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Robert Anderton, Benedetta Di Lupidio, Barbara Jarmulska

Product market regulation, business churning and productivity: evidence from the European Union countries

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Abstract

Productivity performance in European countries has been a policy concern for some time. This paper shows that productivity can be enhanced by product market policies which, by increasing competition and efficiency, facilitate higher rates of firms' entry and exit (i.e., firm churning). Drawing on annual country-sector data for the period 2000-2014 across the EU countries, we find that: (i) competition-enhancing regulation is associated with a higher rate of firm churning; (ii) business churning, in turn, appears to be positively related to higher total factor productivity at the sector level by facilitating the entry of new competitive firms and the exit of less productive ones. Overall, we conclude that stringent product market regulation can be indirectly associated, via its impact on business dynamism, with the somewhat weak productivity performance in a number of EU countries. Thus, our results point towards significant productivity gains that could follow from the introduction of further competition-enhancing measures in product markets.

JEL Classification: L51, P23, D21, D24, O40

Key-Words: Regulation, Product Market, Creative Destruction, Total Factor Productivity, Growth

Non-technical summary

Structural reforms in product markets have been undertaken over the past decades in a number of EU countries to promote competition and therefore improve economic performance. While the level of product market restrictiveness still varies substantially across countries, efforts in reform implementation prompted questions in both academic and policy circles. What are some of the effects of undertaking product market reforms on productivity dynamics? And especially, what are some of the possible channels through which regulation can enhance competition and hence influence total factor productivity? In this paper, we look at one particular channel and investigate whether product market regulation influences business churning, i.e. the entry and exit of firms, and whether increased churning and the resulting increased competitive environment can lead to improvements to productivity dynamics.

By using annual data from Eurostat's Business Demography Database at sector and firm size-class level for the period 2000-2014, we conduct a panel econometric analysis carried out in two steps: (i) we estimate whether product market regulation (proxied by the OECD ETCR indicator) is statistically significantly related to firm churning – including its two components, birth and death rates, separately; and (ii) we estimate whether churning is statistically significantly related to total factor productivity (TFP), labour productivity, as well as to the allocative efficiency across firm size classes and productivity growth within firm size classes. In general, the analysis is always conducted separately for micro (less than 10 employees) and larger firms, given the substantial degree of heterogeneity among these two size classes both in terms of business churning and productivity growth.

The paper finds econometric evidence that fostering competition-enhancing regulation in product markets, by reducing entry barriers and increasing the degree of competition, facilitates the entry of new competitive firms into the market. At the same time, the results also show that other less productive and inefficient firms may exit the market due to the higher competitive pressures. These first step results are also robust to a different type of regulatory indicator provided by the World Bank which measures administrative costs of starting a business. Furthermore, the results confirm that this creative-destruction process eventually results in improvements to the sectoral total factor productivity performance. In particular, larger firms' churn has a positive and significant impact on productivity growth through the reallocation of resources towards more productive firms within the same size group. In our model, we control for the cyclical position of the sector by using an

exogenous measure of the growth of the value added of the downstream sectors from the World Input-Output Tables (hence avoiding possible endogeneity problems associated with using actual sector specific output). Finally, the results of various robustness checks - such as using an alternative empirical measure of TFP and a broader specification capturing TFP catch-up mechanisms - confirm that higher business churning results in higher productivity.

1. Introduction

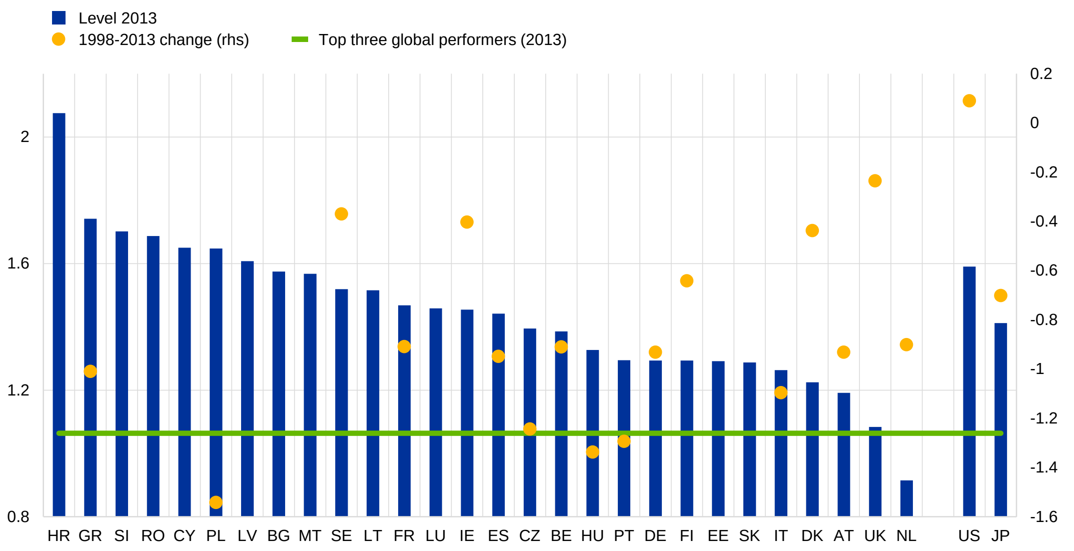
Product market institutions and regulations can have a substantial impact on market access and structure. By facilitating the speedy entry of new firms and the exit of inefficient firms - i.e. higher rates of business churn – competition-enhancing measures in product markets can allow production factors to be more efficiently reallocated between firms and sectors, therefore encouraging productivity improvements and innovation.

During the last twenty years, many EU countries have made significant progress in improving product market structures with the objective of better-functioning markets and making the regulatory environment friendlier to competition. Product market reforms comprise a wide spectrum of policies, including liberalising or relaxing regulation in the professional services, retail trade and network industries, mainly by enhancing competition through the reduction of barriers to entry, the privatisation of network industries and state-owned enterprises.

According to the OECD Product Market Regulation (PMR) indicators[1] (Figure 1), many EU countries, particularly several euro area countries, reduced product market regulation significantly over the past two decades. Nevertheless, compared to the best performers, product market regulation is still high across many EU countries, where product market reforms remain a priority in order to catch up with best practices and push forward the convergence process. At the same time, the productivity performance of many euro area countries has been relatively subdued[2], which in turn contributed to a somewhat disappointing growth dynamics (ECB, 2017 and ECB, 2018). Conversely, many central and eastern European countries have performed relatively better on average in terms of productivity growth, mainly due to the process of convergence and catching up (ECB, 2018).

[1] The latest data available are from 2013.
[2] Despite the large inflows of foreign capital from which euro area converging economies benefited before the crisis, the accumulated capital did not lead to rapid technological change and productivity growth[2] (Balta, 2013).

Figure 1
OECD – Product Market Regulation (PMR) indicators



Notes: Countries are ordered by rank in 2013.The OECD Product Market Regulation (PMR) indicators are a comprehensive and internationally comparable set of indicators that cover formal regulations in the following areas: state control of business enterprises; legal and administrative barriers to entrepreneurship; and barriers to international trade and investment. A higher value means stricter regulation. The frontier is the best performer in the OECD (in this case, the Netherlands). The top three global performers in order of ranking are the Netherlands, the United Kingdom and Austria. Index ranges from 6 (worst) to 0 (best).
Sources: OECD PMR indicators and ECB calculations.

As summarised by Griffith and Harrison (2004), the channels through which product market regulation affects countries' economic performance are manifold. They relate to stimulating productivity through competition-enhancing reforms that aim to liberalise or improve the market functioning by reallocating resources (allocative efficiency), improving the utilization of production factors (productive efficiency[3]) and providing incentives for firms to implement new technologies and move towards the technology frontier (dynamic efficiency[4]), thereby enhancing the framework conditions for growth (Nicoletti and Scarpetta, 2003; Nicodème and Sauner-Leroy, 2004).

In this paper, we aim to gauge whether product market reforms can affect productivity dynamics through business churning. We perform an EU cross-country panel econometric analysis at industry and firm size class level, and analyse the extent to which a less stringent regulatory framework is

[3] By increasing the number of competitors and hence reducing the incumbents' market power, firms are forced to decrease their mark-ups and allocate both inputs (labour and capital) and goods more efficiently to the production process (van Riet and Roma, 2006).
[4] Greater competitive pressures can influence dynamic efficiency by incentivising managers to adopt new technologies (Parente and Prescott, 1994), speed-up the replacement of old products and processes (Schumpeterian creative destruction process) in order to avoid bankruptcy (see Aghion, Dewatripont and Rey, 1999) and therefore increase the pace of productivity dynamics.

related to increased business churning and therefore able to boost aggregate productivity. The paper is organised as follows. The next section provides a brief overview of the existing literature. Section 3 describes the churning channel – through which competition-enhancing regulation in product markets could impact productivity – while section 4 discusses the data, including the definitions of variables and the methods employed to evaluate our hypotheses. Section 5 reports the results following a brief description of the methodology used, which comprises two empirical steps: first, we analyse the impact of competition-enhancing regulation on business churning; second, we examine the impact of business churning on productivity. Finally, section 6 concludes.

2. Theoretical and empirical background

A large literature investigates the effects of relaxing anti-competitive product market regulation on productivity gains (Bourlès et al., 2010; Conway et al., 2006), both from a static and dynamic perspective. Static gains are mostly associated with a one-off shift of the status quo, when long-lasting inefficiencies are eliminated, for instance through the opening of monopolistic markets to competition. While in the short-run greater competition generally leads to an increase in the level of productivity through gains in allocative and productive efficiency, in the long-run an increase in competition may also potentially affect dynamic efficiency, by stimulating firms to innovate products and processes and hence move towards the technology frontier. Nicoletti and Scarpetta (2003) demonstrate that policies of market entry liberalisation are associated with productivity dynamics. Moreover, based on a firm level analysis for the United Kingdom, Nickell (1996) finds a significant positive relationship between competition[5] and productivity growth.

Disney et al. (2000) find similar results for UK firms using a large data set. In particular, they find that the pressure exerted by new competitors is key for pushing firms to adopt new technology and implement organizational changes (so-called 'internal' restructuring), which in turn has an impact on productivity growth. In terms of relative importance, however, the 'external' restructuring alone (i.e. entry of new competitive firms and exit of inefficient ones) accounts for 90% of productivity growth. By introducing market entry and allowing incumbent firms to innovate, the new endogenous growth models[6] extend the Schumpeterian models and show that more product market competition due to new competitors entering the market may stimulate innovation to overcome competition. Foster et

[5] As measured by increased number of competitors or by lower levels of rents.
[6] See for instance Aghion et al. (1997), Aghion et al. (2001), Aghion et al. (2002), Aghion et al. (2003), Aghion and Griffith (2005).

al. (2001) and Bartelsman et al (2004) show that aggregate productivity is driven to a large extent by net firms' entry.

Moreover, many micro-econometric studies address the effects of regulatory reforms in the service sector (especially in utilities, communication, and the transport sector) on the dynamics of productivity and conclude that, on many occasions, greater competition results in productivity gains. Olley and Pakes (1996) find that the US telecommunication industry, following deregulation, experienced productivity growth. A number of other empirical studies conclude that there is a positive relation between an increase in competition and the productivity level of industrial firms (see Caves and Barton, 1990; Haskel, 1991; Green and Mayes, 1991; Nickell et al., 1992; Nickell, 1996; Pilat, 1996).

3. The effect of product market regulation on productivity: the churning channel

Against this background, we focus on the possible effects that competition-enhancing regulation in product markets has on increasing business churning and demonstrate that the latter has a positive impact on productivity performance. Adopting competition-enhancing measures in product markets may increase competitive pressure and, as a consequence, force inefficient firms to exit the market. At the same time, given the more competitive environment, highly productive incumbent firms could expand and new competitive ones would be able to enter the market. This, in turn, would improve the allocation of resources between firms (shifting them towards the most productive ones). Hence, the increased business churn may have a positive impact on aggregate productivity. This mechanism, also known as the Schumpeterian creative destruction process (Schumpeter, 1942), is often regarded as key to business dynamism and economic growth[7]. The productivity developments usually materialise through two different channels. First, incumbent firms threatened by new competitors

[7] Over the long run, firm entry and exit account for a major component of within-industry productivity growth and for this reason, obstacles to resource reallocation can have severe economic consequences. The Schumpeterian creative destruction refers to the process whereby new, dynamic and innovative products and processes replace outdated ones. As such, in order to develop more efficient economic structures, the hitherto established products, processes and companies have to be eliminated. This process could be triggered by the implementation of product market reforms aimed at cutting red tape and lower barriers to entrepreneurship. Studies for the US manufacturing sector show that the between-plant reallocation accounts for over 50 per cent of the ten-year productivity growth between 1977 and 1987 (Foster, Haltiwanger and Krizan, 2001). Other studies based on somewhat different methodologies concur with similar conclusions (see Baily, Hulten and Campbell, 1992; Bartelsman and Dhrymes, 1994). However, the process of resource re-allocation across firms is also highly sector-dependent. As shown in Schmitz Jr, J. A. (2005), for instance, allocative efficiency has a negligible contribution to the productivity performance of iron ore mining sector in the US, which is instead driven by within-firm productivity growth.

will be encouraged to innovate[8]. Second, the replacement of old products and processes, as well as the adoption of new technologies, generally leads to an increase of the aggregate productivity at industry level[9].

The wave of product market reforms that took place in the EU over the past years was aimed at making the regulatory environment friendlier to competition. Therefore, in countries – and/or sectors – where the creative destruction process is somewhat distorted by inefficient regulation, it is likely that business churning and hence productivity will be lower. For instance, artificially high barriers to entry will lead to reduced firm turnover and to a less efficient allocation of resources. Thus, making entry and exit (and adjustment more generally) prohibitively costly via distorted market structure and institutions may result in a reduced pace of churning and ultimately lower productivity levels and growth. Likewise, reforms to insolvency regimes – which reduce barriers to corporate restructuring and improve the reallocation of capital to more productive firms – are key to avoid the survival of "zombie" firms. In a more competitive regulatory environment, weak inefficient firms kept alive by an "evergreening" of loans[10] would typically exit or be forced to restructure (Andrews and Petroulakis, 2019; Storz et al., 2017).

4. Data description and definitions

The analysis is performed using data from Eurostat's Business Demography Database, which provides statistics on firms' birth and death rates. The birth (death) rate is defined as the number of enterprise births (deaths) in the reference period (t) divided by the number of enterprises active in t. The business ''churn'' – or firm turnover – is computed as the sum of the birth and death rates. Our dataset covers 28 European Union countries over the period 2000-2014. These annual data are available with a sectoral breakdown, for all companies and for two different firm size classes: below and above ten employees. Eurostat provides business demography statistics on enterprises in two different databases: the first one collects data until 2007 according to NACE Rev. 1.1 while the second one starts in 2004 and uses the new NACE Rev. 2 classification. In order to merge the two databases and coherently match the two different classification systems of industries to allow

[8] According to the Schumpeterian growth model, firms innovate step by step (i.e. a laggard firm must first innovate to catch up with the technology leader before becoming itself a leader in the future).

[9] Scarpetta and Nicoletti (2003) find evidence that regulation limiting entry may hinder the adoption of existing technologies, possibly by reducing competitive pressures, technology spillovers, or the entry of new high-technology firms. In manufacturing, the productivity gains to be expected from lower entry barriers are greater the further a given country is from the technology leader.

[10] It also allows weak banks to avoid recapitalisation by postponing the disclosure of losses in their accounts.

comparability, the NACE Rev. 2 industry breakdown has been converted into the previous NACE Rev. 1.1. Therefore, the economic activities under analysis correspond to the NACE Rev.1.1 classification and relate to manufacturing; electricity, gas and water supply; construction; wholesale and retail trade; hotels and restaurants; transport, storage and communications; real estate, renting and business activities.[11] Finally, the dataset includes additional industry-level data[12], available from Eurostat, which are used to implement a decomposition of labour productivity, as well as to create a measure for allocative efficiency across and within groups of firms classified by size, for country-year-sector combinations.

The analysis of firm demography, i.e. births and deaths of enterprises, can contribute substantially to the understanding of market dynamism and the economic growth process. The data show that there is a reallocation of resources that differs across sectors and countries and especially across firm characteristics. In particular, we see a remarkable difference in the birth/death/churn rate of smaller (less than 10 employees) and larger companies (10 employees or above), with smaller businesses showing much higher rates as compared to the larger firm size category (Table 1).

Table 1
Average cross-sectoral entry, exit and churn rates in the EU by firm's size categories over the period 2000-2014 (in percent)

Variable	Small companies (<10 employees)	Other companies (>= 10 employees)
Churn rate	20.7	3.1
Birth rate	11.3	1.7
Death rate	9.4	1.4

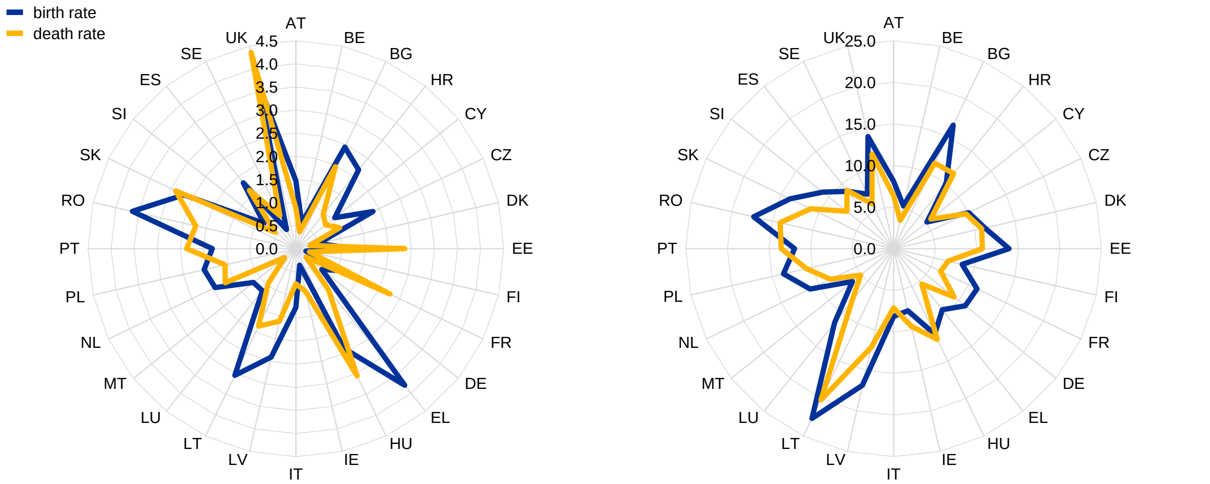
Notes: The average birth and death rates are computed across the following sectors: manufacturing; electricity, gas and water supply; construction; wholesale and retail trade; hotels and restaurants; transport, storage and communications; real estate, renting and business activities.
Sources: Eurostat Business Demography Database and ECB calculations.

[11] Education, mining and quarrying, health, financial intermediation and other sectors were excluded from the analysis for two main reasons: (1) these sectors have been only marginally affected by changes in the product market regulation; (2) their aggregate productivity dynamics is more likely driven by idiosyncratic sectoral characteristics than changes in regulation and business churning.
[12] Covering the time period 2005-2014.

Figure 3 shows the time pattern over the period 2000-2014 of the two firm size categories under analysis (below and above 10 employees), across sectors and countries. The evolution of birth and death rates is fairly symmetric: a decline in birth rates of companies in 2008-2010 (especially in companies employing less than ten employees) coincided with a similar in magnitude but reversed phenomenon in death rates. After the financial crisis, the churn rate across sectors and countries has picked-up (mainly in the case of firms employing less than ten employees) reaching levels in line with those of the years before the economic recession. A secular decline[13] in the churning rates of large companies as of the early 2000 can be observed[14].

Figure 2
Average cross-sectoral entry and exit rates by country over the period 2000-2014 (in percent)

(lhs figure: companies above ten employees; rhs figure: companies below ten employees)

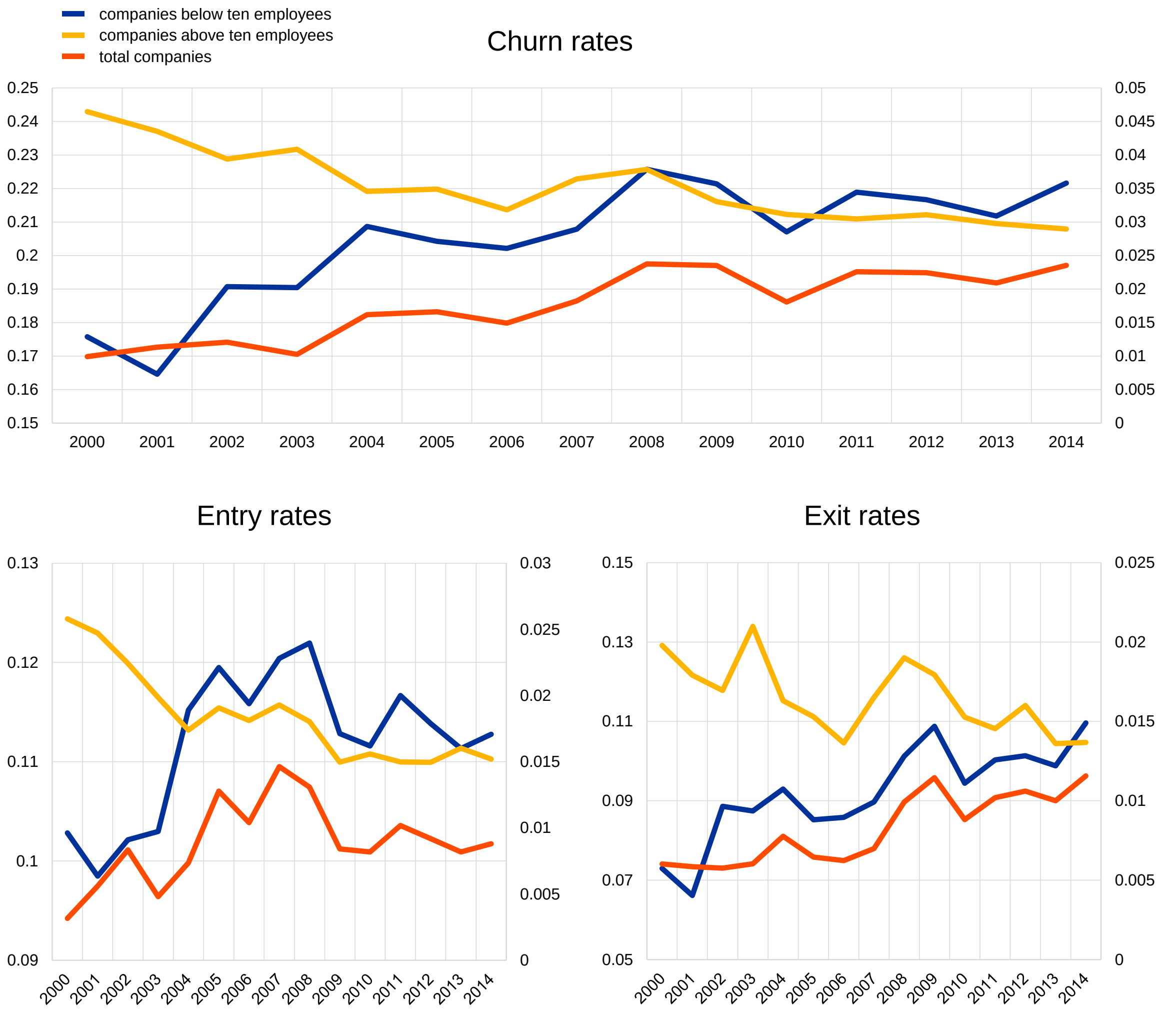


Notes: The average birth and death rates are computed across the following sectors: manufacturing; electricity, gas and water supply; construction; wholesale and retail trade; hotels and restaurants; transport, storage and communications; real estate, renting and business activities.
Sources: Eurostat Business Demography Database and ECB calculations.

[13] This is in line with the pace of business dynamism in the U.S., where firm churning rates have been on a persistent decline during the last few decades. See for instance Decker, R. A., Haltiwanger, J., Jarmin, R. S., & Miranda, J. (2016). Declining business dynamism: Implications for productivity. Brookings Institution, Hutchins Center Working Paper.
[14] 2000 is the beginning of the time period under analysis.

Figure 3
Average EU cross-sectoral churn, entry and exit rates over the period 2000-2014

(lhs axis: companies below ten employees, total companies; rhs axis: companies above ten employees)



Notes: The average churn, entry and exit rates are computed across the following sectors: manufacturing; electricity, gas and water supply; construction; wholesale and retail trade; hotels and restaurants; transport, storage and communications; real estate, renting and business activities.
Sources: Eurostat Business Demography Database and ECB calculations.

Another key variable of our analysis is total factor productivity (TFP) growth. TFP is generally defined as the portion of output that is not explained by the amount of inputs used in production, and therefore referred to as a representation of technological progress. We compute TFP on the basis of a production function, as a residual of the gross domestic product after the contributions of labour and capital have been taken into account[15]. Its level is determined by how efficiently and intensely

[15] Olley and Pakes (1996) decompose aggregate productivity into an unweighted average of firm-level productivity and a term that captures the covariance between firm size and firm productivity which shows whether greater market shares are

the inputs are utilised in production. As such, the computation of TFP requires some assumptions. In particular, we assume that the elasticities of labour and capital are equal to 2/3 and 1/3, respectively. Although we are aware that in reality structural differences in the production functions may exist so that the elasticities of labour and capital substitution may differ across countries, sectors and over time , in our study we assume that they remain constant and equal to 2/3 and 1/3, respectively. By making this assumption, we are following a number of empirical studies, such as Hall and Jones (1999), Aiyar and Feyrer (2002), Chow and Li (2002), Chow (2008), Zheng et al. (2009), Brandt and Zhu (2010). Moreover, using aggregate values of total employment in millions of persons and consumption of fixed capital in millions we assume constant skill composition of the employed skill force and constant composition of the capital stock. TFP variables were obtained using Ameco data on the basis of neo-classical Cobb-Douglas production function:

$$Y_{ijt} = A_{ijt}{L_{ijt}}^{\alpha}{K_{ijt}}^{\beta} \quad (1)$$

where real value added in each country, sector and time is produced with labour (total employment, L_{ijt}) and physical capital (K_{ijt}), and the process is enhanced by the index of technological efficiency, A_{ijt}, being the measure of the total factor productivity. The TFP figures are computed at country and sector level, without differentiating between firm's size categories.

The variable of interest in our analysis, namely product market regulatory provisions across countries, is measured by the OECD Regulation in Energy, Transport and Communications Index (PMR ETCR). The OECD provides also a broader set of Product Market Regulation (PMR) indicators, which measure the degree to which policies promote or inhibit competition in areas of the product market where competition is viable. However, data availability for the PMR indicators is limited to the years 1998, 2003, 2008 and 2013. Hence, the advantage of using the PMR ETCR indicator is that it provides annual observations over the full period 1975-2013. Moreover, it's highly positively correlated with the broader PMR indicator mentioned above. The PMR ETCR is an index which spans from 0 to 6 (a low value corresponds to light regulation). However, the range of regulatory provisions covered by the ETCR indicators is not as broad as that of the indicators of the PMR. The PMR ETCR covers 7 non-manufacturing sub-sectors (telecoms, electricity, gas, post, rail, air passenger transport, and road freight) in which anti-competitive regulation tends to be concentrated. Given that

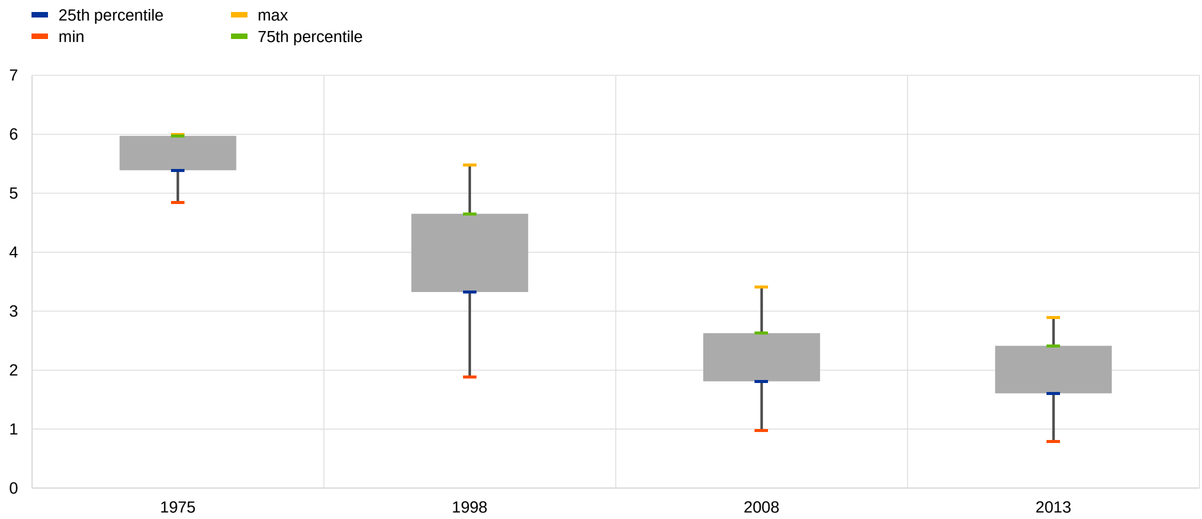
associated to more efficient firms. Alternatively, aggregate productivity growth can be decomposed in a "within" component (capturing enhanced productivity at firm level), a "between" component (capturing enhanced productivity due to reallocation effects), and other components capturing the productivity contribution of firm turnover (Baily, Hulten and Capbell (1992); Griliches and Regev (1995); Foster, Haltiwanger and Krizan (2001). Depending on the aggregate productivity decomposition used, whether it is multi-factor or labour productivity, the type of weights (employment or product) assigned to each component, the length of the time period under analysis, the estimated results may differ substantially.

manufacturing sectors are typically lightly regulated and open to international competition, the PMR ETCR index is commonly used as a good proxy of product market regulation in the whole economy[16].

Figure 4

OECD – Product Market Regulation in energy, transport and communications (PMR ETCR) indicators

(Scale 0-6 from least to most restrictive)



Notes: The box plot shows, in each year, the extreme values (min-max, i.e. the two whiskers extending from the box), as well as the third and second quartiles (the edges of each box) of the regulatory indicator for the EU cross-country distribution. The OECD Product Market Regulation in energy, transport and communications (PMR ETCR) are a comprehensive and internationally comparable set of synthetic indicators of the strictness of product markets regulation in the fields of energy, transport and communication (e.g. entry, public ownership, vertical integration and market structure).
Sources: OECD PMR ETCR indicators and ECB calculations.

Figure 4 documents the evolution of the PMR ETCR indicator on the restrictiveness of product market regulations in network industries from 1975 to 2013, in terms of average dispersion across EU countries as measured by the 25th and the 75th percentiles, as well as the minimum and the maximum. Compared to 1975, when EU countries between the 25th and 75th percentile scored on average above 5.5 in the PMR ETCR indicator, product markets in 2013 are much less strictly regulated, which is a similar profile over time as the PMR indicator. The dispersion in the restrictiveness of the PMR ETCR indicator across countries declined substantially from 1998 to 2013, as shown by the 25th and 75th percentile. Nevertheless, despite the considerable reform progress, in

[16] See for instance Bordon A., Ebeke C., and Shirono K. (2016), 'When Do Structural Reforms Work? On the Role of the Business Cycle and Macroeconomic Policies', IMF Working Paper WP/16/62, and Anderton, et al (2017) ''Sectoral wage equations and structural rigidities'' Open Economies Review, where PMR ETCR is also used as a proxy for the PMR indicator and shows that the two product market regulation series are highly correlated.

some European countries there remains significant scope for further reforms, as these markets are still heavily regulated compared to the OECD best performer, namely Great Britain.

5. Empirical Analysis

The aim of the empirical analysis is to investigate whether the reduction of regulatory barriers has successfully enhanced firm churning and, through this channel, contributed to increased aggregate sectoral productivity. In particular, we use a two-step approach to investigate whether aggregate productivity gains could be attributed to product market reforms through an increase in the rate of business churning. In the first step, we empirically investigate whether product market measures (proxied by the OECD ETCR measure) facilitated the entry and exit of firms. The first step analysis is further tested by using an alternative type of regulatory indicator, measuring administrative costs of starting a business (derived by the World Bank). In the second step, we explore whether total factor (and labour) productivity dynamics at sector level are affected by business churning.[17] Finally, we investigate the relationship between business churning and the components of labour productivity, namely allocative efficiency across firm size classes and productivity growth within firm size classes. In our model, we control for the cyclical position of the sector by using an exogenous measure of the growth of the downstream sectors, constructed from the World Input-Output Tables. The use of this measure avoids possible endogeneity problems related with using actual sector-specific output measures. Finally, we conduct various robustness checks - such as using an alternative empirical measure of TFP and a broader specification capturing TFP catch-up mechanisms – with a view to further test the impact of business churning on productivity.

5.1 The effect of product market regulation on business churning

In the first step of the analysis, we assess the impact of product market regulation on the business churn rate and, separately, on its two components: birth and death rates. This relationship is explored through the estimation of the following equation:

$$rate_{ijt} = \beta_0 + \beta_1 PMR\_ETCR_{it} + \beta_2 * cyclical\_indicator_{ijt} + \gamma_i + \delta_{jt} + \varepsilon_{ijt} \quad (2)$$

[17] A somewhat similar approach based on two sequential steps is used by Cincera and Galgau (2005) and in European Commission (2014). European Commission, 2014. *Market Reforms at Work in Italy, Spain, Portugal and Greece*, 5/2014.

where countries are denoted by *i* = 1,…,N and sectors by *j* = 1,…,N. $rate_{ijt}$ identifies birth, death and churn rates (in percentage points) of companies in a given country, sector and time, while PMR_ETCR_{it} refers only to country and time and does not differ by sector. Our prior is that the PMR ETCR parameter will be negatively signed, because we expect a higher level of stringency of regulation to be associated with lower level of business churning. The cyclical indicator (explained in detail below) captures the cyclical position of the sector of interest and is expected to have a positive sign for the birth rate (i.e., the stronger the cyclical position of the sector, the higher the expected entry rates of firms), but a negative sign for the death rate (i.e., the stronger the cyclical position of the sector, the lower the expected exit rates of firms). γ_i and δ_{jt} represent sector and country-time fixed effects, while ε_{ijt} is the error term. The above equation is estimated separately for the two firm size classes under analysis, namely small and larger companies.

The $cyclical\_indicator_{ijt}$ is a control variable aiming to capture the cyclical position of the given sector. Following Bartelsman, Caballero, and Lyons (1994), the indicator is constructed using the growth of value added of downstream sectors, i.e. sectors that buy inputs from the sector of interest:

$$cyclical\_indicator_{ijt} = \sum_l w_{ijklt} * dyn\_value\_added_{klt} \quad (3)$$

where $dyn\_value\_added_{klt}$ is the growth of value added in country *k*, sector *l* at time *t*, and weights w_{ijklt} are shares of the purchases of sector *j* in country *i* in period *t* from sector *l* in country *k* in period *t* ($purchase_{ijklt}$), in all purchases done by sector *j* in country *i* in period *t* (from all sectors and countries, $\sum_{kl} purchase_{ijklt}$):

$$w_{ijklt} = {purchase_{ijklt}} \Big/ {\sum_{kl} purchase_{ijklt}} \quad (4)$$

The cyclical indicator is computed using World Input-Output Tables, providing data in years 2000-2014 (Timmer, M. P., Dietzenbacher, E., Los, B., Stehrer, R. and de Vries, G. J., 2015), and deflated by the GDP deflator. Since the indicator is defined at the sector-level, it is well suited to be used to control for the cyclical position of a given sector when analysing the sectoral business churning and the sectoral productivity developments. Furthermore, by capturing the demand fluctuations in a given sector, expressed as the exogenous cyclical position of its domestic and foreign downstream sectors in a given time, it addresses potential endogeneity problems related with using measures of the cyclical position of the whole economy (e.g. GDP growth or *lagged* GDP growth), or the sectors own value-added growth.

We carry out regression analysis using country-time and sector fixed effects.[18] We also perform a number of tests to check the robustness of the model. The Wooldridge test for autocorrelation in panel data models (Wooldridge, 2001)[19] and the likelihood ratio test show, respectively, the existence of first-order serial correlation and heteroskedasticity. In addition, an issue which has to be addressed is the standard error clustering bias originating from the use of dependent and explanatory variables which vary at different level of aggregation. For instance, in the first step regression, the PMR_ETCR variable varies at country level while the outcome variables (i.e. birth, death and churn rates) vary at a higher level of disaggregation, namely at industry level. This means that the effective sample size of each estimated regression is somewhat close to the number of clusters at the lower level of aggregation. When the number of clusters is very small, the results may underestimate either the serial correlation in a random shock or the intra-class correlation as in the Moulton problem. In our case, for instance, the standard errors of the PMR_ETCR coefficient can be downward biased due to contemporaneous correlation of the error terms across industries within countries (Moulton, 1990).[20] To account for this problem, we estimated each regression using Driscoll and Kraay's standard errors[21] – which correct not only for heteroskedasticity and general forms of cross-sectional ("spatial") correlation, but also for temporal dependence (Hoechle, 2007). For a robustness check, we also use cluster-robust variance estimators (i.e. clustered standard errors) at country-sector level, which account for both heteroskedasticity and serial correlation[22]. Statistical inference based on these cluster-robust standard errors broadly confirms the previous results.

"Outlier" observations can exert a strong influence on the fitted least square regression models, both on the slopes and the intercept. For this reason, we use the Cook's distance or Cook's D[23] statistical approach to deal with outliers in the least-squares regression analysis. The Cook's D methodology identifies influential data points by estimating robust regression[24] using two different functions assigning weights to the observations, Huber weights and biweights (Hamilton 1991). This technique assigns each observation a weight between 0 and 1, where a lower weight corresponds to

[18] The standard F-tests for the presence of country-time and industry dummies strongly support (at the 1 per cent level) their inclusion in the productivity equation. In the sensitivity analysis, we also considered country-specific time trends. However, none of the estimated coefficients of the time trend was statistically significant (even at the 10 per cent level) and, thus, these trend variables were not included in the preferred specifications.

[19] Stata command xtserial.

[20] The tests for cross-sectional dependence (contemporaneous correlation) have not been performed due to insufficient observations across the panel. According to Baltagi (2008), cross-sectional dependence is a problem mainly in macro panels with long time series (over 20-30 years), which is not the case in our analysis.

[21] Stata command xtscc.

[22] David M. Drukker, 2003. *Testing for serial correlation in linear panel-data models*, The Stata Journal 3, Number 2, pp. 168–177.

[23] Excluding observations for which Cook's D is above 1.

[24] We used *rreg* Stata command.

a higher residual. In order to eliminate the effect of the outliers in the fitted model, we exclude the observations that are assigned with a weight equal to zero.[25]

Table 2

Impact of product market regulation (PMR ETCR and DBI SB) on business churning – first step results

	companies < 10 employees				companies >= 10 employees			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1st step	Churn rate	Birth rate		Death rate	Churn rate	Birth rate		Death rate
Cyclical Indicator	0.0000	0.0010***	0.0002**	-0.0008***	-0.0002**	0.0004	0.0002	-0.0003***
	(0.0003)	(0.0003)	(0.0001)	(0.0002)	(0.0001)	(0.0002)	(0.0001)	(0.0000)
PMR ETCR	-0.0338***	-0.0198***		-0.0126***	-0.0000	0.0023***		-0.0028**
	(0.0052)	(0.0033)		(0.0046)	(0.0015)	(0.0004)		(0.0013)
DBI SB cost			-0.0005*				0.0002**	
			(0.0004)				(0.0000)	
N	1204	1240	1596	1230	1464	1496	1756	1498
R-sq	0.6291	0.5294	0.6111	0.6625	0.6997	0.6410	0.6247	0.7050

Notes: Fixed-Effects Model. Fixed effects for country-time and sector have been included. Dataset trimmed for outliers. Robust Driscoll and Kraay's standard errors in parentheses:* p<0.1, ** p<0.05, *** p<0.01. PMR ETCR is the Product Market Regulation in Energy, Transport and Communications Index from the OECD. DBI SB cost is the cost of starting a new business from the World Bank Doing Business Indicator.

The results from the first stage of the analysis are in line with our priors (Table 2). The sector-specific cyclical indicator is statistically significant and the signs of its parameter show, as expected, that when demand increases for the outputs of the sector of interest then this has a positive impact on the birth rate in that sector and a negative impact on the death rate. Furthermore, Table 2 also suggests that an improvement in the level of competition-enhancing regulation, measured by the PMR ETCR indicator, has a positive impact on the churning dynamics of small firms (LHS Table 2). The analysis provides different and somewhat mixed results for those companies that employ more than 10 employees (RHS Table 2). For these companies, a more stringent regulation seems to depress business churning through the exit channel – i.e. the less competition-friendly the regulatory environment, the more likely incumbent firms are to remain in business, regardless of their productivity and efficiency performance. On the other hand, the entry of new big competitors into

[25] Trimmed observations were almost exclusively attributable to one of two cases. The first category are individual observations in small countries (Luxembourg, Slovenia, Slovakia, Czech Republic) where in some years particularly high death or birth rates can happen even without a particular reason, due to low denominator (number of active firms). The second category is connected with the years of a financial crisis, where some sectors in some countries were particularly hard hit – for example we trim the observations of death rates in Portugal in real estate and construction.

the market seems to be positively affected by a stricter regulation, possibly because this effect captures companies that may start already fairly large and that are more able to pay any costs associated with regulation. In addition, the creation of large companies might respond to a different set of incentives, as for example mergers and acquisitions or political decisions, especially in former state-owned sectors.

As a robustness check, Table 2 also shows the results from the analysis exploring the relation between birth rates and changes in "red tape" costs – proxied by the Doing Business indicator on administrative costs of starting a business (DBI SB costs), as an alternative to the PMR ETCR indicator. The results for small companies suggest that the costlier the procedures to start a business are, i.e. the stricter the regulation, the lower the birth rates. In contrast, the indicator has a significant positive impact on birth rates of large companies. However, as explained above, the creation of large companies might respond to a different set of incentives, and the cost of starting a business for large companies may be less relevant than for small ones.

Overall, we conclude from these results that a higher degree of competition due to competition-enhancing reforms in product markets positively affects the process of firm exit, regardless of their size. In terms of birth rates, the impact of relaxing regulation on the creation of new firms is mixed – positive for small companies and negative for larger ones. It is worth noting that since new businesses usually start small, it sounds reasonable that relaxing product market regulation has a stronger and positive effect on the entry rate of companies with a small size compared to larger firms. As a result, competition-enhancing regulation in product markets seems to play a key role in fostering the creative-destruction process of firms.

We also explore the impact of the *change* in regulation (both PMR ETCR and DBI SB costs) on business churn, birth and death rates through the estimation of the following equation in first differences:

$$\Delta rate_{ijt} = \beta_0 + \beta_1 \Delta regulation_{it} + \beta_2 * cyclical\_indicator_{ijt} + \omega_t + \varepsilon_{ijt} \qquad (5)$$

where countries are denoted by *i* = 1,…,N and sectors by *j* = 1,…,N. $\Delta rate_{ijt}$ identifies the change in birth, death and churn rates of companies in a given country, sector and time, while $\Delta regulation_{it}$ refer only to country and time and do not differ by sector. ω_t represents time fixed effects while ε_{ijt} is the error term. As before, the equation is estimated separately for the two firm size classes under analysis, namely small and larger companies.

Table 3

Impact of product market regulation (PMR ETCR and DBI SB) on business churning – first step results estimated in first differences

	companies < 10 employees				companies >= 10 employees			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1st step	**ΔChurn rate**	**ΔBirth rate**		**ΔDeath rate**	**ΔChurn rate**	**ΔBirth rate**		**ΔDeath rate**
Cyclical indicator	0.0002	0.0001	0.0003**	-0.0019	-0.0013	0.0003	0.0005	-0.0011
	(0.0001)	(0.0000)	(0.0001)	(0.0000)	(0.0011)	(0.0004)	(0.0004)	(0.0009)
ΔPMR ETCR	-0.0282**	-0.0083		-0.0172***	-0.0160**	-0.0038**		-0.0170***
	(0.0121)	(0.0115)		(0.0001)	(0.0063)	(0.0018)		(0.0045)
ΔDBI SB cost			-0.0012**				-0.0005***	
			(0.0007)				(0.0002)	
N	1151	1215	1390	1171	1401	1440	1613	1430
R-sq	0.0530	0.0296	0.0538	0.0881	0.0504	0.0629	0.0562	0.0559

Notes: Regression in first differences. Time fixed effects have been included. Explanatory variables and dependent variables are in first difference. Stata command: *areg, absorb() cluster()*. Robust standard errors in parentheses:* p<0.1, ** p<0.05, *** p<0.01. PMR ETCR is the Product Market Regulation in Energy, Transport and Communications Index from the OECD. DBI SB cost is the cost of starting a new business from the World Bank Doing Business Indicator.

The results, presented in Table 3, show that an increase in the regulatory burden in product markets will mainly hamper the creative destructive process via the death rate channel. At the same time, the entry of both small and larger companies into the market seems to be negatively and significantly affected by the administrative costs of starting a business. Overall, these results are somewhat similar to the results in Table 2 although the R-squared is much smaller when the equation is estimated in first differences.

5.2 The effect of business churning on productivity growth

The second stage of the analysis quantifies the relationship between business churning and aggregate productivity growth at the industry-level. As in the previous stage, we estimate the model for the two different firm size categories.

Following the approach employed by Cincera and Galgau (2005) we estimate the following equation:

$$\Delta\, ln\_tfp_{ijt} = \beta_0 + \beta_1 * rate_{ijt-1} + \beta_2 * cyclical\_indicator_{ijt} + \gamma_i + \delta_{jt} + \varepsilon_{ijt} \qquad (6)$$

where $\Delta\, ln\_tfp_{ijt}$ is the total factor productivity dynamics at country-sector level. $rate_{ijt}$ identifies birth, death and churn rates of companies in a given country, sector and time, the $cyclical\_indicator_{ijt}$ explained above is a control variable aiming to capture the cyclical position of the given sector, while γ_i and δ_{jt} represent sector and country-time fixed effects and ε_{ijt} is the error term. We expect the parameters for the cyclical indicator and the churn/birth/death rates to be all positively signed.

Table 4

Impact of business churning on aggregate productivity – second step results

	companies < 10 employees			companies >= 10 employees		
	(1)	(2)	(3)	(4)	(5)	(6)
2nd step	TFP growth					
Cyclical indicator	0.0024***	0.0024***	0.0025***	0.0025***	0.0025***	0.0026**
	(0.0005)	(0.0006)	(0.0006)	(0.0005)	(0.0005)	(0.0006)
Churn rate (t-1)	0.0816***			0.1923**		
	(0.0256)			(0.0759)		
Birth rate (t-1)		0.1049**			0.1911*	
		(0.0404)			(0.1109)	
Death rate (t-1)			0.1844***			0.3751**
			(0.0450)			(0.1517)
N	1309	1349	1321	1638	1706	1654
R-sq	0.5195	0.5049	0.5186	0.4933	0.4835	0.4964

Notes: Fixed-Effects Model. Fixed effects for country-time and sector have been included. Dataset trimmed for outliers. Robust Driscoll and Kraay's standard errors in parentheses:* p<0.1, ** p<0.05, *** p<0.01

The specification performs well, with the sector-specific cyclical indicator showing the expected positive and statistically significant impact on aggregate productivity (Table 4). As envisaged, the results also show a positive and statistically significant relationship between the variables of business dynamics, as measured by the firm churn/birth/death rates, and the aggregate productivity growth at sector level across both larger and small firms (Table 4). As shown in Table 4, the aggregate sectoral productivity growth is substantially affected by business churning: in terms of firm exits, one interpretation is that the least productive firms exit the market, thereby allowing more productive surviving firms to take full advantage of all the increasing returns and thereby increasing their aggregate productivity dynamics, while aggregate productivity can also increase merely by the exit of less productive firms; meanwhile, firm entry also has a positive impact on aggregate productivity, including the entry of small firms which has a positive and significant impact on TFP growth at the industry level, most probably by increasing competition and putting pressure on incumbent firms to perform better. It is however worth noting that the impact of small companies' churn on TFP growth is somewhat smaller than for larger firms (LHS Table 4)[26]. Further robustness checks broadly confirm the previous findings: first, Table A2 in Annex I shows further results of the impact of business churning using a different measure of TFP growth[27]; second, results in Table A3 based on a broader specification including a TFP catch-up variable confirm the previous findings regarding the positive impact of business churning on TFP.

Next, we investigate the impact of business churning on the TFP components. To this end, we first expand the second stage of the analysis by quantifying the relationship between business churning and aggregate labour productivity growth at the industry-level. This is followed by an analysis of the decomposition of labour productivity into allocative efficiency across firm size classes and productivity growth within firm size classes, using the following productivity decomposition developed by Olley and Pakes (1996):

$$P_{ijt} = \sum_{k\in J} \theta_{ijkt} P_{ijkt} = \frac{1}{N}\sum_{k\in J} P_{ijkt} + \sum_{k\in J}\left(\theta_{ijkt} - \overline{\theta_{ijkt}}\right)\left(P_{ijkt} - \overline{P_{ijkt}}\right) \quad (7)$$

where P_{jt} is labour productivity in country i, sector j and time t, N is the number of company size classes k in sector j, and θ_{ijkt} is the market share of firms within size class k. From here,

$$\sum_{k\in J}\left(\theta_{ijkt} - \overline{\theta_{ijkt}}\right)\left(P_{ijkt} - \overline{P_{ijkt}}\right) \quad (8)$$

is the allocative efficiency across firm size-classes, and

$$\frac{1}{N}\sum_{k\in J} P_{ijkt} \quad (9)$$

is the unweighted average of productivity per size class, reflecting productivity growth within firm size-classes.

We use the labour productivity decomposition into allocative efficiency across firm size-classes and productivity growth within firm size-classes in order to explore for which of them business churning

[26] Some findings in the literature support the view that small companies entering the market are generally less efficient than large entrants and incumbents. Hence, they seem to struggle to narrow down the efficiency differential with large firms. See Taymaz, E., 2005. Are Small Firms Really Less Productive?, Small Business Economics.

[27] TFP growth per person employed from EU KLEMS.

is more relevant. On the one hand, the entry and exit of firms in size class *i* may help reallocating resources towards more productive firms in other size classes, hence increasing the allocative efficiency across the firm size-classes. On the other hand, business churning increases the need of incumbents to keep a competitive edge and therefore to invest in new technology and innovations. Moreover, if the relatively less efficient firms exit the market, the average productivity of the incumbents will be automatically increased. That is, business churning may also increase the within-firm size class productivity growth of incumbents. Hence, we estimate the following equation:

$$\Delta \ln\_TFP\_component_{ijt} = \beta_0 + \beta_1 * rate_{ijt-1} + \beta_2 * cyclical\_indicator_{ijt} + \gamma_i + \delta_{jt} + \varepsilon_{ijt} \qquad (10)$$

where $\Delta\, ln\_TFP\_component_{ijt}$ is the dynamics of one of the TFP components (the aggregate labour productivity or allocative efficiency across firm size-classes/productivity growth within firm size-classes) at country-sector-firm size level. $rate_{ijt}$ identifies birth, death and churn rates of companies in a given country, sector and time, the $cyclical\_indicator_{ijt}$ aims to control for the cyclical position of the given sector, while γ_i and δ_{jt} represent sector and country-time fixed effects and ε_{ijt} is the error term. As before, we expect the parameters for churn/birth/death rates to be all positively signed.

Results for large companies (Table 5 RHS) confirm the overall positive and statistically significant relationship between the sector-specific cyclical indicator, as well as business dynamics, and the labour productivity growth at sector level. In particular, the labour productivity growth is substantially affected by business churning of companies employing more than 10 employees, both through the exit and entry channel. On the other hand, firm's entry and exit for smaller companies (Table 5 LHS) does not deliver significant impacts on the aggregate sectoral labour productivity growth, possibly because they are on average less productive than larger ones[28].

[28] Especially in more capital-intensive sectors, where larger firms can exploit increasing returns to scale. OECD (2017) reveals an increasing labour productivity divide between SMEs and large firms in the post-crisis period, with micro-enterprises lagging behind in a large number of countries.

Table 5

Impact of business churning on aggregate labour productivity – second step results

	companies < 10 employees			companies >= 10 employees		
	(1)	(2)	(3)	(4)	(5)	(6)
2nd step	Labour productivity growth					
Cyclical indicator	0.0041***	0.0041***	0.0041***	0.0066***	0.0057***	0.0067***
	(0.0008)	(0.0007)	(0.0008)	(0.0012)	(0.0010)	(0.0012)
Churn rate (t-1)	-0.0218			0.4138***		
	(0.0365)			(0.1329)		
Birth rate (t-1)		-0.0126			0.5143***	
		(0.0992)			(0.1178)	
Death rate (t-1)			-0.1069			0.6959***
			(0.0751)			(0.2287)
N	899	925	915	812	832	820
R-sq	0.7258	0.7230	0.7194	0.6997	0.6929	0.7020

Notes: Fixed-Effects Model. Fixed effects for country-time and sector have been included. Dataset trimmed for outliers. Robust Driscoll and Kraay's standard errors in parentheses:* p<0.1, ** p<0.05, *** p<0.01

Next, Table 6 quantifies the relationship between the components of the aggregate labour productivity growth and business churning at the industry-level. We find that business churning seems to increase labour productivity growth by improving productivity within the size category of larger companies, which covers both the improved productive efficiency at company-level, and also potentially allocative efficiency across companies within the same size-class. This means that the entry of a new competitor with size *i* improves the allocative efficiency within that same size-class, and not in a different category. At the same time, the exit of an inefficient player with size *i* may increase the labour productivity within the same firm size category. This finding seems to suggest that labour market resources tend to be reshuffled within the same firm size category.

Table 6

Impact of business churning on productivity drivers – second step results

	companies < 10 employees			companies >= 10 employees		
	(1)	(2)	(3)	(4)	(5)	(6)
2nd step	**Growth of allocative efficiency across size classes**					
Cyclical indicator	0.0007***	0.0008***	0.0007***	0.0008***	0.0008***	0.0008***
	(0.0001)	(0.0002)	(0.0001)	(0.0002)	(0.0002)	(0.0002)
Churn rate (t-1)	0.0042			0.0504		
	(0.0235)			(0.0809)		
Birth rate (t-1)		-0.0223			0.0591	
		(0.0464)			(0.1351)	
Death rate (t-1)			0.0431			-0.0580
			(0.0332)			(0.0757)
N	752	779	756	757	782	767
R-sq	0.3919	0.3644	0.3966	0.4004	0.3652	0.3688
	Productivity growth within size classes					
Cyclical indicator	0.0060***	0.0057***	0.0060***	0.0064***	0.0056***	0.0063***
	(0.0010)	(0.0012)	(0.0009)	(0.0013)	(0.0011)	(0.0012)
Churn rate (t-1)	-0.0254			0.3950***		
	(0.0495)			(0.1363)		
Birth rate (t-1)		-0.0474			0.8430***	
		(0.0711)			(0.1917)	
Death rate (t-1)			-0.0060			0.3819**
			(0.1242)			(0.1874)
N	752	771	758	780	798	783
R-sq	0.7011	0.6985	0.6963	0.7054	0.7113	0.7173

Notes: Fixed-Effects Model. Fixed effects for country-time and sector have been included. Dataset trimmed for outliers. Robust Driscoll and Kraay's standard errors in parentheses:* p<0.1, ** p<0.05, *** p<0.01

Finally, we further test the robustness of our two-step methodology by regressing the residuals from the second step regression (equation 6) on the PMR_ETCR index (Table A1 in Annex I), following Ciapanna and Genito (2014). The idea behind this is to check whether there are other aspects in productivity dynamics that can be affected by a changing level of regulation. Therefore, we estimate the following equation:

$$\varepsilon_{ijt} = \beta_0 + \beta_1 PMR\_ETCR_{it} + u_{ijt} \tag{11}$$

where ε_{ijt} are residuals from the second step regression (equation 6).

Since we argue that churn/birth/death rates are (partly) determined by product market regulation, we expect the coefficients of PMR ETCR to be insignificant. This is related to the fact that the effect of regulation, or at least the part impacting through business dynamics, is already captured by the churn/birth/death rates included in the regression. The coefficients prove low and statistically insignificant, confirming that product market regulation primarily affects productivity through the churning channel.

Overall, our results confirm that increased business churning is associated with increased productivity. In this respect, it is worth reiterating that structural reforms help in creating a competitive productivity-enhancing environment where the transfer of technology from the more efficient companies to the less efficient ones could be facilitated. The higher the capacity to absorb and adapt foreign knowledge for a given country-sector, the faster it would be to catch-up with the technology leader. In Tables B1 and B2 we estimate a broader specification capturing TFP catch-up mechanisms, and this specification confirms our results that higher business churning results in higher productivity. It is also shown that the TFP catch-up process is ongoing in Europe but seems to be a slow process which may be related to the degree of product market regulation in Europe. Furthermore, the overall results of heterogeneous impacts of firms of different size class on labour productivity shown earlier in the paper may suggest how to better target policies that can reduce barriers and capitalise on opportunities for productivity growth.

6. Conclusions

To conclude, our results show that fostering competition-enhancing regulation in product markets helps to increase business dynamism through increased entry and exit rates of firms. This, in turn, is found to improve the aggregate sectoral productivity performance. Moreover, a sector-specific cyclical indicator captures a significant variation in the cyclical position of the sector thereby showing, as expected, that a demand increase in the downstream sectors positively affects the birth rates in the sector of interest – i.e. the one which the downstream sectors buy input from – and negatively the death rates.

In particular, in the first step of our analysis, we find that an improvement in the level of competition-enhancing regulation, proxied by the OECD's product market regulation ETCR indicator, positively affects the business churn rate. In the case of firms with less than ten employees, this holds for both transmission channels (death and birth rates), while in companies employing more than ten people, the impact of product market regulation on business churn seems to be related to firm exits. This is consistent with the fact that new firms usually start small and therefore product market measures aiming at increasing competition mainly affects the creation of micro companies. The first step analysis is further tested by using a different type of regulatory indicator, measuring administrative costs of starting a business. The results confirm the previous findings and suggest that reducing administrative costs has a positive effect on smaller firms' entry rates.

The second step of our analysis estimates the relationship between business dynamics and sectoral total factor productivity. Overall, we find a statistically significant positive correlation between our key explanatory variables (churn, birth and death rates) and the TFP dynamics, which suggests that increased business churning is indeed associated with increased productivity. Furthermore, our results show that business churning seems to increase labour productivity by improving the allocation of labour market resources of large companies within the same size category. Finally, the results of various robustness checks – such as using an alternative empirical measure of TFP and a broader specification capturing TFP catch-up mechanisms – confirm our results that higher business churning results in higher productivity.

The results from our analysis point towards substantial benefits that could follow further competition-enhancing measures in product markets. Such measures seem to be beneficial for fostering the entry of new companies, which usually start small. At the same time, providing supportive business regulatory environment would allow them to grow and become more productive. This could hold true especially in a number of European countries, since the differences in the level of regulation, as measured by the product market regulation indices, and the trends observed in recent years, are very heterogeneous. However, we have to bear in mind that the conclusions are somewhat illustrative, given that the estimations are conducted at an aggregate level. As such, it's important to be aware of the limitations of the presented analysis. This holds true especially with regard to the information on the level of regulation available, since aggregate indexes do not allow for differentiation between various ways that regulation has been implemented across the countries. As far as data on business dynamism is concerned, enhancing the analysis with the use of granular, micro-level data could be a useful next step leading to a better understanding of the issues. This would possibly allow for a better understanding on the differences between firms in terms of their reaction to changes in the level of regulation, as well as of the drivers of productivity dynamics.

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Annex I

Table A1
Impact of product market regulation (PMR ETCR) on residuals from the second stage analysis

	All companies		
	(1)	(2)	(3)
1st step	Residuals from the second stage analysis		
PMR ETCR	-0.0006	-0.0000	-0.0009
	(0.0008)	(0.0012)	(0.0010)
N	1375	1430	1385
R-sq	0.0923	0.0916	0.0913

Notes: Fixed-Effects Model. Fixed effects for country-time and sector have been included. Residuals from the second stage analysis (regression a1) are regressed on PMR ETCR. Dataset trimmed for outliers. Robust Driscoll and Kraay's standard errors in parentheses: * p<0.1, ** p<0.05, *** p<0.01.

Table A2
Impact of business churning on productivity growth – second step results

	companies < 10 employees			companies >= 10 employees		
	(1)	(2)	(3)	(4)	(5)	(6)
2nd step	TFP growth (EU KLEMS)					
Cyclical downstream indicator	0.0010**	0.0010**	0.0010**	0.0008***	0.0008**	0.0008**
	(0.0003)	(0.0004)	(0.0004)	(0.0002)	(0.0003)	(0.0003)
Churn rate (t-1)	0.0861**			0.1635**		
	(0.0404)			(0.0894)		
Birth rate (t-1)		0.0064			0.0482	
		(0.0788)			(0.0601)	
Death rate (t-1)			0.2367***			0.4645**
			(0.0426)			(0.2460)
N	778	805	788	965	1020	978
R-sq	0.2928	0.2907	0.3047	0.2735	0.2692	0.2799

Notes: Fixed-Effects Model. Fixed effects for country-time and sector have been included. TFP growth per person employed (source: EU KLEMS). Dataset trimmed for outliers. Robust Driscoll and Kraay's standard errors in parentheses:* p<0.1, ** p<0.05, *** p<0.01.

Annex II

In this section, we carry out a robustness check of our results by expanding our specification to check whether technological diffusion has an impact on enhancing the aggregate sectoral productivity of companies, We follow Nicoletti and Scarpetta (2003) and include two additional variables to our main specification: the TFP dynamics of the leading country in a given sector[29] and a TFP technology catch-up variable which partly captures technological diffusion and is proxied by the lagged ratio between the productivity level of a given country sector and the productivity level of the country leader in that sector (Table 4).[30,31] :

$$\Delta\, ln\_tfp_{ijt} = \beta_0 + \beta_1 * cyclical\_indicator_{ijt} + \beta_2 * rate_{ijt-1} + \beta_3 \max\_\Delta\, ln\_tfp_{jt} + \beta_{34}\left({tfp_{ijt-1}}/{\max\_tfp_{jt-1}} \right) + \gamma_i + \delta_{jt} + \varepsilon_{ijt} \quad (12)$$

where $\max\_\Delta\, ln\_tfp_{jt}$ is the TFP growth in the leader country and ${tfp_{ijt-1}}/{\max\_tfp_{jt-1}}$ measures the technological catch-up vis-à-vis the leader country. The equations are estimated, as in the previous equations, by means of an OLS panel regression, including country-time and sector fixed effects. As before, we perform the estimation using Driscoll and Kraay's standard errors.

The previous general findings presented in Table 4 are confirmed in the above more elaborate specification (Table B1). In particular, results in Table B1 suggest that aggregate sectoral productivity benefits from firms' entry and exit of both small and larger companies. In addition, although we find that the TFP leader variables do not directly lead to an increase in TFP growth, the statistical significance of the TFP catch-up variable suggests that technological diffusion may play role in TFP growth. Evidence from the literature suggest that technology diffusion and adoption play a key role in enhancing firm productivity, and rely on substantial and well-directed technological efforts and on absorptive capacity (Cohen & Levinthal, 1989). In each industry, the countries that are further away

[29] This variable captures possible technology diffusion from the leader country. We assume that the level of productive efficiency may also depend on knowledge transfer and technology absorption from the leader in a given country/sector.
[30] Following Nicoletti and Scarpetta (2003).
[31] 75% of the leading countries (per year and sector) were among those lightly regulated, as proxied by the PMR indicators being below average.

from the technological frontier tend to experience higher levels of productivity growth as they try to catch-up with, and learn from the technology leader. However, the small magnitude of the TFP technology catch-up parameter suggests that technology diffusion may be hampered in Europe as catching up with the TFP leaders on productivity seems to be a weak and slow process[32]. Results are consistent with the view that a high degree of product market regulation in EU countries can deter TFP-catch up and technological diffusion; hence product market reforms and competition-enhancing regulation may strengthen the TFP catch-up process.

Table B1
Impact of business churning on aggregate productivity

	companies < 10 employees			companies >= 10 employees		
	(1)	(2)	(3)	(4)	(5)	(6)
2nd step	TFP growth					
Cyclical downstream indicator	0.0023***	0.0024***	0.0024***	0.0026***	0.0025***	0.0026***
	(0.0005)	(0.0006)	(0.0005)	(0.0006)	(0.0005)	(0.0006)
Churn rate (t-1)	0.0656**			0.1685**		
	(0.0297)			(0.0644)		
Birth rate (t-1)		0.0877**			0.1963**	
		(0.0442)			(0.0848)	
Death rate (t-1)			0.1468**			0.3163**
			(0.0481)			(0.1497)
TFP catch-up	-0.0615***	-0.0639***	-0.0579***	-0.0553***	-0.0599***	-0.0556***
	(0.0120)	(0.0129)	(0.0113)	(0.0088)	(0.0102)	(0.0078)
TFP leader	0.0848	0.0953	0.0860	0.0880	0.0883	0.0952
	(0.0686)	(0.0744)	(0.0648)	(0.0088)	(0.0617)	(0.0607)
N	1310	1350	1320	1644	1713	1663
R-sq	0.5329	0.5255	0.5387	0.5008	0.4919	0.4975

Notes: Fixed-Effects Model. Fixed effects for country-time and sector have been included. Dataset trimmed for outliers. Robust Driscoll and Kraay's standard errors in parentheses:* p<0.1, ** p<0.05, *** p<0.01

[32] While technology diffusion to frontier firms seems to have been increasingly fast in recent years, its diffusion to the rest of the firms has been increasingly slow, which in turn negatively affects the productivity growth of the total economy (Andrews et al., 2015).

In addition, in Table B2 below we add an intercept dummy for the central and eastern European (CEE) countries as well as an interaction term between the TFP catch-up variable and the CEE countries, and find that both variables are statistically significant. The results reveal that the TFP catch-up process in CEE countries, which are experiencing a convergence process, is faster than in the rest of the EU countries. As a result, when the catch-up variable is interacted with the CEE countries dummy, the magnitude of its coefficient is further reduced for the rest of the EU countries, implying that technology diffusion across more advanced EU countries is even slower than suggested by the results in Table B1.

Table B2
Impact of business churning on aggregate productivity – CEE countries

	companies < 10 employees			companies >= 10 employees		
	(1)	(2)	(3)	(4)	(5)	(6)
2nd step	TFP growth					
Cyclical downstream indicator	0.0025***	0.0025***	0.0026***	0.0025***	0.0026***	0.0027***
	(0.0006)	(0.0006)	(0.0007)	(0.0006)	(0.0006)	(0.0007)
Churn rate (t-1)	0.0686**			0.1425**		
	(0.0265)			(0.0756)		
Birth rate (t-1)		0.0833**			0.1604**	
		(0.0356)			(0.0907)	
Death rate (t-1)			0.1509***			0.2913**
			(0.0442)			(0.1637)
TFP catch-up	-0.0481***	-0.0477***	-0.0455**	-0.0408***	-0.0428***	-0.0385***
	(0.0156)	(0.0152)	(0.0148)	(0.0102)	(0.0121)	(0.0085)
CEE	-0.0627***	-0.0221	0.0816**	0.0996***	0.1584***	0.0456**
	(0.0160)	(0.0225)	(0.0284)	(0.0149)	(0.0368)	(0.0193)
CEE*TFP catch-up	-0.0626**	-0.0656**	-0.0574**	-0.0778**	-0.0761**	-0.0906**
	(0.0236)	(0.0232)	(0.0231)	(0.0281)	(0.0288)	(0.0319)
N	1313	1354	1321	1640	1704	1656
R-sq	0.5214	0.5030	0.5260	0.4985	0.5008	0.4989

Notes: Fixed-Effects Model. Fixed effects for country-time and sector have been included. Dataset trimmed for outliers. Robust Driscoll and Kraay's standard errors in parentheses:* p<0.1, ** p<0.05, *** p<0.01

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Robert Anderton
European Central Bank, Frankfurt am Main, Germany; email: robert.anderton@ecb.europa.eu

Benedetta Di Lupidio
European Central Bank, Frankfurt am Main, Germany; email: benedetta.di_lupidio@ecb.europa.eu

Barbara Jarmulska
European Central Bank, Frankfurt am Main, Germany; email: barbara.jarmulska@ecb.europa.eu

Postal address 60640 Frankfurt am Main, Germany
Telephone +49 69 1344 0
Website www.ecb.europa.eu

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