II.2. Drivers of total factor productivity growth in the EU — the role of firm entry and exit

This section investigates the relationship between business dynamics and total factor productivity growth. Schumpeterian growth models predict a positive association between business dynamics (market entry and exit of firms) and productivity improvements, through the process of innovation and creative destruction. Macro-level data for EU countries over the period 2002-2012 are used to quantitatively assess this relationship, while controlling for other important factors such as distance to the technological frontier, R&D investments, and capacity utilisation. The results provide evidence of a positive relationship between the market entry of new firms and productivity growth. A 1 percentage point increase in the birth rate of new firms is associated with an increase in total factor productivity growth by 0.1 percentage points. This finding is also validated when using alternative specifications of the model. Also some evidence is found for a positive role of market exit in explaining total factor productivity growth. However, the impact of the exit rate is less when the productivity levels of countries are lower, and the econometric estimates are less compelling. The results suggest that policies promoting the entrance of new firms can be conducive to productivity growth, whereas facilitation of market exit (for example, by modernising insolvency legislation) is relevant particularly in countries with relatively high productivity levels. ([31]*)*

Introduction

This section investigates the relationship between economy-wide productivity growth and the market entry and exit of firms. This work is part of ongoing research in the European Commission on drivers of productivity. It complements the analysis in the Product Market Review 2013 ([32]), where it was found that an increase in market entry is positively associated with allocative efficiency (defined as the extent to which the most productive firms also have the highest market shares). ([33]) It also complements a previous contribution to this report on the drivers of total factor productivity (TFP), considering a variety of factors, but not the firm entry/exit channel. ([34])

According to economic theory, there is a link between these firm dynamics and productivity developments. Various channels proposed in the literature may explain this link. These include Schumpeterian creative destruction (replacement of less efficient firms by more efficient ones through the process of innovation), the disciplining effect of market entry on existing firms, and reallocation of productive resources towards more efficient uses facilitated by the process of market entry and exit.

Policymakers recognise the importance of firm dynamics for economic performance. Indeed in many countries, they try to imp rove the conditions to start a business, or to smooth market exit conditions, facilitated by appropriate insolvency legislation.

When these policies are successful, one would expect that there are also benefits at the macro level, for example in terms of GDP, employment, and productivity. The empirical evidence on the macroeconomic benefits of firm dynamics is rather scarce. The aim of this section is to provide a quantitative assessment of the relationship between firm dynamics and productivity developments in EU countries, while including other relevant variables. The analysis concentrates on growth in TFP, as this is — in the long run — a crucial factor in determining living standards of the population.

The role of firm entry and exit in explaining economic growth is explicitly considered in Schumpeterian growth literature. For example, Aghion, Akcigit and Howitt ([35]) show that — in a basic theoretical industrial organisation model (see also Tirole ([36])) — the rate of economic growth

([31]) This section was prepared by Erik Canton.
([32]) European Commission (2013), 'Product Market Review 2013: Financing the real economy', *European Economy*, No 8, European Commission.
([33]) See also Canton, E., D. Ciriaci, and I. Solera (2014), 'The economic impact of professional services liberalisation', *European Economy, Economic Papers*, No 533, European Commission, who investigate the relationship between product market regulation, business dynamics, and allocative efficiency for selected regulated professions.
([34]) Balta, N., and P. Mohl (2014), 'The drivers of total factor productivity in catching-up economies', *Quarterly Report on the Euro Area*, Vol. 13, No 1, pp. 7-19.
([35]) Aghion, P., U. Akcigit, and P. Howitt (2013), 'What do we learn from Schumpeterian growth theory?', Harvard University, mimeo.
([36]) Tirole, J. (1988), 'The theory of industrial organisation', MIT Press.

Box II.2.1: Derivation of total factor productivity

An indicator for total factor productivity (TFP) is derived from a standard growth accounting exercise. Output is produced based on a Cobb-Douglas specification of the following type:

(1) $$Y = A(LHQ)^{\alpha} K^{1-\alpha}$$

where Y is total output, L is employment, H is the average number of hours worked, Q is labour quality, K is the capital stock, and A is an index measuring total factor productivity. Assuming constant returns to scale, the production elasticity of labour (capital) is given by α ($1-\alpha$). This production function then implies:

(1') $$A = Y/((LHQ)^{\alpha} K^{1-\alpha})$$

Taking logarithms and first differencing, the growth rate of TFP is calculated as:

(2) $$\Delta a = \Delta y - \alpha(\Delta l + \Delta h + \Delta q) - (1-\alpha)\Delta k$$

where small letters indicate logarithms. In order to enable cross-country comparison, GDP data from Eurostat based on chain-linked volumes are used. GDP and the capital stock are in constant prices. Account is taken of the labour quality, using the initial education level of labour as a proxy. This initial education level is computed as the average productivity per person employed relative to the productivity of the low-skilled.

increases with the birth rate of new firms. This is because innovation leads to market entry and to replacement of existing firms (creative destruction).

Aghion, Blundell, Griffith, Howitt and Prantl ([37]) studied a sample of over 3 800 British firms in the manufacturing sector during the period from 1980 to 1993. They found that foreign entry into the United Kingdom (measured by the change in employment levels in foreign-owned plants) has a positive impact on incumbent firms' growth in TFP. This result is in line with the theoretical prediction in Schumpeterian models that entry drives TFP growth, as incumbent firms that are closer to the technological frontier innovate more in order to escape competition from entry. In a similar framework, Aghion and Bessonova ([38]) used a sample of Russian manufacturing firms to show that incumbent firms' reaction to foreign entry depends on their position relative to the technological frontier. Specifically, incumbent firms closer to the frontier prior to foreign entry innovate more when faced with entry. On the contrary, incumbent firms that are further away from the technological frontier appear to innovate less when there is increased entry and eventually exit the market.

Cincera and Galgau ([39]) report that a 1 percentage point increase in the current entry rate leads to a relatively large rise in labour productivity growth by 0.6 percentage points. ([40]) They based their conclusions on sectoral data that included industry, country and year dummies and lagged entry rates, but not other control variables that may be relevant, such as investment.

Griffith and Harrison ([41]) studied the impact of a wide range of product market reforms (including those that facilitate entry) on economic rents and productivity growth in a sample of EU countries during the 1980s and 1990s. Contrary to most of the empirical literature, Griffith and Harrison found that regulatory reforms that increased market entry — and thus reduced the level of economic rents — appear to be associated with lower levels of labour and total factor productivity.

(37) Aghion P., R. Blundell, R. Griffith, P. Howitt, and S. Prantl (2004), 'Entry and productivity growth: Evidence from microlevel panel data', *Journal of the European Economic Association*, Vol. 2, pp. 265 – 276.

(38) Aghion, P., and E. Bessonova (2006), 'On entry and growth: theory and evidence', *Revue OFCE*, pp. 260-278.

(39) Cincera, M., and O. Galgau (2005), 'Impact of market entry and exit on EU productivity and growth performance', *European Economy, Economic Papers*, No 222, European Commission.

(40) The authors interpret 0.6 as an elasticity.

(41) Griffith, R. and R. Harrison (2004), 'The link between product market reform and macro-economic performance', *European Economy, Economic Papers*, No 209, European Commission. They use a two-step approach in which they first estimate the relationship between product market reforms and the level of economic rents; and, then, the relationship between rents and macro-economic performance, using indicators of product market reforms as instruments for economic rents (mark-ups).

Table II.2.1: **Descriptive statistics**

Acronym	Description	Observations	Mean	Standard deviation
Δln(TFP)	growth rate of TFP (%)	300	0.73	2.81
Distance	distance to the TFP frontier (%)	300	41.03	34.42
Birth	birth rate of new firms (%)	257	10.62	4.02
Death	death rate of existing firms (%)	225	9.19	3.69
R&D	R&D investments (% of GDP)	298	1.50	0.94
Caputil	capacity utilisation (%)	281	77.71	7.22
Gov	government expenditure (% of GDP)	257	45.04	6.33

Source: DG ECFIN calculations based on LIME Assessment Framework and Eurostat data.

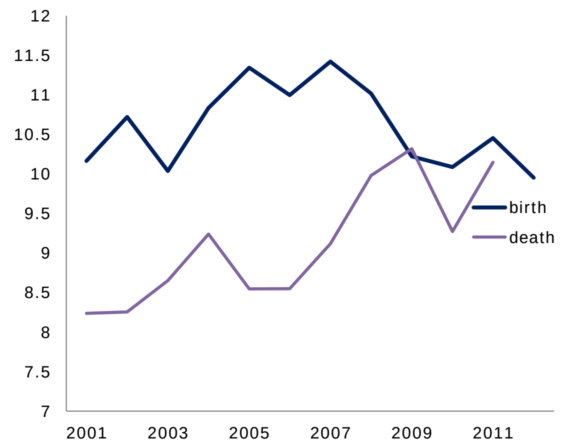
The role of exit is also important in explaining productivity growth. Foster, Haltiwanger and Krizan (42), for example, found that restructuring was the main cause of the productivity gains in the US retail trade sector during the 1990s. Restructuring in this case is entry by more productive establishments from large, national chains, which displaced much less productive single-unit establishments. Similarly, for a large sample of UK manufacturing establishments during the period 1980-1992, Disney, Haskel and Heden (43) reported that 'external' restructuring (i.e. exit, entry and changes in market shares) accounted for 80-90 % of TFP growth at establishment level. They also found that much of the external restructuring effect comes from multi-establishment firms closing down poor-performing plants and opening high-performing new ones.

Data

The total factor productivity (TFP) data used in this section are derived from the growth accounting methodology developed in the context of the LIME Assessment Framework (LAF) database. (44) This growth accounting approach provides a detailed breakdown of the underlying drivers (more details are provided in Box II.2.1).

The other variables come from Eurostat, and cover 25 Member States (all EU countries except Croatia, Greece and Luxembourg) during the period from 2002 to 2012. Unfortunately, no other countries could be included because comparable data, such as for the US, were not available. The sample size is also limited, which limits the econometric analysis. Table II.2.1 presents some descriptive statistics.

Graph II.2.1: **Firm entry and exit (%)**



Source: Eurostat

The dependent variable in the empirical analysis is the annual TFP growth rate, which in the sample is about 0.73 % on average. The key explanatory variables are birth and death rates, which are equal to the number of firms created and de-registered, respectively, in year 't', divided by the number of all active firms in the same year. Birth and death rates are about 10 %, with average birth rates somewhat higher than average death rates: the number of firms therefore shows a net expansion over time. The time pattern of birth and death rates (averaged across countries in the sample) are shown in Graph

(42) Foster, L., J. Haltiwanger and C.J. Krizan (2006), 'Market selection, reallocation, and restructuring in the U.S. retail trade sector in 1990s', *Review of Economics and Statistics*, 88(4), pp. 748-758.

(43) Disney, R., J. Haskel and Y. Heden (2003), 'Restructuring and productivity growth in UK manufacturing', *Economic Journal*, 113, pp. 666-694.

(44) Mourre, G. (2009), 'What explains the differences in income and labour utilisation and drives labour and economic growth in Europe? A GDP accounting perspective', *European Economy, Economic Papers,* No 354, European Commission.

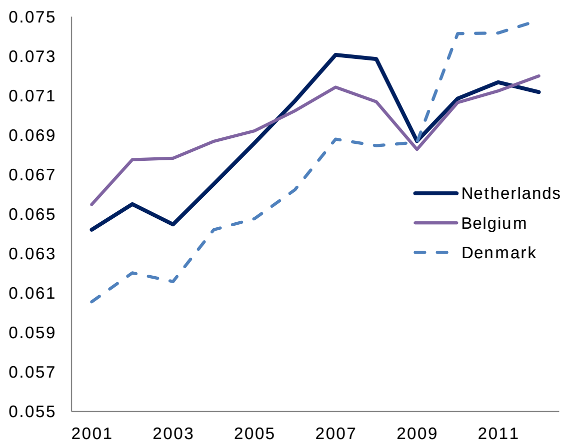
Table II.2.2: **Correlation matrix**

	Δln(TFP)	Distance	Birth	Death	R&D	Caputil	Gov
Δln(TFP)	1						
Distance	0.32	1					
Birth	0.22	0.44	1				
Death	-0.04	0.39	0.62	1			
R&D	-0.15	-0.60	-0.35	-0.33	1		
Caputil	0.12	-0.47	-0.22	-0.35	0.48	1	
Gov	-0.25	-0.55	-0.43	-0.30	0.70	0.32	1

Source: DG ECFIN calculations.

II.2.1. The graph shows that, after 2007, birth rates went down, while death rates increased.

Graph II.2.2: **Leapfrogging in TFP frontier: Belgium, the Netherlands, and Denmark**
(2001-2012)



Source: DG ECFIN calculations.

Another important independent variable in the regression framework is a country's distance to the technological frontier, where the frontier is represented by the country with the highest TFP level in the sample. During the period of investigation, TFP leadership was held by Belgium (2002-2005), the Netherlands (2006-2009), and Denmark (2010-2012). (45) This is known as leapfrogging: countries taking over TFP leadership from each other. The leapfrogging pattern is illustrated in Graph II.2.2.

As shown in Table II.2.1, the distance, i.e. the TFP gap between a particular country and the TFP leader, is on average 41 %. Such a large average distance towards the frontier in EU countries suggests substantial cross-country discrepancies in TFP levels. Yet it also shows the potential gains from catching-up that could be achieved by laggard countries.

The notion of distance towards the TFP frontier is important for the analysis for two reasons. First, countries lagging behind in terms of TFP levels can benefit from relatively fast productivity growth by adopting and implementing state-of-the-art technologies developed elsewhere.

The empirical relevance of this catching-up mechanism is widely documented in the economic growth literature. It is illustrated in Graph II.2.3. While distance towards the frontier is decreasing over time, this pattern of convergence was interrupted in 2009, and there is even evidence of some widening afterwards. Second, TFP growth in the frontier economy could generate positive spillovers to laggard countries. To capture the diffusion of existing technologies and knowledge from the frontier country to laggards, TFP growth at the frontier is also included as an explanatory variable in the regression framework. (46)

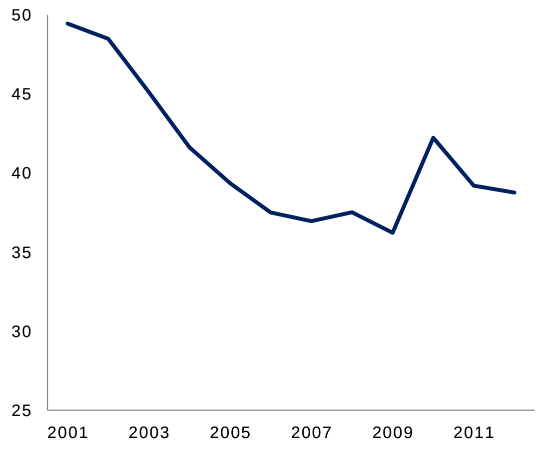
In addition to the business dynamics indicators and distance, several other explanatory variables were included. Specifically, the model includes R&D intensity (total R&D spending as a percentage of GDP) (47), the capacity utilisation rate (%) and government expenditure (as a percentage of GDP). The time series for the capacity utilisation rate and government expenditures are shown in Graph II.2.4 and Graph II.2.5, respectively.

(45) The pattern of TFP leadership may differ when other data sources are used. For example, an exercise using EUKLEMS data is provided in Kegels, C., M. Peneder, and H. van der Wiel (2008), 'Productivity performance in three small European countries: Austria, Belgium, and the Netherlands', FPB, WIFO and CPB.

(46) Cf. OECD (2015), 'The future of productivity', OECD, Paris.

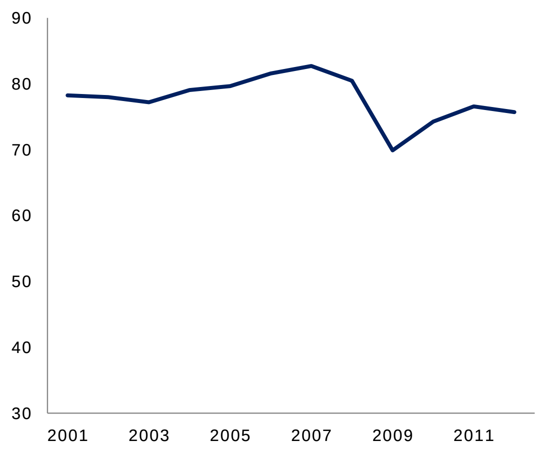
(47) There is an extensive literature on the relationship between R&D investments and productivity growth, see for example Griffith, R., S. Redding, and J. van Reenen (2004), 'Mapping the two faces of R&D: Productivity growth in a panel of OECD industries', *The Review of Economics and Statistics*, Vol. 86, No 4, pp. 883-895.

Graph II.2.3: **Distance towards frontier (%)**



Source: DG ECFIN calculations.

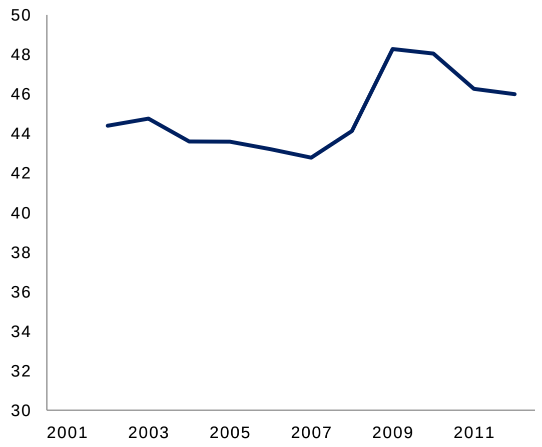
Graph II.2.4: **Capacity utilisation (%)**



Source: Eurostat.

Before turning to the econometric analysis, some descriptive statistics are presented. Table II.2.2 shows correlation coefficients. It shows in particular that the correlation between TFP growth and the birth rate is positive, while the correlation between TFP growth and the death rate is much weaker and negative. Also, birth and death rates are strongly correlated, which suggests that they should be included separately in the regressions (as the inclusion of both indicators simultaneously might give rise to multi-collinearity issues). The counter-intuitive result that TFP growth is negatively correlated with R&D intensity may be due to the fact that countries further away from the frontier tend to have lower R&D intensity and higher TFP growth, benefiting from the catch-up mechanism mentioned earlier. This illustrates the need to build a multiple regression model in order to check for the major drivers of TFP growth simultaneously. Indeed, as will be shown later, the above-mentioned counter-intuitive result on the relationship between TFP growth and R&D intensity disappears in the regression analysis.

Graph II.2.5: **Government expenditure (% of GDP)**



Source: Eurostat

Empirical analysis

This section describes the econometric findings. The approach and main results for the relationship between business dynamics and TFP growth are presented in Box II.2.2.

Birth rate and total factor productivity growth

The results provide evidence of a positive relationship between market entry of new firms and productivity growth, where a 1 percentage point increase in the birth rate of new firms is associated with a 0.1 percentage point increase in TFP growth. This finding is validated when using alternative specifications of the model. In quantitative terms, this indicates a rather strong relationship between firm entry and productivity developments (NB average TFP growth in the sample period is 0.7 % per year). These results are in line with the creative destruction mechanism widely documented in the literature. The other explanatory variables included in the regression framework typically appear with significant regression coefficients with the expected sign. For example, the distance variable appears with a positive coefficient, implying catching-up of laggard countries, and R&D investments also show up with a positive coefficient, confirming their importance for TFP growth.

Death rate and TFP growth

The empirical results for the relationship between the death rate of firms and TFP growth are less conclusive. For the four regression models used in case of firm entry, no significant positive coefficients for the death rate are found. In one model, the coefficient is even negative, and statistically significant. Interestingly, adding an interaction term between the death rate and distance to the TFP frontier generates a positive and significant coefficient of the death rate, and a negative coefficient of the interaction term. This result says that the cleansing effect of firm exit is mainly found in countries operating at or close to the TFP frontier.

In this context, Mongelli, Reinhold and Papadopoulos recently argued that specialisation in countries like Germany and Austria is taking place in line with competitive market forces. This is because allocative efficiency is relatively high so that more productive firms attract a relatively large part of the labour market. (48) In contrast, for example in Italy and Portugal (which operate at a greater distance to the technological frontier), there is evidence that allocative efficiency is much lower, and that the reallocation process seems hampered by frictions. This could imply that in countries with an inefficient allocation of labour, firm exit may also hit the more productive firms. More research would be needed to investigate these mechanisms in greater detail.

Another finding is that the coefficient of the death rate may be higher in the pre-crisis period (though the standard error is slightly too large to draw a firm conclusion). The usual pattern of creative destruction under 'normal' circumstances may differ from the pattern emerging in a deep recession. Indeed, firm exit in a deep and prolonged recession could be dictated by other factors. For example, in a balance sheet recession, even productive firms could be forced to discontinue business operations when credit lines are frozen. All in all, the relationship between the death rate and TFP growth is inconclusive, but there is some evidence that this relationship could depend on a country's distance to the TFP frontier.

(48) Mongelli, F.P., E. Reinhold, and G. Papadopoulos (2016), 'What's so special about specialisation in the euro area? Early evidence of changing economic structures', *Occasional Papers*, No 168, European Central Bank.

Discussion and conclusion

Improving the conditions for new firms to enter the market — and for existing ones to exit — is important to obtain an efficient allocation of resources and ultimately to increase productivity and enhance economic growth. This section has analysed the relationship between business dynamics and TFP growth using macro-level data. The results provide evidence of a positive contribution of firm entry to TFP growth, and this finding is validated when alternative specifications are tested. A 1 percentage point increase in the birth rate of new firms is associated with a 0.1 percentage point increase in TFP growth. There is also some evidence of a positive role of market exit in explaining TFP growth, but the impact of the exit rate weakens when countries are lagging behind in terms of productivity levels. So the 'cleansing effect' of inefficient firms leaving the market only seems to yield macro-relevant benefits in countries close to the TFP frontier. (49) All in all, the evidence reported in this note mainly refers to the productivity-increasing impact of firm entry, and is less clear about the role of firm exit.

In addition to the results for birth and death rates of firms, several other conclusions can be drawn. First, the TFP growth rate in the frontier economy exerts a positive effect on the TFP growth rate in lagging countries, indicating knowledge spillovers. The distance to the TFP frontier has a positive impact on TFP growth — the well-documented catch-up effect — but the role of distance for productivity growth weakened during the crisis period. R&D intensity appears with a sizeable and statistically significant regression coefficient in the empirical estimates, but this impact of R&D on TFP growth weakened during the crisis years.

It should be noted that the time series available for empirical analysis is relatively short, which makes it difficult to assess whether the obtained results truly represent a long-run effect, or whether the impact becomes weaker over time. Such a distinction between short and long-run effects is therefore left for further research. The econometric conclusions should therefore be interpreted with some caution. This is particularly the case for the estimated effects of the death rate.

(49) Also see Lee, Y., and T. Mukoyama (2008), 'Are there cleansing effects of recessions? Entry and exit of manufacturing plants over the business cycle', VOX, 7 January 2008.

Additional research in this area could consider sector-level data (as for example in Balta and Mohl ([50])), provided that sectoral TFP data can be computed using suitable price deflators to enable cross-country comparability. This would also be a response to the issue that this section uses economy-wide TFP data, while the birth and death rates refer to the business sector only (cf. Box II.2.2).

Another logical extension could be to investigate the role of physical distance between countries. This would enable an investigation of whether countries geographically closer to the frontier economy can benefit more from productivity spillovers, for example through trade links or more intense cross-border movement of workers.

It would also be interesting to investigate the relationship between market entry and productivity performance at the level of individual firms, using for example the ORBIS database. ([51]) The OECD is actively undertaking research using such micro-databases, which enables studying new research questions, for example related to learning from technological leaders at the national or global level (see OECD ([52])).

The findings on the empirical relationship between firm entry and TFP growth provide an additional mechanism through which firm entry can be conducive to productivity, in addition to its impact through allocative efficiency and mark-ups. The results can be used in ECFIN's workstream on quantifying the economic impact of structural reforms (see also the first article in this review). For example, reforms of the justice system have been shown to have an impact on firm entry rates ([53]), and — combined with the findings in this note — the impact on TFP growth can be calculated.

([50]) Balta, N., and P. Mohl (2014), 'The drivers of total factor productivity in catching-up economies', *Quarterly Report on the Euro Area*, Vol. 13, No 1, pp. 7-19.

([51]) Provided by Bureau Van Dijk.

([52]) OECD (2015), 'The future of productivity; Annex 2 Frontier firms, technology diffusion and public policy: Micro evidence from OECD countries', ECO/CPE/WP1(2015)6/ANN2, OECD, Paris.

([53]) See for example ECFIN (2014), 'Market reforms at work in Italy, Spain, Portugal and Greece', *European Economy*, 5.

Box II.2.2: **Business dynamics and total factor productivity growth: econometric analysis**

The general regression model takes the form:

$$\Delta \ln(TFP)_{it} = \alpha + \beta BD_{it} + \gamma Z_{it} + \varepsilon_{it},$$

where i denotes country, and t denotes time. BD (business dynamics) is either the birth rate or the death rate, while Z is a vector of control variables. β and γ are the vectors of the regression coefficients, and ε is the error term. α is an intercept term.

Role of firm entry

The table below presents the results for the birth rate of new firms. The econometric approach is Ordinary Least Squares (OLS) in model (1) and (2), while panel data estimation methods are employed in model (3) (fixed country effects) and (4) (random effects). Year dummies are included in all specifications and robust standard errors are calculated to control for heteroskedasticity.

Regression (1) is the basic model where TFP growth is explained from the TFP growth rate in the frontier economy, the country's distance towards the TFP frontier, the birth rate and R&D intensity. The regression coefficient of the birth rate implies that a 1 percentage point increase in the birth rate corresponds with a rise in the TFP growth rate by 0.1 percentage points, and this effect is statistically significant at the 5 % level. The TFP growth rate in the frontier country appears with a positive and statistically significant regression coefficient. This suggests that the frontier economy generates positive technology spillovers to laggard countries. The distance variable has a positive regression coefficient, meaning that countries further away from the technological frontier tend to show faster TFP growth, illustrating the catch-up mechanism widely documented in the economics literature (see for example Barro and Sala-i-Martin (1)). Also an economically and statistically significant regression coefficient of R&D intensity is found, in line with the literature. In model (2) the capacity utilisation rate and government expenditure are added as additional control variables to the OLS equation. The TFP data refer to the whole economy (as opposed to the market economy). The inclusion of government expenditure is an (admittedly crude) attempt to take into consideration the size of the non-market economy. Both control variables appear with statistically significant regression coefficients. A higher capacity utilisation rate corresponds with an increase in TFP growth, while higher government expenditures are negatively associated with TFP developments. Inclusion of these additional variables does not have an important impact on the other explanatory variables, except for a now somewhat stronger effect of R&D investments on TFP growth.

Model (3) is a fixed effects version of model (2), where the variable measuring TFP growth in the frontier economy has been dropped because of multi-collinearity with the year dummies. The coefficient of the birth rate is somewhat higher, whereas the standard error of the coefficient of R&D investments is sharply increased, due to the inclusion of country fixed effects. The last regression model, model (4), uses a random effects estimator. Now the results closely resemble the ones presented in model (1) and (2). To decide between the fixed effects and the random effects model, a Hausman test has been run, suggesting that the random effects model is the preferred method. Also, to choose between the random effects model and a simple OLS specification, the Breusch-Pagan Lagrange multiplier test has been performed. This test showed that there is no evidence of significant differences across countries, so that the simple OLS model can be used. All in all, regression (2) can be considered as the preferred specification.

Some additional sensitivity checks have been carried out. (2) First, the stability of the coefficients of the distance variable, the birth rate and R&D spending has been investigated by including interaction terms between these variables and a dummy for the crisis period (taking value 1 for 2008 and afterwards). The interaction term with the birth rate is not significant, meaning that there is no evidence for a significant change in the coefficient before and during the crisis. The interaction terms with distance and R&D spending both appear with negative and significant regression coefficients, and the results imply that during

(1) Barro, R., and X. Sala-i-Martin (2003), 'Economic growth', second edition, MIT Press.
(2) The econometric results are not presented, but are available from the author upon request.

(Continued on the next page)

Box (continued)

the crisis period the catching-up process of TFP levels across countries essentially appears to have come to a stand still (Graph II.2.3), and that R&D investments may have contributed much less to TFP growth.

Second, along the lines of the above-mentioned study by Aghion and Bessonova, it has been investigated whether the impact of firm entry and R&D on TFP growth depends on the country's distance to the TFP frontier. This is done by including interaction terms between the birth rate and the distance variable and between R&D spending and the distance variable to the model specification. Both interaction terms appear with insignificant coefficients, so in these regressions no support is found for the role of distance through entry and/or R&D.

Table 1: **Birth and TFP growth**

	(1) OLS Δln(TFP)	(2) OLS Δln(TFP)	(3) FE Δln(TFP)	(4) RE Δln(TFP)
$\Delta\ln(TFP^F)$	0.441***	0.422***		
	(0.056)	(0.058)		
Distance	0.017***	0.017**	0.040	0.017**
	(0.006)	(0.007)	(0.050)	(0.008)
Birth	0.103**	0.105**	0.167**	0.106***
	(0.041)	(0.045)	(0.078)	(0.035)
R&D	0.280*	0.430**	1.471	0.445*
	(0.166)	(0.171)	(1.248)	(0.255)
Capacity utilisation		0.088**	0.211*	0.087***
		(0.034)	(0.109)	(0.030)
Government exp.		-0.093***	-0.063	-0.092**
		(0.030)	(0.085)	(0.043)
Observations	241	218	218	218
R-squared	0.548	0.581	0.599	0.586

Note: Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

In the regression results presented above it was assumed that the birth rate is an exogenous variable, uncorrelated with the disturbance term. In order to correct for potential endogeneity bias, an instrumental variables (IV) approach is adopted, using the lagged birth rate and foreign direct investment as a fraction of total investment as instruments. This generates results broadly in line with above reported findings. However, more work — especially on finding suitable instruments — would be needed before causality can be determined with more certainty.

Role of firm exit

Table 2 presents the results for the death rate. The econometric analysis is carried out in a similar fashion as for the birth rate. The impact of the death rate is less conclusive, and its coefficient is mostly insignificant.

Similar sensitivity checks have been carried out as in the case of firm entry. As these checks now generate new findings with regard to the role of the death rate, the main findings are reported in Table 3. First, for the main explanatory variables interaction terms with the dummy for the crisis period are included. Results are shown in model (1). The findings suggest that the catching-up mechanism appears to have come to a halt in the crisis period, and R&D spending contributes less to TFP growth in the crisis years. The death rate and the interaction term between the death rate and the crisis dummy appear with insignificant coefficients.

Second, inclusion of interaction terms with the distance variable now generates interesting findings, as shown in model (2). The death rate appears with a significant regression coefficient of 0.185, while the interaction term with the distance variable has a significantly negative coefficient. The estimated coefficient of the death rate pertains to the situation when the distance is zero, i.e. in the country operating at the TFP frontier. This result implies that the death rate contributes to TFP growth, but this contribution becomes weaker if countries are further away from the TFP frontier. The empirical results imply that the contribution is zero at a distance of 44.6 % to the frontier. Similar findings are obtained for R&D investments: R&D spending has the strongest effect on TFP growth in countries close to the frontier, and the impact weakens for countries at greater distance to the frontier.

(Continued on the next page)

Box (continued)

Table 2: **Death and TFP growth**

	(1) OLS Δln(TFP)	(2) OLS Δln(TFP)	(3) FE Δln(TFP)	(4) RE Δln(TFP)
Δln(TFP^F)	0.437***	0.414***		
	(0.056)	(0.060)		
Distance	0.024***	0.024***	0.054	0.027**
	(0.007)	(0.007)	(0.053)	(0.012)
Death	-0.013	-0.022	-0.154*	-0.049
	(0.053)	(0.057)	(0.076)	(0.062)
R&D	0.325*	0.515**	2.796*	0.599*
	(0.196)	(0.199)	(1.373)	(0.332)
Capacity utilisation		0.093**	0.206*	0.089**
		(0.040)	(0.110)	(0.039)
Government exp.		-0.112***	-0.089	-0.111**
		(0.034)	(0.075)	(0.048)
Observations	209	188	188	188
R-squared	0.536	0.572	0.620	0.595

Note: Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Finally, along the lines of the earlier mentioned contribution of Balta and Mohl, the effect of the death rate and R&D investments on TFP growth, conditional on the distance towards the TFP frontier, is presented in the Graph included below. The econometric method developed in Kam and Franzese is used. (3) The two panels show the marginal effects and their 90 % confidence bands. The left panel refers to the death rate and the right panel to R&D. Statistically significant effects are found when the zero line is not inside the two bounds. The results show that the marginal effect of the death rate is only significant in countries at or very close to the TFP frontier. The marginal effect of R&D is significant if the country's distance to the technological frontier is not too large (smaller than about 18 %). This evaluation of marginal effects across the complete spectrum of the distance variable thus shows that the results on the interaction terms presented in model (2) in Table 3 should be used with caution.

(3) Kam, C.D., and R.J. Franzese (1999): 'Modeling and interpreting interactive hypotheses in regression analysis: A refresher and some practical advice', University of California, Davis.

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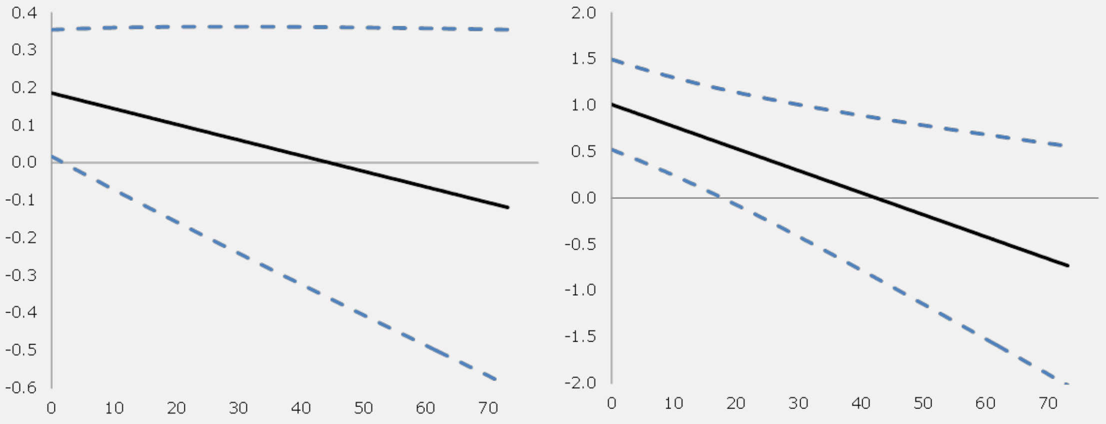
Box (continued)

Table 3: **Alternative specifications**

	(1) Δln(TFP)	(2) Δln(TFP)
Δln(TFP^F)	0.431***	0.425***
	(0.054)	(0.057)
Distance	0.044***	0.085***
	(0.008)	(0.026)
Distance×crisis	-0.049***	
	(0.012)	
Death	0.094	0.185*
	(0.057)	(0.102)
Death×crisis	-0.128	
	(0.090)	
Death×distance		-0.004*
		(0.002)
R&D	0.958***	1.008***
	(0.238)	(0.294)
R&D×crisis	-0.772**	
	(0.360)	
R&D×distance		-0.024**
		(0.009)
Capacity utilisation	0.090**	0.098**
	(0.036)	(0.040)
Government exp.	-0.114***	-0.097***
	(0.033)	(0.034)
Observations	188	188
R-squared	0.627	0.599

Note: Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Graph : **Marginal effects of death rate (left panel) and R&D (right panel) on TFP growth, conditional on distance to the frontier**



Source: DG ECFIN calculations.