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On the forecasting power of corporate sales growth determinants

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Abstract
This article presents a panel regression model to evaluate the forecasting power of the determinants of corporate sales growth cited in the literature. The model is estimated using information on 189 thousand unique firms over 2008-2021. The results point for a negative relation with size, age (firm, employees, and managers), employees and managers' gender (female) and productivity, and a positive relation with access to external funding, profitability, belonging to an economic group, the shareholder being simultaneously a worker, employees' education, lagged investment and financing flows, as well as changes in the external environment (industry, local and macroeconomic). The relation with leverage is concave and depends on debt composition. The effect of autocorrelation depends on the activity sector and it is typically positive for larger firms. Our specification outperforms a model where the growth rate of sales is the same for all firms. The variables that contribute the most to the model performance are those related with the external environment, in particular the growth rate of domestic demand and exports. Except for investment-related variables, most other firm-level variables cited in the literature have a negligible forecasting power. (JEL: C53, D22, G30, L25)

1. Introduction

Forecasting sales is of great importance within all firms. Sales forecasts affect investment decisions, inventory and human resources management and financial planning. Within firms, they can also be used as a criterion to evaluate performance. Sales forecasts are relevant as well for several stakeholders outside the firm, such as prospective shareholders, who rely on these to value the firm, and lenders that often take sales forecasts into account when deciding whether to grant credit and to determine the loan credit spread. Sales forecasts can also be useful for policy makers. Among other things, they can be used to evaluate whether credit is being allocated to the most promising firms, as an input to measure the credit risk in banks' corporate portfolio or to improve macroeconomic forecasts.

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There is a very significant literature, mostly in industrial economics and corporate finance, which explores the determinants of firms' growth. This literature focuses mostly on firms' characteristics like size, age, access to external funding, financial health, profitability, productivity, ownership structure, access to foreign markets and human capital characteristics. There are also some papers that explore firms' dynamics, looking at the effect of autocorrelation patterns, investment, and financing decisions, as well as changes in the external environment. The latter includes looking at fluctuations in industry, local and macroeconomic aggregates. Most studies in the literature measure corporate growth by looking to the growth rate of either the number of employees or real sales.

Though the literature has been able to show that several of these determinants are relevant in explaining corporate growth, in-sample goodness-of-fit measures are typically very low, especially in the case of very small firms. This has led Geroski (2005), among others, to argue that firms' size reflects mostly a sequence of purely stochastic shocks, similar to a random walk, an assumption also made by several structural corporate finance models (e.g. Eisdorfer *et al.* 2019). While there is a vast literature on corporate growth, the number of studies addressing firms' sales forecasting is relatively small, often focused on specific sectors or applied to public companies and frequently consider time horizons below one year.

In this article, we estimate a panel regression model for the 1-year growth rate of firms' sales using a sample of firms corresponding to 77% (73%) of sales (employees) in Portugal (average values per year). We contribute to the literature in two ways. First, we confirm most of the results in the literature. It is the case of size, age (firm, employees, and managers) and gender (female, both for employees and managers), which show a negative relation with corporate sales growth, and access to external funding, profitability, belonging to an economic group, employees' education, lagged investment and financing flows, and external environment dynamics (industry, local and macroeconomic), which show a positive relation. The relation with leverage is concave and depends on debt composition. The effect of autocorrelation depends on the activity sector and it is typically positive for larger firms. A noteworthy exception is productivity. While most studies point either a positive or insignificant relation, we find a significant negative relation for all productivity measures considered. Our results are based on a large database composed by roughly 1.2 million observations and 189 thousand unique firms spread over 14 years (growth rates between 2008-2021) and covers several firms' characteristics, detailed financial information (annual balance sheet and income statement), loan and security level information and human capital characteristics. We are not aware of any study with this level of information for such a large number of private firms.

Second, while most previous studies only explore whether specific factors determine corporate growth or maximise the forecasting performance, we take these two questions jointly. We estimate the model using growth rates between 2008 and 2017 and evaluate its performance using those between 2018 and 2021. The out-of-sample mean absolute difference between observed and forecasted sales growth rates equals 0.223, 0.011 below a model where the growth rate of sales is the same for all firms. This corresponds to

a relative mean absolute deviation of 0.951. The variables that contribute the most to improve sales forecasts are those related with the external environment, in particular the macroeconomic aggregates. Except for investment-related variables, most other firm-level determinants cited in the literature have a negligible forecasting power. In contrast with the literature, autocorrelation has no forecasting power, something that is related with the strong negative effect of the pandemic shock in 2020 which is carried over to 2021 forecasts, as a result of the positive autocorrelation coefficient in several sectors.

The remainder of the paper is organised as follows. In section 2 we review the literature on corporate growth determinants, highlighting our contribution. In section 3 our dataset is described along several descriptive statistics. Section 4 presents the econometric model. Section 5 analyses the forecasting performance of the model and section 6 concludes.

2. Related literature and contribution

2.1. Firms' characteristics

Size and age are by far the two most studied corporate growth determinants. Most of the literature on the relation between size and corporate growth is organized around Gibrat's law, which posts that corporate growth rates are independent of size. There are however some arguments that may justify differences in growth rates across sizes. For the transaction and technological theories, firms grow faster until reaching their optimal size. As smaller firms are more likely to be below their optimal size, or minimum efficient level, one should expect them to grow faster.[1] In contrast, the Marris' managerial theory highlights that due to agency problems larger firms focus more on growth than in profitability. Finally, industrial organization theories see sales growth as the result of a competitive process (Shapiro 1989). While smaller firms benefit from greater flexibility, lower wages, political sympathy, and closer managers, they also have higher financing costs and more difficulty to finance their projects, especially during recessions.[2]

Though earlier papers, mostly based on large manufacturing firms found that Gibrat's law was a good approximation of reality, from the 80s onwards the empirical evidence has been more in favour of a slightly negative relation (Hall 1987; Evans 1987a,b, among many others). Some studies show however that this negative relation holds only for samples composed mostly of small firms (Geroski and Gugler 2004) or

[1] These theories differ on the rationale behind the optimal size. For the transaction cost theory, this is determined by the costs and benefits of internalising some function as compared to buying it in the market. For the technological theory, the optimal size is determined by the interplay of the increasing returns to scale associated with production technology and the diseconomies of scale stemming from the spread of managerial input, loss of control and information, less flexibility and less motivating environments.

[2] Some studies highlight that public policies often discriminate negatively larger firms through progressive taxation, higher firing costs and ineligibility to public support measures, ultimately affecting smaller firms' willingness to grow.

that it declines very markedly when controlling for firms' age (Lawless 2014). Rossi-Hansberg and Wright (2007) analyse the impact of size in capital-intensive and labour-intensive sectors and find that the gap between the growth rate of small and large firms is significantly smaller in the latter. Consistent with this Daunfeldt and Elert (2013) find that Gibrat's law is rejected mostly in industries with high minimum efficiency levels.

Firms' age and sales growth are generally conceived to be negatively related. This is the case in Jovanovic (1982) and Ericson and Pakes (1995) models, where firms gradually learn about their productivity level and choose output and investment accordingly. As uncertainty is higher in the first years, these models predict stronger growth for those younger firms that stay in the market. More recently, Coad (2018) argues that age captures several predictable changes in non-observable firms' characteristics like improvements in internal organization and reputation, which tend to be more pronounced in the early ages of the firm leading to faster growth. In addition, older firms are less responsive to market opportunities, less willing to adjust the already established routines, and may have difficulty adjusting their product profile to the evolution of tastes.

The negative relation between age and sales growth has empirical support in the literature (Evans 1987a,b). Several studies point that the effect of age on sales growth is concentrated in the first 5-7 years and that this non-linearity should be addressed in the econometric specification (Huynh and Petrunia 2010; Lawless 2014). In line with most previous studies, we find a negative and non-linear relation between sales growth rates and both size and age, even controlling for employees' age, a variable found to be correlated with firms' age (Ouimet and Zarutskie 2014). On average the gap between the growth rate of small and large firms is higher in sectors of activity with higher capital intensity. Size and age show however a negligible contribution to explain corporate growth and to improve the model forecasting accuracy.

Access to external funding has also been pointed as an important determinant of corporate growth, as firms may not be able to generate the financial means needed to make the investments required to grow. The literature on this regard is vast and analyses the contribution of business angels (Levratto *et al.* 2018), venture capital and private equity funds (Paglia and Harjoto 2014), trade credit (Yazdanfar and Öhman 2015), banks (Rahaman 2011) and public capital markets (Borisov *et al.* 2021). Two important conclusions are worth pointing. First, firms that have access to external sources of funding grow faster because they rely less on internal financing to make their investments (Aghion *et al.* 2007).[3] Second, firms that are heavily dependent on bank credit grow less than others when these institutions face a negative shock (Chava and Purnanandam 2011; Dimelis *et al.* 2017).

Access to external funding is often determined by financial health. The empirical literature on the impact of leverage has reached mixed results. While Huynh and Petrunia (2010) find a positive relationship between sales growth and firm leverage,

[3]The only exception is suppliers' credit. In this case, most studies associate higher levels of accounts payable with difficulties obtaining cheaper and more stable sources of funding (Petersen and Rajan 1997).

Lang *et al.* (1996) point for a negative relation. One possibility for this discrepancy is the existence of different channels that relate leverage and sales growth leading to a non-monotonic relation (Coricelli *et al.* 2012). While high levels of debt may reflect external creditors confidence on the firm projects, too high leverage ratios may lead the firm to reject profitable projects, incur in bankruptcy costs or sell some of its assets at below market prices. Though statistically significant, firms that have bank loans or issue debt securities grow only slightly more than others. Sales growth is found to have a concave relation with leverage. The net effect is nevertheless positive except for very high values and depends considerably on debt composition. Access to external funding, leverage and debt composition together have a relevant contribution to increase the model fit but contribute marginally to improve sales forecasts.

The theoretical literature on firm growth, in particular the growth of the fittest theory, sees profitability and productivity as relevant corporate growth determinants. In a world with imperfect capital markets, one expects more profitable firms to face less financial constraints than firms that must resort to external sources to make their investments. Coad (2009) emphasises that more profitable firms are also more motivated to grow as their business model proved to be successful. In corporate valuation, firms' long term (or 'sustained') growth rate is often determined by the level of retained profits multiplied by the return on equity. Regarding productivity, industrial organization theories emphasize that competitive pressures should lead more productive firms to grow more than others. The empirical evidence on a positive relation between profitability/productivity and sales growth is nevertheless scarce. Coad (2009) concludes that profitability and productivity are able to discriminate mostly whether firms are going to fail and Bottazzi *et al.* (2008) find a barely weak significant relation between sales growth and both profitability and productivity in a large sample of Italian firms.[4] Using rank variables clustered by industry and year, we find that the more profitable and the less productive is the firm relative to its peers, the higher is its sales growth rate. Together these variables contribute modestly to improve the model fit and forecasts.

Some studies explore whether the ownership structure affects corporate growth. Harhoff *et al.* (1998) find that limited liability firms have higher expected growth rates and relate this with the risk-taking incentives resulting from shareholders wealth not being at stake. Following the managerial theory suggestion that managers attach utility to size and growth, Hay and Kamshad (1994) find that owner-controlled small and medium-sized enterprises (SMEs) have lower growth rates. Carney (2005) highlights that family control imposes capital constraints that can inhibit corporate growth and Salvato (2004) argues that family businesses tend to put continuity before growth. Beck *et al.* (2005) find a positive, borderline significant relation between sales growth and foreign ownership. Finally, there is some empirical evidence that firms holding partnership arrangements with other firms grow faster (Variyam and Kraybill 1992).We find that firms with crossholdings with other firms grow considerably more than others.

[4]Coad (2009) points that increasing productivity often requires the firm to downsize its activities. A negative relation between productivity and sales growth may also be the result of less productive firms increasing their size to become more productive.

Additionally, we identify whether the shareholder works in the firm and consider this as a proxy of whether the owner controls the firm. In contrast with the literature, this variable is found to have a positive significant coefficient. These variables have a negligible contribution to increase the model fit and do not contribute to improve sales forecasts.

The relation between access to foreign markets and corporate growth has also been addressed in the literature with most studies pointing for a positive relation (Beck *et al.* 2005). One reason for this is that exporting firms are likely more productive and innovative (Golovko and Valentini 2011) before becoming exporters (Wagner 2007). Conversely, exporting may lead to productivity gains because of higher competition and learning in foreign markets. The effect is however not always significant as it is the case of Liu *et al.* (1999). We find that exporting firms grow faster, but this variable contribution to improve the model fit and forecasts is almost null.

Finally, the role of human capital characteristics on corporate growth has also been explored, mostly by those following a resource-based view of organization growth. Among the most studied attributes are age, education and gender. Studies on the relation between owner-managers' (owners and/or managers) age and corporate growth generally point for a negative relation, something that has been justified with younger CEOs higher propensity to enter into M&A activity, investments and internationalization strategies as a result of their lower risk aversion (Serfling 2014), career concerns (Navaretti *et al.* 2022) and lower likelihood of adverse health events (Bennedsen *et al.* 2020). A negative relation has also been found for employees. In this case, this has been mainly related with older employees' reduced ability and willingness to innovate and adopt new technologies, outdated skills and higher risk aversion (Ouimet and Zarutskie 2014). Education has been found to have a positive relation with corporate growth, both for owner-managers (Wiklund and Shepherd 2003) and employees (Magoutas *et al.* 2012). Some studies specifically associate this pattern with greater innovation and openness to change (Wiersema and Bantel 1992) and the capacity to run internationalisation strategies (Herrmann and Datta 2005), in the case of owner-managers, and higher productivity and capacity to adapt to new technologies, in the case of employees. Last, studies on the relation between owner-managers' gender and corporate growth generally find that male-led firms have higher growth rates, something that liberal feminist theories relate with woman lack of access to important resources (education, professional experience, working hours due to domestic responsibilities) and social feminist theories link with different attitudes towards risk and different goals (Fischer *et al.* 1993 and Gottschalk and Niefert 2013). In the case of employees, there are still very few studies and results are less consensual (see Koch *et al.* 2013). In line with the literature, we find a negative relation with age and gender (female), both for managers and employees. We also find a positive relation with the share of higher education, but only in the case of employees. Taken together, these variables have a modest contribution to increase the model fit and do not contribute to improve the model forecasts.

2.2. *Autocorrelation, lagged investment and lagged financing*

Autocorrelation in firms' growth rates have also been a topic of research, both in industrial economics and sales forecasting literature. While earlier studies mostly based on large manufacturing firms find positive autocorrelation, more recent research highlights that autocorrelation depends on some firms' characteristics, in particular size and industry. Coad (2007a) points that small firms' growth rates are very erratic and, as a result, these firms exhibit negative autocorrelation. In contrast, larger firms make medium-term strategic plans and respond less to the ongoing external environment leading to positive autocorrelation. Fairfield *et al.* (2009) find significant differences in the speed of mean reversion in sales growth rates across industries and show that a model which takes these differences into account has a better performance. We observe significant differences in autocorrelation depending on size and sector of activity. In particular, micro firms and firms in the construction, real estate and agriculture sectors show autocorrelation coefficients below others.[5] Autocorrelation has a relevant contribution to the model fit but no contribution to increase its forecasting power unless we exclude 2021, the year of the recovery from the pandemic shock.

Some studies use lagged investment decisions to predict sales growth. Kesavan *et al.* (2010) use the lagged growth rate in the number of stores to predict next year sales of US retailers whenever contemporaneous store growth forecasts are not available. Coad (2007b) finds a significant positive relation between sales growth rates and lagged growth rates of employment using a reduced-form vector autoregressive model. Geroski *et al.* (1997) and Bottazzi *et al.* (2001) explore the impact of the investment in intangible assets (R&D, innovation, advertising) and find it to be non-significant, despite positive. Geroski and Toker (1996) focus on the role of advertisement and innovation expenditure and conclude that these variables are especially important to preserve market leadership. We find that lagged investment variables, in particular the growth rate of the inventory stock and of the number of employees, have positive and significant coefficients and sizable explanatory and predictive power. Interestingly, for most lagged investment variables, the impact of a decrease is greater than the impact of an increase, something that we have not seen highlighted in the literature.

As corporate growth requires investment, which must be preceded by financing, it is likely that lagged financing flows predict corporate growth. Frank and Sanati (2021) explore the role of profitability and lagged external financing flows in asset growth using aggregate and firm-level information. They show using vector-autoregressive models that only lagged equity issuances predict asset growth. Lagged profitability is statistically not significant despite its sizable impact and debt issuance tends to follow asset growth instead of preceding, something that they relate with creditors collateral requirements. Huang and Ritter (2021) study whether different sources of financing

[5] Coad (2007a) uses quantile regressions to show that positive (negative) shocks are more likely after very strong negative (positive) shocks and that this effect is more relevant for smaller firms. In unshown work, we tried to accommodate this finding by including a quadratic term. Though significant, this was found to contribute negatively to the model out-of-sample performance.

have different objectives and conclude that most equity issuers and an overwhelming majority of net debt issuers would face immediate cash depletion without external financing suggesting that they would have cancelled investments or sold assets if they had not received additional cash. We find a significant positive relation between sales growth rates and lagged external cash flows, and a surprising negative small relation with the cash flow from operations. Only changes in total debt contribute to improve the model fit and forecasting performance.

2.3. External environment

It is widely acknowledged that the performance of a firm is influenced by its external environment. The literature has consistently emphasized the significance of three key environmental characteristics in shaping the performance of firms, namely industry performance, local dynamics, and macroeconomic variables.

The effect of industry on corporate performance is addressed in the literature in three different ways. The most popular is to consider industry fixed effects (or industry-time fixed effects). This is the case of Geroski and Gugler (2004), Fairfield *et al.* (2009) and Lawless (2014). These are intended to capture several industry characteristics like life-stage, level of innovation, competition, and market concentration. For forecasting purposes one can either assume that past performance is going to be repeated and use the industry fixed effect or consider it as a control variable and assume the same growth rate across all industries. A common alternative, which we follow, is to use the average (or median) growth rate of the industry at each moment in time. This is the case of Audretsch and Mahmood (1994), Audretsch (1995) and Geroski and Toker (1996). This approach requires however projections of industry growth rates to produce firm-level forecasts. Finally, some studies explicitly consider industry characteristics as firm growth determinants. This is the case of Audretsch (1995), who shows that new firms grow more in sectors where the minimum efficient scale is higher, and Geroski and Toker (1996), who find a positive relation between market concentration and corporate growth. Studies that focus mostly on persistent industry characteristics, either taken explicitly or through fixed effects, usually have little explanatory power (Coad 2009), in contrast to those that account for the industry performance over the business cycle. Industry growth, taken as the difference between the median industry real sales growth rate and the real gross domestic product growth rate, is by far the variable that contribute the most to explain the variation in firms' growth rates. Its contribution to improve the out-of-sample forecasting accuracy is more limited, likely reflecting the relatively low accuracy of the auxiliar industry growth model.

Except for a minority of cases, countries exhibit relevant local heterogeneities emerging from socio-demographic characteristics and dynamics, labour force characteristics, infrastructure supply, investment opportunities and the level of local administration efficiency, availability of business-to-business services and financial support. These differences can be accounted through dummy variables or considering actual growth rates. Dougal *et al.* (2015) study the impact of local firms' investment on the investment of other firms headquartered nearby controlling for industry dynamics

as well as firm, time and local fixed effects. They find that the contemporaneous impact of local dynamics is almost half of the one found for the industry. Moreover, while industry impact is mostly contemporaneous, local dynamics have a more gradual passthrough. Jannati (2020) shows that productivity shocks to the largest firms in the US economy affect firms that are geographically close in the following year. They show evidence that these spillovers occur not only through direct relationships (e.g. firms in the same sector or suppliers/clients), but also through knowledge externalities, impact on local public government budgets and changes in collateral values. Parsons *et al.* (2020) show that the sales growth rate of firms within the same city have a degree of comovement of roughly one-fourth of the one found for firms in the same industry. In line with these studies, we find a positive relation with the difference between the median municipality real sales growth rate and the real gross domestic product growth rate. In the case of micro firms, where local dynamics have a stronger impact, the effect is roughly two thirds of the one found for the contemporaneous industry growth rate. This variable has a moderate explanatory power and a detrimental contribution to the model forecasting performance.

The effect of macroeconomic dynamics on corporate growth has been largely measured by using time fixed effects, as seen in the works of Coad (2007a) and Oliveira and Fortunato (2006), among many others. Exceptions to these include Higson *et al.* (2002), Higson *et al.* (2004), Beck *et al.* (2005) and Hölzl and Huber (2009). The first two studies analyse the sensitivity of growth rates to aggregate shocks conditioning on firm size for the US and UK, respectively. They find that firms in the middle range of the growth range are more affected by aggregate shocks than others. Beck *et al.* (2005) use several macroeconomic variables as control variables and find a positive significant relation between firms' 3-years sales growth rates and average GDP growth and inflation. Their coefficients are nevertheless small in size suggesting that these variables are relevant only on the time dimension. Hölzl and Huber (2009) study the evolution and cyclical dependency of the cross-sectional distribution of firm-level job creation rates from 1975 to 2004 for the Austrian private sector and conclude that the smallest firms are largely unaffected by the business cycle. None of these studies differentiates the impact of domestic demand and exports growth rates on corporate sales. We find that macro variables contribute significantly both to explain and to forecast firm-level sales growth. Micro firms are found to depend slightly less on the business cycle but differentiating based on size does not contribute to increase the forecasting power.

3. Data

Our main source of information is the Central Balance Sheet Harmonised Panel (CBHP). This panel is based on *Informação Empresarial Simplificada* (IES), the system through which corporations report mandatory information to the tax administration and statistical authorities. CBHP provides financial information (annual balance sheet and income statement) as well as several firms' characteristics like sector of activity, number

of employees, age, legal form, access to foreign markets, whether the firm belongs to any economic group and location for virtually all non-financial firms operating in Portugal. *Central de Responsabilidades de Crédito* (CRC) is used to assess whether the firm has obtained credit from resident financial institutions, the loan amount, and if it has any amount overdue. *Sistema Integrado de Estatísticas de Títulos* (SIET) is used to assess whether the firm has access to capital markets and the amounts issued. *Quadros de Pessoal* (QP) supplies information on the age, qualifications and gender of employees and managers. We merge QP with all our datasets for the period between 2006 and 2013. For the remaining years, in the case of firms born up to 2013, it is assumed that all workers (employees and managers) do not change their characteristics, except for age, which is assumed to increase 0.5 years every year. This value is compatible with an increase in our age-related variables between 2014 and 2020 similar to the one observed between 2006 and 2013. For all firms born after 2013, we use an unmatched QP database (6% of all observations) and consider mean values across clusters determined by year of birth, location (NUTS 2), number of workers, legal form, and sector of activity.[6] Finally, historical information on macroeconomic aggregates is obtained from *Instituto Nacional de Estatística* (INE) and macroeconomic forecasts correspond to those regularly published by *Banco de Portugal* in its December Economic Bulletin.

Our initial dataset consists of all private non-financial firms in activity at the end of the year between 2006 and 2021. This corresponds to more than 825 thousand unique firms and approximately 6.2 million observations. After the computation of sales growth rates, we apply six filters to this dataset. First, we eliminate all observations where the total asset value is different from the sum of total liabilities and equity (0.6% of initial observations). Second, we eliminate all observations with sales and assets below 100 thousand euros at 2021 prices (63.6% of initial observations). Third, we eliminate firms with less than two remunerated employees working full-time and total salary expenditure less than two times the minimum national wage (5.3% of initial observations). Fourth, we eliminate firms with reporting gaps in any year between the first and the last time the previous two conditions are fulfilled (6.5% of initial observations). Fifth, since some variables are computed based on the variation of past accounting figures and we need one year to compute the growth rate of sales, we restrict our analysis to firms that reported IES for at least three consecutive times (4.3% of initial observations). Finally, we eliminate observations with zero sales in the forecasted year (0.1% of initial observations).

The imposed restrictions have two objectives in mind. First, we do not want to capture neither self-employment dynamics nor firms with intermittent activity or whose existence is mostly motivated by tax efficiency reasons. Second, we want to avoid our results to be overaffected by micro-firms that represent 88% of our initial dataset but only 16% of total revenues as this would turn our results less comparable to other works. Our final dataset is an unbalanced panel composed by 189 thousand unique firms and

[6] The corresponding group is determined based on the Gower distance between CBHP and QP observations to mitigate the impact of methodological differences in the two databases.

1.2 million observations (6.4 growth rate observations per firm) covering approximately 77% of total sales, 56% of total assets and 73% of employees in the initial dataset. The lower figure observed for assets results from a high number of firms in the real estate sector with sizable assets and a low level of sales. Micro, small, medium and large firms represent 59%, 34%, 6% and 1% of the observations. In approximately 73% of the observations, firms have credit in CRC or credit lines with maturity above 1-year. In only 0.6% of the observations, firms have some amount due in SIET. A high number of firms (26% of the observations) belongs to some economic group.[7] Based on the highest level of aggregation in the European classification of economic activities methodology (NACE), trade is the most represented sector corresponding to more than one third of all observations, followed by manufacturing and construction. Except for accommodation and food services and consulting, all other sectors represent less than 5% of observations each. Electricity, Mining and Water are the smallest sectors representing less than 0.5% of the observations. The list with all activity sectors is presented in section 5 (Table 4).

Table 1 presents descriptive statistics for most variables used in the econometric model presented in section 4. All variables are winsorized at the 1% and 99% levels, including the sales growth rate, which is computed as the log-change in real sales. Hereafter, we refer to real sales as sales (2021 prices). In line with most other studies, the sales growth rate has heavier tails than the Normal distribution, a pronounced left skew leading to a negative mean and a high concentration around the median, which is slightly below zero.

The mean and the median leverage ratio are 66% and 67%, respectively. A distinctive feature of Portuguese firms is that on average (median) financial debt, which comprises liabilities in the CRC and SIET, represents only 28% (21%) of total debt. Trade credit and liabilities to the government represent 29% (25%) and 10% (5%), respectively. The remaining debt, which represents 33% (26%), corresponds mostly to liabilities to related parties, notably loans from shareholders and group companies. Firms have credit overdue in CRC in 4.1% of all observations, varying between 6.1% in 2012 and 1.7% in 2020. [8] While exports represent only 9% of total sales, they are positive in 33% of the observations. Regarding human capital characteristics, we observe a higher share of men, especially in management positions. Workers in these positions are typically older and more educated, though they have higher education only in a quarter of the observations. Shareholders work for the firm in 59% of the observations.[9]

Investment-related variables show a significant level of concentration around the median, which is either zero or close to it, and fat tails. A pronounced positive skew is

[7] A firm is considered as a member of an economic group if it is owned or own shares in another firm in the period between 2014 and 2018.

[8] We consider a firm has credit overdue whenever credit in arrears in December is at least 100 euros.

[9] We consider as managers all workers that are simultaneously employers, directors, and top executives in QP. This criterion is sequentially relaxed for those firms without managers after applying this rule. For those firms without any employers, directors or top executives we use salary and age. Our median (mean) firm has 1 (1.5) managers. We consider as employees all workers that are not managers. Those workers that are employers are assumed to be shareholders that work for the firm.

Variable	Mean	SD	P5	P25	P50	P75	P95
$\Delta \ln$(Sales)	-0.06	0.39	-0.71	-0.16	-0.01	0.12	0.43
Sales	3 058	32 059	137	268	541	1 376	8 284
Assets	3 732	65 082	129	249	510	1 325	8 595
Number of employees	20.8	137.6	2.0	4.0	7.0	15.0	60.0
Age (firm)	17.5	13.0	3.0	8.0	14.0	24.0	43.0
Total debt / Asset	0.66	0.33	0.14	0.44	0.67	0.85	1.16
Financial debt / Asset	0.19	0.21	0.00	0.00	0.12	0.31	0.61
Trade credit / Asset	0.19	0.19	0.00	0.05	0.14	0.28	0.59
Liab. to the gov. / Asset	0.05	0.07	0.00	0.01	0.03	0.06	0.18
Liab. to related parties / Asset	0.23	0.25	0.00	0.05	0.14	0.32	0.74
Median age (managers)	46.6	9.7	31.0	40.0	46.0	53.5	63.5
Median age (employees)	39.6	7.9	27.0	34.0	39.0	44.5	53.0
Share higher educ. (managers)	0.27	0.43	0.00	0.00	0.00	0.50	1.00
Share higher educ. (employees)	0.12	0.24	0.00	0.00	0.00	0.14	0.68
Share female (managers)	0.27	0.40	0.00	0.00	0.00	0.50	1.00
Share female (employees)	0.41	0.35	0.00	0.08	0.33	0.68	1.00
Capex/Asset	0.07	0.16	0.00	0.00	0.01	0.06	0.34
$\Delta \ln$(Inventory)	0.02	0.63	-0.99	-0.10	0.00	0.15	1.09
$\Delta \ln$(Number of employees)	0.04	0.27	-0.37	-0.03	0.00	0.12	0.56
CFO / Asset	0.06	0.20	-0.26	-0.02	0.06	0.15	0.40
Net capital injection / Asset	0.00	0.09	-0.09	0.00	0.00	0.00	0.09
(ΔTotal Debt)/Asset	0.09	0.35	-0.25	-0.07	0.01	0.13	0.66

TABLE 1. Descriptive statistics.

Notes: All variables are winsorized at the 1% and 99% yearly values. All statistics are computed after the application of the filters. Whenever a firm is liquidated (born), we annualize the last (first) year of sales to account for the number of days in operation. All monetary values are stated at 2021 prices (thousands of euros). All variables are in natural units. All age-related variables are measured in years and correspond to the firm-level median value. Financial debt corresponds to the sum of debt in CRC and debt in SIET. Liabilities to related parties are computed as total liabilities minus financial debt, liabilities to the government and trade credit. We consider as workers all those that are full-time paid. See footnote 9 for a detailed explanation on how managers are identified. Capex is computed as the difference between fixed assets in two consecutive years plus depreciations. CFO refers to the cash flow from operating activities.

observed in the case of capex and the log-change in the number of employees. Regarding financing variables, the cash flow from operating activities (CFO) and the net capital injection distributions are symmetric around their median/mean values. While CFO is positive on average, the net capital injection is on average close to zero with shareholders injecting capital (receiving net dividends) in 39% (50%) of the observations. In contrast, the change in total debt distribution is right-skewed. While the number of positive and negative changes is very similar, debt increases tend to be significantly larger.

4. Econometric model

In this article, we aim at measuring the forecasting power of the most cited corporate growth determinants. For this reason, we split the dataset in two. The first ten years (i.e. growth rates between 2008 and 2017) are used to estimate the model. The remaining four years (i.e. growth rates between 2018 and 2021) are used to evaluate its performance. Our first sales growth rate corresponds to the log-change in sales between 2007 and 2008. The year of 2006 is lost to account for autocorrelation in sales growth and to compute investment and financing-related variables. To ease comparison with other studies in the corporate growth literature we opt to use a linear model. As several other articles in

the literature (e.g. Bottazzi *et al.* (2011) and Coad (2007a,b) we estimate the model using least absolute deviation (LAD) instead of ordinary least squares (OLS). Our choice is motivated by better forecasting performance and results presented in other studies in the literature, which have found that LAD performs better than OLS when the data shows fat tails and is not symmetric, two common characteristics in sales growth datasets.

Table 2 presents our econometric specification, where we denote the growth rate of firm i at year $t+1$ as Δ ln(Sales$_{i,t:t+1}$). In addition to the coefficient estimates and the respective significance level, we present the difference between the coefficient of determination with and without each variable and its category based on the Koenker and Machado (1999) measure. The latter is preferred over the traditional R^2 for theoretical consistency reasons. A positive value in each row indicates that the variable/category contributes to better explain the variation in sales.

We organize the determinants in the literature around three types, namely firms' characteristics (size, age, access to external funding, leverage and debt composition, relative fit, ownership structure, access to foreign markets, and human capital characteristics), firm-specific dynamics (autocorrelation, lagged investment and lagged financing), and external environmental dynamics (industry, local, and macroeconomic aggregates growth rates). In the latter case, observed contemporaneous values are used to estimate the model and then replaced by forecasts to compute the model predictions. In line with the literature, we consider heterogenous effects by sector of activity in the case of size and sector of activity and size in the case of autocorrelation. We use the highest level of aggregation in NACE, which comprises 17 sectors in our dataset. Trade, which is the most populated sector, is the omitted category in the econometric output. For simplicity, Table 2 presents only the coefficients on those sectors of activity which represent more than 5% of the observations. We do not include any fixed effects. Despite the high number of variables, except for the leverage ratio for which we include a squared term, all other variables show a generalized variance inflation factor (VIF) below 5 after adjusting for the degrees of freedom using the standard formula and squaring back the term. Most terms present a value close to 1 suggesting a low risk of multicollinearity. The null hypothesis of non-stationary is rejected when applying the IPS unit root panel test.

With a few exceptions, all terms are found to be statistically significant whenever we compute standard errors using the Huber sandwich estimate implemented in the `rq` function in `R`. The model has a coefficient of determination of 0.081 based on Koenker and Machado (1999) measure and 0.121 based on the more traditional R^2. The same model estimated using OLS has an R^2 equal to 0.156. The goodness of fit measures obtained are in line with those presented in the literature for SMEs.[10] Whenever considering the forecasted environmental variables, something that it is not done by the referred goodness of fit measures, we observe a correlation across time of 64% (i.e.

[10] As a robustness check of whether our results are biased by the removal of the initial and final years of the considered firms, we reestimate the model adding back those observations with less than 100 thousand euros of sales and assets (real terms) of those firms that enter the final dataset and still fulfil all other restrictions (11% of the final database). We do not find any material difference in the estimated coefficients.

between the yearly median observed and predicted sales growth rate) and a correlation on the cross-section of 31% (i.e. between firms' median observed and predicted growth rates). Removing in turn all variables related with firms' characteristics, firm-specific dynamics and the external environment lead the Koenker and Machado (1999) measure to decrease by 0.008, 0.02 and 0.045, respectively.

4.1. Firms' characteristics

We measure size and age using the logarithm of sales and age, as it is common in the literature. As expected, we find a negative relation with sales growth in both cases. Taking the trade sector as reference, firms in the 5th percentile of sales and age distributions are found to grow 2.3 and 0.9 percentage points more than firms in the 95th percentile. The gap between the growth rate of small and large firms is typically higher in sectors of activity with higher capital intensity.[11] Though significant, size and age have a negligible contribution to improve the model fit.

Access to external funding is measured through two dummy variables stating whether the firm has access to bank loans and the debt securities market, respectively. A firm is considered to have access to bank loans whenever it has credit in CRC (granted or potential) with original maturity above one year. The firm has access to the debt securities market if it has any amount due in SIET. Both terms are positive and statistically significant, but have almost no explanatory power.

Our results point for a concave relation between leverage, measured by the ratio between total debt and assets, and sales growth. Leverage contribution depends however on debt composition. In particular, the lower the share corresponding to financial debt and liabilities to the government and the higher the share of credit granted by related parties, the higher the sales growth rate. The positive relation with loans granted by related parties suggests that this type of credit has some characteristics in common with equity. Whenever the share of financial debt, liabilities to the government and liabilities to related parties equals the average values in the dataset a positive net effect is obtained for leverage ratios up to 75%. For this firm, the highest net effect is observed for leverage ratios close to 40% and equals 0.5%. The dummy variable indicating whether the firm has overdue loans has a sizable negative coefficient and taken alone is the firm characteristic that contributes the most to improve the model fit. The leverage ratio and debt composition have also a relevant explanatory power.

We measure profitability and productivity using the firm rank within its industry and year (see industry definition in section 4.3). For profitability, we use the ratio of earnings before interest taxes and depreciations (EBITDA) and assets. For productivity, we consider the cost shares approach presented in Foster *et al.* (2016). In line with the theory, we find a sizable positive relation between profitability and sales growth. Firms in the 95th percentile grow 3.2 percentage points more than firms in the 5th percentile. In contrast to theory, we find a negative relation between the productivity rank and sales

[11] We find a correlation of -0.33 (0.27) between the median capital (labour) weight across the 17 sectors of activity and the estimated sector-specific coefficients.

Dependent variable: Δ ln(Sales$_{i,t:t+1}$)			Coefficient	Add. fit by variable	Add. fit by category
Intercept			0.1315***		
Firms' characteristics	Size	ln(Sales$_{i,t}$)	-0.0055***	0.000	0.000
		Manufacturing*ln(Sales$_{i,t}$)	-0.0002***	0.000	
		Construction*ln(Sales$_{i,t}$)	0.0003***		
		Acc. and food*ln(Sales$_{i,t}$)	0.0005***		
		Consulting*ln(Sales$_{i,t}$)	-0.0003***		
	Age	ln(Age$_{i,t}$)	-0.0034***	0.000	0.000
	Access to external funding	AccessBankLoans$_{i,t}$	0.0026***	0.000	0.000
		AccessDebtSecurities$_{i,t}$	0.0036*	0.000	
	Leverage and debt composition	TotalDebt$_{i,t}$/Asset$_{i,t}$	0.0341***	0.001	0.005
		(TotalDebt$_{i,t}$/Asset$_{i,t}$)^2	-0.0366***		
		FinDebt$_{i,t}$/Asset$_{i,t}$	-0.0085***	0.000	
		LiabGovernment$_{i,t}$/Asset$_{i,t}$	-0.1066***	0.000	
		LiabRelatedParties$_{i,t}$/Asset$_{i,t}$	0.0204***	0.000	
		FinancialDebtOverdue$_{i,t}$	-0.1035***	0.002	
	Relative fit	ProfitabilityRank$_{i,t}$	0.0353***	0.001	0.001
		ProductivityRank$_{i,t}$	-0.0198***	0.000	
	Ownership structure	EconomicGroup$_{i,t}$	0.0182***	0.001	0.001
		WorkingEmployer$_{i,t}$	0.0042***	0.000	
	Access to foreign markets	Exporter$_{i,t}$	0.005***	0.000	0.000
	Human capital characteristics	AgeManagers$_{i,t}$	-0.0007***	0.000	0.001
		AgeEmployees$_{i,t}$	-0.0007***	0.000	
		HigherEducationManagers$_{i,t}$	-0.0007	0.000	
		HigherEducationEmployees$_{i,t}$	0.0079***	0.000	
		FemaleManagers$_{i,t}$	-0.004***	0.000	
		FemaleEmployees$_{i,t}$	-0.0075***	0.000	
Autocorrelation, lagged investment and lagged financing	Autocorrelation	Δ ln(Sales)$_{i,t-1:t}$	0.0416***	0.000	0.003
		Small*Δ ln(Sales)$_{i,t-1:t}$	0.0222***	0.000	
		Medium*Δ ln(Sales)$_{i,t-1:t}$	0.0537***		
		Large *Δ ln(Sales)$_{i,t-1:t}$	0.0527***		
		Manufacturing *Δ ln(Sales)$_{i,t-1:t}$	-0.0871***	0.003	
		Construction *Δ ln(Sales)$_{i,t-1:t}$	-0.204***		
		Acc. and food *Δ ln(Sales)$_{i,t-1:t}$	-0.0378***		
		Consulting *Δ ln(Sales)$_{i,t-1:t}$	-0.0811***		
	Lagged investment	Capex$_{i,t}$/Asset$_{i,t-1}$*1$_{(Capex_t>0)}$	0.0587***	0.001	0.009
		Capex$_{i,t}$/Asset$_{i,t-1}$*1$_{(Capex_t<0)}$	0.3691***		
		Δ ln(Inv$_{i,t-1:t}$)*1$_{\Delta Inv_{i,t-1:t}>0}$	0.0326***	0.005	
		Δ ln(Inv$_{i,t-1:t}$)*1$_{\Delta Inv_{i,t-1:t}<0}$	0.0508***		
		Δ ln(NumEmp$_{i,t-1:t}$)*1$_{\Delta NumEmp_{i,t-1:t}>0}$	0.0541***	0.003	
		Δ ln(NumEmp$_{i,t-1:t}$)*1$_{\Delta NumEmp_{i,t-1:t}<0}$	0.1133***		
		AdvertisementRank$_{i,t}$	0.0257***	0.000	
	Lagged financing	CFO$_{i,t}$/Asset$_{i,t}$	-0.0201***	0.000	0.002
		NetCapInj$_{i,t}$/Asset$_{i,t-1}$*1$_{NetCapInj_{i,t}>0}$	0.1039***	0.000	
		NetCapInj$_{i,t}$/Asset$_{i,t-1}$*1$_{NetCapInj_{i,t}<0}$	0.0208***		
		Δ Debt$_{i,t-1:t}$/Asset$_{i,t-1}$*1$_{\Delta Debt_{i,t-1:t}>0}$	0.0319***	0.002	
		Δ Debt$_{i,t-1:t}$/Asset$_{i,t-1}$*1$_{\Delta Debt_{i,t-1:t}<0}$	0.137***		

Dependent variable: Δ ln(Sales$_{i,t:t+1}$)			Coefficient	Add. fit by variable	Add. fit by category
External environment	Industry	g_Ind$_{j,t:t+1}$-g_GDP$_{t:t+1}$	0.965***	0.000	0.020
		Small$_{i,t}$*(g_Ind$_{j,t:t+1}$-g_GDP$_{t:t+1}$)	-0.987***	0.000	
		Medium$_{i,t}$*(g_Ind$_{j,t:t+1}$-g_GDP$_{t:t+1}$)	-0.1057***		
		Large$_{i,t}$*(g_Ind$_{j,t:t+1}$-g_GDP$_{t:t+1}$)	-0.1121***		
	Local	g_Local$_{h,t:t+1}$-g_GDP$_{t:t+1}$	0.6149***	0.000	0.002
		Small$_{i,t}$*(g_Local$_{h,t:t+1}$-g_GDP$_{t:t+1}$)	-0.1698***	0.000	
		Medium$_{i,t}$*(g_Local$_{h,t:t+1}$-g_GDP$_{t:t+1}$)	-0.3453***		
		Large$_{i,t}$*(g_Local$_{h,t:t+1}$-g_GDP$_{t:t+1}$)	-0.635***		
	Macro	ShareDom$_{i,t}$*g_DD$_{t:t+1}$	0.5244***	0.000	0.004
		ShareExp$_{i,t}$*g_Exp$_{t:t+1}$	0.0652***		
		Small$_{i,t}$*ShareDom$_{i,t}$*g_DD$_{t:t+1}$	0.0537***	0.000	
		Medium$_{i,t}$*ShareDom$_{i,t}$*g_DD$_{t:t+1}$	0.0563***		
		Large$_{i,t}$*ShareDom$_{i,t}$*g_DD$_{t:t+1}$	0.0987***		
		Small$_{i,t}$*ShareExp$_{i,t}$*g_Exp$_{t:t+1}$	0.1209***		
		Medium$_{i,t}$*ShareExp$_{i,t}$*g_Exp$_{t:t+1}$	0.1554***		
		Large$_{i,t}$*ShareExp$_{i,t}$*g_Exp$_{t:t+1}$	0.2218***		

TABLE 2. Determinants of firms' growth rates (1-year ahead).

Notes: *** indicates that the variable is significant at 1% level. ** indicates that the variable is significant at 5% level. * indicates that the variable is significant at 10% level. The standard errors are computed using the Huber sandwich estimate implemented in the rq function in R. All monetary variables are deflated using the consumer price index. Trade is the omitted sector when interacting sector of activity with the logarithm of sales. Micro firms in the trade sector is the omitted group when interacting sector of activity with the autoregressive term. For simplicity, we do not present those sectors of activity which represent less than 5% of the observations (12 sectors). AccessBankLoans and AccessDebtSecurities are dummy variables taking 1 if the firm has at least 50 euros in credit (granted or potential) with an original maturity above one year in December of each year and the amount due in SIET is higher than zero, respectively. FinancialDebtOverdue is a dummy variable taking 1 when the firm has credit overdue of at least 100 euros in December of each year. HigherEducationManagers/HigherEducationEmployees and FemaleManagers/FemaleEmployees correspond to the share of managers and employees with higher education and female gender, respectively. ShareDom and ShareExp correspond to the proportion of sales to domestic and foreign markets, respectively. g_DD and g_Exp correspond to the real growth rate of domestic demand and exports. The additional fit associated with ln(Sales$_{i,t}$), g_Ind$_{j,t:t+1}$-g_GDP$_{t:t+1}$ and the combination of ShareDom$_{i,t}$*g_DD$_{t:t+1}$ with ShareExp$_{i,t}$*g_Exp$_{t:t+1}$ is zero by definition due to the presence of heterogenous effects by size. If this was not the case, these variables would have a contribution roughly equal to the value presented in the category.

growth with firms in the 5th percentile growing 1.8 percentage points more than firms in the 95th percentile. This finding is robust to the consideration of other productivity measures such as labour and capital productivity and it is consistent with the findings in Banco de Portugal (2019). Profitability and productivity have nevertheless a modest explanatory power.

Belonging to an economic group is significant and has a sizable impact on the sales growth rate with firms that belong to some economic group growing more 1.8 percentage points than others. Firms whose shareholders work for the firm grow 0.4 percentage points more. Assuming that this measure is a good proxy of whether the firm is controlled by its owners, our results go against the literature cited in section

2. Exporting firms are found to grow 0.5 percentage points more than others. These variables have a negligible impact on the model fit.

In line with the literature, a negative relation with age and gender (female) is found both for employees and managers. When the median manager (employee) age equals 31 (27), firms are estimated to grow 2.2 (1.8) percentage points more than when it equals 64 (53). Also, an all-female firm is estimated to grow 0.4 and 0.8 percentage points less than an all-male firm depending on whether one considers management positions or other employees, respectively. Surprisingly, the share of higher education is found to be significant only in the case of employees. In this case, a firm where all employees have higher education is estimated to grow 0.8 percentage points more. Human capital characteristics contribute modestly to improve the model fit, even taken altogether. As a robustness check, we compare our results with the ones estimated considering a dataset up to 2013 (i.e. the last year we are able to merge our dataset with QP without taking additional assumptions) and similar coefficients are obtained.

4.2. Autocorrelation, lagged investment and lagged financing

We consider the effect of lagged sales growth rate with heterogenous effects by size and sector of activity. The omitted group, which corresponds to micro firms in the trade sector, shows a small positive autocorrelation coefficient (approximately 0.04). As expected, autocorrelation increases with firm size with medium and large firms presenting coefficients significantly higher than micro and small firms. Micro firms in roughly half of all sectors of activity exhibit negative autocorrelation. Autocorrelation is especially negative in the construction, real estate and agriculture sectors. Autocorrelation is higher and positive for all corporate sizes in the education, health and transportation and storage sectors. Overall, the obtained autocorrelation coefficients are in line with those typically presented in studies focusing on SMEs and considerably below the ones reported for large public companies. Autocorrelation has a relevant contribution to model fit.

We use several variables to proxy for investment, namely, the ratio of capex and lagged assets, the log-change in inventory, the log-change in the number of employees and the ratio of advertisement expenses and lagged assets, ranked by industry and year. Except for the latter, we distinguish the impact of increases and decreases with decreases having a stronger impact on sales growth. All these variables are statistically significant with the log-changes in inventory and the number of employees contributing to improve the model fit considerably. Firms in the 95^{th} percentile of these variables are estimated to grow 8.5 and 7.3 percentage points more than firms in the 5^{th} percentile, respectively.

We use 3 variables to measure the impact of financing variables, namely, the ratio of operating cash flows and lagged assets, the ratio of net capital injections and lagged assets and the ratio of changes in debt and lagged assets. All variables are found to be significant with the latter two variables exhibiting the expected positive signal and the ratio of operating cash flows and lagged assets showing a surprising negative impact. As for investment-related variables we distinguish the impact of increases and decreases. While positive net capital injections have a greater impact than negative net capital

injections, the opposite occurs in the case of changes in total debt. This result should stem from firms typically exhibiting negative capital injections (reflecting dividend payments) and either positive or small negative changes in debt (reflecting new credit or gradual amortizations). A different pattern may signal confidence in the firms' ongoing projects, in the case of a positive capital injection, or financial constraints, in the case of negative changes in debt. In contrast with the literature, where the role of equity issuances is usually more emphasized, changes in debt stand out as the most important of the three variables. In this case, firms in the 95th percentile are found to grow 5.5 percentage points more than firms in the 5th percentile. This compares with 1.1 and -0.9 percentage points in the case of net capital injections and operating cash flows, respectively. Only lagged debt financing has a relevant contribution to the model fit.

4.3. External environment

We consider three categories of environmental variables, namely, the median industry sales growth rate in excess of the real gross domestic product growth rate (g_Ind$_{j,t:t+1}$-g_GDP$_{t:t+1}$), the median municipality sales growth rate in excess of the real gross domestic product growth rate (g_Local$_{h,t:t+1}$-g_GDP$_{t:t+1}$) and the real growth rate in two macroeconomic aggregates, namely domestic demand (g_DD$_{t:t+1}$) and aggregate exports (g_Exp$_{t:t+1}$). We interact these variables with corporate size. In addition, in the case of domestic demand and exports real growth rates, we interact these variables also with the firm-level share of domestic and foreign sales, respectively.

All external environmental variables are contemporaneous to our dependent variable. To avoid obtaining biased coefficients, we estimate the model using the actual values. Auxiliar models are developed to make predictions in the case of the industry and municipality growth rates (Online Appendix A) and official Banco de Portugal forecasts are used in the case of macroeconomic aggregates. The auxiliar industry and municipality models are simpler versions of the firm-level model where we consider only autocorrelation and the impact of the real growth rate in domestic demand and aggregate exports with heterogenous impacts by sector of activity and district, respectively. Macroeconomic forecasts correspond to those regularly published by Banco de Portugal in its December Economic Bulletin. In the case of 2020, the June Economic Bulletin forecasts are used to turn the model performance in this year, which is strongly affected by the surprising pandemic shock, more comparable with other years.[12]

The yearly industry median growth rate of firms' sales (g_Ind$_{j,t:t+1}$) is computed considering 313 industries. For most firms, the industry corresponds to the 5-digits NACE disaggregation. A cluster analysis algorithm is used to merge sector codes with less than 50 firms per year in all years with other sector codes at the 5-digits level.[13]

[12]Between December 2019 and June 2020, the forecasted growth rates of domestic demand and exports for 2020 fell from 2.6% to -8.2% and from 2.6% to -25.3%, respectively.

[13]The scclust algorithm (size-constrained clustering) is used to determine industries. All levels of NACE hierarchical structure are used as determinants to avoid that the algorithm unnecessarily merges very distant sectors. The sales median growth rate by year is used to guarantee a unique solution. Approximately 55% of the clusters correspond to a single 5-digits sector of activity.

Micro firms show the highest sensitivity to the industry with a coefficient equal to 0.96. This compares with approximately 0.86 for small, medium and large firms. The industry excess growth rate is the variable that contributes the most to improve the model fit.

The yearly municipality median sales growth rate (g_Local$_{h,t:t+1}$) is computed for the 308 municipalities composing the Portuguese territory. As expected, the impact of the municipality depends crucially on firms' size. While in the case of micro firms it is found to be around 0.6, in the case of large firms it is broadly zero. The municipality excess growth rate has a moderate contribution to improve the model fit.

Regarding macroeconomic aggregates, we find that corporate growth is more sensitive to domestic demand than to exports even before multiplying by the respective share on total sales. In the case of a large firm that exports half of its sales, sales growth increases roughly twice as much in the case of a 1 percentage point increase in domestic demand comparatively to the same increase in aggregate exports. While smaller firms are more affected by local and industry dynamics, larger firms are the most impacted by country-wide aggregates, in particular exports. The real growth rate of macroeconomic aggregates is among the variables that contribute the most to explain firms' sales growth.

5. Forecasting performance

Table 3 presents some descriptive statistics on the observed and predicted sales growth rates over the testing years. On average, the model overestimates firms' sales growth rates. The median predicted growth rate is nevertheless below the observed. This pattern is not observed in all years. In 2018 and 2019, the mean and the median predicted sales growth rates are relatively close to the corresponding observed values. In 2020, the year of the pandemic shock, on average, the model significantly overestimates sales growth rates, something that does not occur when considering the median. This overestimation occurs despite the forecasted growth rates in domestic demand and exports being lower than the observed and should be related with the unique characteristics of the pandemic shock, which affected some sectors in an unusual way.[14] The model underestimates sales growth rates in 2021, the year of the recovery from the pandemic shock, whenever considering both the mean and the median. This underestimation results in great part from the positive autocorrelation coefficient included both in the firm and in the auxiliary models, which pushes the predictions downwards for those firms, industries and municipalities most affected by the pandemic in the previous year. Observed values are significantly more dispersed than predicted and considerably more skewed to the left.

Table 4 presents the out-of-sample mean absolute deviation (MAD) and relative mean absolute deviation (RMAD) by year, age, size and sector of activity. The RMAD is computed as the ratio between the MAD of the model and the MAD of an alternative model that assumes that the growth rate of sales is the same for all firms. This alternative

[14] The June 2020 Banco de Portugal Economic Bulletin forecasts equal -8.2% for domestic demand and -25.3% for exports. These compare with observed growth rates of -4.0% and -22.6%, respectively.

		Mean	P50	SD	Skewness
2018	Observed	0.00	0.02	0.31	-1.69
	Predicted	0.03	0.03	0.07	0.08
2019	Observed	0.01	0.03	0.30	-1.55
	Predicted	0.02	0.02	0.06	0.03
2020	Observed	-0.17	-0.08	0.45	-1.65
	Predicted	-0.08	-0.07	0.09	-0.20
2021	Observed	0.09	0.09	0.33	-1.15
	Predicted	0.01	0.01	0.07	0.56
Total	Observed	-0.02	0.02	0.37	-1.69
	Predicted	0.00	0.00	0.08	-0.35

TABLE 3. Descriptive statistics on observed and predicted sales growth rates.

Notes: Whenever one considers the December 2019 Economic Bulletin forecasts, the mean predicted sales growth rate in 2020 equals 0.02 instead of -0.08. All values are in natural units.

model is compatible with the hypothesis made in several structural corporate finance models that the logarithm of sales follows a random walk with drift. For the same reasons presented for the main model, we estimate this growth rate using LAD instead of OLS obtaining -2% (OLS leads to -7.3%). This corresponds to the historical median between 2008 and 2017, which is lower than the one observed for the whole period. RMAD is particularly suited to make comparisons among groups of individuals because it controls for the level of dispersion within each group.

The model leads to a MAD of 0.223 (in natural units), a value 0.011 below the alternative model. This corresponds to a RMAD of 0.951, a value close to the one found whenever applying the model to the years between 2008 and 2017 (0.956). The root mean squared error (RMSE) equals 0.353, which compares with 0.369 in the alternative model (relative RMSE equals 0.957).[15] These results suggest that the determinants pointed in the literature have a modest forecasting power. This conclusion is not surprising given the low goodness of fit measures presented in section 4 and in the literature, which has led some authors to argue that firms' growth rate is largely random. The fact that the RMAD obtained is consistently below 1, both in-sample and out-of-sample, suggests however that forecasting firms' growth rates may be worthwhile. Unfortunately, we are not able to formally test whether the obtained RMAD is significant due to the low number of out-of-sample years.

To better evaluate the model performance, we compare the results with those obtained by an autoregressive model with order 1, AR(1) model, a simplified version of our model, where we consider only those variables that contribute to improve the forecasting performance and a naïve model where the predicted sales growth rate equals the previous year growth rate. The first two models are presented in the Online Appendix B. The AR(1) RMAD equals 1.006 whenever considering all years and slightly below 1 when excluding 2021. The simplified model RMAD equals 0.951, a value

[15] The same model and the alternative estimated using OLS lead, respectively, to a MAD of 0.235 and 0.232 (RMAD equals 1.013) and a RMSE of 0.353 and 0.37 (relative RMSE equals 0.956), all above or roughly equal the corresponding values estimated using LAD.

	Mean Absolute Deviation (MAD)	Relative Mean Absolute Deviation (RMAD)
Year		
2018	0.183	0.943
2019	0.182	0.938
2020	0.295	0.975
2021	0.230	0.938
Age		
Age<=5	0.298	0.941
Age>5 & Age<=20	0.224	0.952
Age>20	0.190	0.957
Size		
Micro	0.234	0.959
Small	0.212	0.941
Medium	0.195	0.933
Large	0.165	0.928
Sector of activity		
Agriculture	0.239	0.960
Mining	0.239	0.964
Manufacturing	0.201	0.948
Electricity	0.232	0.999
Water	0.246	0.969
Construction	0.284	0.956
Trade	0.181	0.954
Transportation and storage	0.209	0.940
Accommodation and food services	0.295	0.908
Information and communication	0.256	0.951
Real estate	0.375	0.960
Consulting	0.235	0.964
Administrative	0.318	0.931
Education	0.206	1.024
Health	0.182	1.021
Art and sports	0.392	0.961
Other services	0.193	0.976
Total	0.223	0.951

TABLE 4. MAD and RMAD by corporate year, age, size and sector of activity.
Notes: All values are in natural units.

roughly equal to the main model. The naïve model RMAD equals 1.43. Finally, as a robustness check, we reestimate the model using different firms in the training and test datasets with RMAD increasing by 0.001.

MAD is lower in the years before the pandemic likely reflecting a lower level of uncertainty. RMAD is similar in all years except 2020, where RMAD equals 0.975. Though higher than average, the latter is lower than 1.017, which is the value obtained when considering the forecasts in the December 2019 Economic Bulletin.

Likely reflecting their lower risk profile, the MAD is lower for older and larger firms. Firms in the health and trade sectors show the lowest MAD, while firms in the real estate and arts and sports sectors show the highest. RMAD is lower for younger and larger firms and in the case of firms in the accommodation and food services sector, followed by the administrative sector. The model is not able to beat the alternative model in the case of the education and health sectors.

Figure 1 presents a binscatter of predicted and observed sales growth rates. A binscatter is a type of scatter plot where the data is aggregated into bins to increase its readability. In this case, the mean (blue dots) and the median (red dots) value of the variable in the y-axis (observed sales growth rate) are presented for groups of observations determined based on the variable on the x-axis (predicted sales growth rate). The value presented in the x-axis corresponds to the average value for those observations. The observations associated with each point are determined based on the rank of the variable in x-axis so that each point represents the same number of observations. A 45 degrees line is added to help on the graph interpretation. Points above (below) the 45 degrees line suggest that the model is underestimating (overestimating) the observed sales growth rate. The predicted values are close to the average and median observed values for positive and slightly negative growth rates. For large negative sales growth rates predictions though, the observed growth rate is on average considerably lower than the predicted growth rate, something that does not occur in the case of the median. This result suggests that the distribution of observed sales growth rates is very asymmetric for those cases where the model predicts significant negative growth rates, likely from the model not being able to adequately predict extreme negative growth rates ending up not capturing well the significant skewness in the data.

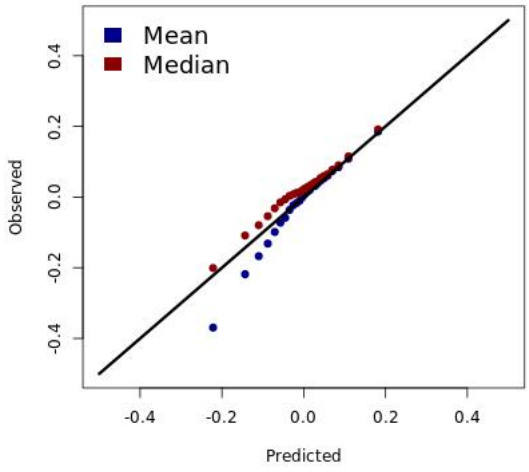

FIGURE 1: Binscatter of predicted and observed sales real growth rates (2018-2021).

Notes: The binscatter gives the mean (blue dots) and the median (red dots) value of the variable in the y-axis variable for groups of observations chosen based on the variable on the x-axis. The value presented in the x-axis corresponds to the average of those observations. All values are in natural units. The observations associated with each point are determined based on the rank of the variable in x-axis so that each of the 25 points represents the same number of observations (4% of all observations).

Table 5 explores the contribution of each variable and category to the RMAD. Each row corresponds to the difference between the RMAD with and without the corresponding variable and category. For simplicity reasons, we present only those variable categories which contribute to decrease RMAD by at least 0.001.

Dependent variable: Δ ln(Sales$_{i,t:t+1}$)			Additional RMAD by variable	Additional RMAD by category
Firms' characteristics	Leverage and debt composition	TotalDebt$_{i,t}$/Asset$_{i,t}$	0.000	-0.002
		(TotalDebt$_{i,t}$/Asset$_{i,t}$)^2		
		FinDebt$_{i,t}$/Asset$_{i,t}$	0.000	
		LiabGovernment$_{i,t}$/Asset$_{i,t}$	0.000	
		LiabRelatedParties$_{i,t}$/Asset$_{i,t}$	0.000	
		FinancialDebtOverdue$_{i,t}$	-0.002	
Lagged investment and lagged financing	Lagged investment	Capex$_{i,t}$/Asset$_{i,t-1}$*1$_{(Capex_t>0)}$	0.000	-0.009
		Capex$_{i,t}$/Asset$_{i,t-1}$*1$_{(Capex_t<0)}$		
		Δ ln(Inv$_{i,t-1:t}$)*1$_{\Delta Inv_{i,t-1:t}>0}$	-0.004	
		Δ ln(Inv$_{i,t-1:t}$)*1$_{\Delta Inv_{i,t-1:t}<0}$		
		Δ ln(NumEmp$_{i,t-1:t}$)*1$_{\Delta NumEmp_{i,t-1:t}>0}$	-0.003	
		Δ ln(NumEmp$_{i,t-1:t}$)*1$_{\Delta NumEmp_{i,t-1:t}<0}$		
		AdvertisementRank$_{i,t}$	-0.001	
	Lagged financing	CFO$_{i,t}$/Asset$_{i,t}$	0.000	-0.003
		NetCapInj$_{i,t}$/Asset$_{i,t-1}$*1$_{NetCapInj_{i,t}>0}$	0.000	
		NetCapInj$_{i,t}$/Asset$_{i,t-1}$*1$_{NetCapInj_{i,t}<0}$		
		Δ Debt$_{i,t-1:t}$/Asset$_{i,t-1}$*1$_{\Delta Debt_{i,t-1:t}>0}$	-0.003	
		Δ Debt$_{i,t-1:t}$/Asset$_{i,t-1}$*1$_{\Delta Debt_{i,t-1:t}<0}$		
External environment	Industry	g_Ind$_{j,t:t+1}$-g_GDP$_{t:t+1}$	0.000	-0.002
		Small$_{i,t}$*(g_Ind$_{j,t:t+1}$-g_GDP$_{t:t+1}$)	0.000	
		Medium$_{i,t}$*(g_Ind$_{j,t:t+1}$-g_GDP$_{t:t+1}$)		
		Large$_{i,t}$*(g_Ind$_{j,t:t+1}$-g_GDP$_{t:t+1}$)		
	Macro	ShareDom$_{i,t}$*g_DD$_{t:t+1}$	0.000	-0.013
		ShareExp$_{i,t}$*g_Exp$_{t:t+1}$		
		Small$_{i,t}$*ShareDom$_{i,t}$*g_DD$_{t:t+1}$	0.000	
		Medium$_{i,t}$*ShareDom$_{i,t}$*g_DD$_{t:t+1}$		
		Large$_{i,t}$*ShareDom$_{i,t}$*g_DD$_{t:t+1}$		
		Small$_{i,t}$*ShareExp$_{i,t}$*g_Exp$_{t:t+1}$		
		Medium$_{i,t}$*ShareExp$_{i,t}$*g_Exp$_{t:t+1}$		
		Large$_{i,t}$*ShareExp$_{i,t}$*g_Exp$_{t:t+1}$		

TABLE 5. Contribution to out-of-sample performance of explanatory variables.

Notes: A negative value implies an improvement to the model accuracy relative to the hypothesis that the growth rate of sales is the same for all firms. The additional RMAD of g_Ind$_{j,t:t+1}$-g_GDP$_{t:t+1}$ and the combination of ShareDom$_{i,t}$*g_DD$_{t:t+1}$ with ShareExp$_{i,t}$*g_Exp$_{t:t+1}$ are zero by definition due to the presence of heterogenous effects by size. If this was not the case, these variables would contribute to improve the model performance by roughly the value presented in the category. This justifies why these variables are included in the simplified model presented in the Online Appendix B. See variables definitions on notes to Table 2.

Most firms' characteristics have almost no impact on RMAD. The only exception is the flag variable indicating whether the firm has debt overdue. Whenever one excludes all firms' characteristics from the model, RMAD increases by 0.003.

Autocorrelation does not improve the RMAD, something that results from the detrimental contribution in 2021. Excluding this year, autocorrelation contributes to

decrease RMAD by 0.002. All lagged investment variables have sizable contributions to decrease RMAD. The growth rate in inventory and the number of employees stand out as the most important contributing with -0.004 and -0.003, respectively. A similar contribution is found for the lagged variation in total debt, the only lagged financing variable that contributes to improve sales forecasts. RMAD increases by 0.014 whenever one excludes autocorrelation, lagged investment and lagged financing variables simultaneously.

External environmental variables stand out as the variables that contribute the most. Altogether they contribute to decrease RMAD by 0.038. The largest contribution comes from the macro variables, followed by the industry. Municipality growth rates are slightly detrimental to the model forecasts. Though positive to the model performance, the industry growth rate contribution is relatively modest compared to its contribution to explain observed growth rates, something that reflects the difference between observed and forecasted industry growth rates (see Figure A.1 in the Online Appendix B). The inclusion of heterogeneous impacts by size has a negligible impact in RMAD for all external environmental variables.

6. Conclusion

In this study, we evaluate the out-of-sample forecasting power of the sales growth determinants cited in the literature using a database composed mostly by micro and small firms. This is done using a linear regression model as in most papers in the empirical literature in industrial economics. The growth rates between 2008 and 2017 are used to estimate the model and those between 2018 and 2021 are used to evaluate its performance. Except for productivity, for which a negative relation is found, we confirm most of the results found in the literature based on the training dataset. This is the case of size, age (firm, employees, and managers) and gender (female, both for employees and managers), which show a negative relation with corporate sales growth, and access to external funding, profitability, belonging to an economic group, employees' education, lagged investment and financing flows, and external environment (industry, local and macroeconomic), which show a positive relation. The relation with leverage is concave and depends on debt composition. The effect of autocorrelation depends on the activity sector and it is typically positive for larger firms.

Our model leads to a mean absolute deviation of 0.223, 0.011 less than an alternative model that considers that the growth rate of sales is the same for all firms. This corresponds to a relative mean absolute deviation equal to 0.951. Our results suggest that the sales growth determinants pointed in the literature have a modest forecasting power. This conclusion is not surprising given the low in-sample fit of this type of models, which has led some authors to argue that firms' growth rate is largely random. The variables that contribute the most to improve sales growth forecasts are those related with the external environment, in particular the growth rate of domestic demand and exports. Except for investment-related variables, most other firm-level variables cited in the literature have a negligible forecasting power.

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