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Growth processes of Italian manufacturing firms

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Abstract

This paper presents a multidimensional empirical analysis of firm growth. Exploiting census data on Italian manufacturing firms, 1989-1997, we estimate a reduced-form VAR to analyze the co-evolution of employment growth, sales growth, growth of profits and labour productivity growth. Our main findings suggest that (i) employment growth precedes sales growth; (ii) productivity growth lacks any strong association with subsequent growth of the other indicators; (iii) profits growth represents the 'absorbing dimension' of the growth processes. This picture contrasts with 'accelerator models', predicting sales are the driver of the growth process, and is also at odds with theories of firm-industry evolution assuming productivity or profits advantages to be the driver of strong market selection/reallocation mechanisms. Instead, the findings reveal the existence of (weak) Penrose and (strong) Kaldor-Verdoorn effects, and more generally convey the view that employment growth is the key driver of firm expansion, while profits, once made, are not reinvested.

JEL codes: C30, D20, L20, L25

Keywords: Firm Growth, Panel VAR, Employment Growth, Industrial Dynamics, Productivity Growth

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1 Introduction

Conventional empirical work on firm growth, it would appear, has come to something of a dead end. A very large literature investigating Gibrat's law has not provided conclusive results on whether firm size is in fact a determinant of firm growth. While many studies detect a statistically significant negative influence of size on growth (although often insignificant in practical terms), many others find no such relation. Other works have investigated what one might call 'augmented Gibrat's law' regressions, which usually involves appending other variables in levels on a Gibrat regression equation, and seeing if these are associated with firm growth. Although coefficients for these additional variables are often statistically significant (especially with large samples) the main conclusion that appears to emerge is that firm growth is a random process, and that its determinants are difficult to find (see Coad (2009) for a survey). Most of the variance of firm growth rates over time is within-firm variance, rather than between-firm variance (Geroski and Gugler, 2004). Geroski even goes as far as to say: "The most elementary 'fact' about corporate growth thrown up by econometric work on both large and small firms is that firm size follows a random walk" (Geroski, 2000, p. 169).

This paper aims at providing new insights by taking a different approach. While previous work has typically focused on a single dimension of firm growth, taking either 'physical growth' (measuring size in terms of employment or capital) or 'growth on the market' (with size proxied through sales or value added) as almost interchangeable aspects of the firm growth processes, our central contribution is to offer a multifaceted description of firm growth. We analyze the coevolution of employment growth and sales growth, and also consider how they change in relation to each other as well as in relation to two further dimensions, i.e. growth of profits and growth of labour productivity.

Perhaps surprisingly, the empirical literature on firm growth has paid very little attention to provide a detailed analysis that is able to consider, at the same time, the many and complex dynamics possibly relating the different dimensions of firm growth we encompass in this work. The multidimensional approach we present here is a suitable test bed. We apply a reduced-form vector autoregression model, which is suited to analyze the associations among the growth variables without making a priori assumptions on the underlying lead-lag structure. In this methodological respect, our study is similar to the recent work by Coad (2010a) on French manufacturing firms [1]

We find that employment growth precedes sales growth and growth of profits, and that sales growth is very strongly associated with subsequent growth of profits and mildly associated with subsequent productivity growth. There is negligible feedback of growth of sales or profits with

[1]See below for direct comparison of results. Another work sharing a similar multidimensional approach is Bottazzi et al. (2008), who however only provide descriptive evidence on pairwise relationship among sales growth and *levels* of both productivity and profitability.

subsequent employment growth, however, while labour productivity growth seems to have a more sizeable but negative effect. Further, no clear association is found between employment or profits growth and subsequent changes in labour productivity. Productivity growth, in turn, has a sizeable association with subsequent growth of profits, while very weak relationship with subsequent growth of either employment or sales. As a result, growth of profits tends to represent the absorbing dimension of the overall processes of firm growth.

This picture is substantially robust with respect to disaggregated analysis conducted by firm size classes and sector of activity, while it exhibits some correlation with time or cycle effects when we allow coefficient estimates to vary over two sample sub-periods. In addition, quantile regressions reveal asymmetries between the growth processes of growing and shrinking firms.

The work is organized as follows. In Section 2 we discuss the theoretical background and formulate some hypotheses. In Section 3 we present the database. In Section 4 we discuss our baseline regression methodology, while Section 5 presents our main results. Section 6 explores alternative specifications including profitability and a measure of fitness in the VAR model. An extended analysis of the baseline framework is then explored in Section 7, where we show results disaggregating by firm size, sector of activity and different sample sub-periods, and also apply quantile regressions techniques to investigate variation of results in different quantiles of the growth rates distributions. We conclude in Section 8.

2 Theoretical Background

Theoretical work on firm growth has often viewed the ability of firms to improve efficiency and increase profitability as the two dimensions of performance inherently related to the process of growth. An example among classical studies is the work by Penrose (1959) who suggests a negative relationship between firm growth and productivity growth, because expansion projects are a distraction for managers and divert their attention from keeping operating costs down (the so-called 'Penrose effects').[2]

In more recent times, the idea that re-allocation of market shares, i.e. growth of size, occurs in favour of the more efficient and more profitable (incumbent or entrant) firms, has become the standard interpretative framework in models of firm-industry evolution (among the many, see Jovanovic, 1982; Ericson and Pakes, 1995; Melitz, 2003; Asplund and Nocke, 2006). Similarly, other influential theorists (such as Nelson and Winter, 1982; Metcalfe, 1994; Dosi, 2000), posit a positive association between productivity or profits growth and subsequent growth in the market, according to the evolutionary principle of 'growth of the fitter'.

[2]See also Little (1962) and Baumol et al. (1970), who consider the growth of profits not only as a measure of performance, but also as a measure of firm growth in itself.

In these models the timing structure underlying the sequence of growth patterns typically identifies technological considerations as the first driver: increases of productivity will tend to bring about, for instance via lower prices, increases in profits and market shares. Profits, in turn, allow the disposal of resources needed to invest and pursue further growth, especially in presence of financial market imperfections. Of course, one can imagine (at least) two orders of considerations which might make this seemingly consistent picture on the time structure of multidimensional growth much less clearcut. First, it is plausible that feedback effects are in place, leading to an opposite lead-lag structure. The working of a micro version of the Kaldor-Verdoorn law would imply a positive effect of growth of output on productivity, due to increasing returns, adoption of new vintages of capital, and learning effects.[3] In this view growth of sales would be a means to gather the needed resources for subsequent efficiency enhancing or innovative investments, which eventually lead to higher profits. Second, it is not clear how growth of employment is placed within the temporal/logical chain defining the growth process. Theories tend to refer to growth on the market, which does not need to coincide with growth of employment. One conjecture, put forward by theories identifying demand shocks as the main driver of the growth processes, is that growth of sales act as an anticipatory variable leading to adjustments in labour (see for instance Delmar, 1997). However, whether growth of employment precedes or follows adjustments of productivity, profits and sales tends to depend on both cost of labour and technical/organizational adjustments related to changes in productivity, as well as on flexibility of labour markets.

The preceding discussion leaves us without a unifying and uncontroversial framework able to guide our attempt at analyzing firm growth as a multi-dimensional process. From a methodological point of view, this lead us to apply vector autoregression (VAR) analysis, which allows to estimate associations among the growth variables without making stringent assumptions on the structure of the relationships. We conclude this section presenting a number of working hypotheses, based on the theoretical predictions, relating to sign and time structure of the relationships, whose empirical validity we are then going to "test" in our VAR analysis.

These hypotheses are summarized in Figure 1. Concerning autocorrelation of our growth variables, we would expect positive autocorrelation in the case of 'increasing returns,' and no growth autocorrelation if firm growth is truly a random walk. Negative autocorrelation would indicate that firm growth is an erratic process, according to which firms find it difficult to sustain a steady growth profile over time.

Next, moving to cross-relationships across variables, the first two rows discuss predictions concerning employment and sales growth. A number of theories have suggested variables that will be associated with subsequent growth of employment, such as the accelerator theory of firm growth, whereby sales growth leads to employment growth. Concerning the factors

[3] See McCombie (1987) for an introduction to the Kaldor-Verdoorn law.

DEPENDENT VARIABLES \ LAGGED VARIABLES	Empl	Sales	Profit	Prod
Empl	+ (Success breeds success) 0 (Random walk) - (Erratic growth)	+ (Accelerator)	+ Models of industry evolution 0 (No 'Financial Constraints')	+ Models of industry evolution
Sales		+ (Success breeds success) 0 (Random walk) - (Erratic growth)	+ Models of industry evolution 0 (No 'Financial Constraints')	+ Models of industry evolution
Profit	+ - (Managerial waste)	+ - (Managerial waste)	+ (Success breeds success) 0 (Random walk) - (Erratic growth)	+
Prod	+ (Kaldor-Verdoorn) - (Penrose)	+ (Kaldor-Verdoorn)	+	+ (Success breeds success) 0 (Random walk) - (Erratic growth)

Figure 1: Theoretical predictions

affecting growth of firm size, whether measured by employment or sales growth, we can resort to the above-mentioned consensus in models of firm growth and industry dynamics, predicting that growth of size is positively influenced by previous growth of profits and productivity. The financial constraints theories of firm growth, however, support predictions where the baseline case is that growth of size is expected to be unrelated to profits or, more generally, to internally generated financial resources. If firm growth is in fact positively related to profits, then these firms are said to be financially constrained.[4]

We then show that growth of the other variables are expected to lead to growth in the amount of profits. From the theory, indeed, only in extreme cases of managerial waste will firm growth be associated with lower profits.[5] Such extreme cases, however, represent relatively rare occurrences, and one can reasonably suspect that additional employees and additional sales will, on average, make a positive contribution to the amount of profits made by the firm.

Finally, we consider theoretical work on the determinants of productivity growth. According to the 'dynamic increasing returns' hypothesis derived from the Kaldor-Verdoorn law, we would expect growth of employment and sales to have a positive impact on subsequent productivity growth. Rapid employment growth, however, may be associated with lower productivity levels if a firm's employees are distracted by the tasks of training new employees, and are not able to focus on keeping operating costs down (the 'Penrose effects' scenario). None of the theories we are aware of present an explicit discussion of how profits growth is associated with productivity growth. The common implicit assumption is however that productive firms are more profitable (and vice versa), and indeed these two variables are often used interchangeably as indicators of relative firm performance.

[4]For a more detailed discussion of standard theories of financial constraints, see Coad (2010b).

[5]See Marris (1964) and Jensen and Meckling (1976) for an introduction to the managerial theory of firm growth. Managers of larger firms tend to have higher pay, as well as other benefits such as more power and prestige. As such, managers may have incentives to grow the firm beyond the 'profit-maximizing' level.

3 Data and variables

This study draws upon the MICRO.1 databank maintained by the Italian Statistical Office (ISTAT).[6] This reports accounting information based on the yearly census of all Italian firms with 20 or more employees, over the period 1989-1997. Firms with 20 or more employees account for around 70% of total employment in Italy (see Bartelsman et al., 2005). Response rates can vary in the different years, but they remain always very high, around 70% or above. Different businesses inside the same firm are assigned to the firm's primary activity.[7] To start with we have a panel of around 22000 firms per year for each year of the period.

Our measure of growth rates is calculated by taking log-differences of relevant variables between two subsequent years. For each firm i at time t, we compute

$$GROWTH(X_{it}) = x_{it} - x_{i,t-1} \quad , \tag{1}$$

where the levels of the considered variable, X, are normalized for the respective annual cross-sectional average, that is

$$x_{it} = log(X_{it}) - \frac{1}{N} \sum_i log(X_{it}) \quad , \tag{2}$$

with N standing for the total number of firms present in each year. The normalization, besides keeping comparability with previous work (e.g. Bottazzi et al. (2007), Bottazzi et al. (2009)), also removes average time trends common to all the firms caused by factors such as inflation and business cycle effects.[8]

In the following, X is measured in terms of Sales, Employment, Gross Operating Surplus (GOS), and Labour Productivity (Prod).[9] In order to avoid misleading values and the generation of NANs in computing growth rates, we retain only those firms with strictly positive values in the levels of the relevant variables.[10] While this choice does not affect sales, employment and productivity, which are always positive (when non-missing) in the data, some additional missing values are generated concerning negative profits.[11]

Table 1 shows year-wise summary statistics, which provide the reader with an idea of

[6] The database has been made available under the mandatory condition of censorship of any individual information.

[7] This operation is performed directly by ISTAT. Hence, we do not have specialization ratios.

[8] In fact, this choice of strategy for deflating our variables was to some extent imposed upon us, since it was not possible, due to limitation in accessing data, to link a suitable sector-by-sector series of producer price indices to be used as deflators.

[9] GOS is referred to as 'profits' in the following. Labour productivity is calculated in the usual way by dividing Value Added by the number of employees. Consideration of multi-factor measures of productivity, typically entailing strong assumptions on specification and estimation of production functions, is left for future work.

[10] NAN is shorthand for Not a Number, which refers to the result of a numerical operation which cannot return a valid number value. In our case, we may obtain a NAN if we try to take the logarithm of a negative

Table 1: Summary statistics for the growth rate series

	Std Dev	Skew	Kurt	10%	25%	50%	75%	90%	obs
1990									
Empl growth	0.1373	0.8786	22.1102	-0.1215	-0.0578	-0.0214	0.0484	0.1362	7733
Sales growth	0.2241	2.9996	54.9442	-0.2062	-0.1040	-0.0121	0.0902	0.2073	7733
GOS growth	0.5919	-0.2877	12.4887	-0.5721	-0.2354	0.0260	0.2574	0.5432	7733
Prod growth	0.1911	0.0827	8.7021	-0.2063	-0.0962	0.0004	0.0943	0.2021	7733
1993									
Empl growth	0.1321	1.2954	28.8620	-0.1189	-0.0456	0.0063	0.0455	0.1117	15268
Sales growth	0.2285	2.3209	98.5156	-0.2297	-0.1064	0.0015	0.1059	0.2277	15268
GOS growth	0.7132	-0.3210	12.2625	-0.6804	-0.2767	0.0161	0.3068	0.6782	15268
Prod growth	0.2021	0.0242	7.7411	-0.2204	-0.1052	-0.0028	0.1026	0.2253	15268
1997									
Empl growth	0.1470	0.9552	15.1643	-0.1272	-0.0632	-0.0240	0.0475	0.1483	10661
Sales growth	0.2466	18.1617	851.0570	-0.1867	-0.0858	-0.0019	0.0827	0.1756	10661
GOS growth	0.6952	-0.4241	11.9866	-0.6364	-0.2622	0.0035	0.2788	0.6626	10661
Prod growth	0.2736	-2.0392	21.6200	-0.2471	-0.0858	0.0281	0.1302	0.2423	10661

the basic characteristics of the growth rate distributions. In general, all of the statistics display considerable stability over time, revealing that the main distributional properties do not substantially change over the period considered. Note also that skewness, kurtosis and quantiles reveal the presence of fat-tailed distributions. These features corroborate previous work (Bottazzi et al., 2007), showing that the growth rate distributions of Italian firms are well approximated by a Laplace (or symmetric exponential) distribution. Finally, we also notice that the distribution of growth rates of GOS has a particularly wide support, which would indicate considerable heterogeneity between firms in terms of the dynamics of their profits.

Table 2 explores the correlations between our indicators of firm growth. We report standard pairwise correlation as well as Spearman's rank correlation coefficients, which are more robust in presence of outliers and fat-tails. All of the series are correlated between themselves at levels that are highly significant. The signs are generally positive, with the exception of the correlation between employment growth and labour productivity growth.[12] However, the correlations are indeed far from perfect, as already noted by Delmar et al. (2003). The largest correlation coefficient is between growth of gross operating surplus and growth of labour productivity (0.6137, or 0.7256 if we look at the Spearman's rank coefficient), while the values are much lower in the other cases. This leaves some room to suspect that there might be some degree of multicollinearity, which might make our results less precisely estimated. With this in mind, in Section 6 we provide robustness analysis exploiting a composite fitness measure that combines productivity and profit. Anyhow, there are reasons to be confident in our baseline estimates. The low degree of persistence in growth rates (already suggested in Geroski (2000)

number, or if we try to divide a number by zero.

[11]This is in line with previous evidence on the relatively widespread presence of negative GOS firms in Italy. For instance, Bottazzi et al. (2008) report negative GOS firms represent about 30% of their sample. To provide an idea of the impact of this choice, Section 6 presents analysis where profit enters in levels rather than in growth rates.

[12]Negative association was already noted on French data (Coad, 2010a, Table 3).

Table 2: Matrix of contemporaneous correlations for the indicators of firm growth. Conventional correlation coefficients are presented first, followed by Spearman's rank correlation coefficients.

	Empl. growth	Sales growth	GOS growth	Prod. growth
Empl. growth	1.0000			
p-value	0.0000			
obs.	93719			
(Sp. Rank)	1.0000			
(p-value)	0.0000			
Sales growth	0.2921	1.0000		
p-value	0.0000	0.0000		
obs.	93719	93719		
(Sp. Rank)	0.3094	1.0000		
(p-value)	0.0000	0.0000		
GOS growth	0.1041	0.3860	1.0000	
p-value	0.0000	0.0000	0.0000	
obs.	93719	93719	93719	
(Sp. Rank)	0.1183	0.5007	1.0000	
(p-value)	0.0000	0.0000	0.0000	
Prod. growth	-0.2911	0.3739	0.6137	1.0000
p-value	0.0000	0.0000	0.0000	0.0000
obs.	93719	93719	93719	93719
(Sp. Rank)	-0.2567	0.4354	0.7256	1.0000
(p-value)	0.0000	0.0000	0.0000	0.0000

and Coad (2007b), but also confirmed by our analysis of autocorrelation of growth variables) will aid in identification in the regression analysis. Moreover, the relatively large number of observations we have will attenuate this potential problem (see Wooldridge, 2003, pp. 96-100).

4 Methodology and estimation strategy

Our aim at exploring the co-evolution of growth of sales, employment, productivity and profits leads us to adopt a VAR model for the empirical analysis. A VAR specification can indeed manage the structure of the mutual influences of a system of variables, describing the key associations rather than assuming a precise timing for lead-lag effects.

Introducing the VAR Our baseline regression equation of interest is therefore of the following form:

$$w_{it} = c + \sum_{\tau=t-k}^{t-1} \beta_\tau b_{i,\tau} + \varepsilon_{it} \quad , \tag{3}$$

where w_{it} is an $m \times 1$ vector of random variables for firm i at time t, β is an $m \times m$ matrix of slope coefficients that are to be estimated for each lag distance k, and ε is an $m \times 1$ vector of disturbances. In our particular case, m=4 and w corresponds to the vector {Empl. growth(i,t), Sales growth (i,t), GOS growth (i,t), Prod. growth(i,t)}, where growth rates are computed as explained above.

We do not include standard dummy control variables, such as year dummies or industry dummies, in the VAR equation. We do not deny that the specificities of individual years or sectors may have non-trivial consequences on the structure of interactions of the VAR series, but there are limits to how much dummy variables can achieve. They can account for discrete changes in the dependent variables between different categories, but they do not allow for changes in the regression coefficients of explanatory variables, when different categories correspond to different growth regimes. Instead, as we anticipate, the influence of temporal or sectoral effects are explored via separate estimates by sub-periods and sector of activity, presented in Section 7 below. In the same vein, our main regression analysis does not directly control for firm size, but we rather explore how estimates vary across size classes, again in Section 7.

Estimation strategy We estimate equation (3) via 'reduced-form' VARs, which do not impose any *a priori* causal structure on the relationships between the variables. These reduced-form VARs effectively correspond to a series of m individual OLS regressions (Stock and Watson, 2001).

A first observation pertains to the possible bias of OLS due to the possible effect of individual unobserved time invariant components. Given our variables are expressed in differences (i.e. in growth rates), however, individual time-invariant component should not play a major role. For the same reason, we can avoid issues related to unit-root processes.

One more substantive problem arising in the specific context of our exercise is that the distribution of firm growth rates typically has much heavier tails than the Gaussian, as indeed found in previous studies as well as in our data (see Section 3). Thus, standard techniques which assume Gaussian residuals, such as OLS and related estimators (like Binder et al., 2005, or panel models), may produce unreliable results.[13] Least Absolute Deviation (LAD) techniques (also known as 'median regression'), which are instead robust to extreme observations, provide a more suited alternative, given the properties of the data. As a result, our preferred specification will be a LAD regression, while OLS regressions are anyhow presented as a benchmark and control case.

Notice also that we do not attempt instrumental variables (IV) techniques, such as the

[13]Panel methods, moreover, and Fixed Effects estimators in particular, can in turn be asymptotically biased (downwards) in panels where T is small (Bond, 2002).

'System GMM' estimator (Blundell and Bond, 1998). This would be of use to unravel the underlying causality involved in the growth process. The performance of instrumental variables estimators, however, depends on the quality of the instruments. If the instruments are weak, IV estimation of a panel VAR leads to imprecise results: the point estimates may be strongly biased (even in large samples), and the confidence intervals surrounding the resulting estimates may also be downward-biased (Murray, 2006). This is likely to be the case in this study. It is indeed difficult to find suitable instruments for firm growth rates, because they are characteristically random and lack persistence over time (see the discussion in Geroski, 2000; Coad, 2007b). Lagged levels, for example, which are often used as instruments for differenced series in dynamic panel data IV-GMM regressions, are of little use in our specific context. As a result, we hesitate to try to establish any strong position on the underlying causality involved in the growth process. Rather, we draw upon the idea that lagging variables in the VAR system are near to capture the causes, while leading variables logically related to the effects.

5 Main results

The regression results obtained from OLS and LAD estimates of the baseline equation 3 are presented in Tables 3 and 4, respectively (cfr. top panels). We limit exposition and comments to regression results including 1 and 2 periods lags. Our preferred specification is the two-lag model, however, because further lags were not significant in most cases and including a second lag helps to attenuate any autocorrelation structure in the residuals.[14]

It is encouraging to observe that the results obtained from the two estimators are not too dissimilar. One major difference is that the magnitudes of the coefficients are smaller using the LAD estimator.[15] It is also worth mentioning that, whilst all the signs perfectly match across the two sets of estimates, the autocorrelation of employment growth changes sign (negative in OLS, positive in LAD). Based on the above considerations about the likely presence of fat tails, we shall consider the LAD as our preferred estimation method and therefore base our interpretations mainly on results of Table 4.

It is rather straightforward to interpret the magnitudes of the coefficients. For instance, take mutual influence between employment and sales growth in the Lag-1 model (top panel of Table 4). The results say that if employment growth increases by 1 percentage point, then

[14]Adding further lags would serve to completely absorb residual autocorrelation, but it would also lead to a much lower number of observations, which can be critical in a short-panel context such as ours. Bearing in mind that serially autocorrelated residuals reduce efficiency, but do not introduce bias Thejll and Schmith (2005), we kept a two-lag model here.

[15]This characteristic was observed in studies concerned with autocorrelation of growth (cfr. Bottazzi et al., 2009), and is explored in Coad (2007a).

Table 3: OLS estimation of equation (3). Coefficients significant at the 5% level in bold.

w_t	β_{t-1}				β_{t-2}					
	Empl. growth	Sales growth	GOS growth	Prod. growth	Empl. growth	Sales growth	GOS growth	Prod. growth	R^2	obs
Empl. growth	**-0.0223**	**0.0515**	**-0.0166**	**0.1028**					0.0304	65632
t-stat	-2.47	8.29	-11.59	16.35						
Sales growth	**0.2897**	**-0.2828**	-0.0017	**0.1198**					0.0527	65632
t-stat	5.53	-4.18	-0.72	3.07						
GOS growth	**0.1494**	**0.2839**	**-0.3869**	**0.1683**					0.0990	65632
t-stat	3.92	7.95	-31.93	4.60						
Prod. growth	**-0.0927**	**0.1130**	**0.0267**	**-0.4472**					0.1046	65632
t-stat	-6.12	8.23	10.30	-29.85						
Empl. growth	**-0.0535**	**0.0620**	**-0.0175**	**0.1054**	**0.0589**	**0.0271**	**-0.0119**	**0.0767**	0.0437	45048
t-stat	4.32	6.51	-9.58	12.88	7.31	5.27	-6.67	10.74		
Sales growth	**0.3090**	**-0.3076**	-0.0014	**0.1209**	**0.1360**	**-0.1362**	**-0.0025**	0.0602	0.0591	45048
t-stat	4.42	-3.39	-0.42	2.46	-3.53	-2.90	-0.83	1.89		
GOS growth	**0.2116**	**0.3768**	**-0.4880**	**0.2446**	0.0277	**0.1730**	**-0.2256**	0.0672	0.1345	45048
t-stat	3.80	6.43	-33.61	5.06	0.73	5.85	-17.20	-1.68		
Prod. growth	**-0.1171**	**0.1474**	**0.0332**	**-0.5425**	**-0.0993**	**0.0730**	**0.0153**	**-0.2584**	0.1409	45048
t-stat	-5.40	6.63	9.82	-27.48	-7.40	6.74	5.18	-18.70		

Table 4: LAD estimation of equation (3). Coefficients significant at the 5% level in bold.

w_t	β_{t-1}				β_{t-2}					
	Empl. growth	Sales growth	GOS growth	Prod. growth	Empl. growth	Sales growth	GOS growth	Prod. growth	R^2	obs
Empl. growth	**0.0352**	**0.0466**	**-0.0106**	**0.0633**					0.0142	65632
t-stat	11.90	26.26	-15.25	25.95						
Sales growth	**0.1336**	**-0.0201**	**-0.0060**	**0.0319**					0.0037	65632
t-stat	18.80	-4.72	-3.63	5.44						
GOS growth	**0.1056**	**0.3105**	**-0.2990**	**0.0968**					0.0283	65632
t-stat	5.95	29.14	-71.85	6.61						
Prod. growth	**-0.0427**	**0.0979**	**0.0100**	**-0.3276**					0.0338	65632
t-stat	-6.10	23.31	6.09	-56.78						
Empl. growth	**0.0244**	**0.0546**	**-0.0111**	**0.0623**	**0.0500**	**0.0220**	**-0.0066**	**0.0419**	0.0208	45048
t-stat	6.12	22.79	-11.52	19.33	12.33	8.37	-6.40	11.04		
Sales growth	**0.1609**	**-0.0347**	**-0.0066**	**0.0299**	**0.0740**	**-0.0401**	**-0.0052**	**0.0185**	0.0056	45048
t-stat	20.63	-7.40	-3.53	4.74	9.33	-7.81	-2.58	2.49		
GOS growth	**0.1248**	**0.3899**	**-0.3794**	**0.1342**	-0.0136	**0.1540**	**-0.1539**	-0.0263	0.0412	45048
t-stat	5.24	27.18	-65.98	6.96	-0.56	9.81	-24.89	-1.16		
Prod. growth	**-0.0696**	**0.1320**	**0.0156**	**-0.4174**	**-0.0703**	**0.0496**	**0.0101**	**-0.2029**	0.0468	45048
t-stat	-7.81	24.61	7.24	-57.82	-7.75	8.46	4.39	-23.89		

ceteris paribus we can expect sales growth to rise by approximately 0.134 percentage points in the following year.[16] Similarly, a 1 percentage point increase in sales growth is estimated to be followed by an approximately 0.047 percentage point increase in employment growth.

In interpreting the results, we can suggest that a value of the coefficients below approximately 0.05, even if statistically different from zero, is a sign of a very weak relationship, not significant in practical terms. Then, values approximately in between 0.05 and 0.1 reveal a weak association, while estimates above 0.1 support the existence of sizeable effects.

We first focus on the Lag-1 results, already providing the bulk of the message which the addition of a second lag will largely confirm (see below). A first observation is that, whilst a substantial previous literature has emphasized the high persistence in the *levels* of the different dimensions of firm dynamics considered here, we find that *growth* rates have little persistence. More than that, we obtain that most of the series (except for employment growth) exhibit negative autocorrelation – this is shown along the diagonals of the coefficient matrices for the lags – which support the idea that growth processes tend to follow an erratic process, with positive growth followed by negative growth one year later. The magnitudes however suggest that this negative autocorrelation is very small, negligible in practical terms, for employment and sales growth, while much more pronounced in the case of profits and productivity growth.

Moving to cross-variable relationships, our results suggest that, although all the variables display statistically significant association with all the other measures, the strength of associations varies considerably across the estimated VAR equations.

First, employment growth is very weakly affected by previous growth of all the other variables. The practically nil contribution of previous growth of sales is particularly important, in view of the above mentioned debate about whether changes in sales precede adjustments in employment or vice-versa.[17] Second, and related to this point, growth rates of sales display a positive and relatively strong relationship with previous growth of employment, while very weak (positive) association is found with lagged growth of labour productivity and an equally very weak (negative) association with previous growth of profits. Third, growth of profits appears to be relatively strongly associated with previous growth of all the other variables, but the influence of sales growth is particularly strong, displaying the biggest coefficient of the entire VAR system. Lastly, growth in labour productivity seems to be preceded by growth of sales only, whereas growth of employment and growth of profits both make a negligible contribution.

[16] Since our variables are expressed in log growth rates (obtained by taking log-differences) they are not exactly equal to conventional growth rates, although log growth rates are a good approximation to growth rates when these growth rates are relatively small in value (Tornqvist et al., 1985).

[17] Our estimate is apparently far more modest than results reported for a sample of Dutch manufacturing firms in Brouwer et al. (1993), who observe that a 1% increase in sales leads to a statistically significant increase in employment of approximately 0.33%.

These patterns remain valid when we also include a second lag in the model, providing more reliable estimates, due to improved ability of this specification in correcting for autocorrelation in the residuals. The significance, signs and magnitudes of the coefficients on the first lag are all very similar. One major difference is that we now observe a more sizeable and negative (-0.0696) first lag contribution of employment growth on subsequent productivity growth. Concerning the coefficients on the second lag, they basically agree with the patterns observed for the first lags. As can be expected, the major difference is that these are generally less significant and smaller than those on the first lag. Noticeable results are that, even at second lag, we find positive autocorrelation of employment growth and negative autocorrelation of other variables. Further, we can confirm the relatively strong effect of sales growth on subsequent growth of profits.

Building upon the specification including both lag-1 and lag-2 effects, Figure 2 provides a graphical summary of our findings. A first striking result is that productivity growth exhibits an overall weak relationship with subsequent growth of the other indicators, suggesting relatively weak workings of virtuous selection/reallocation mechanisms induced by increases in efficiency. Looking at the opposite direction – i.e. at the influence of other growth variables on productivity growth – sales growth tend to have some sizeable influence, suggesting that some form of Kaldor-Verdoorn's effects is in place. At the same time the small but sizeable negative coefficient of growth of employment suggests that Penrose effects are weak but present in our data. It is difficult to say if such a weak ability of feeding productivity growth mainly pertains to an Italian peculiarity. In this respect, particularly compelling seems to be the extremely low contribution of profit growth, possibly pointing to the structurally laggard position of Italian firms in productivity enhancing re-investment of internal resources.

The peculiar role played by profits represents the second finding we want to emphasize here, resulting from the relatively higher magnitudes of coefficient estimates obtained in the profit growth equation, and from the little relevance of growth of profits in the other equations. This suggests that the process of firm growth, broadly defined, is more strongly associated with subsequent growth of profits, which, we could speculate, may be something of an 'absorbing state', providing little feedback by way of subsequent growth of employment, sales, or productivity. If this is in agreement with the expectation that managerial waste cannot be but a rare situation, the findings are at the same time in considerable contrast to widely-shared intuitions that firm growth is mainly sustained by re-investment of profits. This certainly bares important implications for further understanding of firm behavior.

The results presented here are also interesting in comparison with recent findings obtained in the only study which follows a similar approach, but on French manufacturing firms with 20 or more employees (Coad, 2010). As such, it is now possible to be more confident of the main results that emerge from these investigations, and also to become aware of the differences

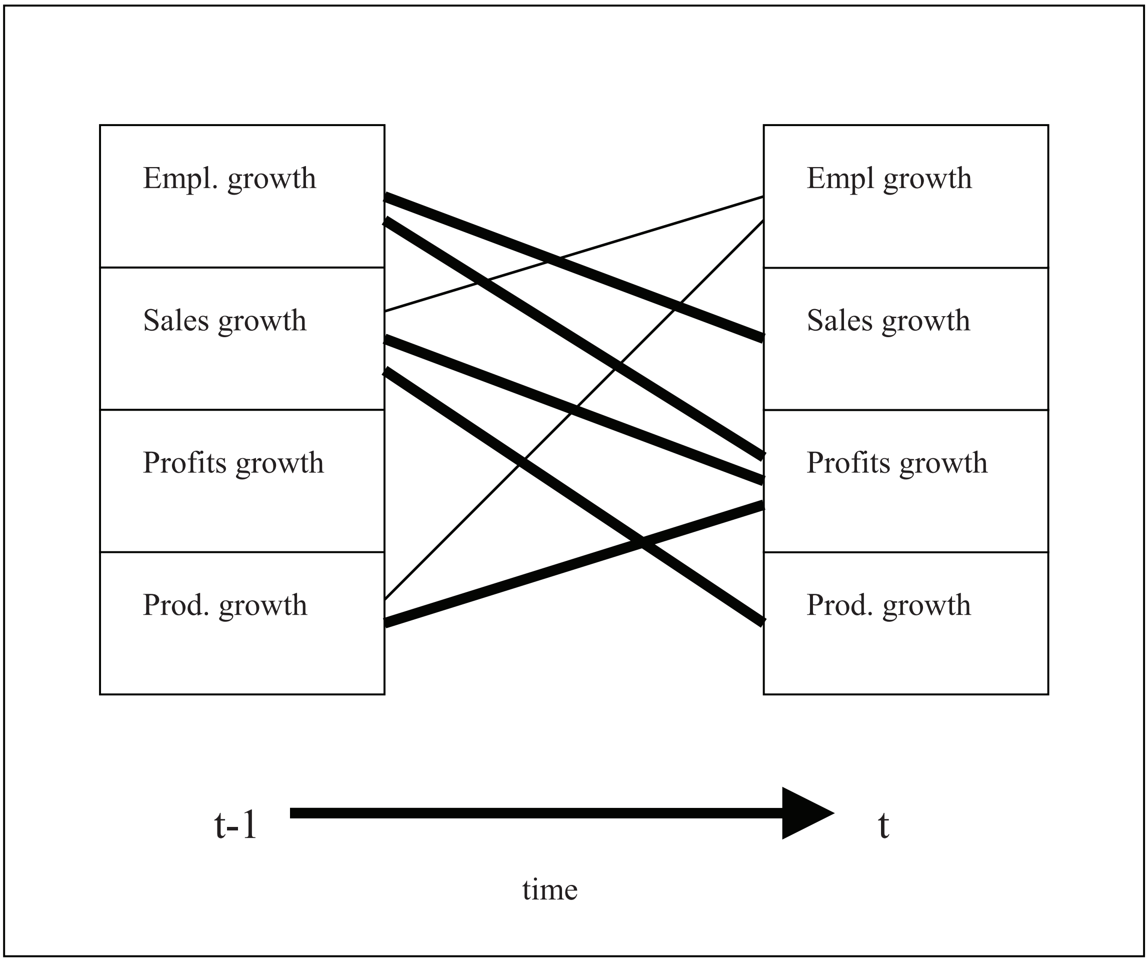

Figure 2: A stylized representation of the firm growth process, based on the first lag of the two-lag estimates in Table 4. Thick lines represent 'strong' associations corresponding to significant coefficients greater than 0.10 in magnitude. Thin lines represent 'weak' associations corresponding to significant coefficients between 0.05 and 0.10 in magnitude. Autocorrelation coefficients are not considered in this figure.

between the two cases.[18] Overall, French and Italian data agree on the main patterns, revealing employment growth and sales growth being followed by growth of profits, with little feedback of profits on subsequent growth of employment and sales. However, although the influence of employment growth on subsequent sales growth is very similar in the two cases (about 0.1609 in Italy, compared to 0.1595 found on French data), we nonetheless observe that profits growth is more strongly affected by previous sales growth than employment growth in the Italian data, while it is employment growth that has the larger effect for French data. Furthermore, we observe a similarly weak effect of growth of other variables on subsequent productivity growth, but, once again, there are some differences. On the one hand, employment growth in the Italian case is negatively associated with subsequent productivity growth, while in the French data the effect is still small but positives. On the other hand, sales growth has a much larger impact on productivity growth in the Italian sample than for the French case. Taking these two results together, we can speculate that employment growth is less advantageous, while sales growth is more advantageous, when undertaken by Italian firms.[19]

6 Alternative specifications

We now provide estimates of different specifications of the baseline framework, at the same time tackling possible problems affecting main results. We first deal with negative profits and then explore the effect of a composite indicator of relative performance.

6.1 Negative profits

A potential caveat of our baseline results presented in Table 4 is that firms with negative values of GOS were excluded from the analysis. The exclusion of these observations was necessary because it is not easy to calculate growth rates of variables that change from having negative to positive values in the levels. In this section, we include firms with negative GOS values by changing our indicator of relative financial performance: instead of considering GOS growth rates, we focus on profitability levels expressed in terms of GOS/sales. This latter variable is basically equivalent to the well-known Return on Sales (ROS) financial ratio.

Table 5 present the VAR results. The estimates show that ROS is positively and significantly associated with subsequent growth of employment, sales and also productivity, but the magnitudes of these effects are very small. Instead, the associations of growth of employment, sales and productivity growth have a much larger positive effect on subsequent values of the

[18] We base our comparisons here on the 2-lag LAD VAR results.

[19] Of course, further work is certainly necessary to see if these differences reflect genuine institutional differences between the countries.

Table 5: LAD estimation of equation (3), where relative financial performance is measured in terms of levels of the profitability ratio (i.e. ROS (GOS/sales)) instead of GOS growth. Coefficients significant at the 5% level in bold.

w_t	β_{t-1}				β_{t-2}					
	Empl. growth	Sales growth	ROS levels	Prod. growth	Empl. growth	Sales growth	ROS levels	Prod. growth	R^2	obs
Empl. growth	0.0046	**0.0556**	**0.0001**	**0.0265**	**0.0395**	**0.0271**	**0.0001**	**0.0205**	0.0194	51891
t-stat	1.29	23.99	23.15	13.44	11.37	11.32	3.59	9.46		
Sales growth	**0.1633**	**-0.0480**	**0.0001**	**0.0216**	**0.0677**	**-0.0368**	**0.0062**	0.0043	0.0077	51891
t-stat	22.69	-10.24	199.99	5.42	9.65	-7.62	257.19	0.99		
ROS levels	**0.0420**	**0.0147**	**0.0001**	**0.0461**	**0.0348**	**0.0022**	**0.0003**	**0.0395**	0.0019	51891
t-stat	11.02	5.91	8.21	21.84	9.35	0.85	21.22	17.08		
Prod. growth	**-0.0468**	**0.1387**	**0.0001**	**-0.3748**	**-0.0699**	**0.0484**	**0.0001**	**-0.1688**	0.0437	51891
t-stat	-6.28	28.61	29.78	-90.82	-9.63	9.76	4.14	-37.35		

profitability ratio. For example, the coefficient of lagged employment growth on profitability is about 400 times larger in absolute value than the coefficient of lagged profitability on employment growth.[20]

6.2 Fitness measure

In the correlation matrix presented in Table 2, we observed that the highest contemporaneous correlations between the VAR series were between GOS growth and labour productivity growth. This hints that a problem of multicollinearity might affect the results, leading to potentially unreliable coefficient estimates. To address this potential problem of collinearity, we build upon the idea that productivity growth and GOS growth can be considered as two alternative indicators of the same underlying phenomenon – relative performance or 'fitness'. Accordingly, we use Principal Component Analysis (PCA) to extract the common variance between levels of profits (GOS) and labour productivity, and then take log-differences of this PCA-generated variable to calculate growth rates of 'fitness'.[21]

At a descriptive level, fitness growth is positively correlated with sales growth (Spearman's ρ=0.3667), but negatively correlated with employment growth (ρ=-0.1887). LAD estimates of a two lags VAR model are then presented in Table 6. Results confirm the main message emerged from the findings obtained in our baseline analysis. Sales growth has a relatively large positive effect on subsequent growth of 'fitness', likely reflecting the strong effect of sales growth on growth of profits which was found in the baseline estimates. Employment growth, in contrast, tends to have a negative effect on subsequent growth of 'fitness' (not significant at the first lag), a result which is presumably due to the negative association of employment growth with subsequent productivity growth. Finally, both sales and employment growth display a negligible association with previous growth of 'fitness', in agreement with both the weak workings of selection/reallocation on productivity and the absorbing role played by profits highlighted by our main analysis.

[20] Our estimates suggest that an increase of ROS of 1 percentage point is associated with an increase in employment growth rate of approximately 0.0001 percentage points in the following period. In contrast, an increase in the employment growth rate of 1 percentage point is associated with an increase in ROS of approximately 0.0420 percentage points.

[21] In order to obtain growth rates of the generated 'fitness' variable, which is calculated in Stata as a zero-mean variable, we add a positive constant to each observation such that the resulting variable consists only of positive numbers. In a further robustness analysis, we repeated the estimates by dropping the two correlated variables one at a time (i.e. dropping productivity growth but keeping GOS growth, and vice versa). Results confirmed the main analysis.

Table 6: LAD estimation of equation (3) with composite fitness measure. Coefficients significant at the 5% level in bold.

w_t	β_{t-1}			β_{t-2}				
	Empl. growth	Sales growth	FIT growth	Empl. growth	Sales growth	FIT growth	R^2	obs
Empl. growth	0.0040	**0.0575**	**0.0181**	**0.0368**	**0.0297**	**0.0118**	0.0198	51142
t-stat	1.30	29.32	16.30	12.18	14.33	10.38		
Sales growth	**0.1565**	**-0.0356**	**0.0053**	**0.0742**	**-0.0407**	0.0037	0.0055	51142
t-stat	21.61	-7.76	2.04	10.50	-8.39	1.37		
FIT growth	-0.0190	**0.1576**	**-0.3300**	**-0.1009**	**0.0614**	**-0.1674**	0.0403	50844
t-stat	-1.76	23.05	-84.91	-9.59	8.49	-41.81		

7 Extended analysis

We now provide a series of extensions to our baseline framework. First, we seek to explore the possible role of size, sectoral and temporal effects, which we capture by repeating the estimates by size classes (Section 7.1), sector of activity (Section 7.2), and sub-periods (Section 7.3). Second, we apply quantile regressions, allowing us to explore the potential asymmetries in the growth process between growing and shrinking firms (Section 7.4). Also notice that inference presented in this Section is based upon 'bootstrapped' standard errors. This represents a further robustness check which might be especially worthwhile, due to the reduced number of observations involved in this disaggregated analysis.[22]

7.1 Size disaggregation

Due care needs to be taken to deal with how growth dynamics vary with firm size. The issue of the dependence of growth on size is an old one within the traditional Gibrat's law framework. On this point, previous analysis based on a similar sample of Italian manufacturing (see Bottazzi et al. (2007)) has not found any dependence between sales levels and sales growth. In addition, recent studies show that the time scale of growth processes can vary between small and large firms: whilst small firms display significant negative autocorrelation in annual growth rates (measured in terms of sales and employment), larger firms experience positive autocorrelation, which is consistent with the idea that they plan their growth projects over a longer time horizon (Coad, 2007a). Still, we lack a precise conclusion on whether it is meaningful to take a 'grand average' between smaller and bigger firms, especially in the context of the kind of multi-dimensional analysis considered in this work, where the VAR estimates allow to investigate the relationship across different aspects of the overall firm growth processes.

We split our sample into 5 *equipopulated* size groups, according to their sales in 1989 (i.e. at the beginning of the sample period) and repeat the estimation of our baseline VAR equation within each size class. As before, we perform LAD estimates of a two lag model. Table 7 present estimates of the first lag coefficients.[23] Generally speaking, the foregoing aggregate analyses (recall Table 4) tend to be confirmed, although we do observe some variation across the size classes. Concerning the pattern of autocorrelations, we still obtain negative signs for growth of sales, profits and productivity, and a positive coefficient for employment growth. The autocorrelation coefficient for employment growth is negative for small firms, but becomes more positive for larger firms. It may also be that the autocorrelation coefficients for the other

[22]Efron and Tibshirani (1993) provide a comprehensive treatment of the techniques.

[23]Although we start with equipopulated groups, the number of observations reported in the Table need not to be the same for each size-class, because the number of non-missing values can vary for each considered variables.

Table 7: LAD estimation of equation (3) across different size groups, according to initial size (as sales in 1989, in thousands of euro). Group 1 contains the smallest firms. A two-lag model is estimated, but only the first lag is reported. Standard errors (and hence t-statistics) obtained from 500 bootstrap replications. Coefficients significant at the 5% level in bold.

w_t	β_{t-1}					
	Empl. gr.	Sales gr.	GOS gr.	Prod. growth	R^2	obs
Class 1: sales < 3174						
Empl growth	**-0.1002**	**0.0427**	**-0.0092**	**0.0882**	0.0237	2898
t-stat	-3.11	2.69	-1.96	3.94		
Sales growth	**0.2079**	**-0.1192**	-0.0114	**0.1014**	0.0098	2898
t-stat	4.03	-3.25	-1.02	2.03		
GOS growth	**0.2942**	**0.1939**	**-0.4496**	**0.3160**	0.0612	2898
t-stat	2.10	2.27	-9.58	2.46		
Prod growth	0.0203	0.0516	0.0092	**-0.3829**	0.0523	2898
t-stat	0.43	1.81	1.11	-7.70		
Class 2: 3174 ≤ sales < 5484						
Empl growth	-0.0010	**0.0600**	**-0.0101**	**0.0681**	0.0219	4217
t-stat	-0.05	5.02	-2.90	4.32		
Sales growth	**0.2475**	**-0.1576**	0.0091	**0.1034**	0.0104	4217
t-stat	6.22	-5.68	0.91	2.71		
GOS growth	0.1555	**0.3880**	**-0.3779**	0.1466	0.0384	4217
t-stat	1.25	5.46	-8.01	1.19		
Prod growth	0.0771	**0.0697**	0.0027	**-0.3244**	0.0365	4217
t-stat	1.52	2.58	0.26	-6.55		
Class 3: 5484 ≤ sales < 9570						
Empl growth	0.0169	**0.0596**	**-0.0155**	**0.0684**	0.0239	4926
t-stat	0.77	5.89	-3.33	3.94		
Sales growth	**0.2365**	**-0.0708**	**-0.0160**	**0.0751**	0.0110	4926
t-stat	6.38	-2.31	-2.56	2.39		
GOS growth	**0.4370**	**0.2784**	**-0.4018**	**0.3586**	0.0372	4926
t-stat	3.71	4.45	-7.36	2.74		
Prod growth	0.0576	**0.0682**	0.0134	**-0.2967**	0.0376	4926
t-stat	1.35	3.41	1.71	-8.03		
Class 4: 9570 ≤ sales < 21135						
Empl growth	**0.0915**	**0.0475**	**-0.0197**	**0.0973**	0.0297	5455
t-stat	4.73	5.07	-4.63	5.75		
Sales growth	**0.2357**	**-0.0952**	**-0.0290**	**0.1240**	0.0093	5455
t-stat	6.05	-3.51	-3.21	3.23		
GOS growth	0.1286	**0.4050**	**-0.3791**	0.2150	0.0394	5455
t-stat	1.22	7.35	-8.54	1.84		
Prod growth	-0.0453	**0.1059**	-0.0006	**-0.3292**	0.0331	5455
t-stat	-1.15	4.29	-0.06	-7.16		
Class 5: sales > 21135						
Empl growth	**0.1308**	0.0211	-0.0059	**0.0474**	0.0265	5653
t-stat	7.81	1.90	-1.30	3.46		
Sales growth	**0.1122**	-0.0413	**0.0180**	0.0032	0.0059	5653
t-stat	3.41	-1.20	2.85	0.14		
GOS growth	0.0537	**0.2980**	**-0.2752**	0.1399	0.0198	5653
t-stat	0.51	2.79	-5.57	1.29		
Prod growth	**-0.1156**	**0.0935**	0.0201	**-0.2993**	0.0216	5653
t-stat	-2.68	2.37	1.51	-6.52		

variables become more positive in larger size classes, but the results are not as clear-cut here. These results are similar to those obtained in Coad (2010a) on French data.

Some interesting patterns are also observed concerning the other coefficients. First, the influence of lagged growth of employment on the other growth rates suggest the existence of patterns similar to what emerged in the aggregate, i.e. that employment growth has bigger influence on growth of sales and profits, than on growth of labour productivity. The magnitudes of the estimates, however, vary across classes, revealing that employment growth has a more negative effect on subsequent productivity growth for larger firms. This finding was also found for French data, so it would appear to be relatively robust. This is consistent with the idea that smaller firms have to struggle to reach the minimum efficient scale (MES), and that, until they reach the MES increases in employment are associated with increases in productivity. Furthermore, it appears that small and medium-sized firms have more to gain from lagged employment growth (in terms of subsequent growth of sales and profits) than larger firms (although this is not confirmed by previous results on French data).

Second, concerning the association of lagged sales growth with subsequent growth of the other variables, we notice the stronger association of growth of sales with subsequent growth of profits that already emerged in the aggregate. In keeping with French results, however, sales growth has a smaller effect on GOS growth for the group of smallest firms.

Third, we can also confirm the effects of past productivity growth on the other variables, although in our dataset the relationships tend to be smaller for the largest group of firms. Finally, concerning the effects of past growth of profits, we can observe the little feedback going from lagged GOS growth to all the other dimensions of the growth process, confirming the suggested role of "absorbing state" played by profits.

7.2 Sectoral disaggregation

A further possibility that deserves investigation is that there may be sector-specific factors characterizing the dynamics of firm growth in different sectors. To account for such differences, we explore LAD estimates of our baseline VAR model for groups of firms operating in the same sector of activity. In an attempt to keep exposition manageable, we focus on four particular sectors. These are chosen to represent the four classes of the standard Pavitt (1984)'s taxonomy of industries, where industrial sectors are classified according to the different characteristics of their innovative activity. We take "Precision Instruments", "Basic Metals", "Machinery and Equipment", and "Textiles", which respectively represent typical examples of industries falling into the "science-based", "scale-intensive", "specialized suppliers", and "supplier-dominated"

Table 8: LAD estimation of equation (3) across different industries. A two-lag model is estimated, but only the first lag is reported. Standard errors (and hence t-statistics) obtained from 500 bootstrap replications. Results significant at the 5% level in bold.

w_t	β_{t-1}					
	Empl. gr.	Sales gr.	GOS gr.	Prod. growth	R^2	obs
ateco 17: Textiles						
Empl growth	**0.0434**	**0.0552**	**-0.0098**	**0.0479**	0.0156	4321
t-stat	2.52	4.63	-2.82	3.97		
Sales growth	0.0687	**0.0878**	**-0.0132**	-0.0206	0.0066	4321
t-stat	1.86	3.87	-2.91	-1.07		
GOS growth	-0.0168	**0.4497**	**-0.2948**	0.0256	0.0319	4321
t-stat	-0.21	7.98	-6.59	0.27		
Prod growth	**-0.1485**	**0.1907**	0.0129	**-0.3966**	0.0417	4321
t-stat	-3.32	6.54	1.38	-9.02		
ateco 27: Basic metals						
Empl growth	0.0267	**0.0389**	**-0.0161**	**0.0332**	0.0087	2340
t-stat	1.06	2.60	-3.15	2.21		
Sales growth	0.0036	0.0305	0.0127	**-0.1314**	0.0068	2340
t-stat	0.07	0.68	1.14	-2.85		
GOS growth	**-0.4409**	**0.5291**	**-0.1529**	**-0.5223**	0.0414	2340
t-stat	-3.42	7.70	-2.52	-3.83		
Prod growth	**-0.2285**	**0.2066**	**0.0170**	**-0.4194**	0.0469	2340
t-stat	-4.14	4.83	2.35	-10.04		
ateco 29: Machinery and equipment						
Empl growth	**0.0666**	**0.0316**	**-0.0144**	**0.0757**	0.0126	9320
t-stat	4.12	5.61	-5.69	7.17		
Sales growth	**0.2339**	**-0.1565**	-0.0087	**0.0948**	0.0114	9320
t-stat	10.65	-8.50	-1.62	4.42		
GOS growth	**0.1569**	**0.2008**	**-0.3137**	0.1214	0.0328	9320
t-stat	2.13	5.28	-11.31	1.75		
Prod growth	-0.0174	**0.0660**	0.0101	**-0.3335**	0.0365	9320
t-stat	-0.77	4.47	1.58	-12.41		
ateco 33: Precision instruments						
Empl growth	**0.1358**	**0.0749**	**-0.0242**	**0.1115**	0.0393	1513
t-stat	4.22	4.47	-3.27	3.78		
Sales growth	**0.2794**	-0.0475	**-0.0219**	**0.1049**	0.0156	1513
t-stat	5.92	-1.05	-2.04	2.14		
GOS growth	0.2663	0.2263	**-0.2931**	0.1175	0.0255	1513
t-stat	1.23	1.89	-3.55	0.54		
Prod growth	0.0435	0.0431	-0.0034	**-0.2570**	0.0292	1513
t-stat	0.74	1.13	-0.21	-3.83		

Pavitt classes.[24]

The regression results are presented in Table 8, where we show lag-1 coefficients from the usual 2-lags VAR model. All in all, sectoral specificities do not directly contrast with aggregate findings, but rather emphasize which of the relationships might be more or less relevant in the different industries.

The estimates for the Machinery & Equipment sector are similar to the patterns observed at the aggregate level. The autocorrelation coefficients indeed agree with what we found in Table 4. The same holds for the cross-variable effects, which confirm, in particular, the small

[24] For reference to the European system of industry classification (NACE, Rev. 1.1), these sectors are NACE 33 (Manufacturing of medical, precision and optical instruments, watches and clocks), NACE 27 (Manufacturing of basic metals), NACE 29 (Manufacturing of machinery and equipment, nec.) and NACE 17 (Manufacturing of textiles). The 2-Digit level of disaggregation is chosen for want of a suitable number of observations in each sector. Taking finer levels of aggregation would have resulted into too low observations per industry, possibly producing unreliable estimates.

feedbacks from GOS to the other variables, and the more sizeable positive relation between productivity growth and subsequent growth of employment and sales. Also, the influence of employment growth to subsequent growth of sales is particularly large.

The estimates obtained in the other sectors, however, generally display lower significance, especially concerning the cross-variable coefficients, a finding which is no doubt partially due to the lower number of observations available for estimation in these sectors. We find a positive, although not very strong, effect of productivity growth on subsequent employment growth in each of the sectors, but the effect is strongest in the Textiles sector.

In each sector, sales growth is positively associated with subsequent growth of profits (GOS) and productivity, but these effects are strongest in the Textiles and Basic Metals sectors. Employment growth, on the other hand, is negatively related to subsequent growth of profits and productivity in the Textiles and Basic Metals sectors, while this negative association is not found for the other sectors.

The results are interesting also in comparison with those obtained from a comparable sectoral disaggregation exercise on French data (Coad, 2010a). In both countries we observe a large positive contribution of employment growth to sales growth in the Precision instruments sector, and also Machinery and equipment sectors, while for the other two sectors (Textiles and Basic Metals) the results are not significant. Another particularly robust finding is the relatively small but significant association of sales growth with subsequent employment growth. These similarities aside, however, we should highlight that there are indeed several differences between the Italian and French cases, not least because only a few of the French results were statistically significant.

7.3 Temporal disaggregation

We now investigate if the structure of the growth relationships stable over the sample time period, hinting at possible association with changing economic or institutional conditions over time.[25]

Given the limited time span available, and also considering the 2-lag structure supported by our baseline analysis, we divide the sample into two sub-periods, 1992-1994 and 1995-1997, and repeat estimates of our VAR system in each sub-period.[26] The two periods can be viewed as sufficiently different, from a macro point of view, and thus likely to provide meaningful test of time variation. A detailed exposition of macroeconomic phenomena is obviously out of the scope of this work. Bearing the risks of crude simplification, the years 1992-94 are strongly

[25] Our definition of growth rates virtually removes average trend in each variable, but does not obviously deal with the effect of cycle and other time-effects on the strength of the investigated inter-relationships.

[26] Also notice that, in a further attempt at exploring temporal variation, we have also re-estimated our baseline model separately for each individual year. Results, available upon request, were overall in agreement with the findings discussed in our main analysis.

Table 9: LAD estimation of equation (3) for two sub-periods: 1992-1994 and 1995-1997. A two-lag model is estimated, but only the first lag is reported. Standard errors (and hence *t*-statistics) obtained from 500 bootstrap replications. Results significant at the 5% level in bold.

w_t	β_{t-1}					
	Empl. gr.	Sales gr.	GOS gr.	Prod. growth	R^2	obs
1992-1994						
Empl growth	**0.0719**	**0.0371**	**-0.0098**	**0.0725**	0.0212	16346
t-stat	10.34	8.95	-6.16	11.53		
Sales growth	**0.2436**	**-0.1217**	**-0.0086**	**0.1123**	0.0077	16346
t-stat	15.69	-13.12	-2.45	8.00		
GOS growth	**0.3466**	**0.2438**	**-0.4062**	**0.3767**	0.0348	16346
t-stat	7.40	8.72	-38.17	8.91		
Prod growth	**0.0366**	**0.0569**	-0.0054	**-0.2436**	0.0272	16346
t-stat	2.39	6.22	-1.57	-17.62		
1995-1997						
Empl growth	-0.0019	**0.0654**	**-0.0122**	**0.0577**	0.0214	28702
t-stat	-0.40	23.16	-10.55	15.93		
Sales growth	**0.1329**	-0.0006	**-0.0086**	0.0108	0.0061	28702
t-stat	12.70	-0.10	-3.30	1.33		
GOS growth	0.0453	**0.4611**	**-0.3767**	**0.0535**	0.0463	28702
t-stat	1.75	29.29	-58.43	2.65		
Prod growth	**-0.1223**	**0.1714**	**0.0273**	**-0.5056**	0.0606	28702
t-stat	-10.97	25.33	9.86	-58.31		

affected by economic instability related to the (temporaneous) exit of the Italian Lira from the EMS in 1992, accompanied by a rapid deterioration of most macroeconomic indicators in the period, which in turn required a strongly restrictive correction of government budget. In 1995-1997, although the previous period's difficulties persist (together with longer-lasting problems), one can identify a general improvement of economic conditions, accompanied by important reforms aimed at stabilizing the pension system, at keeping public deficit under control, at the same time reducing public debt, which eventually ended up (in 1998) with meeting the requirements for entry in the Euro area. Overall, we are comparing two unstable periods, but the first is relatively more recessionary period, while the second can be seen as a recovering one.

Table 9 presents the results. As before, we show Lag-1 coefficients obtained from LAD estimates of our VAR specification with two lags. In general, we find a validation of the picture conveyed by pooling across time. This is particularly evident in the first sub-period. The estimates obtained in these years, indeed, exactly replicate the patterns obtained in Table 4. First, the signs of the autocorrelation structure of the variables is unchanged, also confirming weaker autocorrelation for growth of size, whether measured by sales or employment. Second, we still find that employment growth precedes sales growth. Third, we can confirm the weak, though present, association between productivity growth and previous growth of the other dimensions of the growth process. Finally, growth of profits plays the peculiar role of absorbing variable already highlighted in the previous exercises. The main novel result concerns the relatively stronger relationship between productivity growth and subsequent growth of other variables. This provides at least indirect indication that the deterioration of macroeconomic conditions may have created a more selective environment in those years, fostering the reallocation of size and profits growth toward firms realizing growth of efficiency.

The estimates in the second sub-period are also supporting a similar conclusion that some of the associations might have a time-varying component. Most of the benchmark findings of Table 4 are confirmed, though. The autocorrelations of employment and sales growth turn from weak or very weak to unsignificant, and we also confirm sales growth to proceed employment growth. The absorbing role of profit mainly displays through a very strong association with previous growth of sales, and we still observe profit growth to have negligible impact on growth of other variables. As compared to 1992-1994, the main differences concern the role played by productivity growth. The above mentioned "selection effects" turn back to the more modest magnitudes observed in Table 4 pooling over time, while we observe, at the same time, a relatively stronger feedback from productivity growth to both employment and sales growth. In particular, the negative sign for the influence of productivity growth on subsequent growth of employment signals a relatively significant presence of Penrose effects in this period.[27]

[27]These findings seem to agree with the possibility of different contribution of small and large firms to the

7.4 Asymmetric effects for growing or shrinking firms

In this section, we explore whether there are differential effects of the explanatory variables over the growth rate distribution. The main reason motivating this further extension of the analysis is that, in general, the structure of the relationships among the investigated variables may differ depending on firms' positioning in the empirical distribution of the various dimensions of growth considered here. Factors creating asymmetries across firms can be numerous. There might be differences in firms' objectives. For instance, some firms may prefer to pursue fast growth of sales, re-investing a lot and even at the cost of reducing profits, while other might be satisfied with slower expansion of market shares, but higher growth of profits. This would be reflected by a different correlation structure between sales growth and other growth measures, between firms experiencing faster *vis-à-vis* slower increases in market shares. Other sources of asymmetries may instead be external to the firm, or institutional. Take the case of factors affecting employment growth. It is typically argued that it is relatively easy for firms to hire new employees, while firing costs may limit their ability to adjust via the laying off of workers. This would be a source of asymmetries between firms that undergo employment growth as opposed to employment decline, possibly reflecting in heterogeneous association between employment growth and the other growth variables.

In order to capture this kind of effects, which are somewhat smoothed out in the previous aggregate exercise, we present quantile regression estimates of our baseline VAR model. Intuitively, quantile regression is a weighted regression that provides estimates of the regression equation at various points of the conditional growth rate distribution (conditional on the explanatory variables), thereby allowing to describe the variation in the regression coefficient over the conditional quantiles of the variables.[28]

The four panels of Figure 3 provide a graphical summary of the estimates. On the horizontal axis of each panel we draw the quantiles of the dependent variable, also appearing in the title of each panel. The lower quantiles (closer to 0) represent firms with negative growth rates, whilst the upper quantiles (closer to 1) represent firms with positive growth. The 50% quantile regression corresponds to a median regression, in turn corresponding to the LAD estimates over the entire sample. The vertical axis measures instead the regression (and auto-regression) coefficients obtained on the different lagged explanatory variables from a 2 lags VAR system. Reported lines connect the estimated coefficients across different quantiles, with different line styles identifying the various relationships. Of course, interesting variation across the growth rate distributions corresponds to those lines that are not 'flat' across the conditional quantiles.

processes of job creation and destruction over the business cycle (Davis et al., 1996, Chapter 5).

[28]For an introduction to quantile regression, see Koenker and Hallock (2001); see also Koenker and Xiao (2006) for the case of quantile autoregression.

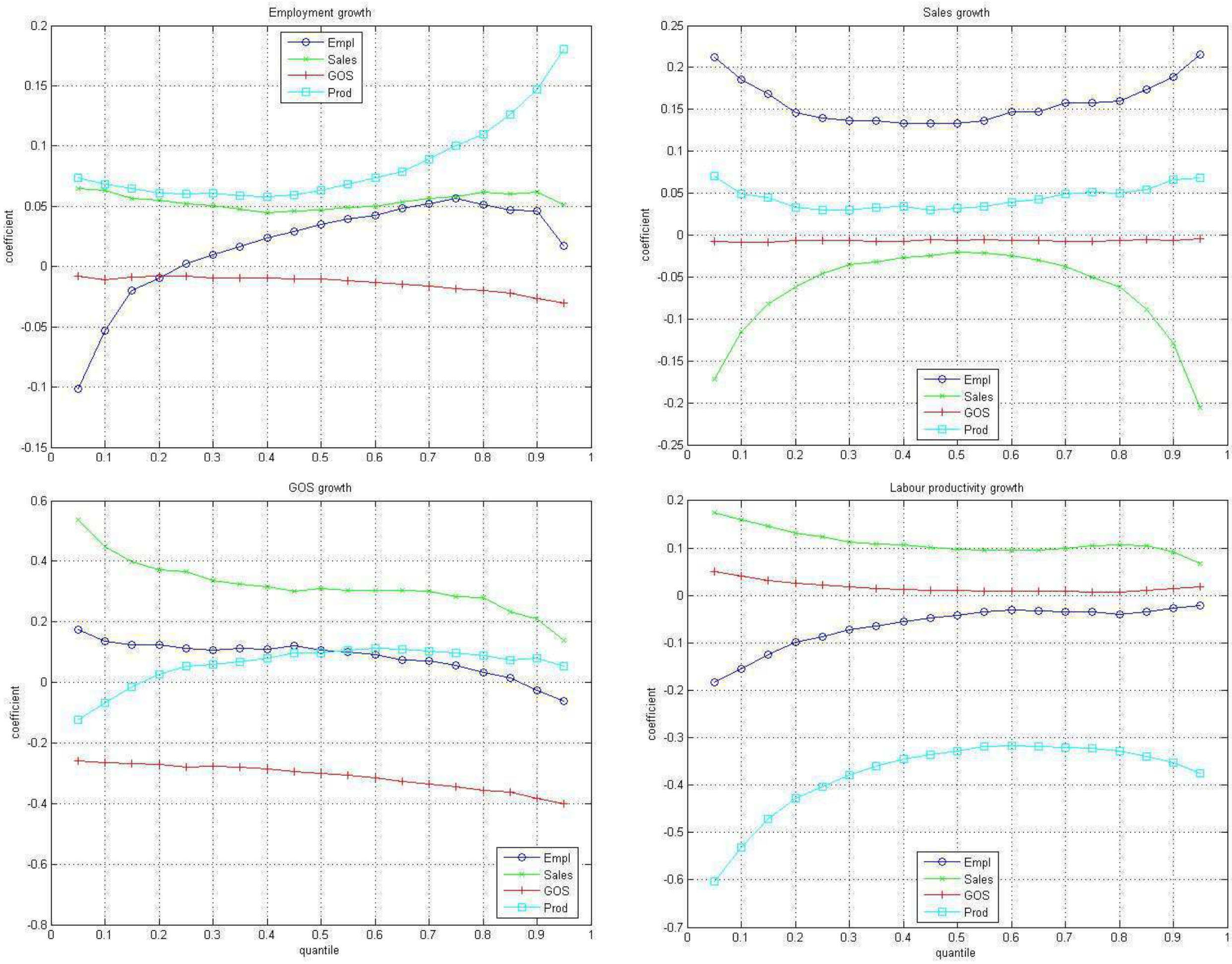

Figure 3: Summary of the quantile regression analysis. The dependent variable are employment growth (top left), sales growth (top right), growth of profits (bottom left) or growth of labor productivity (bottom right). Conditional quantiles (on the x-axis) range from 0 (for the extreme negative growth firms) to 1 (for the fastest growing firms). A two-lag model is estimated over 500 bootstrap runs, but only the first lag is reported.

Overall, we can observe that differential effects are certainly present, offering complementary results to the findings that emerged in the aggregate. Three points in particular seem worth highlighting, because they are similar to some results obtained from French data in Coad (2010a). First, autocorrelation profiles display an inverted-U shape across the quantiles for employment growth, sales growth and productivity growth. These results suggest that forces of negative autocorrelation, noticed in the aggregate analysis, are particularly strong for those firms experiencing extreme growth events in the previous year: if a firm has fast growth (or fast decline) in any one year, it is quite unlikely to repeat this performance in the following year. Second, we observe that employment growth has a positive effect on subsequent growth of profits for those firms experiencing rapid decline in profits, but that this positive effect of employment growth on profit growth is attenuated (and even perhaps reversed) for firms experiencing rapid profit growth. Third, employment growth makes a larger contribution to subsequent sales growth in the cases of fast-decline firms (and also fast-growth firms), but the effect is smaller for slow-growth firms. Taken together, these results suggest that employment growth is particularly beneficial for firms experiencing extreme decline.

8 Conclusion

This paper analyzes growth patterns of manufacturing firms using reduced-form vector autoregression. While the previous literature on firm growth tends to focus on one dimension of firm growth, the approach taken here is to provide a multi-dimensional view, based on a joint analysis of the interrelated processes of employment growth, sales growth, growth of profits and labour productivity growth, and on the interactions among them.

The general description that emerges is that, first, growth rates tend to display negative autocorrelation. Second, concerning cross-variable effects, we observe the lack of any strong association of all the growth indicators with subsequent growth of labour productivity, whereas the growth of profits plays the role of a sort of 'absorbing' variable. Indeed, we noticed that employment growth precedes sales growth and growth of profits, and that sales growth is very strongly associated with subsequent growth of profits. There appears to be very little feedback of growth of sales or profits with subsequent employment growth, however, while labour productivity growth seems to have a more sizeable but negative effect. Further, no clear association is found between employment or profits growth and subsequent changes in labour productivity. Productivity growth, in turn, is more strongly associated with subsequent growth of profits than it is with subsequent growth of employment and sales.

We do not claim to have established any clear-cut direction of causality among the dimensions of firm growth and performance involved in the analysis. Still, lagging variables are logically connected with causes, and in this sense our analysis allows to conclude that our results are apparently inconsistent with some influential theories of firm growth. First, the 'replicator dynamics' model, frequently found in neo-Schumpeterian evolutionary models, as well as the core features of theories of firm-industry evolution, with their emphasis on the workings of strong market selection/reallocation mechanisms, both imply that productivity or profits advantages are the main source of firm growth. In this vein, one should expect that firms experiencing productivity and/or profits growth to grow in size, whilst struggling firms to lose market share. Second, and not altogether unrelated, the 'accelerator' models of firm investment suppose that growth of sales leads to a subsequent re-investing in the firm, which would thus result in employment growth. Our results casts doubt on these theories. Instead, the findings are consistent with (weak, but present) Penrose and (strong) Kaldor-Verdoorn effects, and more generally convey the view that employment growth is the key driver of firm expansion (broadly defined), while profits, once made, are not reinvested.

Where, then, does the initial shock to employment growth come from? The extant literature, in the Gibrat's Law tradition, would suggest that we consider this source of firm growth merely as an exogenous stochastic shock. However, the origins of employment growth certainly deserve more investigation. Proponents of the 'rationalist' school might suggest that employment growth is caused by expectations of profits several years into the future. Taken to the extreme, this 'rationalist' view would suggest that employment growth is *caused* by subsequent growth of profits, which would have been correctly anticipated years in advance. More behavioral theories of the firm, resting on principles such as 'managerial-ist expansion' or 'bounded rationality', downplay the role of accurate anticipations of future profits on firm growth. Our results do not provide direct evidence that it is the expectations of future profits that lead firms to take on new employees. However, the rationalist interpretation seems at odds with the finding that profits growth exhibits negative autocorrelation, implying that current profits cannot be interpreted as a good proxy of future profits. At the same time, our results are at odds with the hypothesis that profitable firms use their profits on expansion, once these profits have been acquired. This is a puzzle, as the explanation that firms can simply rely on external finance, does not seem to be fully convincing. Indeed, in real world, where capital market asymmetries are the norm, profits often play the role of a crucial signal to raise the external financial resources, which firms then should use to expand and grow. Thus, even if firms finance expansion trough credit, one would still expect to observe a positive association of profits with further growth, while our evidence is in sharp contrast with this view.

We also extended the analysis to include the possible role played by size, sectoral and temporal disaggregation, and we applied quantile regressions to investigate variation of estimates across different quantiles of the growth rates distributions, capturing possible asymmetries between growing and shrinking firms. Our main findings are broadly confirmed by these further exercises. Other key results are as follows. First, size disaggregation suggests that employment growth is more strongly associated with subsequent labour productivity growth in the case of small firms, presumably because these firms have to grow to reach their Minimum Efficient Scale. Second, estimates by (2-digit) sectors give initial evidence that there are specificities in the way different growth relations may be relevant in different industries. Third, by repeating the estimates by subperiods, although we can confirm the main picture, we also find that cyclical factors can indeed have an effect on the structure of the growth process, with some more tight selection/reallocation working during relatively more recessionary periods. Finally, quantile regressions suggest that extreme growth events (fast growth or fast decline) are unlikely to be followed by similar extreme events in subsequent years, and that employment growth can also be a source of stability, attenuating the pace of decline for firms experiencing negative growth of sales in following years.

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