, found that imitating a new invention in a manufacturing firm was not free, but could cost as much as fifty to seventy-five per cent of the cost of the original invention.

Finally, few descriptive country studies shows that size distribution of firms in low productivity industries is skewed towards large and small plants. In fact, using comparable measures, many countries, especially developing, exhibits lower share of middle firms than their richer counterparts. What is interesting are the factors that play role in differences in size distributions of firms and what is contribution of dynamics of size distribution of firms to productivity growth.

In the span model of firm size distribution small firms faces regulatory costs to grow larger and/or they stay in informal sector to avoid being taxed. Thus, big establishments are not faced with larger competitive pressure and/or are protected from competition by state (Tybout J.R. 2000). This results in inability to exploit economies of scale by small firms within-industry and maintains inefficiency by large establishments. In that case within-industry level of productivity is much lower than it could be.

3. Empirical formulation

3.1 Model specification

To investigate the effects of industry structure dynamics on productivity growth we estimate a panel model with fixed effects (indicated by results of Hausman test) on a sample data from 57 industries of ten European countries. We infer the degree of competition faced by firms from observations on concentration statistics and market dynamics intensity.
Our model has a form:

$$TFP\_LP_{it} = \beta_0 + \beta_1 HHI_{it} + \beta_2 CRp_{it} + \beta_3 FENi_{it} + \beta_4 FEXi_{it} + \beta_5 Fn_{it} + \beta_6 SR_{it} + \varepsilon_{it}$$

3.2 The productivity measure

TFP is mostly seen in the formulation of a production function where output is the product of a function of observable inputs and a factor-neutral.
$Y_t = A_t F(K_t, L_t, M_t)$,
where Y_t is output, $F(\cdot)$ is a function of observable inputs capital K_t, labor L_t, and intermediate materials M_t, and A_t is the factor-neutral shifter. In this type of formulation, TFP is A_t. It captures variations in output not explained by shifts in the observable inputs that act through $F(\cdot)$.

TFP is, at its engine, a residual. But as with all phenomena that are residuals, it is in a econometric way a measure of our ignorance: it is the variation in output that cannot be explained based on observable inputs. From the econometric point of view there is important problem with that specification, it may suffer from simultaneity problem.

There is risk that part of the TFP will be observed by the firm at a point in time early enough so as to allow the firm to change the factor input decision. If that is the case, then profit maximization of the firm implies that the realization of the error term of the production function is expected to influence the choice of factor inputs. This problem was raised by Olley and Pakes (1996). Levinsohn and Petrin (2003) offer an estimation technique that handle with this problem. Their alternative estimator solves the simultaneity problem by using the firm's investment decision to proxy unobserved productivity shocks[1].

In production function labor input is measured by the total labor compensation of all persons employed (or engaged). Capital stock and intermediate inputs are proxied by the book value. For the econometric analysis, industry-specific variables were estimated and firm-level TFP were aggregate into industry TFP level, so called within - industry productivity growth. The procedure to calculate average TFP based on firm-level data is estimation from a production function framework using OLS for each industry (TFP panel estimation with fixed effects based on Levinsohn and Petrin (Levinsohn, J., Petrin, A., 2003) Variable *TFP_LP* is total factor productivity (output - predicted output), estimated through Levinsohn and Petrin for each industry *i* in each country (simple average over all firms).

[1] The error has two components: the transmitted productivity component given as ωt and ηt, an error term that is uncorrelated with input choices. The key difference between ωt and ηt is that the former is a state variable and, hence, impacts the firm's decision rules. It is not observed by the econometrician, and it can impact the choices of inputs, leading to the well-known simultaneity problem in production function estimation. Estimators ignoring this correlation between inputs and this unobservable factor (like OLS) will yield inconsistent results. (Levinsohn, J., Petrin, A., 2003)

3.3 Data

The industry data are taken from the national statistical offices and Amadeus database and was provided by MicroDyn Project for 10 countries and cover the years from 1995 to 2008. For the purpose of our study we choose four Eastern European countries, Bulgaria, Hungary, Poland, Slovenia and their six Western European counterparts, Germany, Netherlands, Norway, Spain, Sweden, Switzerland. The industries are classified according to the European NACE revision 1 classification. At the lowest level of aggregation, data were collected for 57 industries.

Most time series are part of the present European System of Accounts (ESA 1995) and can be found in the National Accounts of individual countries, at least for the most recent period. To aggregate time series across countries use is made of purchasing power parities (PPPs) that reflect differences in output price levels across countries at a detailed industry level. This price adjustment is often done by means of GDP PPPs that reflect the average expenditure prices in one country relative to another and are widely available through the work of the OECD and Eurostat.

3.3 Definition of variables

As mentioned above *TFP_LP* is total factor productivity (output - predicted output), estimated through Levinsohn and Petrin for each industry *i* in each country (simple average over all firms).

We use following variables to capture characteristics of market structure at time *t* in industry *i*:

*HHI Herfindahl-Index***:** sum of the squares of the employment shares of the firms in industry *i*.
Herfindahl–Hirschman Index is a measure of the size of firms in relation to the industry and an indicator of the amount of competition among them**.** It is defined as the sum of the squares of the employment shares of the firms in industry *i*. or

as the sum of the squares of the market shares of the 50 largest firms (or summed over all the firms if there are fewer than 50) within the industry, where the market shares are expressed as fractions. The result is proportional to the average market share, weighted by market share. As such, it can range from 0 to 1.0, moving from a huge number of very small firms to a single monopolistic producer. Increases in the Herfindahl index typically in literature indicate a decrease in competition and an increase of market power, whereas decreases indicate the opposite. $H = \sum_{i=1}^{N} s_i^2$ where s is the market share of firm in the market, and N is the number of firms.

Concentration ratio (CRp) : share of employees of the 1% absolutely largest firms in industry *i* (based on employment).
Concentration ratio is a measure of the total output or total employment in an industry by a given number of firms in the industry. Concentration ratios are usually used to show the extent of market control of the largest firms in the industry and to illustrate the degree to which an industry is oligopolistic. The concentration ratio is the percentage of market share or percent of industry employment held by the largest firms (m) in an industry. $CR_m = \sum_{i=1}^{N} s_i$ where s is the market share and m defines the with firm.

Number of firms in industry *i* (*Fn*). This variables captures the fragmentation of market structure.

We use following variables to capture dynamics of market structure at time *t* in industry *i*. These variables play a role in capturing firm turnover, i.e market share of firms that entry and exit in industry.

FENi is firm entry intensity: number of employees in firms entering industry *i* in [t-1; t] / total number of employees in t-1

FEXi is firm exit intensity: number of employees in firms which exit industry *i* in [t; t+1] / total number of employees in t

SR survival rate (2 years): share of firms founded in t-2 which still exist (have survived) in t in industry *i*.

The data take the form of an unbalanced panel, and summary statistics are presented in Table 1.

Table 1. Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
CRp	3250	.4072393	.204653	.0488372	1
FENi	3125	2.962654	44.25762	0	1556
FEXi	3250	.0549777	.1356453	0	1
Fn	3251	1762.48	6629.914	1	93825
HHI	3250	.1473247	.1894886	.0005837	1
SR	2567	.6599329	.2997427	0	1
TFP_LP	3133	3.446854	3.226738	-38.32906	17.03638

4. Results

The main results are presented in table 2.

Table 2. Estimation results

	TFP_LP
HHI	.4473034 *** (.0823395)
CRp	-.3117156 *** (.0659448)
FENi	.0056825 * (.0030873)
FEXi	.1315315 *** (.0316931)
Fn	-5.54e-06 *** (1.73e-06)
SR	-.2417123 *** (.0169854)
cons	3.751791 *** (.0254299)
R^2	0.1222

The overall conclusion from this sample is that we observe a robust and significant effect of the measures of competition on productivity growth.
Herfindahl–Hirschman Index proved to be significant for productivity growth. Moving from a huge number of very small firms to a more consolidated market has a positive impact on productivity. Also the fragmentation of market structure (captured by *Fn*) seems to have slightly negative but significant impact.

On the other hand our study also shows that increase in concentration ratios (extent of market control of the largest firms) leads to decrease in productivity. Thus changes in market structure enhance productivity growth i.e. increasing

competition on high concentrated markets leads to productivity growth but conversely also consolidation on competitive markets leads to productivity growth.

Secondly, both firm entry and exit have positive impact on productivity. Despite some studies (Hopenhayn (1992), Melitz (2003),) that shown that levels of productivity of new entrants are much lower that existing firms, new entries inclines old firms to enhance productivity through competition pressure. Firms in competitive more dynamic industry structures are characterized by a stronger impact on productivity.

High values of survival rates may indicate on the one hand high entry barriers or disruption to process of creative destruction. We find significant, negative relationship between survival rate and productivity growth. Slower creative destruction seems to decrease competition pressure and thereby weaken firms incentives to investment or introduce changes that enhance productivity growth. Through investment firms reallocate resources and introduce new method of production.

In fact, recent studies have shown for example that easy monetary policy of Bank of Japan in 1990 – 2005 hampered the process of firms restructuring (J.Peck and E.S.Rosengren 2005). Lower capital interest rate may lower the productivity growth requirement for profitability of existing firms, weakens the incentives of firms to introduce efficiency changes.

Conclusions

Economic theory typically predicts that productivity should increase when a firm's market is expanding since the benefits of reducing costs are higher when spread across a larger market. On the other hand there is a strong line of research stressing the positive impact of increasing competition and claiming that

productivity should jump when a firm's market is being squeezed by new competitors.

Our estimation indicates that indeed monopolistic market structures hampers productivity growth, however consolidated market structures are characterized by faster productivity growth.

In sum, the econometric results provide empirical support for positive impact of less fragmented market structures on productivity, however results also point out the important role which dynamics of firms turnover play in industry performance.

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