

Small Business Growth in the Short Run¹

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ABSTRACT. This paper examines the determinants of short run employment growth in very small firms in the Services sector. The study shows evidence of non linearities in the growth-size relationship, and it is argued that these non linearities reflect the short run constraints that small firms face in adjusting to demand shocks. The paper also suggests that there are other systematic influences on growth apart from size. The paper draws on survey evidence from the Northern Region of the United Kingdom.

1. Introduction

This paper examines the determinants of short run employment growth in small firms in the Services sector. Small firm growth has of course been the subject of extensive research² (for a good survey, see Storey, 1994, ch. 5). Some justification for yet another study is therefore necessary. Such justification may be found in four features of this paper. First, we explore an important and interesting question that has not been investigated sufficiently in empirical work to date: the way in which short run constraints, embodied in the firm's short run cost function, influence the dynamics of the growth process of small firms. Our results are consistent with such constraints 'anchoring' short run firm growth. Secondly, we focus on firms in the Services sector,³ whereas as Variyam and Kraybill (1992) have pointed out, most firm growth studies have been concerned with Manufacturing.⁴

Thirdly, we consider growth over a twelve month period, a time span that is shorter than that

of many other small firm studies (Mata's work (1994) is an exception).⁵ This focus is appropriate from both a managerial and policy viewpoint. Most owner managers in the kind of very small firm considered here are unlikely to have a planning horizon, even of an informal kind, beyond twelve months,⁶ and policy initiatives will need to reflect that fact. There is also evidence to suggest that a twelve month planning horizon is a major concern of bank managers when assessing funding requests from new small firms (Deakins and Hussain, 1993).⁷ For these reasons, insights into the determinants of growth over the period of a year are likely to be important. This will be particularly true for the newest firms which may be able to survive for a short initial 'honeymoon' period, but which need to grow beyond their initial size if they are to survive once this period is over.⁸

Finally, our study largely concentrates on micro businesses, most of them with less than five employees (see section 3 below). A number of studies of firm growth are of course based on coverage of the full size range, including small size bands, but these studies do not provide the kind of focus on very small firms that is provided here. Reid's study (1995) of 73 'small entrepreneurial' firms in Scotland, in which 78 per cent of the sample had between one and ten employees (Reid, 1993, p. 192), is more relevant for our purposes, but it is an exception.

The plan of this paper is as follows. In section 2 we discuss considerations that underlie the growth equation that we estimate. Section 3 describes the data and variables which come from a survey of firms in the North of England. Some empirical results are presented in section 4.

The final section discusses the results of the study, and makes some suggestions for further work.

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2. The growth equation

Our approach is to model the short term growth of small firms as a function of firm size, and of a number of underlying economic influences, thus

$$\dot{S}_{i,t} = f(S_{i,t-1}, \mathbf{X}_{i,t-1}) \quad (1)$$

where

$\dot{S}_{i,t}$ = firm i 's proportionate growth between $t - 1$ and t ;

$S_{i,t-1}$ = the size of the i th firm at time $t - 1$;

$\mathbf{X}_{i,t-1}$ = a vector of variables relating to characteristics of the owner, the firm and its market environment at time $t - 1$.

Much has been written about the dynamics of firm growth,¹⁰ and in particular the relationship between firm growth and size. Most empirical work on this relationship has focused on testing Gibrat's Law which posits that the growth rates of firms are random, and are independent of their sizes.¹¹ This simple stochastic process, with modifications and suitable boundary conditions, generates positively skewed size distributions of firms.¹²

Gibrat's Law is consistent with the assumption that no size of firm is more or less favoured than any other: costs are constant over all output levels (Ijiri and Simon, 1977, p. 141). While this assumption may be appropriate over the longer term, it may have less validity in the short run, where firms are likely to be significantly constrained in their freedom to alter their size. We set out below how these short run constraints may affect the growth-size relationship.

Consider a profit maximising firm operating in a market for a relatively homogeneous service. At any give time, the technology of the firm – embodied in its installed physical capital – is relatively fixed; in other words, there is a specific short run cost function associated with the firm under observation. We assume that this short run average cost function is u-shaped, so that there is a unique short run profit maximising output ($Q_{\pi\max}$).¹³ We also assume that demand varies stochastically over time. These random demand variations may be thought of in terms of changes in orders placed with particular firms, which nevertheless operate in competitive markets, where prices are broadly 'given'. The observed

growth behaviour of the firm will depend on (a) the nature of stochastic demand, and (b) the way in which the firm changes its output rate optimally in response to shocks to demand.

If we limit attention to a single short run cost function, the conditional mean of the firm growth rate under the above assumptions will be negatively related to size, with zero growth expected at $Q_{\pi\max}$. We first establish that in the face of positive and negative shocks, responses of firms operating away from $Q_{\pi\max}$ will be asymmetric. We need to show that positive shocks will induce larger responses than negative shocks for firms operating at scales less than $Q_{\pi\max}$ and that positive shocks will induce smaller responses than negative shocks for firms operating at scales higher than $Q_{\pi\max}$.

This is not difficult. Consider first, a firm on the left of $Q_{\pi\max}$. Responding to a negative shock will lower short run profits, while responding to a positive shock will raise them. Given a relatively sticky price, the firm will be eager to respond to positive shocks up to $Q_{\pi\max}$. Faced with a negative demand shock, however, a firm will try to reduce the severity of this shock by strenuously deploying non-price competitive measures, for instance, by offering better customer service. It is reasonable to conclude that positive shocks will induce larger responses than negative shocks for firms operating at scales less than $Q_{\pi\max}$.

Now consider a firm operating to the right of $Q_{\pi\max}$. Responding to a positive shock will lower its short run profits, while responding to a negative shock will raise them. Given price, the firm will benefit by responding as fully as it can to negative shocks up to $Q_{\pi\max}$. Faced with a positive shock, the firm can and will exercise its choice of not responding to it fully. It can be concluded that negative shocks will induce larger responses than positive shocks for firms operating at scales greater than $Q_{\pi\max}$.

As the cost function is u-shaped, these arguments will apply with even greater force the further away the firm is from $Q_{\pi\max}$. With a positively sloped short run marginal cost curve, and a constant market price, the further to the left of $Q_{\pi\max}$ the firm is located, the bigger the addition (reduction) to profit that a given positive (negative) shock will generate. Thus the smaller the firm is, the more likely it is to respond to

positive shocks, and the less likely it is to respond to negative shocks.

For firms located to the right of $Q_{\pi\max}$, the reverse argument holds: for a given positive (negative) shock, the greater the reduction (addition) to profit. Thus the larger the firm is, the less likely it is to respond to positive shocks, and the more likely it is to respond to negative ones.

The implication of the above analysis is that over the output range relevant to a given short run cost function, the conditional mean of the observed growth rate of the firm can be expected to be negatively related to its size with zero growth expected at $Q_{\pi\max}$.¹⁴

While, at any given time, a number of firms in the sample may be located on the same short run cost function, though at different points, other firms will be on different functions. The growth-size relationship discussed above will be repeated for each short run cost function represented by the firms in the sample. Some firms may of course respond to a shock to their size by moving to a new cost function. However such a move, which will typically involve sunk costs, is likely to occur only as the result of a large shock. Since small shocks are more probable than large shocks there are likely to be relatively few cases of transit to a different cost function.

The above discussion has implications for what we would expect to observe in a cross section sample of the kind examined in this paper. Given that a number of distinct short run cost functions are likely to be covered by the sample, we would expect to see a non-linear growth-size relationship¹⁵ with the degree of non-linearity being dependent on the number of cost functions spanned by the sample. Within the range of each cost function we expect to see a negatively sloped growth size relation; between each pair of successive costs functions, will lie regions where size is unstable, populated only by the relatively few firms 'in transit'. Clearly, the growth equation should not be restricted to a prespecified degree of non-linearity in size. A non-parametric regression can help in determining this specification. The appropriate parametric specification will thus be a polynomial regression with the highest order determined by data.

We have included a number of additional variables to control for influences on growth apart

from size. These are considered in the next section.

3. The data and variables

Data sources

This empirical part of our study draws on data from a previous study undertaken by two of the authors (Johnson and Conway, 1995). These data cover the growth record of 75 businesses in Services over the period winter 1993/1994 to winter 1994/1995. The businesses all met the following conditions:

- i. They were all registered for VAT in March/April 1993.
- ii. They were all located in the Northern Region in the U.K.
- iii. They all remained in business in the region throughout the survey period.
- iv. They maintained their co-operation throughout the survey period.

The limitations of VAT records, particularly with respect to the identification of very small firms are well known (Daly, 1990; Storey, 1994, pp. 50–51; Johnson and Conway, 1997). However they do provide comprehensive coverage within their own terms of reference. The use of VAT registration data also means that all the firms in the study have reached a minimum level of 'seriousness' in their commitment to business activity.

The 75 firms represent a response rate of about 10 per cent. This compares with the response rates of 13 and 7 per cent from postal surveys of rural and urban small firms respectively reported in Keeble et al. (1992), and with the 10 per cent response rate – again in a postal survey of small firms – reported in Mason and Harrison (1993).

There are no obvious grounds for supposing that self-selection by co-operating respondents has generated any serious bias in relation to the characteristics of either the businesses or the respondents involved. All the firms are however by definition *survivors*. Since non survivors are more likely to have experienced negative growth, their exclusion could induce some bias into the results. Furthermore, for a given negative growth rate, the smallest of the firms may be less likely to survive, and hence be more likely to be elimi-

nated from the sample. This in turn will tend to bias upwards the growth of the smallest firms in the sample. While we have been unable to correct for these selection biases, we note that Dunne and Hughes (1994) in their analysis of the size-growth relationship for over 2000 U.K. companies, found that their efforts to incorporate adjustment for sample selection bias did not affect the substance of their results (see also Reid, 1993, p. 199).

The data used in this paper were collected via interviews in the winter of 1993/94, and the winter of 1994/95.

No firm in our study had more than 18 full time equivalent (FTE) employees.¹⁶ Eighty five per cent had five FTEs or less. Employment in the full sample grew by 5.5 per cent over the year.

Measuring growth and size

Growth is measured here in FTEs. Following Barkham et al. (1996), employment is chosen as it is the most robust of the measures available to us. Other measures, e.g. profits, assets or turnover, may of course yield different results. It is also true that firms are unlikely to have employment *per se* as a goal. Nevertheless employment provides one important indicator of business development, and it is of course relevant for policy.

The particular measure of growth¹⁷ used is

$$(\log E_{94/5} - \log E_{93/4})$$

where E is FTE employment, and the subscripts refer to the winter for which the employment data were obtained. Although the precise date in the winter of 1993/94 on which each firm was initially interviewed varied, the second interview in the winter of 1994/95 was carried out as near as possible to the first anniversary of that initial interview.

Initial size (labelled SIZE hereafter) is also measured in terms of FTEs.

Some underlying determinants of growth

In equation (1), we included, alongside initial size, a vector of variables relating to characteristics of the owner, the firm and its market. Variable selection has been determined by the choice of factors examined in previous studies and by the availability of data. The latter consideration means

that our study omits some potentially important influences on growth (e.g. financial variables). At the same time however we have been able to incorporate some potentially relevant variables not considered in previous studies. We now deal with each set of characteristics in turn.

Characteristics of owners

Education (EDUC). In the 17 studies recently reviewed by Storey (1994, p. 127), the influence of education (variously measured) was either insignificant (9), or positive and significant (8). There are no grounds from this work for suggesting that education has a negative effect on growth.

One plausible interpretation of the results of these studies is that although in some cases education may do little to enhance entrepreneurial drive and ambition, in others it may provide an important source of human capital relevant for business activity. This is likely to be particularly true where the business is involved in highly technical fields. In this study EDUC is a dummy variable with the value 0 when the respondent has no A levels, and 1 when he has obtained one or more.¹⁸

Experience (AGE; TIMTR). Numerous firm growth studies have incorporated a business age variable. The *a priori* arguments for such a variable are however mixed. On the one hand the framework of entrepreneurial learning provided by Jovanovic (1982) may be used to argue that older businesses are better at growing, ie they gain in experience. On the other hand an ageing business may run out of corporate energy. (These arguments can of course be reconciled by a nonlinear relationship between age and growth, with the relationship being positive in the early years, and negative in later years.) A number of studies (e.g. Dunne and Hughes, 1994 and Evans, 1987) have reported a negative effect of age on growth. Dobson and Gerrard's study (1989) however – which concentrates on rather smaller firms – shows a positive effect.

Here, we focus on the age and experience of the business *owner*, rather than of the business itself. This is a more satisfactory approach in a study where most firms are very small, and where the

driving force behind the growth of the business is its owner.

We used two measures of the owner's experience, each representing a different level of generality. The first is the age of the respondent (AGE). As with business age, the *a priori* arguments here are conflicting. On the one hand, general experience increases with age, and this may enhance growth opportunities. On the other hand it may be argued that owners become more set in their ways as they age. Their experience then hinders rather than helps their business. Furthermore, the energy that they have to devote to business interests declines with age. Like the trees in Marshall's (1920, p. 263) forest, ". . . sooner or later age tells on them all." As a result the business eventually disappears. Empirical studies of the effect of age on growth have generated mixed results (Storey 1994, p. 134), with a number of studies unable to identify a significant effect of age either way.¹⁹

Age captures the general experience of the business owner. It might however be expected – again following Jovanovic's (1982) analysis of entrepreneurial learning – that the length of experience in the business (TIMTR) would have an impact on business growth. A key argument here is that actual participation in business discloses to its owner – in a way which is not possible by other means – whether or not he/she has the necessary skills to engage in such activity. The more efficient operators remain in business; the less efficient exit. Thus the individual who has already been in business, and who has therefore tested his skills, is more likely to make a success of the current venture than someone who is in business for the first time. However, Storey et al. (1989, p. 29) were unable to detect any impact of previous 'own account' experience on growth.

TIMTR is the number of years spent by the respondent as owner of the business.

Characteristics of the business

The entry process (METHENT). We distinguished between those respondents who entered business by setting up from scratch, and those who bought an existing business. The choice of entry method may have a variety of implications for subsequent growth. First, business energy may be greater in

a newly established operation. The founder needs to get established as quickly as possible, and this may entail faster growth. Someone taking over a business may encounter opposition from existing staff who already have established working procedures. At the same time a new owner of an existing business does not face the teething problems arising from setting up *ab initio* and may be able to treat the business taken over as an established base for growth. The dummy variable used here is METHENT, which takes the value zero for businesses set up from scratch, and 1 for those which were already going concerns. The expected sign on this variable is ambiguous.

Legal status (STATUS). Unincorporated businesses have less access to the funds necessary to finance growth than incorporated businesses. The personal liability associated with sole proprietorships and partnerships is likely to act as an inhibitor of fund raising by the owner(s), as well as making the business less attractive to institutional investors. Unincorporated status may also provide a signal that owners are reluctant to expand via incorporation either because they do not wish to contemplate losing control, or because they find the greater disclosure required uncongenial. Some empirical support for these arguments comes from Hakim's (1989) study of fast growth firms. Reid (1993, pp. 201–203) however included legal status in his analysis of net asset growth in small businesses in Scotland, but found it insignificant.²⁰ The dummy variable used here (STATUS) takes the value zero for unincorporated businesses and 1 for incorporated businesses.

Customers (IMPCUST; TYPCUST). The inclusion of a variable (IMPCUST) which measures the proportion of sales accounted for by the three biggest customers provided an opportunity to examine whether customer dominance affects growth. Adams and Hall (1993) included a similar variable in their study, but were agnostic about whether its effect on growth would be positive or negative. Too much reliance on one customer may curtail opportunities for growth, and limit the firm's learning about the market place.²¹ However if the biggest customer is growing relatively rapidly, with the supplying firm sharing in that growth, then it may make sense to for the firm to

focus its attention on that customer, especially where a strong relationship is established.

Our data set also makes it possible to explore whether the sector – public or private – in which the firm's biggest customer is located has any impact on the firm's growth. One reason for thinking that this variable might be important is that there may be differences in the continuity of orders from customers in the two sectors, with the private sector more likely to change suppliers than their public sector counterparts. Once a firm is on the 'preferred' list of public sector contractors, it is relatively more likely to receive a steady stream of orders, and in this way growth may be encouraged. The two sectors are however subject to different financial constraints which may in turn affect ordering patterns and hence growth. The variable used here is TYPCUST which takes the value 0 where the most important customer is the public sector and 1 where that customer is in the private sector.

Staffing (PPROF). The measure used to capture the character of the firm's employment which in turn might have implications for growth, is PPROF, the number of 'professionals' expressed as a proportion of the labour force. This variable is included on the grounds that the more 'high powered' the firm's labour force, the more growth potential it has. Against this, is the argument that growth may be impeded where highly qualified staff are required because of the recruitment and salary costs involved.

The characteristics of the market

A single market characteristic – turbulence (TURB) – is utilised. Following Beesley and Hamilton (1984), turbulence is measured here as the *sum* of the birth and death rates. VAT registration and deregistrations, both deflated by the stock of VAT registered businesses, are used as proxies for birth and death rates respectively. Turbulence is included here as a measure of the vibrancy of the market. High levels of turbulence tend to reflect considerable dynamism in economic activity, and hence more opportunities for growth; both Beesley and Hamilton (1984) and Audretsch and Acs (1990) find turbulence positively related to industry growth.

4. Results

The results of our econometric analysis of the determinants of firm growth are reported in Tables I and II. Following the analysis in section 2, we ran regressions with SIZE entered in progressively

TABLE I
Some results

	Equation 1 (Services)	Equation 2 (Services)
CONSTANT	0.42	0.66***
EDUC	−0.29**	−0.28**
AGE	−0.51E-3	
TIMTR	0.00	0.46E-4
METHENT	0.01	
STATUS	0.01	0.30
SIZE	−0.14***	−0.43***
SIZESQ	0.01**	0.06***
SIZECUB		−0.002***
IMPCUST	0.00	
TYPCUST	0.00	
PPROF	−0.33**	−0.37***
TURB	0.00	0.00
EDUCxPPROF	0.31	0.33*

*** Significant at 1 per cent.

** Significant at 5 per cent.

* Significant at 10 per cent.

The variables are as follows:

EDUC	(Education): no A levels = 0; A levels = 1.
AGE	(Age): age of respondent (years).
TIMTR	(Time traded): period respondent in business (years).
METHENT	(Method of entry): set up from scratch = 0; purchased business = 1.
STATUS	(Status): unincorporated = 0; incorporated = 1.
SIZE	Opening FTEs
SIZESQ	SIZE squared.
SIZECUB	SIZE cubed.
IMPCUST	(Important customers): % of turnover sold to 3 most important customers.
TYPCUST	(Type of customer): most important customer in public sector = 0; most important customer in private sector = 1.
PPROF	(% of employment accounted for by professionals): number of professionals as % of E.
TURB	(Turbulence): sum of birth and death rates.

Note: Full details of the precise measures used are available from the authors.

TABLE II
Fit and diagnostic statistic

	Equation 1 (Services)	Equation 2 (Services)
R ²	0.07	0.22
F	F(12,62) = 1.47	F(9,65) = 3.36***
Functional form	$\chi^2(1) = 0.09$ (0.76)	$\chi^2(1) = 0.34$ (0.56)
Normality	$\chi^2(2) = 0.43$ (0.81)	$\chi^2(2) = 2.20$ (0.33)
Heteroscedasticity	$\chi^2(1) = 0.20$ (0.66)	$\chi^2(1) = 0.02$ (0.89)
n	75	75

P values in brackets.

*** Significant at 1 per cent.

** Significant at 5 per cent.

* Significant at 10 per cent.

F() tests the significance of the regression. The functional form test is Ramsey's RESET using the square of the fitted values; the normality test is the Jarque-Bera test based on a test of skewness and kurtosis of the residuals; and the heteroscedasticity test is a composite test based on the regression of squared residuals and squared fitted values.

higher powers, alongside all the other variables outlined in the previous section. Non linear formulations, including a variety of interaction effects involving the latter were examined, following a systematic protocol.

Our first equation, Equation 1 still fails the F test, and is not therefore considered further here. We then proceeded in accord with section 2 by entering SIZE in higher powers, and by dropping variables that appeared irrelevant. Equation 2, which passes all the diagnostic tests, is the result. It incorporates SIZE, its square (SIZESQ), and its cube (SIZECUB).

All three size variables are highly significant. Figure 1 plots out the size-growth relationship implied by Equation 2. This figure suggests two short run profit maximising employment levels at around two and seventeen employees.

Equation 2 omits a number of the variables listed in section 2 and included in Equation 1. These are AGE, METHENT, IMPCUST and TYPCUST. Both EDUC and PPROF have negative signs – although both variables are now significant – and the interaction term is positive and significant. The significant negative signs on EDUC and PROF are at first sight a little puzzling.

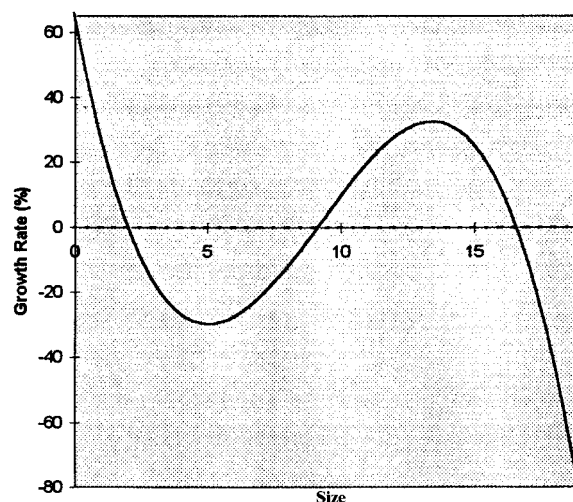


Figure 1. Growth size relationship services.

They may however hint that for the very small Services businesses covered in this study, it is possible for the owners and employees to be overqualified in a way which generates a level of frustration that is inimical to growth. There is however some evidence from the interaction term that complementarities between the human capital of the owner and his workforce may generate a positive effect on growth.

Perhaps the most interesting aspect of the results reported in Tables I and II relates to their implications for short run size. Figure 1 suggests that Services firms are either best kept very small or are expanded significantly. It is interesting that the higher profit maximising scale of around seventeen employees is in the middle of the range at which salaried managerial appointments tend to be made by small firms (Storey, 1994, p. 13). This scale thus implies a significantly different managerial style. Expansion beyond a very small size may thus require a discrete jump to a significantly larger operation. One potential explanation for this finding is that beyond a very small scale, the typical owner of a Services firm finds himself badly stretched, especially where he is relying on the quality of personalised customer service to maintain his business. Only by introducing some formal management structure can this problem be overcome, but significantly greater scale is necessary to support such a development.

5. Review and conclusion

Although small firm growth has been subject to considerable research in recent years, relatively little work has been done on the short run growth of the kind of “micro” businesses considered in this paper. Yet these very small firms represent by far the most common type of business. We also know that twelve months is an important time span, both for the owners of businesses and the financial institutions that deal with them, especially where the businesses are establishing themselves, and where the ability to grow during any initial honeymoon period is likely to be critical. For these reasons, this study is of interest from a policy perspective, an interest which is sharpened by the use of employment change as the growth measure.

The study has sought to relate small firms' short run growth to the constraints that they face. Such constraints affect the willingness of firms to expand or contract.

The non linearities we have found in the size-growth relationship, and in the implications this relationship has for the existence of short run optima need further investigation. The regressions suggest that firms in Services face short run profit maximising scales of around two and seventeen employees. These results are of course highly tentative and it should be recognised that there is no reason to suppose that these scales are time invariant. The findings are however sufficiently robust to justify further work.

Our results also suggest some other influences on short run growth apart from size. In particular, it appears that the human capital of the owner (measured by EDUC) and that of the staff (measured by PPROF) may interact to have a positive effect on growth.

There is clearly much scope for further work, particularly in the analysis of the size-growth relationship in the short run, and in the impact technological constraints may have. Differences between sectors also need exploration. Refinement in the measurement of the variables used, and extension to other time periods and geographical areas, would similarly repay further investigation.

An awareness of the growth-size relationship, and of which output levels are likely to be most profitable, is likely to be of importance in formu-

lating small firms policy, since there is little point in encouraging firms via training or other means to produce at scales which generate lower returns. This study also suggests that contraction may sometimes be an appropriate response to demand shocks.

Notes

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² Examples of recent studies include Dobson and Gerrard (1989), Reid (1993, ch. 11) and Barkham et al. (1996). Audretsch (1995), Mata (1994) and Wagner (1994) have looked at the growth of new firms, the majority of which start off in a small way. As indicated later in the text, there is also an extensive literature on the general relationship between size and growth: see footnote 11. A number of recent contributions to this literature – for example, Evans (1987), Dunne and Hughes (1994) and Hart and Oulton (1996) – include relatively more firms in the smaller size ranges than most other studies.

³ This sector is defined as Sections G to K in the U.K.'s 1992 Standard Industrial Classification.

⁴ The emphasis on Manufacturing is also evident from the surveys by Geroski (1995) and Sutton (1997).

⁵ Apart from Mata's study, the nearest we have been able to get is two years (Woo et al., 1989, quoted in Storey, 1994, p. 125). Dobson and Gerrard (1989), Adams and Hall (1993) and Reid (1995) all use a three year time horizon.

⁶ In their study of real estate agencies in the Netherlands, Risseuw and Masurel (1994) show that only 14 per cent of firms had a written plan with a financial paragraph, and that reviews of plans usually occurred on a yearly basis.

⁷ For the importance of short term (i.e. one year or less) finance for small firms, see Keasey and Watson (1994).

⁸ We are grateful to an anonymous referee for making this point.

⁹ See for example the references in footnote 2.

¹⁰ For recent 'stochastic' optimising models, see Hopenhayn (1992) and Ericson and Pakes (1995). Jovanovic (1982) is also relevant and is referred to in the following section.

¹¹ Thus where $\hat{S}_{i,t} = u_{i,t}$ where $u_{i,t}$ is a normally distributed error term with a constant variance. For a good review of the theoretical and empirical issues raised by Gibrat's Law, see Hay and Morris (1990, p. 537f), Scherer and Ross (1990, pp. 144–145), Dunne and Hughes (1994) and Sutton (1997). For empirical work in the small firm sector, see Reid (1993) and Dobson and Gerrard (1989).

¹² Sutton (1997) has shown that this result still holds even when the Gibrat's Law assumption is significantly relaxed.

¹³ Defined as the output where (a rising) short run marginal cost equates with price. This output level is not necessarily that at which short run average costs are minimised.

¹⁴ See Leonard (1987) for a model that is similar in spirit, but where it is assumed that the process of adjustment to a fixed, desired size is subject to stochastic shocks.

¹⁵ Evans (1987), Hall (1987) and Hart and Oulton (1996) have explored non-linearities in the growth-size relationship, but they have not focused on an economic rationale for non-linearity.

¹⁶ One part-time employee working less than 30 hours per week, equals 0.5 FTE.

¹⁷ An alternative measure of growth $((E_{94/95} - E_{93/94}) / (0.5E_{93/94} + 0.5E_{94/95}))$ was also tried. The use of the mean size in the denominator is suggested by Davis et al. (1996) as one way of ameliorating any regression-to-the-mean bias, although Caree and Klomp (1996) have queried the validity of this approach. The results using this measure did not differ significantly from those reported in section 4.

¹⁸ An alternative measure of educational achievement (degree; no degree) was in fact tried, but produced less clear results.

¹⁹ Some studies have tested a quadratic relationship, but again most of the results show no significant effect.

²⁰ However it was significantly positive in his profitability equation.

²¹ These problems may be further increased if the customer firm is significantly bigger than the supplier, and is able to exploit this size difference.

²² Equations (1) and (2) were also run for thirty firms in the Production sector, but both equations failed the diagnostic tests.

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