Testing the principle of ‘growth of the fitter’: the relationship between profits and firm growth*

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Abstract

This paper is an empirical investigation of the evolutionary principle of ‘growth of the fitter’. Previous studies suggest that growth does not discriminate between firms according to their fitness, when this latter is proxied by productivity. We use the profit rate (operating surplus/value added) as a proxy for fitness and explore its influence on subsequent growth rates by tracking 8405 French manufacturing firms over the period 1996-2004. We overcome problems of unobserved firm-specific effects, persistence and endogeneity by using the ‘system GMM’ estimator developed by Blundell and Bond (1998). Whilst non-parametric plots do not reveal any obvious relationship between profit rates and subsequent growth, regression analysis identifies a small positive influence. Considering the reciprocal influence of growth on profit rates, positive and significant results suggest that ‘Penrose effects’ are not a dominant feature of firm dynamics.

JEL codes: L21, L25, L60

Keywords: Profitability, Firm Growth, Panel Data, Replicator Dynamics, Penrose Effects

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“The race is not to the swift or the battle to the strong, 
nor does food come to the wise or wealth to the brilliant or favor to the learned; 
[nor is expansion of operations to the more profitable firms;]
but time and chance happen to them all.”
Ecclesiastes 9:11, The Holy Bible (NIV).

1 Introduction

The modern economy is increasingly characterized by turbulent competition and rapid technical change, and as a consequence a dynamic theory of competitive advantage may well be more relevant to understanding the economics of industrial organization than the more neoclassical concepts of equilibrium and static optimization. Evolutionary economics has thus been able to make a significant impact on IO thinking, because it proposes a dynamics first! conceptualization of the economy. Evolutionary theory has its foundations in Schumpeter’s vision of capitalism as a process of ‘creative destruction’, and borrows the notions of diversity creation and selection to account for the dynamics of economic development. Alchian’s (1950) theoretical paper argues that the evolutionary mechanism of selection sets the economy on the path of progress, as fitter firms survive and grow whilst less viable firms lose market share and exit. The notion of selection via differential growth is also a central theme in Nelson and Winter’s (1982) seminal book. These authors present a formal microfounded simulation model in which firms compete against each other in a turbulent market environment. Firms that are more profitable are assumed to grow, whilst firms that are less successful are assumed to lose market share. Agent-based simulation modeling has since remained a dominant tool in the evolutionary literature (see, among others, Chiaromonte and Dosi (1993), Dosi et al. (1995), and Marsili (2001); see also Kwasnicki (2003) for a survey). In addition to computer simulation models, the principle of ‘growth of the fitter’ has also formed the foundations of analytical evolutionary models (see, for example, Winter (1964, 1971), Metcalfe (1993, 1998)).

The backbone of these evolutionary models is undeniably the mechanism of ‘replicator dynamics’, by which growth is imputed according to profitability. This mechanism can be presented formally by Fisher’s ‘fundamental equation’, which states that:

$$\delta M_i = \rho M_i (F_i - \bar{F})$$

where \(\delta\) stands for the variation in the infinitesimal interval \((t, t + \delta t)\), \(M_i\) represents the market share of firm \(i\) in a population of competing firms, \(F_i\) is the level of ‘fitness’ of the considered firm, \(\rho\) is a parameter and \(\bar{F}\) is the average fitness in the population, i.e. \(\bar{F} = \sum x_i F_i\). It is straightforward to see that this equation favours the ‘fitter’ firms with increasing market share, whilst reducing that of ‘weaker’ firms. This ‘replicator dynamics’ does sound intuitively appealing, because implicit in it is the idea that selective pressures act with accuracy, that financial constraints prevent inefficient firms from growing, and that the economic system adapts so as to efficiently allocate resources amongst firms, such that firms ‘get what they deserve’. However, these assumptions may not find empirical validation for a number of reasons. First of all, it cannot be assumed that all firms have the same propensity to grow. Some high-profit firms may not be interested in business opportunities that are instead taken up by less demanding firms. Freeland (2001), for example, describes how GM’s shareholders resisted investing in additional business opportunities and sought to restrict growth expenditure even when GM was a highly profitable company. If this is the case, then stricter internal selection will cause high-profit firms to overlook opportunities that are instead taken up by
less profitable competitors. In this way, growth may be negatively related to profitability. An extension of this idea is presented by the managerial literature, which identifies a tension between profits and growth - this arises when managers seek to grow at a rate higher than that which would be ‘optimal’ for the firm as a whole, with the resulting growth rate being limited by shareholder supervision. If shareholders monitor management closely, growth rates are predicted to be low and profit rates high. Second, high profits may be made by firms that can exercise market power by restricting their production to obtain a higher price per unit sold. In this case, a firm which has sufficiently inelastic demand for its goods would have a higher profit rate if it reduces its capacity. In this case too, increases in profits would be associated with negative growth. Third, if a firm occupies a highly profitable niche market, it may not have opportunities to expand despite its high profits. Fourth, a firm may experience a higher profit rate due to efficiency gains by downsizing and concentrating on its core competence. Here again, we have no reason to suppose a positive association between profits and firm growth.

Some empirical studies have also cast doubt on the validity of the principle of ‘growth of the fitter’. Baily et al. (1996) observe that, among plants with increasing labour productivity between 1977 and 1987, firms that grew in terms of employees were balanced out by firms that decreased employment. They find that about a third of labour productivity growth is attributable to growing firms, about a third to downsizing firms, and the remaining third is attributable to the processes of entry and exit. Foster et al. (1998) also fail to find a robust significant relationship between establishment-level labour productivity or multifactor productivity and growth (see also the review in Bartelsman and Doms 2000:583-584). In addition, using a database of Italian manufacturing firms, Bottazzi et al. (2002) fail to find a robust relationship between productivity and growth (see also Dosi (2005)). Furthermore, evidence from UK manufacturing plants reveals a negative between-effect in allocation of market share between firms according to productivity, over a time scale of 6 years (Disney et al. (2003:683)). These studies present some scraps of evidence that the rule of ‘growth of the fitter’ does not necessarily hold when productivity is taken as a proxy for fitness. If profits are taken as the proxy, then profits and growth appear to be statistically inconsistent. Empirical studies have shown that relative profit rates are remarkably persistent, experiencing significant positive serial correlation (see, for example, Mueller (1977) and also Dosi (2005) for a review). Firm growth rates, however, are much more random, and it has been suggested that they are best modelled as a random walk (Geroski, 2000).1 This suggests that above-average profits are not translated into above-average firm growth. Geroski and Mazzucato (2002) comment on this statistical discrepancy and conclude that profits and growth are ‘deeply incongruent’ (p642). It is also relevant to mention that Sargent-Florence (1957) fails to find the expected correlation between growth in market value and growth in assets, for large listed UK firms - “Curiously enough, the two measures pointed in different directions” (p246). In this paper we aim to complement these studies by testing the principle of ‘growth of the fitter’, measuring ‘fitness’ using the profit rate (i.e. operating surplus/Value Added). We prefer this proxy, because Fisher’s fundamental equation is usually applied to evolutionary models by taking profits as the proxy for fitness (e.g., Nelson and Winter, 1982).

As we have seen, very few empirical studies have considered the link between profits and growth.2 This is quite surprising given the central position of replicator dynamics (equation (1)) in evolutionary modeling. What is perhaps more worrying is that the simplifying

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1See Coad (2006) for evidence and a discussion of firm growth rate autocorrelation.

2The work of Bottazzi et al. 2006, which came to the author’s attention but very recently, is also worth mentioning here. Applying non-parametric techniques to Italian manufacturing firms, they fail to find any
assumptions made in evolutionary models have even often been accepted not as simplifications but as fact, and thus adopted by subsequent theory. As Gavetti writes: “[the evolutionary economics] perspective’s need for a stark formal apparatus led to the choice of oversimplified behavioral foundations (Nelson and Winter, 1982), and the effects of this choice remain embedded in current theoretical and empirical work” (Gavetti, 2005:1). The principle of ‘growth of the fitter’ is frequently not just seen as a modeling simplification, but it seems to be largely accepted in theoretical discourse. We therefore consider it necessary to focus explicitly on testing the theory of ‘growth of the fitter’. Indeed, if evolutionary economics claims to be a dynamics first! discipline, it is of paramount importance that it take great care in its conceptualization of economic dynamics.

We perform the analysis using an extensive longitudinal balanced dataset on 8405 French manufacturing firms over the period 1996-2004. We begin by presenting non-parametric plots that allow a visual appreciation of the underlying relationship. We then present a parametric analysis using the ‘system GMM’ panel data estimator, which is of particular interest because of its ability to give consistent coefficient estimates in the presence of endogenous explanatory variables. The layout of the paper is as follows. Section 2 presents the database. Section 3 presents the theoretical motivations for suspecting endogeneity in the relationship between profits and growth, and then presents the ‘system GMM’ panel data estimator which is able to give unbiased and consistent estimates in the presence of endogeneity. Section 4 presents both non-parametric plots and parametric regression results, and section 5 concludes.

2 Database

This research draws upon the EAE databank collected by SESSI and provided by the French Statistical Office (INSEE). This database contains longitudinal data on a virtually exhaustive panel of French firms with 20 employees or more over the period 1989-2004. We restrict our analysis to the manufacturing sectors. For statistical consistency, we only utilize the period 1996-2004 and we consider only continuing firms over this period. Firms that entered midway through 1996 or exited midway through 2004 have been removed. Since we want to focus on internal, ‘organic’ growth rates, we exclude firms that have undergone any kind of modification of structure, such as merger or acquisition. In contrast to some previous studies (e.g. Bottazzi et al., 2001), we do not attempt to construct ‘super-firms’ by treating firms that merge at some stage during the period under study as if they had been merged from the start of the study, because of limited information on restructuring activities. In order to avoid misleading values and the generation of NANs whilst taking logarithms and ratios, we retain only those firms with strictly positive values for Value Added, total fixed assets and employees in each year. Firms are classified according to their sector of principal activity. To start with we had observations for around 22,000 firms per year for each year of the period. In the final balanced panel constructed for the period 1996-2004, we have 8405 firms for each year.

The empirical literature on industrial structure and dynamics proposes several different indicators of firm size, although the most common are probably sales and number of employees.

3 The EAE databank has been made available to the author under the mandatory condition of censorship of any individual information.

4 More specifically, we examine firms in the two-digit NAF sectors 17-36, where firms are classified according to their sector of principal activity (the French NAF classification matches with the international NACE and ISIC classifications). We do not include NAF sector 37, which corresponds to recycling industries.

5 22319, 22231, 22305, 22085, 21966, 22053, 21855, 21347 and 20723 firms respectively.
We consider three candidate measures of firm size – sales, employment, and Value Added. The correlation coefficients for these three indicators are shown in table 1, and the size distributions are shown in figure 1. Value Added is shown to be better correlated with the two other variables, and so it would appear to be the preferable size indicator.

In keeping with previous studies (e.g. Bottazzi et al., 2005), our measure of growth rates is calculated by taking the differences of the logarithms of size:

$$GROWTH_{it} = \log(SIZE_{it}) - \log(SIZE_{i,t-1})$$  \hspace{1cm} (2)

where $SIZE$ is measured in terms of sales, employees or Value Added, for firm $i$ at time $t$. The correlations between the growth rate indicators are shown in table 2, and the growth rate distributions are shown in figure 2. Sales growth is the better correlated with the two other measures. Employment growth is the least strongly correlated with the others, but we consider it to be of interest in its own right – indeed, employment growth is a crucial objective from the point of view of policy-makers.

Care must be taken in constructing our profit rate indicator, because firm profit rates have been criticised as potentially misleading indicators (Fisher and McGowan, 1983). The phenomenon of interest here is the raw commercial viability associated with the production process, without the distortion of such things as taxes or overhead costs. As a result, we construct our profit indicator using a firm’s gross operating surplus (‘excédent brut d’exploitation’ en français). This is then scaled down by Value Added in order to obtain a profit ratio.\(^6\)

\[^6\]To be precise, operating surplus at time $t$ is scaled down by Value Added at time $t - 1$ to avoid spurious results associated with the ‘regression fallacy’ (for more on this, see Friedman (1992)).
One shortcoming of this study is that it considers a balanced panel of surviving firms and does not deal with exit. It may be reasonable to expect that firms with poorer financial performance have a higher hazard rate. Nonetheless, we maintain that the finding that there is virtually no relationship between profit rate and growth rate, even among surviving firms only, is nonetheless quite powerful in itself.

3 Methodology

In this section we will discuss the problem of endogeneity in the relationship between profits and growth from a theoretical perspective. We then present the ‘system GMM’ estimator, which is able to give consistent regression estimates even if some explanatory variables are not strictly exogenous.

3.1 Sources of endogeneity in the regression of profits on growth

In this paper we are interested primarily in the effects of profit rate on firm growth, but we cannot investigate this without considering the (possibly simultaneous) effects of growth on profitability. Several authors have identified ways in which firm growth can be negatively associated with rates of profit. The classical, Ricardian stance is that if a firm is enjoying relatively high profit rates, it will expand to exploit additional business opportunities that are less profit-intensive but that nonetheless generate profit. In neoclassical terms, such a firm grows until its marginal cost of production is equal to the marginal revenue on goods sold. Such a firm begins by exploiting its most profitable business opportunities, and then includes less and less profitable opportunities until the marginal profit on the last opportunity exploited is equal to zero. Thus, a profitable firm that expands in this way maximizes its overall levels of profits, but experiences a decrease in its profit rate when profits are divided by scale of production. Edith Penrose (1959) also suggests that growth may lead to a reduction in the profit rate, although for different reasons. Firm growth requires managerial attention, and if managers focus on the expansion of their firm, their attention is diverted from keeping operating costs down. Thus, ‘Penrose effects’ occur when costs inflate as managers focus not on operating efficiency but instead on exploiting new opportunities. On the other hand, the notion of ‘increasing returns’ predicts that growth will lead to a higher, not lower, profit rate. Static increasing returns may allow a firm to achieve gains from specialization and build up economies of scale in production, thus reducing the unit cost of its products. Dynamic increasing returns, as described by Kaldor and Verdoorn, can also be applied at a firm-level, such that firm growth leads to increases in productivity and thus increases in profit rates. Expanding firms may invest in new technologies and learn about more efficient methods of production. Their growth may also be an anticipation of medium-term demand prospects, which (if correctly anticipated) would allow them to earn large profits in the future. Finally, from the resource-based perspective, growth may lead to increases in profits if it feeds off organizational slack and puts resources that were previously idle or underutilized to good use. An implication of learning-by-doing is that managerial (and other) resources are continually being freed up as time passes and experience accumulates. Large profits can be earned if these newly-liberated resources are used to grow the firm.

In the following quantitative analysis, we will investigate both the effects of profits on growth, and of growth on profits. The quantitative analysis will help us to evaluate the theoretical contributions described above, because we will be able to see if growth has a
positive or negative overall effect on the profit rate.

3.2 An introduction to system GMM

Ordinary Least Squares (OLS) regression estimation requires that the explanatory variables be orthogonal to the residual error term. This condition is not satisfied if the explanatory variables are endogenous, i.e. if there is a bi-directional causation between the dependent variable and the explanatory variables. In such cases OLS performs poorly, yielding biased and inconsistent estimates.

This problem of endogeneity can be overcome by a judicious choice of instrumental variables. These latter are uncorrelated with the error term but are nonetheless able to give information about the explanatory variable, and so they can be included in the regression calculations where appropriate in place of the problematic explanatory variable. If instrumental variables are poorly correlated with the explanatory variable, however, then the instruments are said to be weak. Weak instruments give regression estimates that are biased and inconsistent.

Arellano and Bond (1991) proposed a GMM estimator for panel data which includes instruments yielding additional information about potentially endogenous explanatory variables. The regression equations are expressed in terms of first differences (thus eliminating the time-invariant firm-specific effects), and endogenous explanatory variables are instrumented with suitable lags of their own levels. Monte Carlo tests reveal that this estimator can give superior results to previously used methods (Arellano and Bond, 1991). However, it also has drawbacks. If the lagged levels are weakly correlated with the differences of the explanatory variables, then the supplementary instruments included by this estimator are not very useful, and so large finite sample bias may still occur. Such a weak correlation can arise if the lagged levels to be used as instruments are a highly persistent series. Indeed, persistence in profit rates has been found in previous studies (e.g. Mueller, 1977).

An improved panel data GMM estimator was outlined by Arellano and Bover (1995) and fully developed by Blundell and Bond (1998). Arellano and Bover (1995) construct a panel data GMM estimator in which the regression equations are in levels, and the additional instruments are expressed in lagged differences. Blundell and Bond (1998) augment the original differences GMM estimator with the level-equation estimator to form a system of equations known as ‘system GMM’. The resulting system of regression equations in differences and also levels has better asymptotic and finite sample properties than the Arellano-Bond (1991) differences GMM estimator.

System GMM is a suitable estimator for panel datasets in which the explanatory variables are not strictly exogenous (see Bond (2002) for an introduction to system GMM and associated estimators). Yasar et al. (2005), for example, use GMM to investigate the effects of plant-level productivity on exporting behavior, where the phenomenon of learning-by-doing is suspected of introducing a feedback from exporting behavior to productivity. Blundell and Bond (2000) apply their system GMM estimator to the estimation of a Cobb-Douglas production function, where persistence in series reduces the reliability of the Arellano-Bond estimator (i.e. ‘difference GMM’).

In the context of this study, system GMM is able to deal with endogeneity and firm-specific effects, and can give unbiased and consistent estimates even though the dataset only spans a 9-year period (for system GMM, the minimum requirement is that $T \geq 3$ (Blundell and Bond, 1998)). To help overcome difficulties linked to endogenous explanatory variables, system GMM uses a potentially large matrix of available instruments and weights them appropriately.
However, the inclusion of extra instruments requires additional moment conditions. Consider the panel-data regression equation:

\[
y_{it} = a_{it} + b_{it}x_{it} + u_{it}
\]

(3)

where \( u_{it} = \nu_i + e_{it} \). \( x_{it} \) is a vector of variables that are not strictly exogenous, \( \nu_i \) are the unobserved time-invariant firm-specific effects, and \( e_{it} \) are the observation-specific error terms. The additional moment conditions can be formalized as follows:

\[
E(\Delta u_{it}y_{i,t} - r) = 0; \quad E(\Delta u_{it}x_{i,t} - r) = 0; \quad \text{where } t = 3, \ldots, T \text{ and } r \geq 2
\]

(4)

\[
E(\nu_{i,t}\Delta y_{i,t} - r) = 0; \quad E(\nu_{i,t}\Delta x_{i,t} - r) = 0; \quad \text{where } t = 4, \ldots, T \text{ and } r \geq 1
\]

(5)

Equation (4) comes from the difference GMM estimator’s need for orthogonality between the differences of the errors and the lagged levels of the variables, which are to be used as instruments. Equation (5) comes from the levels-equation GMM estimator’s need for orthogonality between the firm-specific effects and the lagged differences of the variables, which will be used as instruments. If these two moment conditions are not satisfied, then the additional instruments are not valid. It is therefore of use to check the validity of the instruments using specification tests (i.e. tests of overidentifying restrictions). We report Hansen test statistics\(^7\) alongside the regression results, and these test statistics indicate that our instruments are in fact valid and that the moment conditions in equations (4) and (5) are met.\(^8\) Another requirement of the system GMM estimator is that there is no serial correlation (of order 2) in the error terms. We report the relevant statistics with the regression results. Although first-order autocorrelation is present, we generally do not observe AR(2) correlation.\(^9\) We therefore consider the system GMM estimator to be suitable for this study.

4 Analysis

To start with, we present non-parametric scatterplots of the relationship between profits and growth. These plots offer us a visual appreciation of the underlying qualitative phenomenon before we move on to more technical, and perhaps less transparent, quantitative methods.

4.1 Non-parametric analysis

In what follows, we plot the profit rate (at time \( t - 1 \)) on the abscissa, and the growth rate (over the period \( t - 1 : t \)) on the ordinate.

The clouds of points shown in figures 3, 4 and 5 do not reveal any obvious relationship between profit rate and subsequent growth, whether growth is measured in terms of sales, employment or Value Added. We also verified that changing the number of lags in the relationship between profits and growth does not change the picture greatly.

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\(^7\)Tests for over-identifying restrictions usually give the Sargan statistic. However, we prefer the Hansen \( J \) statistic, since the Sargan statistic is not robust to heteroskedasticity or autocorrelation (Roodman, 2005). This Hansen \( J \) statistic is the (robust) minimized value of the two-step GMM criterion function, whereas the Sargan statistic is the minimized value of the one-step GMM criterion function (Roodman, 2005).

\(^8\)In this study, the Hansen statistics are relatively small, and the corresponding \( p \)-values are high, so we cannot reject the null hypothesis that the moment conditions are satisfied.

\(^9\)The null hypothesis of no AR(2) serial autocorrelation is rejected if the \( z \) statistics are high and the corresponding \( p \)-values are low (lower than 0.05 for the 5% significance level).
To ensure that the clouds of points are not merely the result of statistical aggregation, we repeat the analysis at a sectoral level. Figure 6 presents plots for six 2-digit ISIC sectors that have been selected according to the twin criteria of having diverse production technologies and also containing a reasonable number of observations. Once again, we fail to observe a relationship between profit rate and subsequent growth.

4.2 Parametric analysis

The preceding graphs were useful in providing a visual representation of the underlying relationship between profit rate and subsequent growth, but they are admittedly rather crude and were presented merely by way of introduction to the data. In order to rigourously examine the underlying relationship between profit rate and subsequent growth, we need to control for any potentially misleading influence on growth rates of lagged growth, size dependence (i.e. possible departures from Gibrat’s Law) and sectoral growth patterns. Furthermore, graphs can only present associations and are not able to address the direction of causality between the two variables. To face this issue, we will now use panel-data instrumental-variable techniques in an attempt to disentangle the bi-directional relationship between profit rate and growth.
4.2.1 The effect of profits on growth

To investigate the influence of the profit rate on subsequent growth, we estimate the following regression equation:

\[ GROWTH_{it} = \beta + \sum_{k=1}^{q} \gamma_k PROFIT_{i,t-k} + \zeta CONTROL_{i,t-1} + \varepsilon_{it} \]  

where \( \beta \), \( \gamma_k \), and \( \zeta \) are parameters to be estimated, and \( \varepsilon_{it} \) are i.i.d. error terms. \( PROFIT_{it} \) represents the profit rate of firm \( i \) in year \( t \). We control for macroeconomic fluctuations and industry effects by including dummy variables for each year and for each 2-digit manufacturing sector, and control for lags of the dependent variable. Given that the ‘Gibrat’s Law’ literature generally identifies a weak negative relation between firm size and expected growth rate, we also take (lagged) firm size into consideration. These control variables are included in all of our regressions under the variable \( CONTROL \), and are often observed to be significant, but for the sake of space they will not be reported in the results tables.

Table 3 shows the results for various regression estimators. To begin with, we report pooled OLS and fixed effects estimates, but since these estimators do not address the issue of endogeneity they are likely to perform poorly. Indeed, we observe that they yield results that are not in concordance with each other - the OLS coefficients are all positive whilst the fixed-effects coefficients are all negative. In situations of panel data regressions with endogenous variables, OLS is likely to be biased upwards, whilst fixed-effects estimates are prone to being downward-biased (Blundell and Bond, 2000; Bond, 2002). We also observe that the \( R^2 \) statistics for these two estimators are rather low, suggesting that financial performance does not explain a great deal of variation of firm growth.

Turning now to the issue of endogeneity, we begin with the ‘differences GMM’ estimator (Arellano and Bond, 1991). This estimator takes the first-difference of the regression equation (6) and uses lagged levels of the endogenous variables as instruments, in accordance with the moment restriction described in equation (4). However, given that there is persistence in levels, particularly for the profit rates, this reduces the effectiveness of the instruments (hence
Table 3: Regression results - finding the right estimator

<table>
<thead>
<tr>
<th></th>
<th>Pooled OLS</th>
<th>Fixed effects</th>
<th>Diffs GMM (Arellano-Bond)</th>
<th>Levels GMM (Arellano-Bover)</th>
<th>System GMM (Blundell-Bond)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dep var:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sales gr. ((t - 1 : t))</td>
<td>Coeff.</td>
<td>Coeff.</td>
<td>Coeff.</td>
<td>Coeff.</td>
<td>Coeff.</td>
</tr>
<tr>
<td><strong>Op. margin ((t-1))</strong></td>
<td>0.0052</td>
<td>-0.0094</td>
<td>0.0115</td>
<td>0.0024</td>
<td>0.0033</td>
</tr>
<tr>
<td><strong>t-stat</strong></td>
<td>1.58</td>
<td>-1.85</td>
<td>0.24</td>
<td>0.88</td>
<td>1.08</td>
</tr>
<tr>
<td><strong>Op. margin ((t-2))</strong></td>
<td>0.0047</td>
<td>-0.0185</td>
<td>0.0097</td>
<td>0.0031</td>
<td>0.0026</td>
</tr>
<tr>
<td><strong>t-stat</strong></td>
<td>2.25</td>
<td>-1.95</td>
<td>0.20</td>
<td>2.34</td>
<td>2.25</td>
</tr>
<tr>
<td><strong>Op. margin ((t-3))</strong></td>
<td>0.0019</td>
<td>-0.0281</td>
<td>0.0097</td>
<td>0.0034</td>
<td>0.0028</td>
</tr>
<tr>
<td><strong>t-stat</strong></td>
<td>1.24</td>
<td>-1.71</td>
<td>0.21</td>
<td>2.19</td>
<td>2.56</td>
</tr>
</tbody>
</table>

| **\(R^2\) (within)** | 0.1952     |               |                           |                             |                           |
| **\(R^2\) (between)** | 0.1548     |               |                           |                             |                           |
| **\(R^2\) (overall)** | 0.0844     | 0.0384        | -                         | -                           | -                         |
| **\(F\)-stat** | 19.24      | 212.72        | 89.99                     | 119.01                      | 118.87                    |
| **DoF** | 99, 41925  | 10, 33610     | 9, 8404                   | 10, 8404                    | 10, 8404                  |
| **p-value** | 0.0000     | 0.0000        | 0.000                     | 0.000                       | 0.000                     |
| **AR(1) z-stat** | -          | -             | -9.02                     | -13.21                      | -13.80                    |
| **p-value** | -          | -             | 0.000                     | 0.000                       | 0.000                     |
| **AR(2) z-stat** | -          | -             | 0.29                      | 0.06                        | -0.26                     |
| **p-value** | -          | -             | 0.775                     | 0.948                       | 0.798                     |
| **No. Instruments** | -         | -             | -                         | -                           | -                         |
| **Hansen \(\chi^2\)** | -          | -             | 0.20                      | 3.77                        | 7.24                      |
| **DoF (p-value)** | -          | -             | 3 (0.977)                 | 5 (0.583)                   | 9 (0.612)                 |
| **Obs.** | 42025      | 42025         | 33620                     | 42025                       | 42025                     |
Table 4: system GMM regression results: profit rate on growth

<table>
<thead>
<tr>
<th></th>
<th>sales</th>
<th>System GMM</th>
<th>VA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coeff.</td>
<td>t-stat.</td>
<td>Coeff.</td>
</tr>
<tr>
<td>Profits (t-1)</td>
<td>0.0033</td>
<td>1.08</td>
<td>0.0010</td>
</tr>
<tr>
<td>Profits (t-2)</td>
<td><strong>0.0026</strong></td>
<td>2.25</td>
<td>0.0027</td>
</tr>
<tr>
<td>Profits (t-3)</td>
<td><strong>0.0028</strong></td>
<td>2.56</td>
<td>0.0006</td>
</tr>
<tr>
<td>F-stat</td>
<td>118.87</td>
<td></td>
<td>120.35</td>
</tr>
<tr>
<td>DoF &amp; p-value</td>
<td>10, 8404</td>
<td>0.000</td>
<td>10, 8404</td>
</tr>
<tr>
<td>AR(1) z-stat &amp; p-value</td>
<td>-13.80</td>
<td>0.000</td>
<td>-4.62</td>
</tr>
<tr>
<td>AR(2) z-stat &amp; p-value</td>
<td>-0.26</td>
<td>0.798</td>
<td>1.55</td>
</tr>
<tr>
<td>No. Instruments</td>
<td>20</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Hansen</td>
<td>7.24</td>
<td></td>
<td>16.31</td>
</tr>
<tr>
<td>DoF &amp; p-value</td>
<td>9</td>
<td>0.612</td>
<td>9</td>
</tr>
<tr>
<td>Obs.</td>
<td>42025</td>
<td></td>
<td>42025</td>
</tr>
</tbody>
</table>

the very low \( t \)-statistics). To take this into account, we report results from ‘levels GMM’ (Arellano and Bover, 1995), which regresses levels of the variables taking lagged differences as instruments. It appears that the levels GMM estimator is more appropriate in our case. Finally, we report the ‘system GMM’ estimates, which implements a larger instrument matrix by simultaneously exploiting the two moment conditions in equations (4) and (5).\(^{10}\) These latter estimates indicate that there is a slight but positive influence of profits on subsequent sales growth. This influence is statistically significant for the second and third lags, although taking longer lags into consideration did not yield significant results.

We also applied quantile regression methods to the dataset, because previous research has shown substantial variation in coefficient estimates across the conditional firm growth rate distribution (Coad and Rao, 2006). In this particular case, however, nothing of interest was observed – the coefficient estimates remained roughly constant across the spectrum.

Table 4 presents the regression results for both profit indicators and all three growth indicators (results that are significant at the 5% level appear in bold ink). We are able to detect a positive and statistically significant influence of profits on sales growth, when both the second and third lag of profits is taken. Concerning employment growth, none of coefficients on the lagged profit rate are significant at the conventional 5% level. However, the lagged profit rate (at \( t - 3 \)) has a positive and statistically significant effect on Value Added growth 2 years later.

4.2.2 The effect of growth on profits

In light of the discussion in section 3.1, we now consider the influence of growth on profits. An introductory inspection of the scatterplots in figure 7 reveals that there does not seem to

\(^{10}\) It should be noted, however, that the inclusion of these additional instruments does not decrease the validity of the instrument matrix, since the Hansen statistic indicates that the instruments are exogenous. Given the large values for the Hansen test \( p \)-values, we fail to reject the null hypothesis that, collectively, the instruments are exogenous.
## Table 5: OLS and fixed-effects regression results: growth on profits

<table>
<thead>
<tr>
<th></th>
<th>sales growth</th>
<th>empl. growth</th>
<th>VA growth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS</td>
<td>FE</td>
<td>OLS</td>
</tr>
<tr>
<td>Dep var: Profits(t)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growth (t)</td>
<td>0.4529</td>
<td>18.27</td>
<td>0.3872</td>
</tr>
<tr>
<td>Growth (t-1)</td>
<td>0.0442</td>
<td>0.49</td>
<td>0.0734</td>
</tr>
<tr>
<td>Growth (t-2)</td>
<td>0.0117</td>
<td>0.25</td>
<td>0.0829</td>
</tr>
<tr>
<td>$R^2$ (within)</td>
<td>0.0368</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R^2$ (between)</td>
<td>0.0892</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R^2$ (overall)</td>
<td>0.1306</td>
<td>0.0417</td>
<td>0.1148</td>
</tr>
<tr>
<td>$F$-stat</td>
<td>62.72</td>
<td>94.71</td>
<td>41.45</td>
</tr>
<tr>
<td>DoF &amp; p-value</td>
<td>100, 50329</td>
<td>0.000</td>
<td>11, 42014</td>
</tr>
<tr>
<td>Obs.</td>
<td>50430</td>
<td>50430</td>
<td>50430</td>
</tr>
</tbody>
</table>
be any clear relationship between firm growth and future profits.

We estimate the following regression equation:

$$PROFIT_{it} = \theta + \sum_{m=0}^{p} \lambda_m GROWTH_{i,t-m} + \rho CONTROL_{i,t-1} + \xi_{it}$$

(7)

The control variables are firm size \( (t-1) \), 3-digit industry dummies, lagged profit rates and year dummies. This time we report only OLS and FE estimates, since these are more or less in agreement with each other, and give estimates that are of the same sign and fairly similar. Moreover, the system GMM estimator is not as appropriate here, because it is particularly difficult to find suitable GMM-style instruments for growth rates given that they are so random.\(^{11}\) The results are presented in Table 5.

The regression results indicate that there is a positive and significant influence of growth on profit rates, whether growth is measured in terms of sales, employment or Value Added. This influence is strongest for Value Added growth, where a significant effect is detected till the third lag. In all three cases, however, the \( R^2 \) is lower than 17%.

According to our coefficient estimates, an increase in the growth rate of employment of 1% over the period \( t-1:t \) leads *ceteris paribus* to an increase in the profit rate at time \( t \) of about 0.14% – 0.2%. Thus, the results appear to contradict the theoretical ‘Penrose effects’. Instead, dynamic increasing returns and learning effects seem to be more relevant concepts.

Our results suggest that firm growth has beneficial effects on future profit rates. This leads us to question some prevailing theories in Industrial Organization which predict a negative relationship. The standard approach states that firms begin business with their most profitable opportunity and maximize their total profit by moving to exploit other less profitable opportunities until the marginal profit on the last opportunity exploited is equal to zero. An implication of this is that firm growth would be negatively related to the profit rate as the additional activities undertaken are less and less profit intensive. The evidence presented here does not lend support to this idea. It would appear that firms do not start out with their most profitable activities, but instead they learn over time how to produce more efficiently. In particular, periods of growth appear to be important opportunities for learning, whilst a firm that remains the same size lacks such stimuli and would be characterized instead by increasing routinization. In a world of ‘learning-by-doing’, with productivity increasing steadily over time, resources are constantly being freed up. Learning-by-doing implies that, even with a fixed amount of employees and capital inputs, a firm can increase its production over time.

\(^{11}\)On this point, Geroski goes so 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, 2000:169).
In such circumstances, staying at the same size would be akin to stagnation. If firm-level learning does not lead to growth, then the resources liberated by efficiency gains are merely absorbed as organizational slack. Successful firms, however, can apply what they have learned to grow and obtain higher profits.

5 Conclusion

Why do the richest countries face a decline in population, whereas the poorest countries are experiencing a much higher population growth? For an evolutionary theorist, this is a puzzling question. Indeed, the evolutionary principle of ‘growth of the fitter’ is not always observed. In this study, we applied this principle at the level of surviving manufacturing firms, by examining the effect of profit rate on growth. Many theoretical contributions have assumed a direct positive influence of profit rate on growth, but this relationship has received insufficient empirical attention. In this study, non-parametric plots failed to show any clear relationship between profit rate and growth, at both an aggregated and disaggregated level of analysis. Although standard regression techniques (i.e. OLS and fixed-effects) gave opposing results, we applied state-of-the-art panel-data techniques to observe a relationship that is small yet positive. Practically speaking, however, it may be more useful to consider a firm’s profit rate and its subsequent growth rate as entirely independent.

Evolutionary models, and also theoretical discourse, suppose that profitability is the main driver of firm growth. This proposition is overwhelmingly rejected by our data, and there are far-reaching consequences. First of all, we are led to reject theoretical contributions (e.g. Alchian, 1950) that have suggested that selection acts effectively in favour of the ‘fittest’ and against the weakest to improve the overall performance of the economy. If indeed the economy does improve over time, our results suggest that this is due to learning effects within firms rather than the influence of any kind of providential ‘natural selection’. We argue that evolutionary models in the future would do better to abandon the assumption of a direct linear relationship between profit rates and growth rates, and replace it with an assumption of total independence between the two. These new evolutionary models may obtain results that differ markedly from those of previous models. Second, an important policy implication is the issue of taxation of firm profits. The evidence presented here suggests that there is a separation between a firm’s profit rate and its decision to grow. The policy-maker should thus not be afraid that raising taxes on corporate profits would stifle subsequent investment and growth.

Another finding is that, if anything, past growth is observed to have a slightly positive influence on the subsequent profit rate. This goes against the common wisdom and suggests that ‘Penrose effects’ are not a dominant characteristic of industrial dynamics. Instead, growth seems to generate dynamic increasing returns and important learning opportunities.

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12 The reader may question the validity of the demographic analogy. It may be argued that, in poor countries, large families occur because social status is attached to having many children. Also, given the higher mortality rate, and the role of children as ‘insurance policies’ or ‘pension plans’, large families may confer stability. Nevertheless, the analogy is able to reply to these arguments because there is also a certain prestige in having a large firm, and also it may be that firms grow (e.g. by diversification) to enjoy greater stability and to guarantee their longer-term survival.

13 This was first pointed out to me by Giovanni Dosi.
References


Coad A, 2006. Understanding the Processes of Firm Growth - a Closer Look at Serial Growth Rate Correlation. Cahiers de la Maison des Sciences Economiques No. 06-051 (Série Rouge), Université Paris 1 Panthéon-Sorbonne, France.


