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by Patrick Van Cayseele, Jozef Konings and Ilona Sergant

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The Effects of State Aid on Total Factor Productivity Growth

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Abstract

This paper analyzes the relationship between state aid and firm performance in terms of productivity growth. To this end, we use all European state aid cases that were granted (either to an individual firm or a group of firms under the form of a scheme) in manufacturing between 2003 and 2011. Our findings show that state aid measures are able to enhance productivity growth when firms are constraint due to a lack of cash availability. Since laggard firms are more likely to be financially constraint, they experience more TFP growth than 'close-to-frontier' firms when receiving state aid. This beneficial effect of state aid is mainly driven by the post-crisis years in the sample. Our results are consistent with optimal development planning by profit maximizing firms.

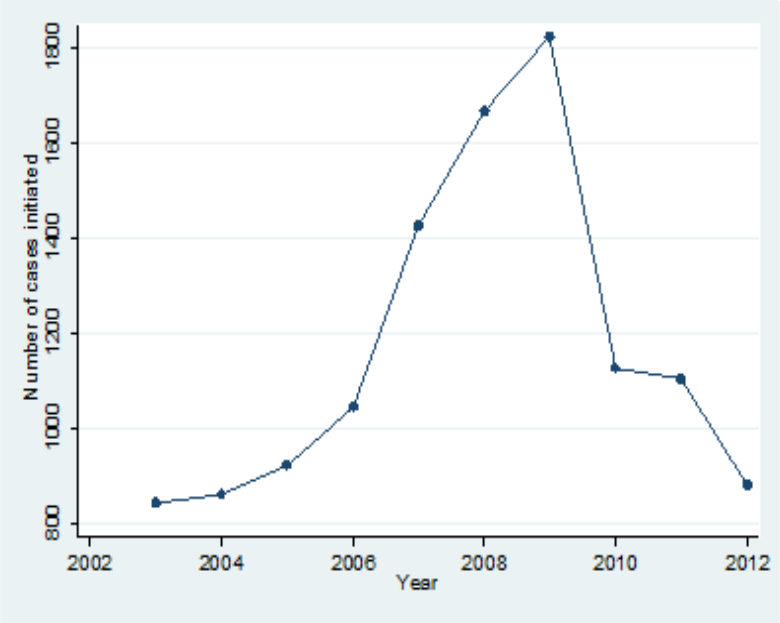
1 Introduction

The State Aid Action Plan that was launched by the European Commission (EC) on the 7th of June in 2005, was meant to pursue 'less and better targeted state aid' in line with the Lisbon Strategy goal 'to become the most competitive and dynamic knowledge-based economy in the world, capable of sustainable growth with more and better jobs and greater social cohesion'. State aid policy can contribute to enhancing growth and innovation by designing it in such a way to sustain competitive markets and by improving the functioning of some markets, it may improve on competitive dynamics and thereby inducing economic growth (Kleiner, 2005).

While state aid in general is prohibited, Article 107 of the Treaty points out a number of exceptions, which allows governments to intervene in the market, by e.g. providing subsidies, under strict conditions. The EC evaluates these by using a 'balancing test' which checks, using various criteria, to what extent the potential positive effects outweigh the negative effect due to the distortion of competition inflicted by the state aid. However, with the break-out of the financial crisis the criteria under which state aid could be granted have been relaxed, including the minimum amount that firms can receive as aid without having to comply with the notification obligation, the so called 'de minimis' rule[1] and hence it is unclear to what extent state aid has continued to be in line with the initial objectives not to distort competition in the market. From Figure 1 it is also clear that there has been an exponential increase in the number of state aid cases since in the crisis years, starting in 2007, to reach a peak in 2009, which confirms a much more lenient attitude of the EC to allow government intervention and/or indicates an increased demand by the Member States demand to grant state aid.

[1] See Commission Regulation (EC) No. 1998/2006 of 15 december 2006 on the application of Articles 87 and 88 of the Treaty to de minimis aid, Official Journal of the European Union, L397/5

Figure 1: Evolution of the number of state aid cases in Europe

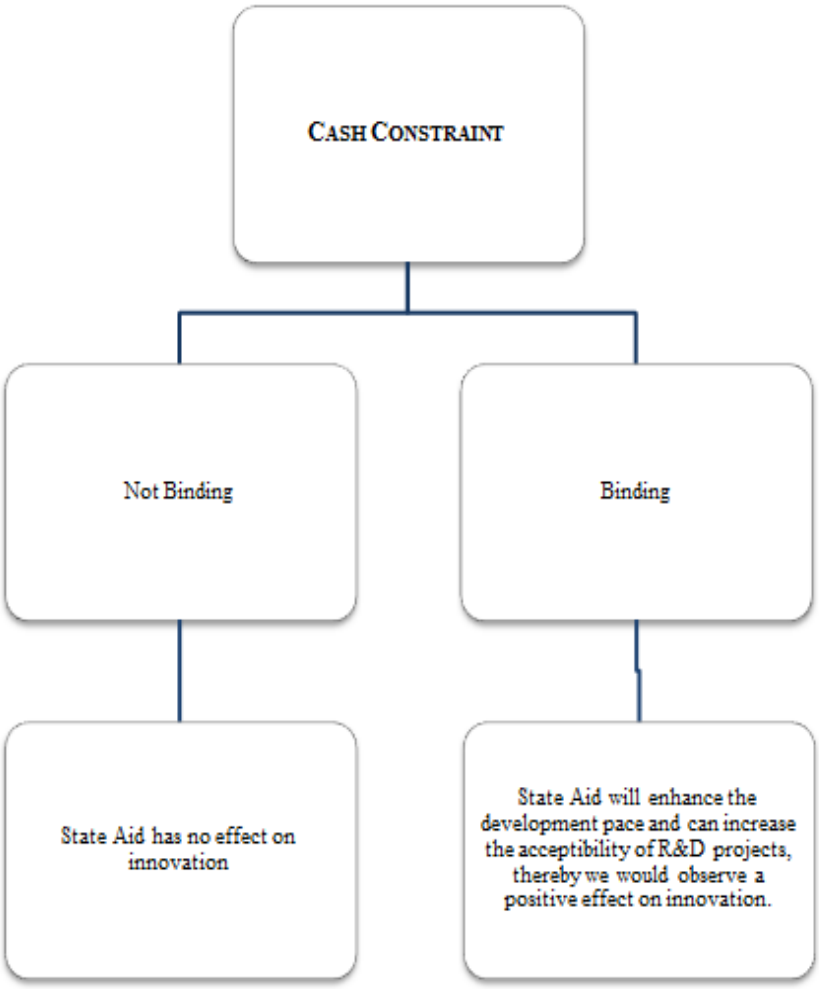


The objective of this paper is to analyze how European state aid has had an impact on firm performance and in particular on firm productivity growth. By focusing on productivity growth, we capture the extent to which state aid enables firms to innovate and benefit from technological progress, which has long lasting effects. The channel through which state aid affects firm-level innovation or productivity growth is through its ability to address market failures. One of the most prevailing market failures a firm encounters when pursuing a R&D project is the absence of sufficient resources to finance industrial research and development. This coincides with the idea that high competitive pressure can slow down the innovation process as pointed out by a number of authors in the context of trade and industrial policy. For instance, in the context of anti-dumping protection Rodrik (1992), Ederington and McCalman (2008), Konings and Vandenbussche (2008) show when firms are temporarily protected from international competition, this can induce domestic firms to restructure and accelerate the speed of adoption of more efficient production technologies. Aghion et al. (2005) show that a reduction in product market competition reduces the technology gap in an industry. Boone (2000) shows that the incentive to innovate in such markets is stronger for less efficient firms when they operate under weak product market competition and hence, 'laggard' firms may be able to catch up with 'frontier' firms. This idea has been developed through characterization of a firm's optimal development plan by Kamien and Schwartz (1978) and their model will serve as a background to interpret our results.

In particular, for a firm to conduct the necessary investment towards innovation, it must have access to a source of financing, either internal through its current profits and accumulated funds, or external through capital markets. Due to a lack of tangible collateral and less profitable prospects in declining markets, a firm might face a binding cash constraint when it is not able to finance its projects by its own resources. State aid can then offer a solution to this type of market failure by alleviating the cash constraint faced by a firm so as to enable it to optimize its development path. Firms pursuing large innovations and new marginal firms are more likely to be constraint by the lack

of cash availability than established firms performing "routine" R&D. When a firm faces a binding cash constraint, government intervention can have a positive impact on innovation, either by hastening the development pace, and thereby shortening the development period (when there is no innovational rivalry), or by increasing the acceptability of R&D projects (when innovational rivalry is present). Figure 2 summarizes this mechanism.

Figure 2: State Aid as a solution to firm's cash constraint



Our results confirm this type of mechanism. In particular, we find state aid to have a positive effect on total factor productivity growth, especially in markets characterized by high within-sector competition (or equivalently, lower cash availability through self-financing). Furthermore, we find that this effect is mainly driven by state aid cases granted in the post-crisis years, suggesting that firms are more likely to experience difficulty in finding the necessary resources to finance their R&D projects while the economy is characterized by a global crisis. When allowing for firm heterogeneity, we find that 'laggard' firms benefit more from state aid than 'close-to-frontier' firms, which is line with our theoretical framework, since they are more likely to be cash constraint due to a lack of current profits and accumulated funds as well as limited access to external financing.

We start in the next section with a description of the state aid procedure in the European Union.

In section 3 we introduce the data and our empirical strategy to estimate TFP, using a control function approach. Section 4 provides the results and in section 5 we show a number of robustness checks, based on our definitions of cash availability and firm heterogeneity. Section 6 concludes the paper.

2 State Aid in the European Union

The legal definition of state aid, provided in Article 107(1) of the Treaty assesses whether a state measure constitutes "state aid", and thereby establishes jurisdiction:

> "Save as otherwise provided in this Treaty, any aid granted **by a Member State or through State resources** in any form whatsoever which distorts or threatens to **distort competition** by **favouring** certain undertakings or the production of certain goods shall, in so far as it **affects trade between Member States**, be incompatible with the common market.[2]"

In general, all measures corresponding to this definition are prohibited with the exception of small amounts of aid (de minimis aid) which are considered not to have a potential effect on competition nor trade between member states[3]. In practice, distortion of competition is assumed as soon as an undertaking receives a financial advantage in a possibly competitive sector[4]. However, certain cases are considered compatible with the common market through one of the exemptions provided for in article 107(2)[5] and 107(3)[6]. This enables member states to undertake government intervention in order to address certain objectives. We can distinguish between three types of objectives. Government interventions can offer possible solutions when market outcomes are not in line with societal goals set by the government as a consequence of market failures. The most important types of market failure in the field of state aid are externalities, public goods, market power, and information asymmetries. Governments might also set strategic economic goals, such as acceleration of growth, innovation objectives, ... and meta-economic goals, e.g. concerning issues of distribution of wealth among people. These goals can be categorized as efficiency objectives on the one hand and equity objectives on the other. Note that a broad set of measures which can also be used to obtain these different objectives, are not covered by the notion of state aid. These general measures include nationwide fiscal measures

[2] The "common market" has to be interpreted as the European (EU) market.

[3] De minimis aid is not considered state aid within the meaning of article 107 as long as the total aid granted to any one undertaking does not exceed EUR 200.000 over any period of three fiscal years (EUR 100.000 in the road transport sector), see Official Journal of the European Union L 379/5. Together with the block exemptions regulations and Commission guidelines, the de minimis regulation is installed to minimize the administrative burden imposed on Member States and to ensure a minimum degree of predictability.

[4] See Communication from the commission (2013), paragraph 188 which states: "*For all practical purposes, a distortion of competition within the meaning of Article 107 TFEU is thus assumed as soon as the State grants a financial advantage to an undertaking in a liberilased sector where there is, or could be, competition*", http://ec.europa.eu/competition/consultations/2014_state_aid_notion/draft_guidance_en.pdf

[5] Article 107(2) stipulates those measures which are automatically considered compatible with the common market. These include "*aid having a social character, granted to individuals; aid to make good the damage caused by natural disasters or exceptional occurrences; and aid granted to the economy of certain areas of the Federal Republic of Germany affected by the division of Germany*"

[6] The Commission has a certain discretion in assessing compatibility where the aid "*promotes the economic development of regions where the standard of living is abnormally low or where there is serious underemployment; promotes the execution of an important project of common European interest; facilitates the development of certain economic activities; promotes culture and heritage conservation.*"

as well as most measures in public education, health care and general infrastructure. These types of government intervention are usually incorporated within the definition of industrial policy[7], although state aid and industrial policy are often used interchangeably in the European context[8].

In spite off the possible benefits relating to granting state aid, possible negative effects should also be considered. Such effects can result from several sources. Friederiszick et al. (2007) distinguish problems which limit the effective use of state aid. The first is the measurability of the market failure the government intervention is assumed to address. Since state aid is funded by state resources, there exists an opportunity cost given that these resources can not be used in other domains of government. In addition, there might be undesirable side effects of state aid which induces the need to consider the impact on the functioning of the market. The last most prominent issue concerning state aid, is the existence of government failures. Following Di Tommaso and Schweitzer (2013), we can distinguish external from internal sources of government failures. The first source refers to the mechanism through which industrial policy objectives, targets, and instruments are defined. Government can be lobbied resulting in objectives driven by the strongest and best organized pressure group (which is generally is not the group of consumers). Politicians can also be driven by the desire of maximizing chances to win elections (Dewatripont and Seabright (2006)) leading to dependence on short-run public opinion. The internal forces of government failure refer to difference in goals set by bureaucracy and goals of a planner, in other words, a government might not per se be benevolent. Supranational state aid can be used to limit these government failures by helping member states to limit inefficient and distortive aid. The initial motivation of state aid control is to avoid subsidies wars and trade disputes between member states (Friederiszick et al. (2007)), resulting in wasteful spending by politicians.

In order to asses state aid measures, the Commission uses a 'balancing test', as first proposed by Friederiszick et al. (2007). State aid is declared compatible whenever the positive effects of the measure by contributing to an objective of common interest, outweigh the negative effects due to distortion of competition. In line with the goals of the renewed Lisbon Strategy, the European Commission launched the 'State Aid Action Plan' in 2005. This plan consists of a roadmap in order to consistently reform state aid rules aiming at 'less and better targeted state aid' through a refined economic approach[9]. On 8 may 2012, another ambitious reform of the State aid rules has been launched, known as the EU State Aid Modernisation (SAM). The objectives of this modernisation are threefold: '(i) foster sustainable growth in a competitive internal market, (ii) focusing on the cases with the largest impact, (iii) streamline the rules and provide for faster decisions.'[10]

In general, state aid is assumed to distort competition and trade within sectors and across countries. Garcia and Neven (2005) provide a benchmark model to analyze the effects on rivals of state aid. In general, price distortions are found to be increasing in concentration. When high competition is rather due to intense rivalry, the magnitude of the distortions depends on the type of state aid intervention.[11]

[7] In the literature however, there is no common definition of industrial policy. E.g. Di Tommaso and Schweitzer (2013) use the following definition of industrial policy: "*IP is the set of all government interventions on production dynamics driven by national societal goals that are based on a clear understanding of the relationship between goals, targets and tools. If one starts with a set of normative societal goals, then one can define specific targets where policy intervenes, and a variety of possible tools indicating how these IP measures could be implemented.*"

[8] see e.g. Bianchi and Labory (2006)

[9] see 'European Commission, State Aid Action Plan, Less and better targeted aid: a roadmap for state aid reform 2005-2009', http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2005:0107:FIN:EN:PDF

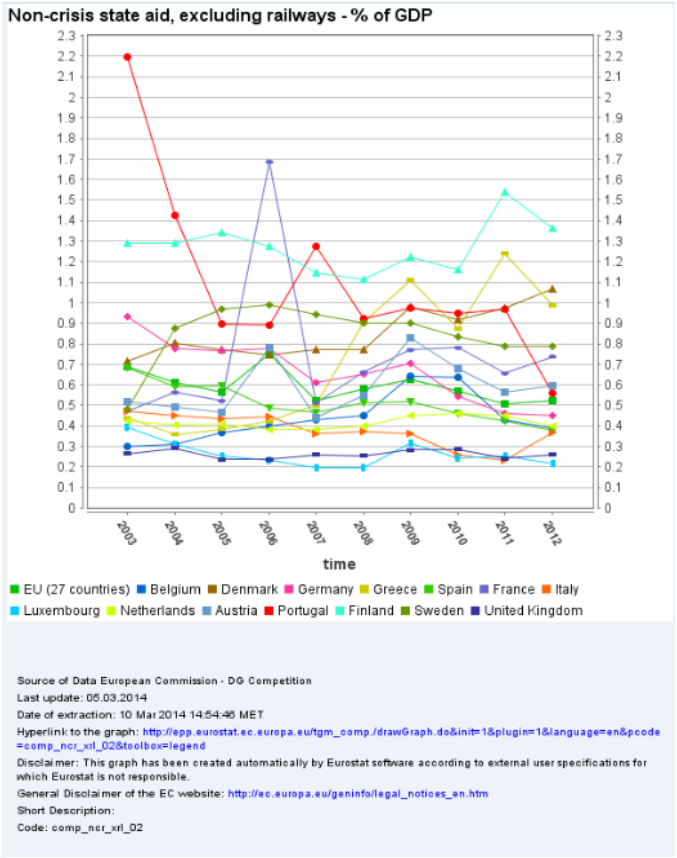
[10] Par. 8 of the Communication on State Aid Modernisation

[11] They consider three types of interventions, namely a reduction in marginal cost, an intervention that induces entry (or prevents exit) and intervention which affects quality

Their analysis is on a theoretical level, and it therefore is unclear which forces dominate.

Although the Commission targets for less and better aid, considerable amounts of aid are distributed across the European Union every year. Figure 3 depicts the evolution of non-crisis aid, excluding railways as percentage of GDP. The amounts of state aid granted is fairly constant over time with the exception of a strong decrease in aid for Portugal and a recent increase in Finland[12]. Given these vast amounts of funds, it seems appropriate to investigate empirically what the effect of State Aid is on factor productivity growth.

Figure 3



[12] For a more elaborate overview on the evolution of state aid, see Bianchi and Labory (2006), and Buiges and Sekkat (2009)

3 Empirical Analysis

3.1 Data

Our primary data source is the Amadeus data base, which consists of the income statements of firms operating in the EU-15[13] between 2003-2011. We retrieved operational and financial information for all firms active in manufacturing and for which data on value added (output) and on input use, such as employment and material costs, was available. The coverage across countries varies somewhat, which is due to difference in the accounting legislation. For instance, in the Netherlands and Germany small firms are not required to report their income statements, while in Belgium and France, all firms are required to publish full or abbreviated company accounts[14]. To avoid that our results are driven by outliers in the data, we trim the variables that we use by cutting observations above the 99th and below the first percentile of the distribution of the variable of interest. We are left with 278, 676 firms for our analysis.

The second data source is the European Commission and consists of all state aid cases since 2000[15]. We can make a distinction between three case types: ad hoc cases, individual applications and schemes. Ad hoc cases and individual applications are cases for which the individual notification is requested by the European Commission. An individual application is aid granted on the basis of an already approved scheme whereas ad hoc cases are unrelated to any scheme. Schemes are measures of a more general character. Once a scheme has been approved, aid towards undertakings may be made without needing to notify individually. We only keep the cases which have a clear link to a region/country and a sector of activity. We are able to match 797 cases to the firm level data over the period 2003-2011. These include 402 schemes, which gives information on the sector for which the scheme is applied, and 395 ad hoc and individual cases, which we matched to the specific firms.

Figures 4 & 5 give an overview of total number of cases by respectively Member State and by sector for all the cases in the period 2000 - 2012, also including those that we could not link to our firm level data.

Figure 4

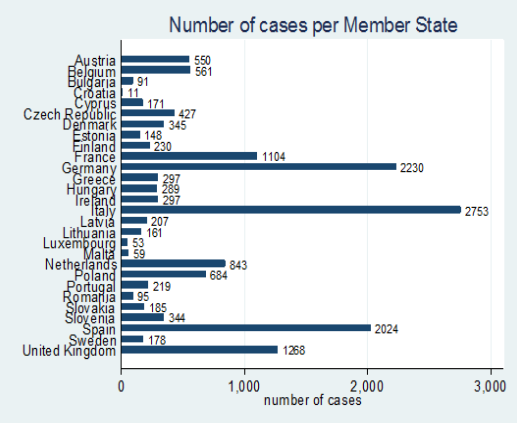
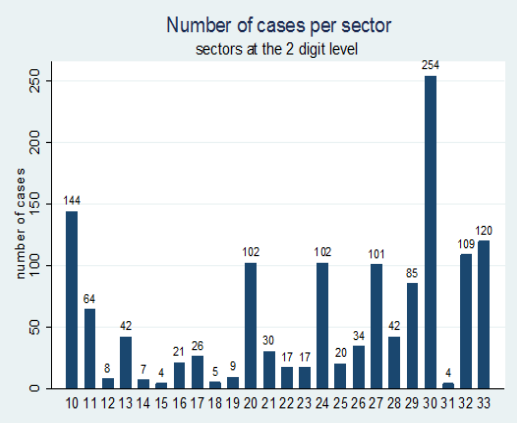


Figure 5



[13] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and United Kingdom

[14] We loose Denmark, the United Kingdom, Greece and Ireland in our final dataset due to missing data.

[15] The case database, available on http://ec.europa.eu/competition/state_aid/ is completed with additional information, e.g. company names available in the Official Journal of the European Union.

In Table 1, we show the summary statistics of the variables that we use to estimate total factor productivity, as well as the growth rate of TFP, where in the second and third panel we distinguish between firms that have received state aid and firms that have not.

Table 1: Summary statistics

	2003-2011		*2003-2006*		*2007-2011*	
	mean	**st.dev.**	**mean**	**st.dev.**	**mean**	**st.dev.**
Overall						
log employment	2.64655	1.186722	2.694917	1.184546	2.615358	1.187079
log tangible fixed assets	5.408022	1.943156	5.346335	1.91334	5.447804	1.961116
log material costs	6.467771	1.859848	6.500961	1.812724	6.446366	1.889307
log value added	6.301164	1.444345	6.312251	1.434214	6.294014	1.450798
TFP growth	-.0063162	.3443653	.0217431	.3211324	-.0312874	.3619714
AID = 0						
log employment	2.624385	1.164422	2.659244	1.16137	2.590693	1.166377
log tangible fixed assets	5.305053	1.911876	5.255552	1.88967	5.352898	1.931895
log material costs	6.3404	1.829721	6.39474	1.774433	6.287878	1.880127
log value added	6.221459	1.437381	6.246884	1.41885	6.196885	1.454648
TFP growth	-.0055993	.3383845	.02212	.318481	-.0390442	.3580968
AID = 1						
log employment	2.669818	1.209253	2.758898	1.222415	2.633843	1.202029
log tangible fixed assets	5.516117	1.969678	5.509158	1.944494	5.518927	1.979754
log material costs	6.601482	1.881706	6.691475	1.864352	6.565138	1.887456
log value added	6.384837	1.446905	6.429489	1.454026	6.366804	1.443629
TFP growth	-.0072139	.3517108	.0210563	.3259087	-.0242339	.3653168

The average firm employs 14 workers and this remains fairly constant over time, comparing the averages before and after the crisis. For the entire sample period the average TFP growth is slightly negative, but there is a clear difference between pre and post crisis years. Before 2007 the average annual TFP growth is 2.17 percent, while after 2007 TFP growth turned negative, on average -3.1 percent. Interestingly, before the crisis the average TFP growth of firms operating in sectors affected by state aid is slightly lower than firms in sectors not affected by state aid. However after the crisis

firms in sectors that receive state aid have a TFP growth, which is almost twice as large (-2.4 percent) compared to firms that do not receive state aid (-3.9 percent). This suggests that the impact of state aid in the crisis years has been fundamentally different than before, so we will exploit this explicitly in our analysis. Note also that the average employment, value added and tangible fixed assets are fairly similar between the group of firms that receive state aid and the group of firms that do not receive state aid. The fact that the average characteristics of firms that received state aid are very comparable to those that do not receive state aid suggests that self-selection or the potential endogeneity of state aid is not very important.

3.2 Estimation Approach

We use a two step approach to analyze the impact of competition and state aid on productivity growth. In a first step we estimate TFP using a control function approach, as first proposed by Olley and Pakes (1996) - hereafter OP - and Levin and Petrin (2003) - hereafter LP -, to deal with the potential endogeneity of the input factors in production. In a second step we then regress TFP growth on indicators of competition and state aid.

3.2.1 Estimating Total Factor Productivity

Following the standard empirical literature, we assume the firm to produce according to the following value added Cobb-Douglas production function[16], given by (in logs)

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \omega_{it} + \eta_{it} \tag{1}$$

where y_{it}, k_{it},and l_{it} denote respectively the logs of value added, capital, and labor of firm i at time t. The sum of the constant term, β_0 and ω_{it} captures Hicks-neutral productivity, where ω_{it} is referred to as "unobserved productivity", as it is known to the firm but unobservable to the econometrician. η_{it} is a standard i.i.d. error term incorporating unanticipated shocks and measurement error. To proxy unobserved productivity, we make use of the firm's choices of intermediate inputs (materials) which is considered a variable nondynamic input. One of the key assumptions of the OP and LP methodology is that this "unobserved productivity" follows an exogenous first order Markov process, given by $p\left(\omega_{it+1}|\left\{\omega_{i\tau}\right\}_{\tau=0}^{t}, I_{it}\right) = p\left(\omega_{it+1}|\omega_{it}\right)$ where I_{it} is the firm's entire information set at time t. The goal of the first stage estimation is to separate ω_{it} from η_{it}. The first stage equation is given by:

$$y_{it} = \phi_t\left(k_{it}, l_{it}, , m_{it}\right) + \eta_{it} \tag{2}$$

where $\phi_t\left(k_{it}, l_{it}, m_{it}\right) = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + h_t\left(k_{it}, l_{it}, m_{it}\right)$ with $h_t\left(k_{it}, l_{it}, m_{it}\right)$ the inverse material input demand function[17]. Assume the productivity process is given by some function g. The law of

[16] As pointed out by De Loecker (2013), the approach can also be used to identify more general production functions.

[17] If a firm's material input demand is given by

$$m_{it} = m_t\left(\omega_{it}, l_{it}, k_{it}\right)$$

and m_t is monotonically increasing in ω_{it}, then we can invert this function to obtain

$$\omega_{it} = m_t^{-1}\left(\omega_{it}, l_{it}, k_{it}\right)$$

motion can be represented by

$$\omega_{it} = g\left(\omega_{it-1}\right) + \xi_{it} \tag{3}$$

where ξ_{it} is usually interpreted as the innovation in the production process that is unexpected to firms. This innovation is by construction uncorrelated with k_{it-1} and l_{it-1}, since both are incorporated in the information set at time t, I_{it}.

The second stage involves estimating the following equation:

$$y_{jt} = \beta_l l_{jt} + \beta_k k_{jt} + \widetilde{g}\left(\phi_{t-1} - \beta_k k_{jt-1} - \beta_m m_{jt-1} - \beta_l l_{jt-1}\right) + \xi_{jt} + \eta_{jt} \tag{4}$$

where l_{jt-1} is used as an instrument for l_{jt}. We follow Wooldrigde (2009) by estimating both stages at once using GMM. All variables needed are appropriately deflated using deflators, obtained from the OECD. We estimate the production function for each sector in each country separately. Table 2 summarizes the obtained average coefficients by sector.

Table 2 : Estimates of the production function

sector	**description**	β_l	β_k
10	Food products	0.702932	0.064131
11	Beverages	0.639899	0.119844
12	Tobacco	0.694182	0.648919
13	Textiles	0.74206	0.041341
14	Wearing Apparel	0.710856	0.067876
15	Leather	0.713055	0.060663
16	Wood	0.744299	0.048459
17	Paper and paper products	0.738571	0.060492
18	Printing and reproduction of recorded media	0.78937	0.044718
19	Coke and refined petroleum products	0.426727	0.061877
20	Chemicals and chemical products	0.722585	0.063507
21	Pharmaceutical products	0.681818	0.044375
22	Rubber and plastic products	0.720724	0.056199
23	Other non-metallic mineral products	0.691757	0.055458
24	Basic metals	0.760559	0.047492
25	Fabricated metal products	0.804088	0.047112
26	Computer, electronic and optical products	0.786203	0.064113
27	Electrical equipment	0.728943	0.051806
28	Machinery and equipment	0.779875	0.043774
29	Motor vehicles, trailers and semi-trailers	0.740443	0.058595
30	Other transport equipment	0.81698	0.056198
31	Furniture	0.739929	0.038024
32	Other manufacturing	0.760292	0.058393
33	Repair and installation of machinery and equipment	0.885243	0.046971

3.2.2 Evaluating the effects of state aid

A firm might consider development of a new product in order to enhance future profits, or to protect itself from potential profit loss when a rivalry product is released. The required funds for these R&D projects might not be available, in which case, we speak of a firm having a binding cash constraint. It is clear that a large number of investments, such as "routine" development conducted by (large) established firms will not suffer from this lack of cash availability, since they can count on their current profits and accumulated funds for the financing of these investment efforts or have tangible collateral to use on the capital markets. However, when firms like to undertake large innovations, the cash availability might not be sufficient in order to follow the optimal development path. In these cases, the market does not lead to the optimal outcome, and government intervention may offer a solution. State aid, granted to this latter type of firms, can alleviate the binding cash constraint and induce firms to hasten their development plan or even enable them to pursue otherwise rejected projects. We expect this effect to be more outspoken in the post-crisis years, since firms will have had more difficulty in finding external funding due to an increased risk aversion by the lenders. 'Laggard' firms are expected to benefit more from state aid than 'close-to-frontier' firms for two distinct reasons: they have a higher potential growth rate, and they are more likely to experience problems with cash liquidity due to insufficient collateral to acquire external funding as well as smaller profits for internal funding.

To put these hypotheses to the test, we need measures of total factor productivity, state aid, cash constraint and distance to the frontier. Our outcome variable is the total factor productivity growth, measured at the firm level, denoted by $dTFP$ and defined by

$$dTFP_{it} = \ln(TFP_{it}) - \ln(TFP_{it-1}) \tag{5}$$

where TFP_{it} is estimated using a control function approach, as outlined above.

To measure the intensity of the competition, we compute the price-cost margin (PCM), also known as the Lerner index. This measure assesses market power within an industry in terms of pricing close to marginal costs. In addition, it is a good proxy to determine the potential cash constraint, since high within-sector competition, and thus a lack of market power, and the associated monopoly profits, are a measure of the firm's ability for self-financing. Under perfect competition, the Lerner index is 0. The Lerner index is computed on country - sector level and is defined as follows:

$$Lerner_{cjt} = \frac{turn_{cjt} - materials_{cjt} - wagebill_{cjt}}{turn_{cjt}} \tag{6}$$

where $turn_{cjt}$, $materials_{cjt}$, and $wagebill_{cjt}$ represent the sum of respectively turnover, material costs and costs of employees of all firms in sector j in country c at time t. The sector level is determined by the 2 digit level sector according to NACE Rev.2. To facilitate the interpretation of competition in our regressions, we use the variable $Competition$ which is defined as $Competition = 1 - Lerner$.

To determine whether or not a firm can be considered a laggard, we use the following definition of its initial distance to the frontier firm:

$$distance_i = \frac{TFP_i}{\max_{i \in j, j \in c}(TFP_i)} \tag{7}$$

where $distance_i \in [0,1]$ and $distance_i = 1$ for i the most efficient firm in terms of total factor productivity within the sector-country level in the year 2003. Table 3 provides the summary statistics for respectively the Lerner index and the distance to the frontier measure.

Table 3 : Lerner index and distance to the frontier by sector

	Lerner		**distance**			**Lerner**		**distance**	
sector	*mean*	*st.dev.*	*mean*	*st.dev.*	**sector**	*mean*	*st.dev.*	*mean*	*st.dev.*
Total	**.0806753**	**.0181941**	**.0689514**	**.077595**					
10	.0653741	.0104211	.0365799	.0416227	22	.0836194	.0128734	.0535895	.0741773
11	.1137235	.020427	.0952782	.0924593	23	.0932374	.0198161	.0703009	.0702026
12	.0957115	.0860097	.1226167	.223631	24	.0754649	.0137362	.0823558	.0829391
13	.0702487	.0119173	.0498968	.0695958	25	.0875876	.0124669	.0660366	.0582866
14	.0648991	.010083	.0741816	.0894123	26	.0872683	.0141921	.1233121	.0986324
15	.0623339	.0126424	.0505291	.0742792	27	.0847989	.0123226	.063204	.0877685
16	.0715799	.0124692	.0977804	.0897869	28	.0824313	.0099504	.050986	.0593868
17	.0815218	.0170461	.1176827	.1096863	29	.0690219	.0170232	.1063967	.1015473
18	.0994184	.0260408	.0827905	.0785129	30	.074633	.0165654	.10907	.1421698
19	.087143	.026835	.3334024	.2751846	31	.0695546	.015826	.0999207	.1043744
20	.0840397	.0112761	.0411989	.0768888	32	.0873673	.0105165	.0656631	.0653706
21	.120836	.0174644	.1489121	.1511593	33	.0734533	.0139611	.0790857	.0573807

We are interested in the overall effect of state aid on firms' productivity growth. State aid can only be effective when it relieves a firm from its cash constraint, i.e. when a market failure prevailed and is resolved by the measure. When this constraint is not binding, state aid will not be able to enhance productivity growth, since the firm then already follows its optimal development path and will not alter its investment behavior. Therefore, we expect state aid to positively affect productivity growth. To establish the existing relationship between productivity growth and state aid, we run the following regressions:

$$dTFP_{it+1} = \beta_0 + \beta_1 AID_{jct} + \alpha_i + \alpha_t + \varepsilon_{ict} \tag{8}$$

where α_i and α_t represent respectively firm and time fixed effects. Firm fixed effects account for unobserved firm heterogeneity that is constant over time while time fixed effects account for demand and supply shocks common to all firms. Fixed effects also control for initial differences between TFP. Typically, firms with low initial TFP are likely to be able to catch up with firms already near the frontier. Note that if the firm's lobbying power to receive state aid, is constant over time, the resulting self selection problem is taken care off by the firm fixed effects. Another way to take into account this self selection issue, is to include a measure that allows for firm heterogeneity within the sector. To this end, we include the initial distance to the frontier, defined as above. We expect $\gamma_1 < 0$, or equivalently that firms operating at low productivity levels grow faster than more efficient firms. In

addition, firms that are investing in a catching-up process are more likely to encounter a binding cash constraint, and thereby will benefit more from state aid measures which offers them more liquidity resources to innovate. We estimate the following equation:

$$dTFP_{it+1} = \beta_0 + \beta_1 AID_{jct} + \gamma_1 distance_i + \gamma_2 distance_i * AID_{jct} + \alpha_j + \alpha_c + \alpha_t + \varepsilon_{ict} \quad (9)$$

where α_j and α_c represent respectively sector and country fixed effects to account for common shocks on respectively the sector and country level.

We expect a state aid measure to be more effective, the tighter the cash constraint. When the within-sector competition is increasing, or equivalently, when pricing is closer to marginal costs, a firms' cash availability decreases and therefore, it finds itself more constraint to follow its optimal development path. To test this hypothesis, we include competition as well as the interaction term of competition with the state aid dummy in our regressions:

$$\begin{aligned} dTFP_{it+1} \quad = \quad & \beta_0 + \beta_1 AID_{jct} + \gamma_1 distance_i + \gamma_2 distance_i * AID_{jct} \\ & + \delta_1 Competition + \delta_2 AID * Competition + \alpha_j + \alpha_c + \alpha_t + \varepsilon_{ict} \end{aligned} \quad (10)$$

where $\delta_2 > 0$, since firms operating in a very competitive market are more likely to benefit from the beneficial effect of state aid.

All specification include time fixed effects. Statistical inference is corrected by clustering the error terms on the 2 digit sector level, which consists of controlling for within-cluster error correlation. Failure to control for within-cluster error correlation can lead to misleadingly small standard errors, and consequently overestimation of the statistical significance of the point estimates. We follow Cameron and Miller (2013) to use bigger and more aggregate clusters up to the point of concern about too few clusters. All cluster correlation of errors that is solely driven by common shocks are accounted for by the fixed effects. As part of the robustness check and for the sake of completeness, we also report the estimation results and corresponding standard errors clustered at the firm level in the appendix.

3.3 Results

Our baseline results of equations (8) and (9) are reported in Table 4. In column (1), we look at the relation between state aid and TFP growth, using a firm fixed effects framework. We don not find a statistical significant relationship between state aid and productivity growth. However, the EC rules of state aid have been relaxed with the financial crisis and from Figure 1, we noted that the number of state aid cases increased exponentially since 2007. In addition, we expect that firms will experience more difficulty in finding funding to proceed their investment plans, which would allow for state aid to be more effective after the crisis than before. We therefore split our sample in a pre- and post-crisis period for which the results are presented in columns (2) & (3). In the pre-crisis period, we note that the effect of state aid is not statistically different from zero. In contrast, during the crisis, the effect of state aid is positive and statistically significant, confirming the hypothesis that state aid was able to alleviate firms from their liquidity problem. Column (4) includes the initial distance to the frontier as well as the interaction with state aid. As expected from the theoretical background,

firms operating further from the technological frontier are catching up by growing faster in terms of total factor productivity. In addition, laggard firms experience a more beneficial effect from state aid measures. Columns (5) and (6) compare the 2 periods in our sample. We can note that in 'normal' economic times, laggards were catching up faster than they are able to during the crisis years. This would indicate that they were more constraint during this second period and thereby state aid can be more effective, which is confirmed by the comparison of the coefficients on the interaction term. Before the crisis, there was overall no statistical significant benefit from state aid. The overall effect of state aid turns positive and statistically significant during the crisis, where the negative sign on the interaction term indicates that laggard firms innovate faster when they are supported by government intervention.

Table 4: Baseline Results

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Overall	Before crisis	After crisis	Overall	Before crisis	After crisis
AID	0.00810	-0.00182	0.0254*	0.00683*	0.00219	0.0178***
	(0.00659)	(0.00807)	(0.0134)	(0.00385)	(0.00749)	(0.00523)
$distance$				-0.338***	-0.475***	-0.214***
				(0.0310)	(0.0467)	(0.0249)
$distance * AID$				-0.105*	-0.110	-0.161***
				(0.0519)	(0.104)	(0.0451)
Constant	0.0475***	0.0452***	-0.0676***	0.129***	0.139***	0.0349***
	(0.00476)	(0.00283)	(0.00900)	(0.0131)	(0.0261)	(0.0109)
Observations	829,121	390,420	438,701	829,121	390,420	438,701
R-squared	0.014	0.002	0.006	0.017	0.015	0.012
Number of bvd_id	207,965	154,506	168,227			

Robust standard errors in parentheses

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

Notes: (i) All specifications include time fixed effects; (ii) The reported standard errors are clustered at the 2 digit sector level to control for within-sector correlation; (iii) Columns (1) - (3) include firm fixed effects; (iv) Columns (4) - (6) include sector and country fixed effects.

To account for competitive pressure that firms within a sector experience, or alternatively the degree of cash constraintness, we include *Competition*, measured as $1 - Lerner$. we also include *Competition* interacted with state aid, or $Competition * AID$, in the next set of regressions, for which the results are presented in Table 5. Column (1) shows that competitive pressure has a positive effect on productivity growth, although its effect is not statistically significant at conventional levels (p value of 0.14). However, during the crisis period, the direct impact of competition on productivity growth increases and is statistically significant at the one percent level. This is consistent with other work,

which shows that competitive pressure and productivity growth is positively correlated (e.g. Nickell, 1995). Furthermore, we find that the effect of state aid is stronger in highly competitive sectors. When a firm faces a more binding cash constraint, state aid induces statistically significant higher level of productivity growth. On average, the overall effect of state aid, is as expected positive. When a firm faces a very low degree of competition, state aid is unable to enhance TFP growth due to a lack of a binding cash constraint and/or because it reduces the incentive to invest as a consequence of a decline in the net gain from innovation. In 'normal' economic times, the overall effect of state aid is not statistically significant. When firms are more constraint due to the financial crisis, the overall effect is always positive. Again, we find a significant different effect of government intervention, given the general economic circumstances in which state aid is provided, where the beneficial effect is mainly driven by the post-crisis years.

Table 5: Competition and State Aid

	(1)	(2)	(3)
VARIABLES	Overall	Before crisis	After crisis
AID	-0.317*	0.207	-0.389*
	(0.182)	(0.328)	(0.224)
$distance$	-0.337***	-0.476***	-0.210***
	(0.0318)	(0.0469)	(0.0281)
$distance * AID$	-0.116**	-0.116	-0.185***
	(0.0552)	(0.104)	(0.0467)
$Competition$	0.434	0.297	0.926***
	(0.281)	(0.269)	(0.302)
$Competition * AID$	0.355*	-0.224	0.449*
	(0.197)	(0.358)	(0.245)
Constant	-0.283	-0.130	-0.853***
	(0.269)	(0.252)	(0.291)
Observations	829,121	390,420	438,701
R-squared	0.017	0.015	0.013
Robust standard errors in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			

Notes: (i) All specifications include time,sector and country fixed effects; (ii) The reported standard errors are clustered at the 2 digit sector level to control for within-sector correlation;

4 Robustness

In this section we conduct various robustness checks using alternative measures to define whether or not a firm is likely to have a binding cash constraint. Also productivity growth as well as distance-to-frontier alternative measures are considered. In addition, we repeat the above specifications leaving out sectors with 'unusual' TFP coefficients, i.e. where either the labor or the capital coefficient exceeds one, as well as leaving out the individual cases. Finally, we provide some results from analyzing the individual cases at the firm level.

4.1 Alternative measures for the cash constraint

In our baseline results, we used competition as a measure for the cash constraint. In this section, we explore 5 alternative measures to define whether or not state aid is able to enhance TFP growth by allowing firms to proceed investment in otherwise rejected R&D projects, and/or to hasten the process towards innovation. Table 6 reports the correlation between the various measures.

Table 6: Correlation between different measures for cash constraint

	Competition	ebitda dummy	minsky	$\|PE\|$
competition	1.0000			
ebitda dummy	0.0727	1.000		
minsky	0.0124	0.3876	1.0000	
$\|PE\|$	0.0043	0.0286	-0.0246	1.0000

4.1.1 Robustness Check 1: Earnings before interest, taxes, depreciation and amortization

A firm's earnings before interest, tax, depreciation and amortization gives an idea whether or not a firm is able to finance its operating activity by the earnings it receives from its products, and hence of its profitability. When $EBITDA < 0$, a firm earns negative profits, meaning it is completely unable to finance any investment through current profits and is less likely to have sufficient cash available. Table 7 provides the results for when we use a dummy variable, which equals 1 if $EBITDA < 0$; From column(1), we can note that firms which have severe problems concerning their profitability, benefit more from state aid measures. By comparing the pre- and post-crisis periods in columns (3) and (4), we learn that this result holds before as well as after the crisis. The overall effect of state aid is positive, in particular for firms who are operating not to close to the technological frontier. This result is mainly driven by the post-crisis years.

Table 7: Ebitda dummy as an alternative measure of cash constraint

	(1)	(2)	(3)	(4)
VARIABLES	Overall	Overall	Before crisis	After crisis
AID	0.00540	-0.235	0.210	-0.295
	(0.00330)	(0.163)	(0.306)	(0.205)
distance	-0.293***	-0.291***	-0.415***	-0.178***
	(0.0285)	(0.0290)	(0.0431)	(0.0264)
$distance * AID$	-0.0963*	-0.103*	-0.103	-0.168***
	(0.0476)	(0.0507)	(0.0948)	(0.0431)
Competition		0.208	0.183	0.648**
		(0.269)	(0.251)	(0.258)
$Competition * AID$		0.263	-0.226	0.342
		(0.177)	(0.334)	(0.224)
constraint	0.210***	0.209***	0.206***	0.213***
	(0.00974)	(0.00948)	(0.00673)	(0.0139)
$constraint * AID$	0.0323*	0.0314*	0.00593	0.0403*
	(0.0167)	(0.0166)	(0.0142)	(0.0226)
Constant	0.111***	-0.0873	-0.0526	-0.566**
	(0.0138)	(0.258)	(0.237)	(0.250)
Observations	828,970	828,970	390,400	438,570
R-squared	0.047	0.047	0.042	0.047

Robust standard errors in parentheses

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

Notes: (i) All specifications include time,sector and country fixed effects;
(ii) The reported standard errors are clustered at the 2 digit sector level to control for within-sector correlation;

4.1.2 Robustness Check 2: 'Minsky' measure[18]

In stead of looking at the capability of a firm to internally financing its investment plans, we now consider to what extent a firm has access to external funding. The 'minsky' measure is defined as

$$minsky = \frac{Interest\ paid}{cash\ flow}$$

and thereby defines to what extent firms are able to finance their current debt with their current cash flow. The higher this value, the less likely a firm can count on finding external funding, which would imply it being more cash constraint. Table 8 rapports the results, when we replace our competition

[18] Minsky, H. P., & Kaufman, H. (2008). Stabilizing an unstable economy (Vol. 1). New York: McGraw-Hill, defines three stages of financing: hedge, speculative and ponzi financing, where in the latter case firms are not able to finance the interest paid by their cash flow.

measure with the 'minsky' dummy. The results are consistent with our previous findings, except for the interaction term $minsky * AID$ which is not statistically significant in either period, indicating that state aid is not able to enhance productivity growth when firms are extremely cash constraint.

Table 8: Minsky measure as an alternative measure of the cash constraint

	(1)	(2)	(3)	(4)
VARIABLES	Overall	Overall	Before crisis	After crisis
AID	0.0133**	-0.290	0.228	-0.345
	(0.00591)	(0.176)	(0.322)	(0.224)
$distance$	-0.176***	-0.280***	-0.394***	-0.173***
	(0.0216)	(0.0248)	(0.0388)	(0.0241)
$distance * AID$	-0.142***	-0.0997*	-0.101	-0.162***
	(0.0444)	(0.0529)	(0.0922)	(0.0461)
$Competition$		0.257	0.159	0.742**
		(0.283)	(0.252)	(0.279)
$Competition * AID$		0.322	-0.248	0.396
		(0.190)	(0.348)	(0.242)
$minsky$	0.123***	0.123***	0.126***	0.122***
	(0.00800)	(0.00589)	(0.00549)	(0.00771)
$minsky * AID$	0.0109	0.00955	0.00399	0.0103
	(0.00850)	(0.00818)	(0.0158)	(0.00797)
Constant	0.00566	-0.155	-0.0503	-0.706**
	(0.0113)	(0.271)	(0.239)	(0.269)
Observations	437,512	826,918	389,406	437,512
R-squared	0.029	0.034	0.033	0.030

Robust standard errors in parentheses

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

Notes: (i) All specifications include time,sector and country fixed effects;

(ii) The reported standard errors are clustered at the firm-sector-country level.

4.1.3 Profit Elasticity

PE is an alternative measure of the intensity of competition and is defined as the percentage fall in profits due to a percentage increase in (marginal) costs. The intuition is that inefficient firms are punished more harshly in terms of profits relative to more efficient ones. Hence, when competition increases, inefficient firms will experience a bigger fall in profits as a result of the same percentage. The PE accounts for increasing competition due to both a fall in entry costs (leading to more entry) and more aggressive conduct by incumbent firms.

Consider a benchmark firm at time t with profits, $\overline{\pi}$, and marginal costs, $\overline{c}_t$[19]. However, the relevant values for firms' profits and marginal costs are not perfectly observed (e.g. a firm may produce other products than those for the market under consideration). Following Boone et al.(2007), we denote the observed profit level, defined as firm's revenue minus variable costs, for firm i at time t by $\pi_{it}u_i$ and the observed marginal costs by $c_{it}v_i$, measured by approximation by the average variable costs. By assumption, these observation errors may differ between firms but are constant over time (or, if the observational errors do change over time, they change in the same way for all firms in a sector such that they are picked up by the time fixed effect)

The estimated equation is

$$\ln\left(\frac{\pi_{it}u_i}{\overline{\pi}_t}\right) = \alpha - \beta_t \ln\left(\frac{c_{it}v_i}{\overline{c}_t}\right) + \varepsilon_{it} \tag{11}$$

or equivalently

$$\ln(\pi_{it}) = \alpha_i + \alpha_t - \beta \ln(c_{it}) + \varepsilon_{it} \tag{12}$$

where the firm fixed effect is given by $\alpha_i \approx \alpha - \ln(u_i) - \beta_t \ln(v_i)$ and the time fixed effect is given by $\alpha_t = \ln(\overline{\pi}_t) + \beta_t \ln(\overline{c}_t)$ .Table 6 describes the summary statistics of the profit elasticity the results for this regression. The coefficient, β, is a direct estimate of the absolute value of the profit elasticity. Since the profit elasticity measures the competitive pressure within the market, and has the drawback of being constant over time due to the estimation procedure, we include the *constraint* variable as measure of the extent that firms are cash constraint. Table 9 reports the results, and we can conclude that including the profit elasticity as additional measure of the competitive environment does not alter previous conclusions.

[19] The benchmark firm could be the median or the least efficient firm in the market.

Table 9: Profit Elasticity

	(1)	(2)	(3)
VARIABLES	Overall	Before crisis	After crisis
AID	-0.00338	-0.00321	-0.0135
	(0.00779)	(0.0118)	(0.0178)
$distance$	-0.293***	-0.415***	-0.183***
	(0.0282)	(0.0425)	(0.0244)
$distance * AID$	-0.0991*	-0.0987	-0.160***
	(0.0487)	(0.0978)	(0.0391)
PE	0.000421	-0.00176	-0.00247
	(0.00365)	(0.00618)	(0.00301)
$PE * AID$	0.00434	0.00284	0.0136*
	(0.00412)	(0.00667)	(0.00723)
$constraint$	0.209***	0.207***	0.214***
	(0.00974)	(0.00679)	(0.0144)
$constraint * AID$	0.0322*	0.00550	0.0408*
	(0.0167)	(0.0143)	(0.0230)
Constant	0.110***	0.116***	0.0641***
	(0.0203)	(0.0329)	(0.0137)
Observations	828,970	390,400	438,570
R-squared	0.047	0.041	0.046

Robust standard errors in parentheses

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

Notes: (i) All specifications include time, sector and country fixed effects; (ii) SE's are clustered at the firm-sector-country level

4.2 Labor productivity growth

Table 10 reports the results when using labor productivity growth, defined as the growth of added value per employee, as outcome variable as an alternative measure of firm performance instead of total factor productivity growth. To measure the extent to which 'laggard' firms benefit from state aid measures, we define distance-to-frontier in terms of labor productivity in a similar way as before, namely

$$distance\_l_i = \frac{LP_i}{\max_{i \in j, j \in c}(LP_i)}$$

Overall, most results remain valid. 'Laggard' firms are able to catch up by growing faster and benefit more from state aid as they are more likely to experience liquidity constraints. Competitive pressure ensures higher growth rates in terms of labor productivity. However, the negative effect on the

interaction term between competition and state aid has become insignificant.

Table 10: Labor productivity growth

	(1)	(2)	(3)
VARIABLES	Overall	Before crisis	After crisis
AID	0.206	0.260	-0.0410
	(0.121)	(0.198)	(0.118)
distance_l	-0.0355***	0.0283***	-0.0857***
	(0.00534)	(0.00479)	(0.00597)
distance_l $*$ *AID*	-0.0431**	0.000383	-0.0483***
	(0.0180)	(0.0133)	(0.0114)
Competition	0.324***	0.229*	0.250***
	(0.0850)	(0.120)	(0.0819)
Competition $*$ *AID*	-0.222	-0.286	0.0520
	(0.130)	(0.215)	(0.128)
Constant	-0.294***	-0.174	-0.271***
	(0.0787)	(0.111)	(0.0786)
Observations	829,345	390,517	438,828
R-squared	0.009	0.005	0.018
Robust standard errors in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			
Notes: (i) All specifications include time, sector and country fixed effects; (ii) SE's are clustered at the sector level			

4.3 Alternative measure for the 'Laggard' firms

When the initial level of TFP is higher, the firm is more likely to be operating closer to the technological frontier. When we replace our original distance to the frontier measure by the initial level of TFP, we obtain the results reported in Table 11. Our results are confirmed.

Table 11: Initial TFP level using alternative clustering

	(1)	(2)	(3)
VARIABLES	Overall	Before crisis	After crisis
AID	-0.242***	0.00138	-0.306***
	(0.0417)	(0.0701)	(0.0575)
initialTFP	-0.0758***	-0.0934***	-0.0575***
	(0.00296)	(0.00414)	(0.00265)
initialTFP $*$ *AID*	0.00175	-0.000560	-0.00702**
	(0.00324)	(0.00466)	(0.00318)
Competition	0.169***	0.0334	0.611***
	(0.0363)	(0.0608)	(0.0497)
Competition $*$ *AID*	0.267***	7.77e-05	0.343***
	(0.0455)	(0.0767)	(0.0628)
constraint	0.196***	0.181***	0.208***
	(0.00290)	(0.00428)	(0.00394)
constraint $*$ *AID*	0.0317***	0.00618	0.0370***
	(0.00446)	(0.00722)	(0.00575)
Constant	-0.139***	-0.0427	-0.591***
	(0.0347)	(0.0587)	(0.0476)
Observations	828,970	390,400	438,570
R-squared	0.058	0.058	0.054

Robust standard errors in parentheses

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

Notes: (i) All specifications include time, sector and country fixed effects; (ii) SE's are clustered at the firm-sector-country level

4.4 Schemes versus individual cases

In general, a distinction is made between schemes, i.e. state aid measures that apply to a sector or region, and individual aid, i.e. state aid granted to a single firm, or a group of firms. The policy to allow schemes to be implemented is more lenient than towards individual aid, because more dispersed is commonly thought of to be less harmful to the economy. However, resources allocated in a scheme are more scattered, which might be in conflict with the goal of targeting aid more efficiently. Tables 12 and 13 provide the results by considering the individual cases and the schemes separately.

Table 12: Schemes

	(1)	(2)	(3)
VARIABLES	Overall	Before crisis	After crisis
$DISP$	-0.470**	-0.306	-0.736*
	(0.219)	(0.266)	(0.358)
distance	-0.347***	-0.481***	-0.229***
	(0.0409)	(0.0525)	(0.0392)
$distance * DISP$	-0.124*	-0.142	-0.210***
	(0.0697)	(0.119)	(0.0578)
Competition	0.462	0.201	1.616***
	(0.277)	(0.220)	(0.376)
$Competition * DISP$	0.519**	0.334	0.820**
	(0.237)	(0.286)	(0.388)
Constant	-0.308	-0.0507	-1.485***
	(0.263)	(0.207)	(0.361)
	0.017	0.015	
Observations	828,757	390,243	438,514
R-squared	0.009	0.005	0.010
Robust standard errors in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			
Notes: (i) All specifications include time, sector and country fixed effects; (ii) SE's are clustered at the sector level			

Dispersed aid, under the form of schemes, is more beneficial when granted to firms which can be considered 'laggards'. Furthermore, high competitive pressure within the sector, and therefore less availability of resources from 'monopoly' rents, induces aid measures to be more effective in terms of productivity growth. This effect, however, is only statistically significant in the post-crisis years. When firms are not financially constraint in pursuing productivity improvements, state aid is unable to enhance the growth path, but private investments will simply get crowded out. In 'normal' economic times, firms are less likely to experience capital market restricitions, which explains why the effect of competitive pressure is not statistically significant before the crisis starting in 2008. These results are in line with the main results as reported in Table 5. For the individual cases, the results concerning the cash constraint, expressed by the competitive pressure in the market remain valid. However, the coefficient on the interaction term between the distance-to-frontier measure and aid becomes statistically insignificant in the post-crisis years, and negative before 2007. The beneficial effect of state aid when granted to firms that operate further from the technological frontier, seems to mainly driven by more dispersed aid.

Table 13: Individual cases

VARIABLES	(1) Overall	(2) Before crisis	(3) After crisis
IND	-0.445***	0.148	-0.708***
	(0.158)	(0.204)	(0.140)
distance	-0.320***	-0.407***	-0.233***
	(0.0380)	(0.0510)	(0.0269)
$distance * IND$	-0.0416	-0.0954*	-0.0606
	(0.0343)	(0.0546)	(0.0398)
Competition	-0.00235	-0.0273	0.0406
	(0.0494)	(0.0845)	(0.0639)
$Competition * IND$	0.489***	-0.152	0.770***
	(0.172)	(0.222)	(0.153)
Constant	0.132***	0.162**	0.0473
	(0.0340)	(0.0689)	(0.0433)
Observations	828,757	390,243	438,514
R-squared	0.016	0.012	0.011
Robust standard errors in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			

Notes: (i) All specifications include time, sector and country fixed effects; (ii) SE's are clustered at the sector level

4.5 The effect of state aid on firms' markups

Since the European Commission has a mission to stimulate the competitive environment within the internal market, we might be concerned that competition might be an endogenous variable in our above regressions. We check for this by regression firms' markups (or Lerner index) on our dummy of state aid, distance-to-frontier measure, and the interaction term, since the firms' ability to raise price over marginal cost, gives a clear view in the self-financing skill for investment of the firm. We find that 'close-to-frontier' firms have higher markups, which is intuitively clear. State aid, however, does not seem to effect markups, leading us to believe that the potential endogeneity of competition is not of great concern in our above obtained results.

Table 14: The effect of state aid on markups

	(1)	(2)	(3)
VARIABLES	Overall	Before crisis	After crisis
AID	0.00122	0.00275	0.000785
	(0.00427)	(0.00511)	(0.00439)
$distance$	0.146***	0.196***	0.112***
	(0.0188)	(0.0191)	(0.0194)
$distance * AID$	0.0131	0.00479	0.0328
	(0.0267)	(0.0462)	(0.0271)
Constant	0.0656***	0.0648***	0.0657***
	(0.00270)	(0.00293)	(0.00286)
Observations	1,237,193	485,185	752,008
R-squared	0.001	0.008	0.001

Robust standard errors in parentheses

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

Notes: (i) All specifications include time, sector and country fixed effects; (ii) SE's are clustered at the sector level

5 Conclusions

This paper examines the relationship between state aid and firms' total factor productivity growth. Overall, our results suggest that state aid is able to alleviate a binding cash constraint firms might face when pursuing growth strategies, and thereby state aid positively affects firm performance in terms of productivity improvements. This effect is mainly driven by the post-crisis years, when firms were more likely to encounter difficulties in finding the necessary resources to follow their optimal development path.

Increased competition induces higher levels of innovation, which is in line with results obtained in earlier empirical studies on the relationship between product market competition and TFP growth. These findings state that firms in highly competitive sectors have a stronger incentive to restructure and/or innovate. This positive effect of competition is present before as well as after the crisis. In addition, we find a positive and significant effect from state aid in highly competitive markets, indicating that state aid is able to accelerate the development pace of these firms. The catching up process of 'laggard' firms is confirmed and as expected, this investment behaviour is stimulated when they are supported by a state aid measure. Our results remain valid throughout several robustness checks.

Determining the optimal use of state aid measures in pursuit of sustainable growth by focusing on the underlying industry dynamics specific to an internal market, both theoretical and empirical, can provide a deeper insight of the results obtained in this paper. Both the duration and the intensity of state aid, as well as the extent to which government resources are dispersed, can be important components to obtain "the least and best targeted aid". Besides obtaining convergence within the internal market and staying a prosperous continent, employment is also at the heart of the European objectives. Identifying the effectiveness of state aid on maintaining/increasing employment rates as well as a potential trade-off between the different goals set out by the Lisbon Strategy, provide an interesting field of future research.

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Appendix A: NACE Rev.2: Manufacturing

Code	*Description*
10	Food products
11	Beverages
12	Tobacco products
13	Textiles
14	Wearing Apparel
15	Leather and related products
16	Wood and products of wood and cork, except furniture; art. of straw and plaiting materials
17	Paper and paper products
18	Printing and reproduction of recorded media
19	Coke and refined petroleum products
20	Chemicals and chemical products
21	Basic pharmaceutical products and pharmaceutical preparations
22	Rubber and plastic products
23	Other non-metallic mineral products
24	Basic metals
25	Fabricated metal products, except machinery and equipment
26	Computer, electronic and optical products
27	Electrical equipment
28	Machinery and equipment
29	Motor vehicles, trailers and semi-trailers
30	Other transport equipment
31	Furniture
32	Other manufacturing
33	Repair and installation of machinery and equipment

Appendix B: Number of observations by country

Country	**Number of observations**
Austria	2860
Belgium	11192
Finland	27864
France	206753
Germany	28349
Italy	414944
Luxembourg	208
Netherlands	316
Portugal	105901
Spain	414574
Sweden	25499

Appendix C: Alternative clustering

We reestimate tables (4) - (6) using an alternative clustervariable. The results obtained are reported in tables (4') - (6'). As expected, the significance of the coefficients is augmented by clustering on a lower level. Table (9) reports our baseline results. The relationship between state aid and TFP growth is overall positive and statistically significant. This result is however completely driven by the crisis years.

Table 4': Baseline Results using alternative clustering

	(1)	(2)	(3)
VARIABLES	Overall	Before crisis	After crisis
AID	0.00810***	-0.00182	0.0254***
	(0.00182)	(0.00350)	(0.00405)
Constant	0.0475***	0.0452***	-0.0676***
	(0.00128)	(0.00148)	(0.00257)
Observations	829,121	390,420	438,701
R-squared	0.014	0.002	0.006
Number of firms	207,965	154,506	168,227
Robust standard errors in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			
Notes: (i) All specifications include time, sector and country fixed effects; (ii) SE's are clustered at the firm-sector-country level			

Table (5') confirms the results obtained in table (5). Laggard firms experience higher growth rates

and are thereby involved in a catching up process which accelerated under state aid. Competitive pressure is growth enhancing, before as well as after the crisis. State aid is capable of enhancing growth in highly competitive sectors when the cash constraint is more binding, i.e. after the crisis.

Table 10 Competition and State Aid using alternative clustering

	(1)	(2)	(3)
VARIABLES	Overall	Before crisis	After crisis
AID	-0.317***	0.207***	-0.389***
	(0.0420)	(0.0729)	(0.0576)
distance	-0.337***	-0.476***	-0.210***
	(0.00731)	(0.0121)	(0.00898)
$distance * AID$	-0.116***	-0.116***	-0.185***
	(0.0138)	(0.0238)	(0.0174)
Competition	0.434***	0.297***	0.926***
	(0.0357)	(0.0613)	(0.0497)
$Competition * AID$	0.355***	-0.224***	0.449***
	(0.0459)	(0.0797)	(0.0629)
Constant	-0.283***	-0.130**	-0.853***
	(0.0342)	(0.0595)	(0.0476)
Observations	829,121	390,420	438,701
R-squared	0.017	0.015	0.013
Robust standard errors in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			
Notes: (i) All specifications include time, sector and country fixed effects; (ii) SE's are clustered at the firm-sector-country level			

The results of table (6') correspond to table (6). All conclusions remain valid.

Table 6': Ebitda dummy using alternative clustering

VARIABLES	(1) Overall	(2) Before crisis	(3) After crisis
AID	-0.235***	0.210***	-0.295***
	(0.0425)	(0.0725)	(0.0578)
distance	-0.291***	-0.415***	-0.178***
	(0.00737)	(0.0121)	(0.00917)
$distance * AID$	-0.103***	-0.103***	-0.168***
	(0.0138)	(0.0237)	(0.0175)
Competition	0.208***	0.183***	0.648***
	(0.0361)	(0.0611)	(0.0497)
$Competition * AID$	0.263***	-0.226***	0.342***
	(0.0464)	(0.0793)	(0.0631)
constraint	0.209***	0.206***	0.213***
	(0.00287)	(0.00417)	(0.00396)
$constraint * AID$	0.0314***	0.00593	0.0403***
	(0.00445)	(0.00727)	(0.00577)
Constant	-0.0873**	-0.0526	-0.566***
	(0.0345)	(0.0593)	(0.0476)
Observations	828,970	390,400	438,570
R-squared	0.047	0.042	0.047

Robust standard errors in parentheses

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

Notes: (i) All specifications include time, sector and country fixed effects; (ii) SE's are clustered at the firm-sector-country level

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