The Relationship Between Training and Employment Growth in Small and Medium-sized Enterprises

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Education and Employment**

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Executive Summary

1.   Background and Aims

1.1   The body of evidence on the impact of the provision of training by businesses and on subsequent business performance is generally considered to be partial, indirect and inconclusive. This is due to a number of reasons, including:

- The relative paucity of data available on a consistent basis on training and/or performance;

- Limited methodological and/or inferential analysis of the relationship between training and performance;

- The relatively limited scope of research in this field. Much of the latter examines only intermediate effects of training, such as acquisition of qualifications.

1.2   This may be due to the fact that many surveys and databases just collect information either business training activity or performance or, if on both, only at a relatively superficial level. Another difficulty lies in the need to take account of heterogeneity in the characteristics and behaviour of businesses which train and those which do not. A further difficulty lies in differentiating the effects of training from the potential myriad of others impacting on performance. These methodological issues have been addressed in an earlier paper for the DfEE (Hughes and Weeks (1999) 'Methodological Approaches to the study of the Impact of Training on Firm Performance', March 1999).

1.3   In addition, many surveys are 'one-off', repeated at irregular intervals or only periodically between relatively short periods, so that dynamic modelling of the relationship between training and performance on a consistent basis is difficult. The research reported here aims to address this concern particularly by extending work carried out previously for the Department and published as Cosh, Duncan and Hughes (1998) 'Investment in Training and Small Firm Growth and Survival: An Empericial Analysis for the UK 1987-95 (DfEE Research Report RR36, 1998). It does so using the methodological insights of Hughes and Weeks (1999).

1.4   Cosh, Duncan and Hughes (1998) examined the relationship between formal training, the determinants of the latter and the impact of this training on business survival and performance over the period 1987-1995 using the ESRC Centre for Business Research's (CBR) 1991 and 1995 surveys of small and medium-sized firms i.e. firms in the manufacturing and business sectors with few than 500 employees. The research compared training activity and performance over the two periods 1987-1990 and 1990-1995 with training measured by a binary indicator in 1991.

1.5 The 1987-1995 analysis found a stronger relationship between training and employment and sales growth in the earlier part of this period (1987-1990) than in the latter part (1990-1995). The explanatory power for the model was also found to be significantly weaker in the latter period. The opportunity to extend this analysis arose as a result of the incorporation of a further year of survey data, relating to firms in 1997, into the CBR dataset.

1.6 The addition of 1997 survey data is important for a number of reasons. First the 1991 survey took place in the middle of an economic downturn with a combination of falling GDP and inflation and rising unemployment. In contrast the 1997 survey was conducted amongst very different macroeconomic conditions with expanding GDP and falling unemployment (see Cosh and Hughes (1998)). The addition of a data point characterised by a very different set of macroeconomic indicators allows an examination of the combined effect of these factors on our findings. Second, in 1997 the survey data contains additional information (beyond a binary indicator of whether firms train) in the form of i) interval level data on training expenditures as a percentage of total sales; and ii) data based upon a number of questions designed to impart information on human resource management including the use of quality circles, labour turnover, job rotation and multi-skilling.

1.7 The available of data which provides some indicator of the *intensity* of training facilitates greater discrimination in isolating the determinants of training. Existing models based upon binary data suffer the problem of measurement error because although we observe (quasi) continuous measures on the *causes* of training, the inter-firm variation in the amount of training is lost. The addition of the 1997 survey produces four observations on a bi-annual panel with two training measurements in 1991 and 1997. Consequently, we are also able to address the issue of the persistence of training and its effects.

1.8 Using the methodological framework outlined in Hughes and Weeks (1999) and the basic economic models in Cosh, Duncan and Hughes (1998) the current report uses the augmented CBR dataset to test a number of hypotheses. These include: a) the extent to which firms differ in terms of employment growth according to whether or not they train; b) how much *additional* information is contained in data which records a measure of the *intensity* of training; and c) and whether firms which persist in training are different from those whose training is a temporary activity. Finally we consider the implications of our results for future research strategies and data collection in relation to evaluating the impact of training on firm performance.

2.   The Structure of the Report

2.1   The first part of the report explores the methodological issues associated with the appropriate measurement of firm level provision of training and the problems of sample selection biases and endogeneity.

2.2   The second part presents our findings for the impact of training on firm performance using these novel methodologies.

2.3   Finally, we explore the implications of our findings for further work in this area.

3.   The Sample

3.1   Our sample of SMEs is derived from a total sample of 2,028 businesses which responded to our 1991 survey of independent businesses in the manufacturing and business services sectors which employed less than 500 employees. For the purposes of the analysis reported here we have excluded from this sample firms which data checks subsequent to 1991 revealed to be either not independent or employing over 500 employees in 1991 (42 firms), firms whose employment or turnover data from 1991 and 1995 produced massively outlying growth between these years (18), firms who did not reply to our 1995 survey and whose status as either alive or dead or a subsidiary could not be identified (25), businesses which became subsidiaries between 1991 and 1995 (164), businesses which had missing or inconsistent answers to the survey questions as to whether or not any formal training was provided (129), and businesses which did not provide a breakdown of training by type (10).

3.2   The remaining base sample of firms analysed therefore consists of 1,640 businesses which were, in 1991, alive and independent, employed less than 500 employees, and which had either ceased training by 1995, or were still alive and independent in that year, and for which consistent data on the provision of training was available.

3.3   The surviving firms from the same sample were resurveyed in 1997. In this survey the firms were not only asked about whether they were providing formal training, but also about the level of their training expenditures as a percentage of sales. The survey also questioned the firms about other aspects of their human resource management.

3.4   The final sample for analysis consists of 768 SMEs which survived and responded to the 1997 survey; and for which we have information about whether they trained for both 1991 and 1997. The sample sizes reported in the main text vary with the time period and the variables included in the analysis because of firm deaths between survey periods, differing response rates to questions (item non-response) and firms not responding in different survey periods (unit non-response). The treatment of possible biases to which this may give rise is discussed in reporting our results below.

3.5   The broad size and sectoral breakdown of the samples for 1991 and 1997 is shown in Table E1 where M represents Manufacturing and S represents Services.

Table E1. **The 1991 and 1997 Samples by Size and Sector**

	1991				**1997**			
	M	**S**	**Total**	*%*	**M**	**S**	**Total**	*%*
Employment Size (1991) Survey								
1 - 9	178	291	469	*28.9*	79	124	203	*26.5*
10-19	171	123	294	*18.1*	92	62	154	*20.2*
20-49	195	149	344	*21.2*	103	61	164	*21.4*
50-499	315	203	518	*31.8*	156	88	244	*31.9*
Total *	859	766	1625	*100.0*	430	335	765	*100.0*
%	*52.9*	47.1	100.0		56.2	43.8	100.0	

* There were 15 firms in 1991 and 3 in 1997 for which missing values prevented their inclusion in this table.

4.   The Measurement of Training

4.1   The addition of the 1997 training measure to that for 1991 is a significant extension to our previous work. First, it allows us to examine the relationship between training and performance using this later measure of formal training. Second, it provides four groups of firms to analyse as shown in Table E2 below.

Table E2. **The Persistence of Training 1991-1997**

		Train 1997		
	Number of Firms	**No**	**Yes**	**Total**
Train 1991	**No**	134	99	233
	Yes	134	401	535
	Total	268	500	768

The majority of our sample are persistent trainers, but there is a significant number of persistent non-trainers. The two other categories are also of interest: those which began training in 1997; and those which ceased. The analysis recognises the problems associated with measuring training at only two points in time. However, these groupings permit a more sophisticated interpretation of the relationship between training and performance. Missing observations of other variables permit analysis of only sub-samples of this entire group in the main body of work reported below.

4.2   The 1997 survey included responses to a question about the scale of training activity, and not simply its incidence. This was measured by training costs as a percentage of sales and was answered only by those engaged in formal training in 1997.

4.3   There was a lower response rate to the training cost question than to the formal training question. This is shown in the Table E3 below.

Table E3. **The Distribution of Training Cost 1997 by Persistence of Training 1991-1997**

Training Costs as a % of sales		Train 91 No Train 97 Yes	Train 91 Yes Train 97 Yes	Total Train 97
>0	<1%	15	39	54
≥1	<2%	12	54	66
≥2	<3%	13	51	64
≥3	<4%	4	30	34
≥4	<5%	2	10	12
≥5	<6%	2	17	19
≥	6%	3	14	17
	Total	**51**	**215**	**266**
		Replied out Of 99	**Replied out of 401**	**Replied out of 500**

The particular problems associated with a variable which is bounded by 0 and 6 and has interval data between these boundaries is discussed below.

4.4   The 1997 survey provides a wide range of information about management attitudes and practices. We examine the association of training with these and other firm level characteristics in two ways. First, we carried out t-tests on the difference in means between trainers and non-trainers in that year. Second, we used the non-parametric Mann Whitney test to eliminate the impact of outliers. These findings are presented in Table E4 below.

Table E4. **Differences in Firm Characteristics Trainers vs Non-trainers 1997**

	Mean Values		Mann Whitney Test
	Trainers	Non-trainers	Significance Level
General			
Profit Margin 1995%	8.85	13.89(***)	.0065(***)
% with CEO holding degree or professional qualification	53.5	37.6 ***	.0018***
Human Resource Management			
% of firms using:			
Total quality management	44.8	14.2***	.0000***
Quality circles	20.6	7.1***	.0024***
Job rotation/multi-skilling	44.8	20.7***	.0003***
Performance related pay	38.1	25.8***	.0041***
Competitive Advantage			
Source of main competitive advantage on scale of 1-5			
Price	2.57	2.92(***)	.0027(***)
Marketing	2.82	2.41***	.0007***
Speed of service	3.72	4.01(***)	.0053(***)
Reputation	4.10	4.10	.4648
Cost	2.75	2.92	.1672
Design	3.49	3.14***	.0089***
Quality	4.12	4.03	.2942
Specialism/niche	4.07	3.90*	.1092
Range	3.77	3.42***	.0006***
Flair	3.35	3.03***	.0047***
Personal attention	4.33	4.46	.1063
Growth Inhibitors			
Significance of factors limiting growth on scale 1-5			
Skilled labour	2.47	2.10***	.0012***
Management skills	2.68	2.17***	.0000***
Marketing skills	2.71	2.47*	.0604*
External Advice			
% firms seeking external support			
Staff training	69.9	15.8***	.0000***
Business Links- training/IIP	46.3	15.0**	.0124**
Financial support -IIP	19.7	3.0***	.0000***
Investment Appraisal			
% using payback	59.9	43.4***	.0050***
% using DCF methods	19.9	5.9***	.0036***

*	10% significance
**	5% significance level
***	1% significance level
( )	shows cases where the average value for non-trainers is greater than that for trainers

4.5 We find no evidence that high profitability in 1995 has led to the adoption of training in 1997, in fact our findings suggest the reverse. Our trainers are more likely to have people with professional qualification running the business. Trainers place greater emphasis on design, quality, product range, marketing and flair as their sources of competitive advantage. They are less likely to emphasise price and speed of service than non-trainers. The trainers, perhaps unsurprisingly, are significantly more likely to identify skill shortages as an inhibitor of their growth performance.

4.6 Trainers are far more likely to have sought external advice to support their training activities. About three quarters of them had drawn upon external advice and about one half had used Business Links.

4.7 The table above suggests that trainers have more sophisticated management than non-trainers. Thus they are far more likely to use investment appraisal methods. However, for our purposes it is their human resource management which is of particular interest. All aspects of human resource management are significantly more prevalent amongst trainers. This raises the question of the interaction between these aspects and the impact of training on performance. This issue is explored below.

5. Modelling Issues

Sample selection bias and endogeneity

5.1 The model developed in the report addresses the question of how to appropriately answer the question of what would have been the performance of trainers if they had not been training. The simple direct comparison of trainers with non-trainers suffers from potential sample selection biases.

5.2 The sample select problem here can arise in two ways. The first concerns potential survivorship biases since the sample analysed are all respondents to the survey in 1997, whether or not they are trainers or non-trainers. If the factors influencing survival are not the same for trainers and non-trainers, then the comparison of these two groups of survivors may be dominated by the effect of these differing survival factors.

5.3 The second concerns the selection of firms into the training group which may be dependent on firm performance. The endogeneity of the incidence of training needs to be taken into account in order to isolate a pure effect of training on performance. This problem is tackled using a two stage estimation procedure which was used in Cosh, Duncan and Hughes (1998).

Training intensity

5.4 Our new data allow us to measure not only the incidence, but also the intensity, of training. The precise form of these data, discussed above, introduces econometric problems. Not only are the data bounded below at zero and bounded above at 6%, but between these cut-off points we have only interval estimates. Without correction, OLS regression estimates will be biased although it is not possible to say much about the direction of the bias. The methods for handling these problems are well-established and described in the paper. They involve obtaining maximum likelihood estimates of a quasi-continuous training cost variable for use in the regression models and providing the necessary correction for the type of censoring described above.

6. Firm Performance, Training and Firm Size

6.1 The simple bivariate associations between training, size and growth are presented in the report. We show that persistent trainers are four times larger on average than persistent non-trainers, when size is measured by employment. Firms which began training in 1997 are of similar size to those which ceased training; and both are larger (significantly smaller) than persistent non-trainers (trainers).

6.2 Training in 1991 is significantly related to employment growth 1987-90 and training in 1997 is significantly related to employment growth 1990-95. However, the similar bivariate analysis reveals no relationship between training in 1991 and employment growth 1990-95.

6.3 Although the proportion of labour costs represented by training costs is associated with larger firms when at its highest level, we find no simple relationship between firm size and this measure of the intensity of training.

6.4 By examining growth deciles for both 1987-90 and 1990-95 we find a negative relationship between firm growth and initial size.

6.5 By exploring the persistence of training we find that persistent trainers do not appear to exhibit a clear trend in terms of employment growth. On the other hand those firms which trained in 1991, but not in 1997 are more frequently observed in the lower employment growth deciles. Firms which began training in 1997 were found to be more concentrated in the higher growth deciles. These issues are explored further in the regression results which follow.

7. Regression Results

7.1 The regression results are drawn from the estimation of a two period model of employment growth based on the Law of Proportionate Effect. This well known characterization of firm growth processes implies that the best predictor of a firms size in one period is its size in the last period plus a random proportionate

change. This basic relationship can be modified by adding explanatory variables such as training. Our results use the correction for endogeneity discussed above. The findings were also checked for survival bias, but no evidence was found for this.

7.2   In the report the parameter estimates using standard least squares are presented above those using robust estimation techniques, which are presented in square brackets. Robust estimates are less sensitive to the influence of extreme observation and are especially appropriate in the context of the analysis of SME's which have relatively volatile performance patterns.

7.3   The results are presented in three sections. The first uses single measures of training for either 1991 or 1997. The second uses combinations of the two measures to provide greater insight into the impact of training, and its persistence, on performance. Finally, the third section evaluates the impact of both the incidence and intensity of training provision by firms.

7.4   We find evidence that small firms grow faster than larger SMEs. We also find a significant effect of training on employment growth if we measure training at the end of the growth period. These regression results support those discussed above.

7.5   More notably, if we utilise robust regressions we find a highly significant training effect, even when training is measured at the beginning of the period. Therefore, after correcting for the two-way nature of the relationship and for extreme observations, we find evidence for training providing a positive impetus to employment growth.

7.6   Two models are examined in the second section. The first distinguishes the training effect of persistent trainers in comparison with the rest of the sample. This reveals a strong significant effect of training for the persistent trainers. The second model compares persistent trainers, those which began training between 1991 and 1997; and those which ceased training 1997, with the base category of persistent non-trainers. The effect of training is positive and significant for both persistent trainers and those which began training, with the former effect the stronger. Those firms which trained in 1991, but not in 1997, did not have a significantly different performance from that of persistent non-trainers. This suggests that there was no residual benefit of their 1991 training.

7.7 We showed above the strong association between sophisticated human resource management practices and training, both measured for 1997. This raised the question of whether the impact of training differed depending on the use of these practices. A reduced sample was formed which contained information both about training and about these practices.

7.8 Amongst persistent trainers we again find in this reduced sample a positive association between training and performance. However, the effect of training amongst persistent trainers is significant only for those which are using sophisticated management practices.

7.9 For firms which began training some time between 1991 and 1997 we are hampered by relatively few observations. However, the same picture emerges in that the effect on growth performance is significant only when beginning training is associated with these more sophisticated management practices.

7.10 The third section examines the combined effect of training incidence and intensity. We show that the expenditure on training as a percentage of sales has a strong positive influence on growth performance.

8.   Interpretations for Future Research and Data Collection

8.1 Our empirical and methodological finds have four major implications. These relate respectively to: the measurement of training; the identification of the wider human relations management context in which training occurs; the virtues of including a panel element in data collection practices; and the need to adopt robust modelling techniques which address both the extreme heterogeneity of small and medium sized business performance and the appropriate treatment of sample selection biases and the endogeneity of the training decision.

8.2 It is important in designing data collection protocols for evaluating the impact of training that measures of the intensity of training are included alongside measures of the incidence of training. These need to be included as a part of the information system design for all participants in schemes from the outset, and in designing control group information collection. Care needs to be taken however in question design to maximize item response rates to such questions. This is because there is a trade off between the increased efficiency of the underlying econometric estimate of the impact of training and the adverse impact reduced sample sizes cause if low item response rates occur. This suggests that pilot studies should be carried out to identify the most meaningful and readily answered questions to ask on training intensity.

8.3 The results support the argument put forward in detail in Hughes and Weeks (1999) that the human relations context can have an important conditioning impact on the estimated role of training in affecting firm performance. Information on these aspects of firm characteristics should also be incorporated in training scheme information systems, alongside information on past involvement

in such activities. Similar issues of question design arise as in the case of measuring training intensity.

8.4   The inclusion of a panel element in information system design is also of great significance. It generates extra data points which allow for the incorporation of dynamic elements to the econometric methodology. Our report shows that this is important in relation to the analysis of endogeneity and causation. It is also revealed as essential if questions about the decision to start, stop and continue training are to be addressed. Each of these are important in a policy context.

8.5   The report reveals that the adoption of robust regression techniques is of great importance in the context of the heterogeneous population of small and medium sized firms with relatively volatile performance characteristics. Conventional OLS techniques may mask the relationships which exist in a central core of the observations under investigation. Our results also reveal the importance of corrections for the endogeneity of training in the evaluation of the latter on performance. They also reveal that considerable insights can be obtained from repeated panel cross sections even if they are not carried out on an annual or even shorter cycle. It is possible in this context to consider questions in surveys which elicit answers on training activity in a series of intervening years even if the timing of each survey is biennial.

8.6   The research has focused on a single measure of performance (employment growth). It has also, because of the agreed limited scope of the research brief, explored a limited range of interactions between training and the human relations and other relevant variables in the CBR dataset. A study with a longer time frame could investigate the interrelationship between training on the one hand, and business survival, innovative activity, and measures of performance based on profitability and productivity. Each of these is possible with the augmented 1987-1997 CBR dataset used in this report.

8.7   Within a non-experimental setting the determination of whether a particular policy is deemed successful is increasingly viewed in terms of whether a positive mean impact can be identified as opposed to learning about structural parameters. In this regard it would be instructive to consider a number of alternate outcome measures of the impact of training on performance. For example, if we view both training frequency and intensity as being affected by employment policy, then counterfactual simulations can be utilised to determine the impact of, for example, the introduction of a training subsidy designed to raise the proportion of firms engaged in training. These outcome measures will also facilitate a more direct comparison across different model specifications.

1 Introduction

This paper examines the impact of training on firm employment growth for a panel sample of UK SMEs. Using a single binary indicator measuring firm training in 1991, Cosh, Duncan, and Hughes (1998) have previously examined the relationship between investment in training and small firm growth and survival. They found a significant impact of training upon performance for the period 1987-90, but with the effect being insignificant for 1990-95. The principal limitations of this study are both the binary nature of the training variable and that this indicator is observed only for a single time period, together with the assumptions which are necessary to account for the effects of endogeneity. In addition, the authors were restricted to a dataset which prevented them from being able to differentiate between firms based upon the *amount* of funds devoted to training and the extent to which training is a *persistent* activity.

In this study we conduct an empirical evaluation of the different methodologies outlined in Hughes and Weeks (1999) utilising an updated version of the CBR SME Dataset which contains a panels of 760 firms with cross-section data for 1991, 1993, 1995 and 1997, with training measured both in 1991 and 1997. The addition of 1997 survey data is important for a number of reasons. First, the 1991 survey took place in the middle of an economic downturn with a combination of falling GDP and inflation and rising unemployment. In contrast the 1997 survey was conducted amidst very different macroeconomic conditions with expanding GDP and falling unemployment (see Cosh and Hughes (1998)). Subsequently, despite the lack of a continuous time series, the addition of a data point characterised by a very different set of macroeconomic indicators will allow us to examine the combined effect of these factors on our findings. Second, in 1997 the survey data contains additional information (beyond a binary indicator of whether firms train) in the form of: i) interval level data on training expenditures as a percentage of total sales; and ii) data based upon a number of questions designed to impart information on human resource management including the use of quality circles, labour turnover, job rotation and multi-skilling. With regards to i) the availability of data which provides some indicator of the *intensity* of training will hopefully facilitate greater discrimination in isolating he determinants of training. Existing models based upon binary data suffer from the problem of measurement error because although we observe (quasi) continuous measures on the *causes* of training, the inter-firm variation in the amount of training is lost[1]. For example, it is possible that the finding of an insignificant effect of training on firm performance for the period of 1990-95 was due, in part, to the discrete nature of the training measure.

A key objective of this study is to examine the relative gain of utilising alternative measures of training activity on firm employment growth. We first do this within the

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[1] In pure statistical terms models which incorporate datat on *both* a discrete indicator such as training and conditional upon training, some measure of the level, produce parameter estimates with higher efficiency.

confines of a two-period model of employment growth and utilise the earlier work of Cosh, Duncan, and Hughes (1997) and Hughes and Weeks (1999) as a point of departure. In future work we intend to examine a number of alternative specifications.

2 Employment Growth and Training: Some Simple Models

To translate this problem into the context of the effects of training on firm employment growth, we first consider a simple abstract model of timing, persistence and the effects of training. We do this by considering a number of firm types which are defined using two binary random variables: whether or not a firm trains and whether or not a firm survives the observation window. We then compare this representation of the data generating process with the data observed by the analyst.

1. Firm i began training in period t_* and survives at least until period t_2. Throughout the period $t_* - t_2$ training may be either persistent or periodic. Firm i' $'$ survives at least until period t_2 but does not train. We let $\mathfrak{M} =$ $'$ denote the sample of surviving firms.

2. Firm j began training in period t_* and fails in period $t_1 < t_2$. Throughout the period $t_* - t_1$ training is persistent or periodic. Firm j' $'$ also fails in period $t_1 < t_2$ but does not train. We let $=$ $'$ denote the sample of firms which fail prior to t_2 .

3. Selection into training for firms i and j may be either i) random or systematically determined by ii) observables or iii) unobservables.

4. The total number of firms alive in period t_* is given by $= \mathfrak{M}$; the total alive period t_2 is $'$.

Based upon 1, 2 and 3 we can clearly identify the issues we will need to tackle if we are to isolate a pure effect of training on employment growth. For example if selection into training is a random process then we can use firms of type i and i' to evaluate the impact of training. To the extent that this process is not random and to the extent that the characteristics of firms which determine employment growth also affect the decision to train, then firms of type i' will not constitute an adequate control sample.

In addition, we need to account for the possible confounding effects of attrition. Since firms enter into our sample only if a performance measure is available in periods t_* and t_2, then in the event of either firm deaths or item non-response, the distribution over our performance variable will be truncated. For example, to the extent that training and slow growth are related to firm survival, our estimates of the impact of training and performance will be misleading. If slow growing trainers are more likely to survive

than slow growing non-trainers, then by focusing only on surviving firms, the results may be biased against finding a positive relationship between growth and training. If firm survival over a period $t_* - t_2$ is independent of the decisions to train, *and* selection into the training state is random, then it is possible to make reliable inferences on the impact of training and employment growth using samples and '. If either or both of these conditions are violated then appropriate corrections will need to be made.

If we assume that firms of type *i* represent random draws from a population of firms and that the *permanent component* of firm performance is constant across training and non-training firms, then a consistent estimate of a training effect on performance (say *P*) is given by

$$E[P_{it_2} - P_{it_1} \mid D_{it_*}] \tag{1}$$

where D_{it_*} is a binary random variable equal to 1 if the firm engages in training in period t_* and zero otherwise. (1) represents a simple difference in the unconditional means of the performance variable.

To the extent that selection into training is determined by different permanent components of performance (e.g. it is well established that larger firms have a higher propensity to train) then we need to control for these factors in evaluating the marginal impact of training. In this context we might add a vector of covariates, (in addition to the training variable) say x_{it}, to (1) and estimate a simple linear regression specification. To the extent that the process determining D_{it_*} is endogenous to firm performance then we obviously need to make appropriate corrections in order to isolate a pure effect of training. For example if $D_{it_*} = 1$ iff $_i < \widetilde{P}$ where $\widetilde{P}$ is a threshold value of performance, then a simple estimate of the effect of training which ignores this selection rule would be biased.

The problems encountered in estimating the impact of training on firm performance are, in general analogous to the evaluation of training programs on individual earnings. In particular, a critical issue which confronts both types of studies is the need to recognise the exact nature of the data constraints and the question that is being asked. For example, assuming that we wish to determine the impact of training on the performance of firms, we might wish to evaluate

$$E[P'_{it_{21}} \mid D_{it_*} = 1] - E[P''_{t_{21}} \mid D_{it_*} = 1] \tag{2}$$

where $P'_{it_{21}} = P_{it_2} - P_{it_1}$ denotes the observe difference in performance for firms that were observed to train in t_* and $P''_{it_{21}}$ is an estimate of the mean outcome that would have been obtained had the *trainers not trained*. The question we need to address is under what circumstances can we use $E[P^*_{it_{21}} \mid D_{it_*} = 0]$, where $P^*_{it_{21}}$ denotes the mean

performance for non-trainers as a proxy for the unobservable $P''_{it_{21}}$. To examine this problem we subtract the mean outcome for non-trainers from the mean outcome of trainers.

$$E(P'_{it_{21}} \,|\, D_{it*} = 1, \, s_{21} = 1) - E(P^*_{it_{21}} \,|\, D_{it*} = 0, \, s_{21} = 1) \qquad (3)$$

and label this express A. We can rewrite A as additive in two terms by adding and subtracting $E(P''_{it_{21}} \,|\, D_{it*} = 1)$ to (3) giving

$$\underbrace{\{E(P'_{it_{21}} \,|\, D_{it*} = 1, \, s_{21} = 1) - E(P''_{it_{21}} \,|\, D_{it*} = 1, \, s_{21} = 1)\} +}_{B} \qquad (4)$$

$$\underbrace{\{E(P''_{it_{21}} \,|\, D_{it*} = 1, \, s_{21} = 1) - E(P^*_{it_{21}} \,|\, D_{it*} = 0, \, s_{21} = 1),\}}_{C}$$

s_{21} is an additional conditioning variable which is equal to 1 if the firm is still alive in period 2. Note that B represents an estimate of what we wish to evaluate – an impact of training based upon subjecting the *same* group of firms to the training and non-training status. Given that we are operating within a non experimental framework $E(P''_{it_{21}} \,|\, D_{it*} = 1, \, s_{21} = 1)$ is not observed. The second term C represents a combination of selection and attrition bias caused respectively, by the fact that non-participants differ from participants in the non-participation state, and non-random firm death If C is zero then the process of selecting a class of training firms from the total population of firms is random. In cases where term C is not equal to 0, inferences will be misleading. Note that in focussing on selection bias we may recast this discussion in terms of whether or not the decision to train is weakly exogenous in the sense of Engle, Hendry and Richard (1983) from employment growth. Given the form of (3) and (4) we have implicitly imposed exogeneity by writing the *conditional* distribution of employment growth. This is only valid if the marginal distribution of the training variable contains no additional information. More formally if we let denote the vector of parameters from a model of the determinants of training, then weak exogeneity of training for employment growth follows if / = Owhere is the impact of training on employment growth assuming training is exogenous.

In the above we have provided an abstract characterisation of a simple process of training and employment growth. If we now overlay this with the imperfect measurements of data observation, a number of additional problems are encountered.

1. If the effects of training are cumulative, then any impact of training will be due to both the incidence of training and how long the firm has trained. Training is therefore imperfectly measured, since duration of training is not observed. Note

that this situation is in contrast to the empirical analysis of the effects of centrally provided training programmes on on individual earnings (see for example, Ashenfelter and Card (1985), Bassi (1983) and Heckman and Robb (1985)). In this instance *individuals* undertake training in a given period and return to paid work. In contract *firms* may train or not train in each period of business life and, in addition, vary the intensity of training programmes.

2.   Consider the situation when we observe more than one indicator of training, namely for all firms we observe $D_{it'}$ and $D_{it''}$ where t' is close to t_1 and t'' is close to t_2 . In an earlier study of firm performance over the period 1991-95 Cosh, Duncan and Hughes (1998) found an insignificant effect due to training if training is measured in 1991. The finding of very different effects according to when selection into training is measured is consistent with a number of earlier studies. For example, Ashenfelter and Card (1985) note that one of the critical influences on the size of the estimated training effects include timing of the decision to participate in training. In the case of centrally provided manpower training programmes, individuals are selected into training based upon earnings relative to a benchmark. The authors find very different training effects, depending upon whether earnings in the year *prior* to training are the appropriate selection rule, or earnings in the training period itself.

3.   The impact of training on firm performance will depend upon a number of factors, such as the *level* of training provision as measured, for example, by the proportion of total labour costs allocated by training. In addition it is necessary to consider the impact of training in conjunction with other factors such as human resource management. This view is based upon the notion that there are complementarities between sets of HRM practices so that the whole is more than the sum of parts. Thus Black and Lynch (1997) in their work on estimating the impact of training on productivity in US establishments specifically include measures of other HRM practices such as total quality management and employee participation alongside training indicators. In making this argument they cite in support the theoretical models of Milgrom and Roberts (1995) and the empirical approaches of Huselid (1995) and Ichniowski, Shaw, and Prennushi (1995) and the industry specific studies of Arthur (1994), Bailey (1993) and Kelley (1994a), Kelley (1994b). In their 1997 study, Black and Lynch find evidence that the way HRM strategies are implemented does affect productivity outcomes. This suggests that the definition, and collation, of variables relevant to the implementation of training, and the HRM context in which they are set, should be an important component of survey design. Such variables could include the proportion of workers in quality circles, employee participation in decision taking, and flexible job definitions as well as benchmarking and total quality

management. These factors may be included as individual variables, or as composite categorical variables derived by factor or cluster analysis. For example, training may have a significant impact on performance if it is associated with other changes in the way in which labour is organised. If the data observed by the analyst are simply a binary indicator of training provision, then the subsequent loss of information will result in a relative loss of efficiency and potential difficulty in isolating a significant training effect.

3   The Measurement of Training

Empirical studies, whether of the case study, or econometric kind, have used a wide variety of definitions of the training variable. In general we can identify two types, based upon observing either a binary indicator of training provision, or some measure of the extent of training. The critical distinction between the two types of measurement concerns the information content of the different measures. To the extent that there exists considerable variation in the intensity of training, then a binary indicator based upon the presence, or absence, of training will contain significant measurement error. A recent extensive review by Storey and Westhead (1997) reveals that the majority of studies examining the impact of training on firms use a limited dependent, or categorical, variable measure. This is usually based on whether or not training, or a particular type of training (formal/informal, part time/full time, government sponsored, etc.) has taken place; and on whether or not a particular group or groups of employees, or managers were involved. A more limited subset of the literature uses a continuous variable approach based on estimates of the intensity of training provided (e.g. hours per week spent in training, numbers of employees trained or training expenditures), or a combination of both categorical and continuous variables.

The nature of the training costs question is also important in terms of the econometric methodology. For example, in the CBR SME dataset the training costs variable has a probability distribution with a number of mass points. Most significantly we only observe training costs *conditional* upon the decision to undertake some form of training. As a result there is a significant probability mass at zero. In addition the data is also censored for the firms which undertake training and report training cost information. Firms which spend more than 6% of labour costs on training do not provide the actual percentage but simply provide an indicator. In this respect the training cost variable is both left and right censored. For trainers spending the least amount on training we only know that the amount lies within the 0-1% interval, and as such we also have interval level data. Between these two extremes firms can indicate whether they spend between 1 and 5% on training costs. Thus we note that the training costs variable combines censored, interval and point level data, and it is necessary to account for these features in any subsequent modelling exercise.

4   A Two Period Model of Employment Growth and Training

We present a widely used model of employment growth derived from the Law of Proportionate Effect. This essentially hypothesises that firm growth is a random walk, with the best predictor of next period's size being this period's size plus a random variable. We may write this model in an equivalent form with growth measured as the log of the ratio of closing and opening size as the dependent variable, namely

$$Y_{it} = w + x_{it1} + {}_l D_{it\,l} + m_{it1} + {}_{it} \tag{5}$$

$$D_{itl} = 1(D^*_{itl} = + z_{it1} + v_l > 0), t_1 < l = t' \, or \, t'' < t_2 \tag{6}$$

where i and t index, respectively, firms and time. Our data restricts us to measuring training at only two points – at the beginning ($l > t_1$) or end ($l > t_2$) of the growth period. w and   are intercept parameters, Y_{it} = log of the ratio of closing (period 2) and opening (period 1) employment size, m_{it1} is the log of employment in period 1,   is a k_x x 1 vector of parameters, x_{it1}, is a 1 x k_x vector of covariates, ${}_l$ is the effect of training in period l on the change in performance measured by the binary indicator $D_{it\,l}$, and D^*_{it1} is an unobserved propensity to undertake training. z_{it1} is a 1 x k_z vector of covariates which influence the decision to undertake training and   is a k_z x 1 vector of parameters. Note that x_{it1} and z_{it1} may be overlapping vectors, given that factors which determine growth may also influence the decision to train. If the error terms ${}_{it1}$ and v_{it1} are correlated, then the pure effect of training on firm performance will be confounded. For example, if training firms are, on average, fast growing, then an ordinary least squares estimator of ${}_l$ in (5) would overestimate the impact of training. In addition, forms with a slump in orders, but with a productive management, may decide to take a long-term view and include a training programme. The key point to emphasise here is that firms may select themselves into training, based upon unobservables that are time variant.

If we take the expectation of (5) with respect to $D_{it\,l}$ we may write

$$Y_{it} = w + x_{it1} + {}_l D_{it\,l} + m_{it1} + E({}_{it} | D_{it\,l}) + {}_{it\,2} \tag{7}$$

where ${}_{it\,2}$ is a zero mean error term. Given that $D_{it\,l}$ is an endogenous regressor, the expectation of the error term is both non-zero and *observation dependent,* and as such may be considered an omitted variable. Assuming that $v_{it} \sim N(0, {}^2)$ we may write this expectation as

$$E({}_{it} | D_{it\,l}) = \hat{ }_i \tag{8}$$

where $\hat{ }_i$ the generalised residuals from a probit model of the binary training indicator can be written as

$$\hat{ }_i = E[v_{it1} | D_{it\,l}] = (D_{it\,l} - \hat{ }_{it\,l}) \hat{ }_{it\,l} (1 - {}_{it\,l})^{-1} \hat{ }_{it\,l} \tag{9}$$

$\hat{}_{it\,l}$ and $\hat{}_{it\,l}$ are, respectively, the probability density function and cumulative distribution function of the normal distribution evaluated at $\hat{} + z_{it1}\hat{}$. Based upon (7) and (8) if we cannot reject the null hypothesis that $= 0$, then $_{it}$ and v_{it} are uncorrelated which therefore implies $_1 / = 0$.

Focussing on simple binary indicators of training provision, we explore two versions of (6). First, we measure training at the beginning of the period, such that $D_{itl} = D_{itl}$, and compare this with the result from measuring training at the end of the period where $D_{itl} - D_{it2}$.[2] Second, we utilise both measures of training and construct a dummy variable $D_{it21} = D_{it2} - D_{itl}$. D_{it21} has four outcomes based on persistent trainers, no trainers and those that train in one period and not the other. Sample frequencies for this variable are presented in Table 2 which also records average employment for each of the four train states. For firms that are alive in both periods, the most prevalent state is occupied by persistent trainers.

Although we refer to firms for which D_{it1} and D_{it2} are equal to 1 as *persistent* trainers, given the lack of a complete time series between these two points, it is not possible to discriminate between firms which undertake training in all intervening years, and firms for which training is periodic. However, a test of the null hypthesis that the training decision in 1997 is independent of the same in 1991 is easily rejected,[3] and suggests that there is some form of persistence over time in the provision of formal training.

4.1 Intensity of Training

We also consider a variant of the specification given by (5) and (6), given that we have access to a measure of training intensity. If we observe training costs for the sub-sample of trainers, then we may rewrite (6) as

$$D_{itl} = 1\,(D^*_{it1} = \quad + z_{it1} \quad + v_{itl} > 0)\,D^*_{it1} \tag{10}$$

where now the latent variable and observed counterpart, D^*_{it1} and D_{it1}, are based upon an intensity measure of training. The observation rule in (10) is such that training costs are zero for non-trainers, or a positive continuous quantity for those firms undertaking some form of training. In this respect the estimation of the parameters for (10) will be similar in spirit to the censored regression model. However, the nature of the training costs data is such that we need to account for both censoring at zero and at an upper threshold of 6%, and in addition, for interval level data for costs less than 6 per cent.

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[2] Note since our other measure of training is recorded in 1997 and the end period is 1995 we make the assumption that firms training in 1997 were also training in 1995.

[3] $x^2_{(1)} = 75.3$.

Training costs for firms are record as:

1. 0 – no training undertaken. Observations $i \in L$ are left-censored.

2. $j < D^*_{it1} = j + 1$ $j = 0, 1, 2, 3, 4, 5$. Training costs lie between j and $(j + 1)\%$ of total labour costs. Observations $i \in I$ are intervals.

3. D^*_{it1} 6. For firms spending more than 6% we only observe an upper censoring indicator, 6. Observations $i \in R$ are right censored.

Based upon the observational rule implied by 1, 2, and 3 the generalised residuals can be estimated using:

$$E(v_{it1} | D_{it1}) = - \sigma_v \phi(\mu)(1 - \Phi(\mu))^{-1} 1(D^*_{it1} \quad 0)$$

$$+ \sigma_v \sum_{j=0}^{5} \frac{\phi(j - \mu) - \phi((1 + j) - \mu)}{\Phi((1 + j) - \mu) - \Phi(j - \mu)} 1(j < D^*_{it1} < (1 + j))$$

$$+ - \sigma_v \frac{\phi(6 - \mu)}{1 - \Phi(6 - \mu)} 1(D^*_{it1} \quad 6)$$
(11)

where $\phi(.)$ and $\Phi(.)$ are, respectively, the standard normal probability density function and cumulative distribution evaluated at $\mu = \gamma' z_{it1} / \sigma_v$. Parameters γ and σ_v are estimated by maximum likelihood with the log-likelihood function, l, given by

$$l = \sum_{i \in L} \log \Phi(- \mu)$$
(12)

$$+ \sum_{i \in R} \log[1 - \Phi(6 - \mu)]$$

$$+ \sum_{i \in I} \log[\Phi((j + 1) - \mu) - \Phi(j - \mu)] \quad j = 0, 1, 2, 3, 4, 5.$$

5   Firm Performance, Training and Firm Size: A Descriptive Detour

In this study we have access to both binary measures of training propensity and an indicator of training intensity, namely training costs as a proportion of labour costs. In Table 1 we explore the proposition that the relationship between the impact of training and employment growth is determined, in part, by the date of the training indicator. Using the Wilcoxon rank sum test we test the hypothesis that there is no relationship between employment growth ($\overline{EG}$) over the period 1987-90 and 1990-95 and the

incidence of training, namely $H_0 : \overline{EG}^1_{8790} = \overline{EG}^0_{8790}$, and $H_0 : \overline{EG}^1_{9095} = \overline{EG}^0_{9095}$ where the superscript 1 (0) denotes training (non-training) firms. In the two instances where training is measured after the employment growth period we observe a significant (positive) difference between training and non-training firms. However, over the period 1990-1995, where training is measured in 1991, we cannot reject the null hypothesis. Table 2 presents the joint frequencies of the training decisions of firms in 1991 and 1997 and the average employment level in 1995 ($\overline{EMPL}_{95}$) for each training state. We note that the most prevalent state is occupied by firms which were observed to train in both periods, which on average are much larger in terms of employment. Table 3 presents data for training costs. The first point to emphasise is that for each firm we have only a single observation for training costs, namely 1997. Second although 500 firms indicated some form of formal training in 1997, we only have 220 non-missing observations of training costs for firms with employment data in 1995. Subsequently, if we first assume that firms which *do not* provide this data are, on average, identical to those who respond, then we have a simple efficiency loss in terms of the subsequent fall in sample size. Thus, although in one instance we can point to an efficiency gain in terms of the higher information content of the training cost variable, we need to account for the fact that we have fewer observations to identify any additional effect of training costs. Obviously to the extent that data is missing non-randomly we need to account for possible biases.

In table 4 we examine the relationship between employment growth (EG), firm size ($EMPL_{87}$ and $EMPL_{90}$) and training frequency (D_{91} and D_{97}) for the two periods 1987-90 and 1990-95. In order to examine the nature of these relationships across the distribution of growth rates we calculate average values based upon deciles of employment growth. These relationships are also presented in Figures 1 and 2. For both the periods 1987-90 and 1990-95 there is a negative relationship between the proportional growth of a firm and initial size. This confirms our prior expectations and, in addition, the findings of Hart and Oulton (1992) who, using UK data for the period 1989-93, demonstrated that small firms generated proportionately more jobs than larger companies. In a follow-up study (see Hart and Oulton (1996)) the authors demonstrate that this finding is robust to both sectoral and class size disaggregation, in keeping with the earlier UK results of the 1980's (see Dunne and Hughes (1994) and Cosh, Hughes, Lee, and Pudney (1998)). For both 1987-90 and 1990-95 we observe a general negative but non-monotonic relationship. If we compare figures 1 (a) and 1(c) and figures 2(a) and 2(c), we also observe that firm size is a good indicator of the decision to undertake training. Thus, given the inverse relationship between employment growth and firm size, we can view the role of training as a marginal effect once we control for initial size.

The relationship between training and employment growth is observed to depend upon when training is measured. In examining employment growth over the period 1987-90 our training indicator is measured in 1991, and for the years 1990-95 we have two measures of training: 1991 and 1997. In Figure 3, we present kernel density plots of employment growth over the period 1990-95, differentiating between the year of the training indicator and trainers and non-trainers. Figure 3 confirms the findings of

Cosh, Duncan and Hughes (1998), namely that the different between employment growth of trainers and non-trainers is negligible when training is measured in 1991. When our training measure is based upon 1997 data we do observe a difference.

In figures 2(a) and 2(b) we present the *marginal* frequencies for training propensity (measured in 1991 and 1997) across the deciles of employment growth. For the training indicator based upon 1991 data we do not observe any identifiable relationship between training and firm performance. In contrast, the training measure for 1997 suggests a relatively strong relationship, with the exception of a group of mid sized firms. If we move from marginal to joint frequencies based upon considering training decisions in both 1991 *and* 1997, we observe a number of interesting features. Figure 4 presents this data, and we examine the issue of both training persistence and firms which either train (not-train) in 1991 and cease (begin) training in 1997. We again emphasise that our use of the term persistence is an abuse of the vernacular, given that we do not have a complete set of time series observations over the period 1991-1997. Firms which are persistent trainers do not seem to exhibit a clear trend with regards growth of employment. The most notable trend is exhibited by firms which were training in 1991 but not in 1997. In this instance there is a clear negative relationship insofar as the highest frequency of firms in this state are observed in the lowest employment growth deciles. Note also that firms which started training in 1997 were more concentrated in the upper deciles of the employment growth distribution (see Figure 4(c)).

6   Firm Performance and Training: Results from a Two Period Model of Employment Growth

In Table 5 we present our results based upon the estimation of a two period model of employment growth given by (5) and (6) and (12)[4]. We present results for eight variants labelled i) to viii) and focus upon the following outputs: is a measure of convergence and represents the effect of initial employment size T_{91}, T_{97} and T_{9197} represent the effect of training on employment growth with training (measured using a simple binary indicator) recorded in 1991, 1997 and in both periods.   represents the correction for

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[4] Note that the use of a two-step Heckman procedure to correct for sample selection provides consistent parameter estimates for the employment growth equation. However, estimates of standard errors are inconsistent.

the potential endogeneity of the training decision[5]. Given that the generalised residuals are positive by construction we can provide an interpretation based upon the sign of this coefficient. If $> 0 (< 0)$, this indicates that unobserved factors which lead to a high propensity to train also result in a higher (lower) level of performance. Subsequently if we do not account for this correlation we will consistently overestimate (underestimate) the effects of training on performance. $\Pr > F$ and $\Pr > x^2$ are the p values for the Ramsey Reset (omitted variable) test and heteroscedasticity. Parameter estimates presented in square brackets are robust estimates based upon the use of an observation specific set of weights which downweight the influence of outlier observations.[6]

In evaluating the results in Table 5 it is important to bear in mind the following. First, our regression results are presented in three sections. Section I presents results for models which we utilise a binary training indicator measurement in *either* 1991 or 1997. Section II incorporates *both* measures of training and allows us to differentiate between firms which were observed to train (not train) in both periods and those firms which trained (did not) in 1991 and were not training (training) in 1997. In Section III we consider the added value of including a measure of training costs. Note also that A indicates that the sample consists of firms which were alive in both 1987 and 1990; *B* indicates all firms which were alive in 1987, 1990 and 1997. Thus results i) and ii) allow an informal evaluation of the impact of survival bias when comparing parameter estimates across the two periods.[7]

In both periods, and across all variants, the hypothesis that small firms grow faster than larger firms cannot be rejected. If we compare variant ii) with the OLS estimates for variant iii) we note that the rate of convergence is significantly higher for the 1987-90 period relative to 1990-95. One of the reasons for this is that a law of proportionate effect specification becomes less persuasive as the period of employment change increases, since the impact of the initial value will decay with time. Evidence of this is found from the size of the coefficient on lagged employment. For both periods we find a significant training effect if we measure training at the *end* of the period (compare variants i) ii) and iv) with iii)). However, if we utilise robust regressions and thereby

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[5] A formal test of a null of no attrition bias due to firm failure in the size growth relationship was also carried out. Based upon the same method used to test for the endogeneity of training the null could not be rejected at the 5% level. This test was performed in a conditional fashion in that a control for the endogeneity of training was also conducted. We note that in this study controls for endogeneity and sample attrition bias due to business failure have been applied assuming that these two factors are independent.

[6] The precise form of the robust estimator used in this application is based upon the work of Goodall (1983) and Rousseeuw and Leroy (1987). We first estimate the regression using standard least squares and using Cooks D we exclude observations for which D > 1. Following this the algorithm procedures iteratively applying both Huber weights (see Huber (1964)) and biweights(see Andrews, Bickel, Hampul, Huber, Rogers, and Turkey (1972)).

[7] A formal test of a null of no attrition bias due to firm failure in the size growth relationship was also carried out. Based upon the same method used to test for the endogeneity of training the null could not be rejected at the 5% level. This test was performed in a conditional fashion in that a control for the endogeneity of training was also conducted. We note that in this study control for endogeneity and sample attrition bias due to business failure have been applied assuming that these two factors are independent.

seek to discriminate between 'good' and 'bad' parts of the sample, we find a highly signficant effect due to training. This is so even when training is measured at the beginning of the period. In a further analysis not reported here we found that for variant iii) the influential observations (i.e. those which were subsequently downweighted) were almost equally concentrated in the lower and upper deciles across the distribution of employment growth. However, this pattern was not present for the 1987-90 period and, in fact, influential observations were almost uniformly distributed over employment growth deciles.

In Section II we report results based upon analysis using the binary indicators of training in 1991 and 1997. Variant v) is based upon an approach in which the underlying model of the training decision is specified by differentiating between two groups: firms which were observed to train in both periods, and all others. Using the robust estimator we find a strong significant effect due to persistent trainers over and above the residual category. In variant vi) we examine whether we can differentiate between the persistent trainers and the three remaining groups take separately. The 3 (dummy) variables (T_P, T_B and T-C) represent the impact on employment growth of persistent trainers (P), those which began (B) training in 1997 and those firms which ceased training in 1997(C), *relative* to the base category non-trainers. Thus, we record a highly significant difference between persistent trainers and non-trainers, and firms which trained in 1997 and not in 1991, again relative to the referent group non-trainers. The difference between non-trainers and firms which trained in 1991 but were not training in 1997 was not significant.

The 1997 survey provides a wide range of information about management practices and attitudes. We have set out earlier the reasons for believing that training should be evaluated in the context of the overall set of human relations practices at work in a firm. We therefore examine the association of training in 1997 with these and other firm level characteristics in two ways. We carried out simple t-tests on the differences in means between trainers and non-trainers, and used the non-parametric Mann Whitney test to eliminate the impact of outliers. Our findings are presented in Table 6. We find no evidence that high profitability in 1995 has led to the adoption of training in 1997, in fact our findings suggest the reverse. Training firms are more likely to have people with professional qualifications running the business, place greater emphasis on design, quality, product range, marketing and flair as their sources of competitive advantage. They are also less likely to emphasise price and speed of service than non-trainers. The trainers, perhaps unsurprisingly, are significantly more likely to identify skill shortages as an inhibitor of their growth performance.

Trainers are far more likely to have sought external advice to support their training activities. About three quarters of them had drawn upon external advice and about one half had used Business Links. Our results also suggest that trainers have more sophisticated management than non-trainers. Thus they are far more likely to use investment appraisal methods. However, for our purposes it is their human resource management which is of particular interest. All aspects of human resource management are significantly more prevalent amongst trainers. This raises the question of the interaction between these aspects and the impact of training on

performance.

Of particular interest is the impact of the use of total quality management and quality circles in conjunction with training on firm performance, differentiating firms, as before, according to the training categories T_P and T_B. given that data on human resource management are only available for 1997, we are able to identify four categories of firms. Persistent trainers which do not use either technique we denote T_PS_0; persistent trainers which are using these practices are denoted T_PS_1. Firms which began training in 1997 are divided into similar categories, namely T_BS_0, T_BS_1. These four groups are compared with non-trainers in 1997 and the results are presented in Table 7. The results suggest that the impact of training is dependent on the labour practices within which it is embedded. Thus, we find that the impact of training on employment growth is significant only when associated with the adoption of more sophisticated human resource management techniques. This is true both for persistent trainers and for those which began training in 1997. Training without the adoption of such practices is associated with a positive, but insignificant, impact on growth performance.

In Table 8 we present the results from estimating a multinomial choice model of the joint frequencies over the D_{91} and D_{97} variables. The referent category is those firms observed *not* to train in both periods. Our results are consistent with expectations insofar as the biggest different in terms of the impact of firm level variables upon the probability of belonging to the four training states, is between the persistent and the non-trainers (referent group). the positive coefficients for *lempl, innov* and *skill* indicate that initial employment size, innovation activity and the existence of recruitment problems in certain skill categories are all significant indicators of persistent training, relative to non-training. For the other two categories ($train_{97}$ not $train_{91}$, not $train_{97}$ $train_{91}$) we observe a similar positive effect due to initial employment size, and for those firms which were not observed to train in 1997 there is a significant effect of the recruitment variable, *skill.*

In Section III we examine the extent to which including a measure of training intensity provides additional information over and above the binary indicators of training. Results vii-viii are based upon estimating the censored regression models given by (12) and using the generalised residuals to correct for endogeneity. In interpreting the effect of the training costs variable we should consider the fact that although over 500 firms supplied information on employment, training and related characteristics for 1990 and 1995, only 266 firms responded to the training cost question. Subsequently, although there is obviously a theoretical information gain with regards the use of training costs data relative to simple binary indicators of training provision, the loss of observations through item non-response will reduce the precision with which we an estimate any effect.

In results vii we include only the training cost variable *Tcost,* and find a significant impact of training expenditure on employment growth. In viii we include both measures of training, namely the 3 dummy variable *T_P, T_B* and *T_C* together with *Tcost*. Once we control for the *qualitative* effects of the decision to train, we still find a significant effect for the training costs variable, but at a reduced level of significance.

7 Conclusions

Our empirical and methodological findings have four major implications. These relate respectively to: the measurement of training; the identification of the wider human relations management context in which training occurs; the virtues of including a panel element in data collection practices; and the need to adopt robust modelling techniques which address both the extreme heterogeneity of small and medium sized business performance and the appropriate treatment of sample selection biases, and the endogeneity of the training decision.

It is important in designing data collection protocols for evaluating the impact of training that measures of the intensity of training are included alongside measures of the incidence of training. These need to be included as part of the information system design for all participants in schemes from the outset and in designing control group information collection. Care needs to be taken, however, in question design to maximize item response rates to such questions. this is because there is a trade off between the increased efficiency of the underlying econometric estimate of the impact of training and the adverse impact reduced sample sizes cause if low item response rates occur. This suggests that pilot studies should be carried out to identify the most meaningful and readily answered questions to ask on training intensity.

The results support the argument put forward in detail in Hughes and Weeks (1999) that the human relations context can have an important conditioning impact on the estimated role of training in affecting firm performance. Information on these aspects of firm characteristics should also be incorporated in training scheme information systems, alongside information on past involvement in such activities. Similar issues of question design arise as in the case of measuring training intensity.

The inclusion of a panel element in information system design is also of great significance. It generates extra data points which allow for the incorporation of dynamic elements to the econometric methodology. Our report shows that this is important in relation to the analysis of endogeneity and causation. It is also revealed as essential if questions about the decision to start, stop and continue training are to be addressed. Each of these are important in a policy context.

The report reveals that the adoption of robust regression techniques is of great importance in the context of the heterogeneous population of small and medium sized firms with relatively volatile performance characteristics. Conventional OLS techniques may mask the relationships which exist in a central core of the observations under investigation. Our results also reveal the important of corrections for the endogeneity of training in the evaluation of the latter on performance. They also reveal that considerable insights can be obtained from repeated panel cross sections even if they are not carried out on an annual or even shorter cycle. It is possible in this context to consider questions in surveys which elicit answers on training activity in a series of intervening years even if the timing of each survey is biennial.

The research has focused on a single measure of performance (employment growth). It has also, because of the agreed limited scope of the research brief, explored a limited range of interactions between training and the human relations and other relevant

variables in the CBR dataset. A study with a longer time frame could investigate the interrelationship between training on the one hand , and business survival, innovative activity, and measures of performance based on profitability and productivity on the other. Each of these is possible with the augmented 1987-1997 CBR dataset used in this report.

Within a non-experimental setting the determination of whether a particular policy is deemed successful is increasingly viewed in terms of whether a positive mean impact can be identified as opposed to learning about structural parameters. In this regard it would be instructive to consider a number of alternate outcome measures of the impact of training on performance. For example, if we view both training frequency and intensity as being affected by employment policy, then counterfactual simulations can be utilised to determine the impact of, for example, the introduction of a training subsidy designed to raise the proportion of firms engaged in training. These outcome measures will also facilitate a more direct comparison across different model specifications.

8 Appendix

CAGE: Chief executive age in years (1991 survey)

COMPS: Number of serious competitors

EG_{8790}:   employment in 1990/employment in 1987

EG_{9095}:   employment in 1995/employment in 1990

$EMPL_{tt}$:   employment level in 19tt

GROWTH: variable which measures the firms's growth objective son a scale of 1-4

INNOV: binary variable which equals 1 if the firm innovated during the last 5 years and zero otherwise (1991 Survey)

LARGEST: % of sales to largest customer (1991 survey)

$LEMPL_{87}$:   Natural log of employment 1987

$LEMPL_{90}$:   Natural log of employment 1990

LENTAGE: Natural log of enterprise age in 1995

RSKILL: ratio of managers and higher professionals to total employment (1991 survey)

SEC(N)DUM: 11 industrial sector dummies (N=1,...,11)

SEC1:   chemicals man-made fibres, rubber and plastics

SEC2:   metal goods and mechanical engineering

SEC3:	electrical and instrument engineering
SEC4:	food drink and tobacco
SEC5:	textiles, leather footwear and clothing
SEC6:	timber furniture, etc.
SEC7:	paper, printing and publishing
SEC8:	metals minerals and other manufacturing
SEC9:	advertising and management consultancy
SEC10:	technical and professional consultancy services
SEC11:	other services
SKILL:	binary variable equals 1 if th firm is finding it difficult to recruit in certain skill categories and zero others (1991 Survey)
TCOST:	expenditure on training as a percentage of sales (1997 Survey)
T_{91}/D_{91}:	binary variable equals 1 if the firm provided formal training in 1991 and zero otherwise
T_{97}/D_{97}:	binary variable equals 1 if the firm provided formal training in 1997 and zero otherwise
T_P:	binary variable equals 1 if the firm provided training in both 1991 and 1997 and zero otherwise
T_B:	binary variable equals 1 if the firm provided training in 1997 but not in 1991 and zero otherwise
T_C:	binary variable equals 1 if the firm provided training in 1991 but not in 1997 and zero otherwise
Y:	natural log of employment growth for 1987-90 or 1990-95
Notes:	Any of the above terms appearing with 'sq' implies the square of the term. For example, RSKILLSQ=RSKILL *RSKILL

References

ANDREWS, D.F., P.J. BICKEL, F.R. HAMPEL, P.J. HUBER, W.H. ROGERS, AND J.W. TUKEY (1972): *Robust Estimates of Location: Survey and Advances.* Princeton University Press, Princeton, NJ.

ARTHUR, J. (1994): "Effects of Human Resource Systems on Manufacturing Performance and Turnover," *Academy of Management Journal,* 37, 670-87.

ASHENFELTER, O., AND D. CARD (1985): "Using the Longitudinal Structure of Earnings to Estimate the Effect of Training Programs," *Review of Economics and Statistics,* 67(4), 648-60.

BAILEY, T. (1993): "Organizational Innovation in the Apparel Industry," *Industrial Relations*, 32, 30-48.

BASSI, L. (1983): "Estimating the Effect of Training Progams with Non-Random Selection", *The Review of Economics and Statistics,* pp. 36-43.

BLACK, S., AND L. LYNCH (1997): "How to Compete the Impact of Workplace Practices and Information Technology on Productivity," Working Paper Series, National Bureau of Economic Research, Inc.

COSH, A., J. DUNCAN, AND A. HUGHES (1997): "Investment in Training and Small Firm Growth and Survival," Research Report, ESRC Centre for Business Research, University of Cambridge.

――――― (1998): "Investment in Training and Small Firm Growth and Survival", Research Report, (RR36), DfEE, Sheffield, January.

COSH, A., AND A. HUGHES (1998): "Enterprise Britain: Growth Innovation and Public Policy in the Small and Medium Enterprise Sector, " ESRC Centre for Business Research , University of Cambridge, Cambridge.

COSH, A., A. HUGHES, K. LEE, AND S. PUDNEY (1998): "Semi-Parametric Estimation of the Company Size Growth Relationship", in *Applied Economics and Public Policy,* ed. by I. Begg, and B. Henry, pp. 107-144. DAE Occasional Paper No 63, Cambridge University Press.

DUNNE, J.P., AND A. HUGHES (1994): "Age, Size, Growth and Survival: UK Companies in the 1980's," *Journal of Industrial Economics,* LX11(1).

GOODALL, C. (1983): "M-Estimators of Location: An Outline of the Theory," in *Understanding Robust and Exploratory Data Analysis,* ed. by D.C. Hoaglin, F. Mosteller, and J.W. Tukey, pp. 339-431. John Wiley and Sons, New York.

HART, P.E. AND N. OULTON (1996): "Growth and Size of Firms", *The Economic Journal,* 106, 1242-52.

HECKMAN, J., AND R. ROBB (1985): "Alternative Methods of Evaluating the Impact of Interventions: An Overview," *Journal of Econometrics,* 30, 239-267.

HUMBER, P.J. (1964): "Robust Estimation of a Location Parameter," *Annals of Mathematical Statistics,* 35, 73-101.

HUGHES, A., AND M. WEEKS (1999): "Methodological Approaches to the Study of the Impact of Training on Firm Performance," Centre for Business Research and Department of Applied Economics, University of Cambridge (mimeo).

HUSELID, M. (1995): "The Impact of Human Resource Management Practices on Turnover, Productivity, and Corporate Financial Performance," *Academy of Management Journal,* 38(3), 635-672.

ICHNIOWSKI, P., K. SHAW, AND G. PRENNUSHI (1995): "The Effects of Human Resource Management Practices on Productivity," NBER Working Paper No. 5333, November.

KELLEY, M. (1994a): "Information Technology and Productivity: The Elusive Connection," *Management Science,* 40, 1406-25.

——— (1994b): "Participative Bureaucracy and Productivity in the Machined Products Sectors," *Industrial Relations,* 35, 374-399.

MILGROM, P., AND J. ROBERTS (1995): "Complementarities and Fit: Strategy, Structure and Organizational Change in Manufacturing," *Journal of Accounting and Economics,* 19, 179-208.

ROUSSEEUW, P.J., AND A.M. LEROY (1987): *Robust Regression and Outlier Detection.* John Wiley and Sons, New York.

STOREY, D., and P. WESTHEAD (1997): "Training Provision and the Development of Small and Medium Sized Businesses," Department of Education and Employment Research Report RR26, HMSO Sheffield.

Table 1: Training and Employment Growth

1987-90
Training Measured in 1991

$H_0: \overline{EG}^1_{8790} = \overline{EG}^0_{8790}$

$H_1: \overline{EG}^1_{8790} > \overline{EG}^0_{8790}$

p-value 0.0006

1990-95
Training Measured in 1991

$H_0: \overline{EG}^1_{9095} = \overline{EG}^0_{9095}$

$H_1: \overline{EG}^1_{9095} > \overline{EG}^0_{9095}$

p-value 0.9482

1990-95
Training Measured in 1997

$H_0: \overline{EG}^1_{9095} = \overline{EG}^0_{9095}$

$H_1: \overline{EG}^1_{9095} > \overline{EG}^0_{9095}$

p-value 0.0000

Table 2: The Persistence of Training and Employment Size

		Average Employment		
		$\overline{\text{EMPL}}_{95}$	Count	(%)
Training States				
$\overline{D}_{91}$	$\overline{D}_{97}$	19.78	118	(17)
D_{91}	D_{97}	80.39	363	(53)
D_{91}	$\overline{D}_{97}$	34.36	118	(17)
$\overline{D}_{91}$	D_{97}	29.01	88	(13)
			687	

D_t $(\overline{D}_t)$ = train (not train) in time t

Table 3: Training Costs and Employment Size

Training costs proportion of labour costs	Average Employment		
	$\overline{\text{EMPL}}_{95}$	Freq.	(%)
less than 1%	44.30	49	(22)
1%	46.81	54	(24)
2%	47.02	48	(22)
3%	66.93	32	(15)
4%	80.25	8	(4)
5%	88.15	13	(6)
6% or more	136.62	16	(7)
		220	

Table 4: Employment Growth, Training Frequency and Firm Size:
Means by Deciles (F_i) of Employment Growth

	1987-90			1990-95			
	D_{91}	EG_{8790}	$LEMPL_{87}$	D_{91}	D_{97}	EG_{9095}	$LEMPL_{90}$
F_1	0.496	-0.649	3.082	0.724	0.521	-0.952	3.283
F_2	0.738	-0.146	3.713	0.652	0.536	-0.379	3.091
F_3	0.491	-0.004	2.631	0.691	0.588	-0.201	3.335
F_4	0.805	0.080	4.091	0.779	0.735	-0.094	3.844
F_5	0.774	0.184	3.327	0.571	0.591	-0.006	2.798
F_6	0.840	0.278	3.288	0.775	0.700	0.062	3.900
F_7	0.696	0.382	2.760	0.783	0.698	0.166	3.482
F_8	0.672	0.586	2.470	0.741	0.685	0.303	3.123
F_9	0.720	0.876	2.330	0.716	0.776	0.481	2.764
F_{10}	0.706	1.618	1.550	0.632	0.764	0.968	2.450

Table 5: Impact of Training on Firm Performance[1,2]

Section I: Training 1991 or 1997[1,2]

	Period	Y	T_{91}	T_{97}	T_{9197}	λ	$\bar{R}^2$	N	Reset Pr > F	Hetero Pr > χ^2
i)	1987-90 A	-0.369** [-0.318***]	2.751** [2.364***]	-	-	-1.615** [-1.389***]	0.648	1,011	0.000	0.000
ii)	1987-90 B	-0.317** [-0.208***]	1.743** [1.151***]	-	-	-0.962*** [-0.622***]	0.410	502 502		
iii)	1990-95 B	-0.078** [-0.083***]	0.239 [0.393***]	-	-	-0.107 [-0.262***]	0.067	522	0.443	0.191
iv)	1990-95 B	-0.067*** [-0.127***]	-	0.179** [0.181***]	-	0.007 [0.017]	0.087	522	0.679	0.026

Section II: Training 1991 and/or 1997

	Period	Y	T_P	T_B	T_C	T_{9197}	λ	$\bar{R}^2$	N	Reset Pr > F	Hetero Pr > χ^2
v)	1990-95 A	-0.089** [0.089***]	-	-	-	0.285 [0.350***]	-0.081 [-0.124]	0.102	522	0.799	0.111
vi)	1990-95 B	-0.065*** [-0.059***]	0.187** [0.206***]	0.144* [0.154***]	-0.043 [0.016]	-	NA	0.115	522	0.794	0.181

Section III: Training Intensity 1997

	Period	Y	T_P	T_B	T_C	Tcost	λ	$\bar{R}^2$	N	Reset Pr > F	Hetero Pr > χ^2
vii)	1990-95 B	-0.055** [0.063***]	-	-	-	0.027*	-0.002 [0.038***]	0.077 -	355 [-0.001]	0.654	0.058 355
viii)	1990-95 B	-0.051*** [-0.065***]	0.107 [0.141]	0.005 [-0.001]	-0.026 [0.019]	0.081 [0.087*]	-0.003 [-0.006]	0.080	355 355	0.871	0.244

[1] Note: the measure of fit $\bar{R}^2$ is not available for the robust regressions.

[2] Regressions i) to viii) include, apart from the results reported, the following set of covariates log of initial level of employment ($LEMPL_{87}$ or $LEMPL_{90}$), % of sales to largest customers (LARGEST), the age of the chief executives in years (CAGE), the log of the age of enterprise (LENTAGE), and number of serious competitors (COMPS), sector dummies (SEC_i, $i = 1, ..., 11$). See Appendix.

Table 6. **Differences in Firm Characteristics Trainers vs Non-trainers 1997**

	Mean Values		Mann Whitney Test
	Trainers	Non-trainers	Significance Level
General			
Profit Margin 1995%	8.85	13.89(***)	.0065(***)
% with CEO holding degree or professional qualification	53.5	37.6 ***	.0018***
Human Resources Management			
% of firms using:			
Total quality management	44.8	14.2***	.0000***
Quality circles	20.6	7.1***	.0024***
Job rotation/multi-skilling	44.8	20.7	.0003***
Performance related pay	38.1	25.8***	.0041***
Competitive Advantage			
Source of main competitive advantage on scale of 1-5			
Price	2.57	2.92(***)	.0027(***)
Marketing	2.82	2.41	.0007***
Speed of service	3.72	4.01(***)	.0053(***)
Reputation	4.10	4.10	.4648
Cost	2.75	2.92	.1672
Design	3.49	3.14***	.0089***
Quality	4.12	4.03	.2942
Specialism/niche	4.07	3.90*	.1092
Range	3.77	3.42***	.0006***
Flair	3.35	3.03***	.0047***
Personal attention	4.33	4.46	.1063
Growth Inhibitors			
Significance of factors limiting growth on scale 1-5			
Skilled labour	2.47	2.10***	.0012***
Management skills	2.68	2.17***	.0000***
Marketing skills	2.71	2.47*	.0604*
External Advice			
% firms seeking external support			
Staff training	69.9	15.8***	.0000***
Business Links- training/IIP	46.3	15.0**	.0124**
Financial support -IIP	19.7	3.0***	.0000***
Investment Appraisal			
% using payback	59.9	43.4***	.0050***
% using DCF methods	19.9	5.9***	.0036***

*   10% significance
**   5% significance level
***   1% significance level
()   shows cases where the average value for non-trainers is greater than that for trainers

Table 7: Impact of Training on Firm Growth in Association with use of TQM and/or Quality Circles

Section II: Training and Management Practices		
Variable	OLS	Robust Regression
	-0.098**	-0.099***
T_PS$_0$	0.049	0.066
T_PS$_1$	0.186**	0.196***
T_BS$_0$	0.081	0.069
T_BS$_1$	0.250**	0.255**
$\overline{R}^2$	0.095	-
N	281	281

See footnote to Table 5

Table 8: Log Likelihood

Variable	Coeff.	t-stat	$P > |t|$
Persistent			
lempl	1.228	7.771	0.000
growth	0.161	0.693	0.488
lentage	−0.302	−1.737	0.082
innov	1.148	4.052	0.000
skill	1.165	3.814	0.000
rskill	2.314	1.270	0.204
rskillsq	−3.409	−1.701	0.089
cage	−0.010	−0.671	0.502
largest	−0.132	−1.072	0.284
comps	0.005	0.825	0.409
_cons	−2.780	−2.255	0.024
$D_{97} \, not \, D_{91}$			
lempl	0.724	3.960	0.000
growth	0.420	0.149	0.882
lentage	−0.397	−1.771	0.077
innov	−0.005	−0.016	0.987
skill	0.160	0.409	0.683
rskill	1.420	0.697	0.486
rskillsq	−0.706	−0.340	0.734
cage	0.009	0.452	0.651
largest	−0.085	−0.572	0.567
comps	0.003	0.373	0.709
_cons	−2.025	−1.371	0.170
$D_{91} \, not \, D_{97}$			
lempl	0.606	3.702	0.000
growth	0.124	0.485	0.628
lentage	−0.076	−0.409	0.682
innov	0.508	1.658	0.097
skill	0.699	2.110	0.035
rskill	−1.735	−0.916	0.360
rskillsq	0.472	0.223	0.823
cage	0.007	0.418	0.676
largest	−0.134	−0.996	0.319
comps	−0.004	−0.456	0.648
_cons	−1.807	−1.369	0.171

Figure 1: Training and Employment Size by Deciles of Employment Growth: 1987-90
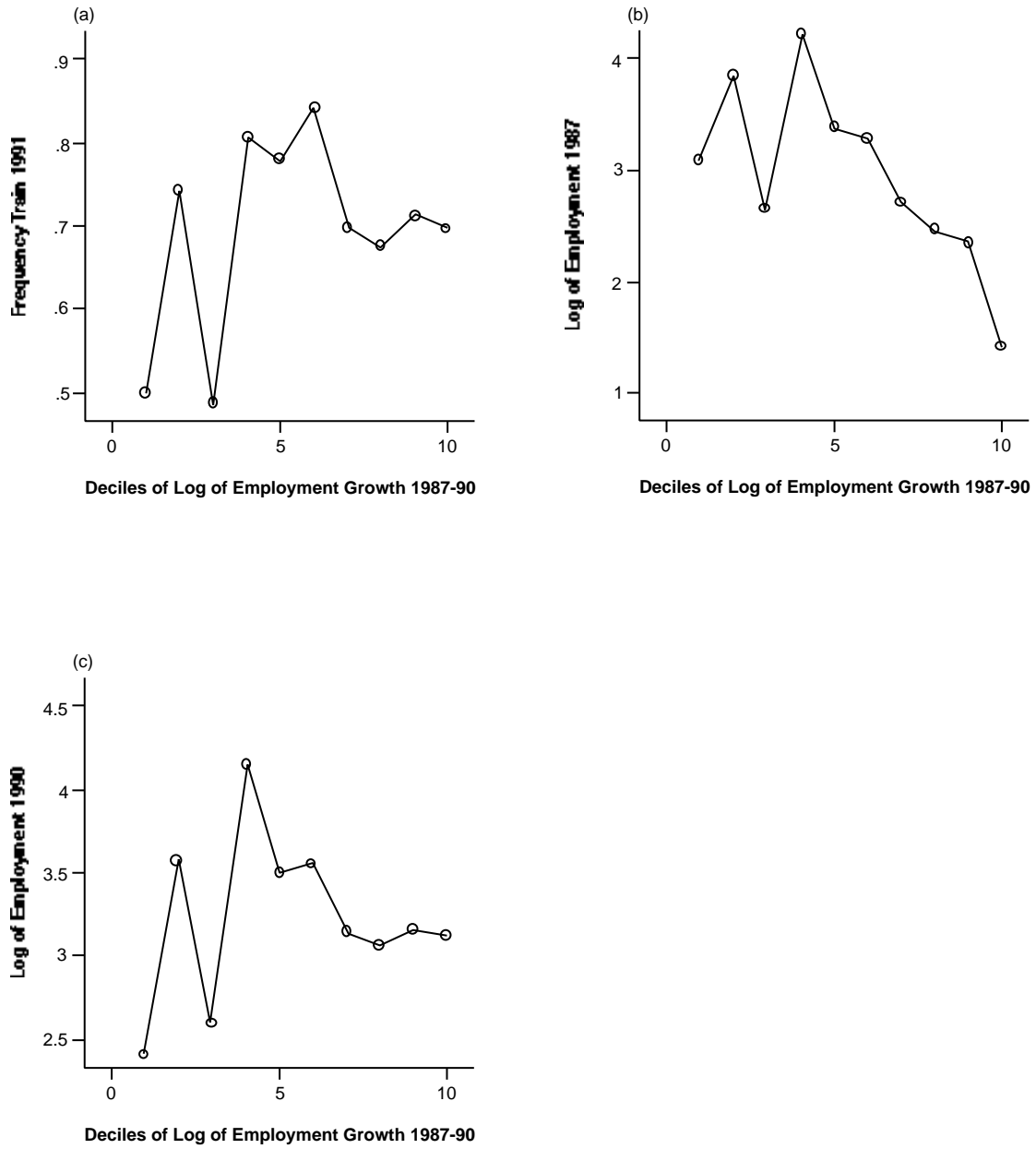
Figure 1: Training and Employment Size by Deciles of Employment Growth: 1990-95

(a)

Frequency Train 1991

Deciles of Log of Employment Growth 1990-95

(a)

Frequency Train 1997

Deciles of Log of Employment Growth 1990-95

(c)

Log of Employment 1991

Deciles of Log of Employment Growth 1990-95

(d)

Log of Employment 1995
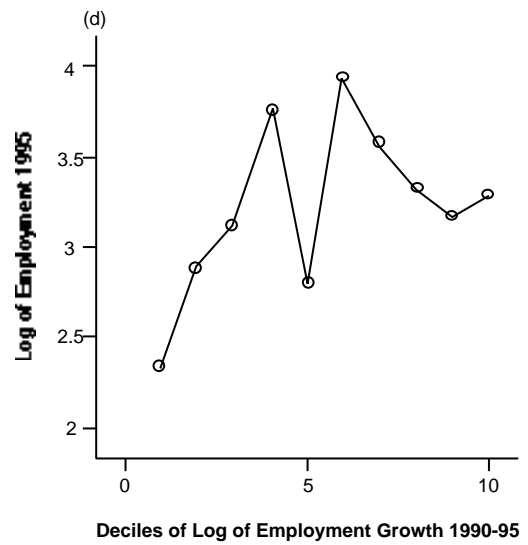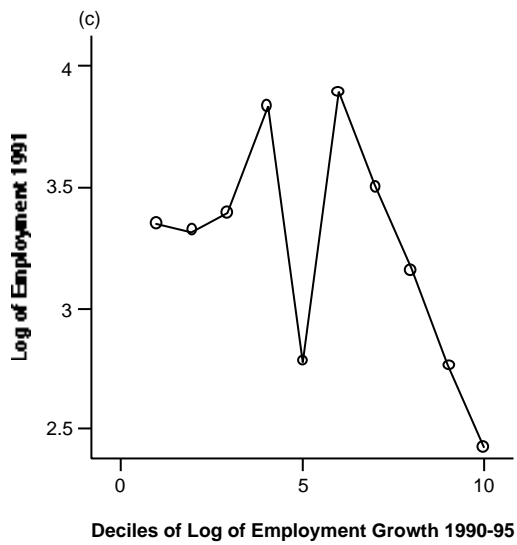
Deciles of Log of Employment Growth 1990-95
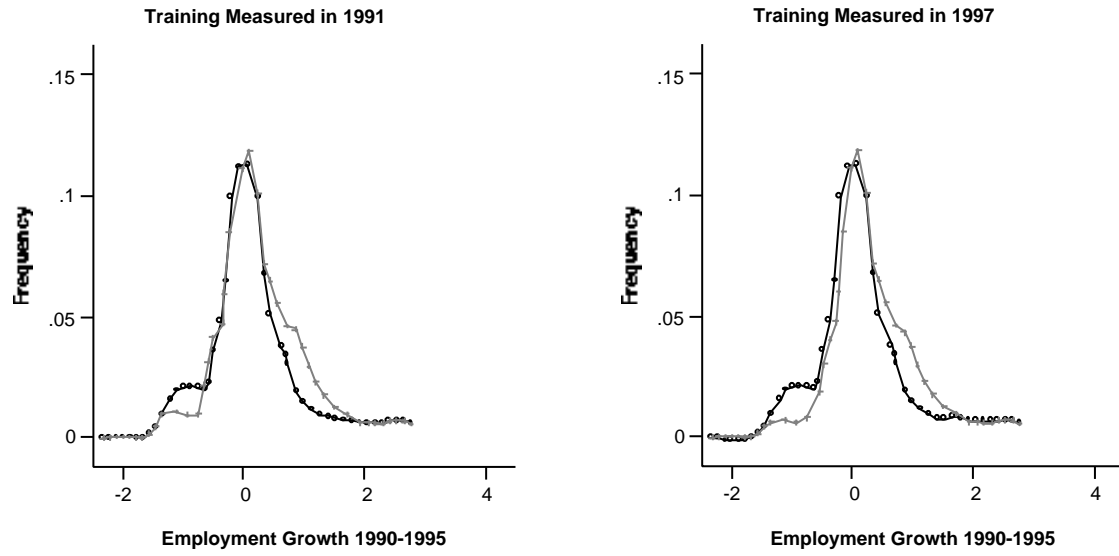
Figure 3: Kernel Density Employment Growth by Training Measures

Figure 4: Training Propensity: 1991 and 1997

(a)

Train 1991 and 1997

Deciles of Log of Employment Growth 1990-95

(b)

Not Train 1991 and 1997

Deciles of Log of Employment Growth 1990-95

(c)

Not Train 1991 train 1997

Deciles of Log of Employment Growth 1990-95

(d)

Train 1991 not 1997

Deciles of Log of Employment Growth 1990-95