Determinants and Effect of Firm-level Adjustment on Productivity

DARAMOLA, OLADIPUPO,AKIN

Determinants and Effect of Firm-level Adjustment on Productivity

By

Oladipupo A Daramola

Abstract

This thesis examines the motivations for and impacts of different channels of adjustment on firm-level productivity. It specifically focuses on how firms systematically choose between different paths of adjustment and the impact of these choices on firm-level productivity.

The first empirical chapter of this thesis examines the determinants of firms' choice of adjustment. Using a multinomial logit model, it considers the role of the following 4 characteristics: firm size, adjustment size, firm-level variables (R&D, age, multi-plant and foreign ownership) and other factors. The chapter shows that large firms tend to rely more on external forms of adjustment – greenfield investment and mergers and acquisition for expanding firms and; plant closure and plant sale for contracting firms - than small firms. It also shows that firms tend to rely more (less) on external forms of expansion (contraction) when the desired size of adjustment is large. With regards to the firm-level variables considered, this chapter shows that R&D is negatively related to greenfield investment with no/negligible effect on mergers and acquisition, plant closure and plant sale. Age has a negative (no) impact on greenfield investment (mergers and acquisition) and plant closure (plant sale). Multi-plant firms tend to rely more on external forms of adjustment. Lastly, we find that foreign-owned firms are more likely to acquire and close existing plants.

The second empirical chapter studies the impact of alternative forms of adjustment on firm-level productivity. This chapter uses the system GMM approach to tackle two sources of bias: simultaneity of adjustment paths-productivity relationship and endogeneity of factor inputs (and self-selection of firms in and out of an industry) in the production function. This chapter shows that there is no statistical relationship between adjustment paths and the long-run productivity of firms. However, given our choice of appropriate control groups and the fact that we use the system GMM approach to alleviate endogeneity concerns, we view our finding of no long-run adjustment effect as novel.

Determinants and Effect of Firm-level Adjustment on Productivity

By

Oladipupo A Daramola

A Thesis Submitted for the Degree in Doctor of Philosophy in Economics

University of Durham

Durham University Business School

2019

Table of Contents

List of Tables

List of Figures

Statement of Copyright

Acknowledgment

First and foremost, I would like to thank God for giving me the strength to complete this thesis.

I am most indebted to my first supervisor, Professor Richard Harris, who has always been willing to take time from his busy schedule to offer comments on my work at different stages; suggest readings into fascinating economics area; share his breadth of knowledge in a wide range of areas and answer my many questions. I am grateful for his outstanding support and guidance throughout my PhD journey. I also owe my deepest appreciation to Dr. John Moffat for his highly constructive comments; insightful advice, reliable eye for detail and the many pleasant conversations we have had throughout my PhD.

Thank you to my family, particularly, my mother for her support throughout my academic journey. Your prayers, support and help has played an important role in the completion of this difficult, but very rewarding course of my PhD.

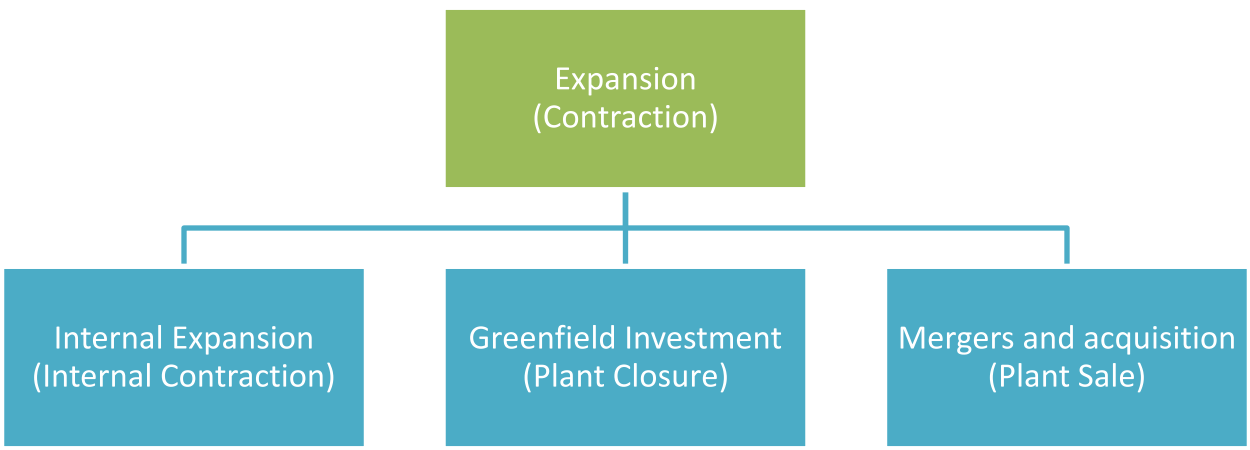
There are many more people to whom I am thankful. I am grateful to the Economic and Social Research Council for generously funding my PhD. I am also grateful to all the staffs at Durham University Business School for providing academic supports for PhD students including myself. Lastly, I would like to thank all of my PhD colleagues for the lovely conversations.

1 Introduction and Motivation

1.1 Introduction

Productivity growth is central to the process of economic growth. Through decompositions, economic researchers have found that the major contributor to productivity growth is reallocations of resources between firms/plants. More specifically, previous analyses show that the opening/closure of firms/plants is the largest contributor to TFP growth (over 50 per cent in Disney et al., 2003; and Harris and Moffat, 2013a). However, relatively little is known about the factors that explain the investment decisions firms make in order to expand or contract and whether the choice of the method used has an impact on subsequent performance. Most theoretical and empirical models of firm restructuring focus on the overall changes in the output of firms; but give little attention to how these changes are achieved and their effect on the firm's ex-post performance (e.g., Jovanovic, 1982; and Hopenhayn, 1992).

Figure 1-1: Channels of Adjustment



Changes in firm-level output[1] can be achieved in 3 principal ways. Firms seeking to increase output may do so at existing plants, create new plants or acquire existing plants from other firms. We refer to these options as internal expansion, greenfield investment and mergers and acquisitions respectively in Figure 1.1. On the other hand, firms can reduce output at existing plants or by closing or selling plants. These

[1] We make a reasonable assumption that changes in employment translates into changes in output.

options are shown in Figure 1.1 as internal contraction, plant closure and plant sale respectively[2]. Each option can have different implications for productivity. For instance, mergers and acquisition could result in higher productivity than internal expansion if the change in corporate ownership that often follows the former is used as a mechanism to keep good firm-employees match and discard bad matches. Thus, understanding the motivations for and impacts of the different adjustment channels is crucial for policy makers if they are to develop policies likely to raise economic growth. This thesis aims to contribute towards providing such an understanding.

This chapter introduces the thesis and is structured as follow: the next section provides a motivation for the thesis. In section three, we briefly explain our key research questions, contribution, data and methodology. Section four describes the content of each chapter in the thesis. The fifth section concludes.

1.2 Research Motivation and Contribution

The contribution of corporate restructuring (or firm's adjustment or firm's expansion and contraction) to productivity growth is important for policy. For instance, evidence that mergers and acquisition reduce competition and thus, productivity, provides the UK government with a rationale for investigating potential mergers on competition grounds (Competition and Markets Authority, 2014). Mergers and acquisition are often linked to reduced competition which in turn, leads to reduced quality of goods and services and/or increase in the prices of goods and services and; a reduction in consumer surplus. This has led to increased regulation and a more restrictive competition policy for potential mergers in the UK. However, anti-competitive laws that prevents firms from merging may remove an important contribution of mergers and acquisition on UK productivity growth as various researchers have shown (e.g., the so-called 'resource reallocation' from low to high productivity firms – see Disney et al., 2003; and Harris and Moffat, 2013a). This also extends to other forms of firm's adjustment such as internal expansion, greenfield investment, plant closures etc. For instance, policies aimed at reducing the number of plant closure in the UK particularly, after the 2008 financial crisis, may create zombie firms - firms that would have closed in normal economic circumstances due to low productivity - and have a detrimental effect on productivity growth (Caballero et al., 2008, Harris and Moffat, 2016).

[2] There are also inter-dependencies between the different expansion and contraction channels. For instance, a firm may acquire plants from another firm and sell some of its existing plants not required for future production. The full list of options available to firms are shown in Chapter 3 (in particular, table 3.3 and 3.5) of this thesis.

To have a better understanding of these policy issues requires information on the determinants of productivity and, in particular, whether different forms of firm's adjustment have varying consequences on productivity. Various researchers have analysed the effect of different path of adjustment on firm performance (or productivity), however, there is little systematic analysis on the effect firms' choice of adjustment (as shown in Figure 1-1), on productivity. Researchers such as Maksimovic and Phillips (2001) and Schoar (2002) have studied the effects of mergers and acquisition on productivity but these effects are not compared to alternative forms of expansion such as internal expansion or greenfield investment. More recently, Breinlich et al. (2012) analysed the role of firm-level adjustments in explaining aggregate productivity growth. However, to our knowledge, none of these studies have systematically compared the effect of different forms of adjustment on firm-level productivity. In other words, it is expected that choosing one particular path of adjustment over another would have different consequences for productivity and failing to separate firms' choices could lead to biased estimates. For instance, a firm that chooses greenfield investment over mergers and acquisition may see an increase in productivity due to improved technology embedded in new plants.

The focus of this thesis is therefore, to cover a comprehensive set of determinants of productivity, and is centrally concerned with examining the impact of the aforementioned channels of adjustment on productivity. In other words, the thesis aims to investigate the productivity impact of choosing a particular path of expansion or contraction over another. First, we hypothesize in chapter two, using different theoretical models that firms' chosen path would have different impacts on productivity. The main sources of such variation in productivity impact are motivated by input quality differences that standard input measures do not capture. For instance, if the capital (or plant) vintage from greenfield investment and mergers and acquisition differ in how much technological progress they embody, the capital (in a production function) would embody different levels of productivity depending on whether it is new (i.e., greenfield) or old (i.e., acquired).

Another strand of related literature seeks to understand the determinants of firm's adjustment (particularly the factors determining why firms choose a particular channel of adjustment over another); nonetheless, there are only a limited number of studies as to what leads firms to choose a particular path of adjustment, despite its evident importance for economic growth policies. While it is important to consider the productivity impacts of different paths of adjustment, one must also understand how firms choose between the different channels of adjustments as differences in productivity across firms are likely to be influenced by their non-random choices of adjustment path. The expectation is that firms choose the path of expansion and/or contraction that maximizes profit, given the different revenue streams and more importantly different costs associated with each path of expansion (e.g., greenfield investment involves large sunk costs while mergers and acquisition involves substantial transaction costs). In other words, we expect that a firms' decision to use a particular path of expansion and/or contraction is dependent on a minimum productivity/profitability threshold that is required to secure non-negative profits, as well as its market environment (e.g., new technological possibilities, increased competition and policy-induced uncertainty such as Brexit)[3]. Thus, The second part of this thesis attempts to provide a comprehensive treatment of firm's expansion and contraction options, whereas previous studies have tended to focus only on a subset of these options, for instance, on the choice between mergers and acquisition and greenfield investment (i.e., Jovanovic and Rousseau, 2002) or on the determinants of plant sale (i.e., Yang, 2008). The thesis also uses a comprehensive set of determinants of firms' choice of expansion and contraction which serves as another departure from the standard industrial economics literature. The inclusion of variables such as ownership-type and age are necessary to avoid an omitted variables problem.

Thus, the scope of this thesis is to understand the motivations for and the productivity impacts of different channels of firm's adjustment. This thesis utilises the Annual Business Survey (ABS, formerly, Annual Respondents Database) to consider these important policy issues. First, and as shown in greater detail in chapter three of this thesis, we find that all 6 modes of expansion and contraction – internal expansion, greenfield investment, mergers and acquisition, internal contraction, plant closure and plant sale – are empirically important. In our UK data, which spans from 1997 to 2012, we found that all 6 forms of adjustment account for a large proportion of employment expansion and contraction. Second, we observe in our data that the choice of adjustment mode varies with firm-level characteristics such as firm size and ownership type. For instance, we observe that mergers and acquisition is increasingly used as firm size increases. The importance of firm size concerning the choice between mergers and acquisition versus greenfield investment has also been confirmed by recent empirical studies, notably Jovanovic and Rousseau (2002) and Warusawitharana (2008). Based on these facts, we applied the appropriate econometrics techniques to analyse i) the way in which firms systematically choose

[3] Our hypothesis is built in more detail in chapter two. Please refer to chapter 2.2.1 to see how we used different theoretical models to show how firms systematically choose between the different paths of expansion and contraction.

between different forms of expansion and contraction and ii) the impact of these choices on productivity.

1.3 Key Research Questions, Data and Methodology

Following the findings of Disney et al. (2003), a body of research that not only addresses the characteristics of entering, exiting and surviving firms, but also examines the relationship between reallocating productive capacity between firms/plants and productivity growth, has emerged. However, and as stated in sections 1.1 and 1.2 above, one dimension that remains underexplored is the methods firms choose to increase/decrease their output (see, for instance, figures 1.1) and whether the methods chosen have an impact on subsequent performance. This leads us to 2, broad, interrelated research questions.

1. What determines firms' choice of adjustment when changing their productive capacity?
2. What are the impacts of firms' choice of adjustment on productivity?

The first research question is concerned with whether profit-maximizing firms systematically choose between different paths of adjustment given that each path is characterized by different revenue streams and, more importantly, different costs. In the theoretical literature on firm expansion, models of firm organizational capability have shown that the existence of fixed and inframarginal costs associated with adding plants means that firms must be more productive to overcome such costs before they can realise higher profits from additional plants. However, these models do not distinguish greenfield investment from mergers and acquisitions, implicitly treating them as equivalent. Capital reallocation models which separate greenfield investment from mergers and acquisitions have shown that the substantial transaction and conversion costs associated with mergers and acquisitions must be weighed against the advantages of mergers and acquisition over greenfield investment. In particular, mergers and acquisition may bring new revenue streams through additional product variety that may come with acquired plants. In sum, these models predict that high-productivity firms are more likely to expand via external forms of expansion but the relationship between the method of external expansion - greenfield investment or mergers and acquisition - and productivity level is ambiguous and must be empirically tested. In a similar vein, the theory of firm organizational capability and capital reallocation suggest that high-productivity firms are more likely use external forms of contraction, when contracting. However, the relationship between a particular method of external contraction – plant sale or plant closure - and productivity level is unclear and should be empirically tested.

Turning to the impact of firms' choice of expansion on productivity, we use the matching and vintage capital theory to provide predictions. Matching theory suggests that there are substantial reshuffling costs associated with the hiring and firing process of internal expansion that involves finding a good firm-employee match. Mergers and acquisition, on the other hand, provide firms with the opportunity to avoid such reshuffling costs by upgrading the skills of existing workers; sorting and matching of workers across plants and discarding a bad match. However, matching theory fails to account for the productivity difference between greenfield investment and mergers and acquisition. Vintage capital theory has shown that, following a technological shock that allows 'existing' plants to be used more efficiently, mergers and acquisition would be preferred over greenfield investment, which should in turn lead to higher ex-post productivity levels. However, if the technological shock is associated with new technology that is embedded in greenfield plants, firms are more likely to use greenfield investment that should result in greater firm-level productivity. These models therefore, predict that mergers and acquisition should result in higher productivity than internal expansion due to the former resulting in a good worker-firm match without much costly reshuffling process. However, there is no clear-cut prediction as to whether choosing mergers and acquisition would result in higher productivity performance than greenfield investment or vice versa (e.g., Jovanovic, 1979; Lichtenberg and Siegel, 1987; Homes and Schmitz, 1990; Van Biesebroeck, 2003; Han and Rousseau, 2009).

Regarding the impact on productivity of firms' choice of contraction paths, we use the theoretical ideas from uncertainty during organization decline and firm boundary under comparative advantage to offer predictions. The theory of uncertainty during organization decline uses the notion of 'job insecurity' to show that employees may react negatively to the uncertainty caused by the weeding process of internal contraction. In comparison, plant closure can be used to set clear goals with high certainty of job loss outcome that involves a notice period and negotiations with workforce. Plant closure thus, removes the uncertainty of job loss and creates a better environment for employees to improve and innovate. However, this theoretical idea cannot be used to account for any productivity difference between plant closure and plant sale (both external contraction). To do so, we use the theory of firm boundary under comparative advantage. This theory has shown that plants sold are more efficient than closed plants because the former command a higher market price than the latter. As a result, selling plants should result in lower ex-post productivity than closing plants since the former are more efficient that the latter. However, this may fail to hold if potential plant sellers are not willing to sell plants with recent vintage to their competitors. Overall, these models predict that firm's ex-post productivity performance from plant closure should be higher than that of internal expansion, but there is no clear-cut prediction as to whether a particular path of external contraction would lead to a better or worse productivity impact.

The aforementioned theoretical predictions (see chapter two for detailed discussion) are subsequently tested for their empirical validity in chapters four and five. This thesis tests such predictions using data from the Annual Business Survey (ABS, formerly, Annual Respondents Database)[4]; Business Enterprise Research and Development (BERD) database and Annual Inquiry into Foreign Direct Investment (AFDI). All these data are collected by the Office for National Statistics in the UK. First, a firm- and plant-level panel dataset on manufacturing and marketable services was constructed using the ABS database. This dataset was them linked with other panel data covering business research and development (BERD data) and information on foreign direct investment (AFDI data). These data sources are accessible via the UK Data Service by a certified secure lab user.

The most important objective of this thesis is to help fill the gap in the literature by using a combination of relevant econometric techniques to test the validity of theoretical predictions on a detailed panel dataset on a large sample of UK firms. First, the thesis investigates if heterogeneity in productivity levels (and firm-level characteristics) causes firms to differ in the methods chosen to change output. Multinomial logit is used to model the unordered multiple-choice variable of whether to increase output at "own" existing plant (internal expansion), open "new" plant (greenfield investment), or acquire existing plant from "other" firms (mergers and acquisition) based on firm characteristics. For contracting firms, the choice is whether to reduce output at "own" existing plant (internal contraction), close "existing" plant (plant closure), or sell "existing" plant (plant sale). Secondly, using the generalized method of moments (GMM) approach, the thesis examines the productivity impact of alternative forms of adjustment.

Previous empirical studies have used different models such as least squares dummy variable (LSDV) model, within-group fixed effects (WG) least squares models and so on, to estimate productivity via a log-linear production function. However, these models often fail to control for endogeneity and selection bias in the production function specification (see, Battese and Coelli, 1995). As earlier discussed, firms' decision to adjust via external forms of adjustment will be taken on the basis of an assessment of the benefit that will accrue to the firm and this benefit will itself be a function of the characteristics of the firm. In other words, firms may possess certain characteristics such that they achieve better performance (in terms of higher productivity) vis-à-vis internal expanders and/or 'no adjusters' even when they do not adjust via

[4] See chapter three for detailed description of the ARD and how our dataset is constructed.

external forms of adjustment. These characteristics may include better managerial capabilities, organisational skills etc. that are associated with achieving higher productivity and the decision to self-select into external forms of adjustment. To address such self-selection issue, we use system GMM estimator to estimate TFP via a log-linear production function. By allowing for fixed effects, and by using lagged values (in levels and first difference) of the explanatory variables as instruments, system GMM deals with the problem of selection bias and endogeneity of other explanatory variables in our model.

1.4 Thesis Structure

In addition to this introduction, this thesis consists of 5 chapters. The next chapter provides a theoretical and empirical underpinning for firms' choice of adjustment and its effect on productivity. Chapter two is therefore made up of 2 parts. The first part uses firm organizational capability and capital reallocation theory to motivate why firms might choose a particular part of adjustment over another. It also uses matching theory, vintage capital theory, the theory of uncertainty during organization decline and the theory of firm boundary under comparative advantage to offer predictions on the productivity impact of alternative forms of adjustment. The second part of chapter two provides a review of extant empirical literature that has attempted to address the determinants of firm's choice of adjustment. Like the theoretical literature, most empirical papers are limited in the way they are largely unsystematic. For instance, there is a large literature in corporate finance that have considered the determinants of mergers and acquisition and asset sales without comparing them to alternative forms of adjustment such as greenfield investment or plant closures (e.g., Maksimovic and Phillips, 2001; Yang, 2008; Schoar, 2002). As a result, this part is organized into measures that have been frequently used in empirical literature to proxy for productivity and sunk cost of adjustment and to examine the relationship between firm-level productivity and different paths of adjustment. Lastly, in chapter two, we review empirical papers that have analysed the role of firm-level adjustment in explaining productivity levels.

Chapter three begins by describing the key database – the Annual Business Survey (ABS, formerly, Annual Respondents Database) - used for our empirical analyses of chapters four and five. First, a firm- and plant-level panel dataset on manufacturing and marketable services firms/plants was constructed using the ABS database. This dataset was then linked with other panel data covering business research and development (BERD data) and information on foreign direct investment (AFDI data). This chapter then proceeds to explaining how firms are classified into different categories of adjustment. The process involves using local unit and enterprise unit (plant and firm respectively) unique identifiers in the ARD to capture demographic events. A description of each path of adjustment was then provided. Finally, this chapter provides some comparison between firm-level characteristics such as firm size and ownership structure and different channels of adjustment. This showed that firms that rely on external forms of adjustment - greenfield investment and mergers and acquisition for expansion and, plant closure and plant sales for contraction – tend to be larger and UK-owned.

Chapter four addresses the question of whether profit-maximizing firms systematically choose between different paths of adjustment. In particular, this chapter examines the relationship between firms' choice of adjustment and their characteristics that serve as proxies for productivity. The chapter starts by setting out the appropriate econometrics model in which the probability of firms choosing a particular path of adjustment is explained by a set of proxy variables for sunk cost and productivity. Because the dependent variable takes the value 0, 1 and 2 depending on whether a firm expands internally (contracts internally), creates a new plant (closes an existing plant) or acquires an existing plant (sell an existing plant) respectively, the multinomial logit model is employed in this chapter. Our result indicates that large firms tend to rely more on external forms of adjustment than small firms. We also find that firms tend to rely more (less) on external forms of expansion (contraction) when the desired size of adjustment is large. With regards to the firm-level variables used, we find that age, multi-plant ownership and foreign ownership are positively associated with external forms of expansion while R&D is negatively related to the same forms of expansion. For contraction, we find a negative relationship between the probability of using external forms of contraction and firm's age and single-plant ownership. Finally, we find that foreign ownership is positively associated with plant closure while the impact of foreign ownership on probability of plant sale is close to zero.

Chapter five examines the productivity impact of alternative forms of adjustment. We apply the system GMM estimator to overcome 2 sources of bias: the first arises due to the simultaneity of adjustment paths-productivity relationship and the second arises due to the endogeneity of factor inputs (and self-selection of firms in and out of an industry) in the production function. To further strengthen our empirical argument, we use OLS, fixed-effects and Levinsohn-Petrin estimators to highlight the aforementioned simultaneity and endogeneity concerns. We find that these estimators produce unreasonably low capital coefficients, suggesting that the estimators fail to control for simultaneity and endogeneity problems. The result from our preferred system GMM estimator reveals that there is no statistical relationship between adjustment paths and the long-run productivity of firms operating in different sectors (except for plant closure in the high-tech KI service sector). Given our choice of appropriate control groups and the fact that we use the system GMM approach to alleviate endogeneity concerns, we view our finding of no long-run adjustment effect as novel.

Chapter six is the last chapter of the thesis and it provides a summary of the whole study together with some policy recommendation. The chapter begins by setting out the contribution to literature made by this thesis. It then summarises the results from the empirical analyses of chapters four and five. Based on these findings, some policy recommendations are made. Lastly, this chapter offers some suggestions for future research.

1.5 Conclusion

This chapter has introduced and provided a motivation for this thesis on the grounds of understanding the role firm-level adjustment plays in explaining productivity differences. Question was also raised on how firms choose between different forms of adjustment. The thesis uses theoretical studies to justify why one might expect firms to systematically choose between different forms of adjustment and for varying impacts of those choices on productivity. Recent developments such as the greater availability of firm- and plant-level datasets and advances in econometric methods facilitate research in this area. Using annual survey data from the UK, this thesis therefore seeks to address a gap in the literature by analysing i) the way in which firms systematically choose between the different channels of adjustment, and ii) the impact of the choice of adjustment channel on firm's productivity. The thesis use insights from key theoretical models and employ econometric techniques such as multinomial logit and system generalized method of moments (GMM) to test theoretical predictions. The last section of this chapter gave an outline of the subsequent chapters of the thesis.

2 Literature Review

2.1 Introduction

This chapter will review the theoretical and empirical literature on the determinants of firms restructuring and its impact on productivity in order to build expectations of what will be found in our empirical analyses of chapters four and five. Thus, this chapter is made up of 2 parts. The first part discusses theoretical papers and uses the ideas from these papers to generate hypotheses. In other words, we set out what the theoretical literature suggests may be expected from the empirical analyses of chapters four and five. Chapter four tests the microeconomic decisions concerning firms' choice of adjustment. A handful of theoretical models have been developed that provide predictions as to how firms choose between different channels of adjustment, but none has modelled the full set of adjustment paths that are available to firms – i.e., the choice between internal expansion, greenfield investment and mergers and acquisition for expanding firms. As a result, we use insights from key theoretical literatures to provide predictions for our empirical analysis of chapter four. In chapter five, we examine the productivity impact of choosing alternative forms of adjustment. The first part of this chapter also draws on different theoretical literatures to generate hypotheses regarding the impact of different paths on adjustment on productivity.

The second part of this chapter focuses on reviewing empirical literature. Empirical papers that have attempted to address how firms choose between alternative forms of adjustment have also been less systematic, often considering firm's choice of adjustment as dichotomous i.e., firms' choice between greenfield investment and mergers and acquisition. However, empirical literature has found firm-level variables such as size and ownership structure to be associated with their chosen path of adjustment. As such, the second part of this chapter surveys firm-level variables that have been frequently documented in literature to play a role in determining firms' choice of adjustment. This will help to provide lessons on how to empirically estimate the determinants of firm's adjustment in chapter four and point us to variables that are likely to proxy for productivity and sunk costs (i.e., the factors that theory predicts drives firms' chosen path of adjustment). The second part of this chapter also review empirical papers that have studied the impact on productivity of alternative forms of adjustment. The final part of this chapter concludes.

2.2 Theoretical Review and Hypotheses

This section will begin by reviewing theoretically papers that suggest how firms might systematically choose between different forms of adjustment. This will provide guidance on how to empirically estimate firms' choice of expansion and contraction paths in chapter four. It will then turn to theoretically motivating the impact on productivity of choosing alternative forms of adjustment. This will be useful in giving a priori expectation for chapter five which investigates the productivity impacts of choosing different paths of adjustment.

2.2.1 Theoretical Motivation for Choice of Expansion and Contraction Channels

Firms facing increased demand or a fall in production cost may obtain additional revenue from increased production and incur additional cost as a result of the expansion process (Baumol, 1962)[5]. The amount of additional revenue and cost from expansion depends, in turn, on the path of expansion chosen. Internal (or workforce) expansion increases revenues from expanding outputs of the firm (assuming output prices are fixed) but raises labour cost (wages multiplied by labour quantity) especially for large expanding outputs due to diminishing marginal product of labour from fixed capital and increasing labour quantity. Firms can, on average, reduce labour cost through new greenfield technology, but greenfield investment that achieves average labour cost reduction is costly i.e., the large sunk set-up cost of building new plants. So, the sunk set-up cost of greenfield investment mitigates the increased profit resulting from labour cost reduction. Similarly, the substantial restructuring such as workforce reduction (i.e., Shleiffer and Summers, 1988) and divestitures (i.e., Kaplan and Weisbach, 1992), that often follows mergers and acquisitions can be used to reduce average labour cost and thus increase profit. However, profit is reduced by the large transaction costs associated with searching and paying for suitable plants and conversion costs to overcome the lack of fit between the 2 organisations. If new product varieties are attached to acquired plants, mergers and acquisitions may bring additional revenue through product variety. Both greenfield investment and mergers and acquisition may lead to efficiency loss associated with dedicating a firm's (fixed) organizational capital such as managerial resources on too many plants. There are similar adjustment costs and revenue when firms need to contract. Ultimately, the decision that the firm faces is to choose the path of adjustment that maximizes

---

[5] An alternative view posits that firm's expansion decisions are driven by opportunistic agents (usually salaried managers), who attempt to distort the profit-maximization motive for their personal needs and ambition (See, Baumol, 1959; Jensen and Meckling, 1976; and Jensen, 1986). However, the personal ambition and profit-maximization motive may become equivalent if salaried managers can successfully retain and reinvest profits in the firm. In these settings, the successful expansion of the firm from reinvested profits satisfies managerial personal needs for higher salaries, power and prestige (Penrose, 1959).

profit, given the different revenue streams (e.g., additional revenue from mergers and acquisitions) and more importantly different costs associated with each path of adjustment (e.g., greenfield investment involves large sunk costs while mergers and acquisition involves substantial transaction costs).

A handful of theoretical models (e.g., Jovanovic and Rousseau, 2002; Breinlich and Niemann, 2011a) have been set out to explain the determinant of firms' expansion and contraction path, but none in one integrated setting. Broadly speaking, these theoretical models can be categorized into 2 distinct strands in the corporate finance literature – the theory of organizational capability and capital reallocation theory – with neither theory accommodating all 3 forms of expansion and contraction paths. Despite their difference in details, we use insights from each theoretical study to make predictions on how firms systematically choose between different forms of expansion and contraction.

2.2.1.1 Theory of Firm Organizational Capability

The theory of firm organizational capability (as proposed by Breinlich and Niemann, 2011a) seeks to explain how firms partition a given expansion size between internal and external expansion and how such partition varies across firms with different productivity levels. They do so using a model in which firms must incur a fixed cost of opening/buying plant and they differ in both organizational capital and efficiency but not across the individual plants belonging to a given firm (i.e., productivity heterogeneity across firms but not across plants within the firm). There are 2 premises of this model. The first is that firms must incur a sizeable fixed cost for each plant added to its operation and that these costs must be paid up front. Hence, firms must experience a substantial and persistent increase in demand or fall in costs to be willing to pay for such setup sunk costs[6]. The second premise is that firms must commit some of their fixed organizational capital (e.g., managerial time) on managing additional plant. As they dedicate this organizational capital on managing more plants, the less good they become at managing each of their plants e.g., because of scarce managerial resources (see, Lucas, 1978 and; Schoar, 2002 for theoretical and empirical motivations respectively). However, this inframarginal cost effect (as referred to by Nocke and Yeaple, 2008, 2014) from additional plants increases less quickly for high efficiency firms[7]. Therefore, the impact of adding plants to firm's operation consists of additional revenue from

[6]Clark and Wrigley (1997) argue that the existence of uncertainty over the stability of market prices and perhaps the time it will take to recover the sunk setup cost deters potential acquirers/greenfield investors from immediate acquisition/construction even when an opportunity to make profit is identified. As a result, the perceived opportunity to make profit and cover the sunk set up cost has to be viable over a predetermined time horizon.
[7] Here, organizational efficiency determines the rate at which firms become less productive at managing each plant as they add more plants to their operation, thus reflecting firm-level productivity.

increased production and additional cost from fixed and inframarginal cost of production. As such, there is a trade-off between firm scope and profitability at firm's individual plants.

As demand increases or operation cost falls such that external expansion becomes profitable (i.e., the additional revenue exceeds the fixed and inframarginal cost of adding plants), firms are more likely to increase their number of plants. However, firms that were previously more efficient take better advantage of the increased demand or fall in cost by adding more plants because the inframarginal cost from adding plants rises less quickly for these firms. It follows therefore that more efficient (high-productivity) firms increase their number of plants more strongly in response to a substantial and persistent increase in demand or fall in cost than less efficient (low-productivity) firms. The same firms also shed more plants when cost rises, or there is a substantial fall in demand. This is because the inframarginal benefit – benefit from managing fewer plants due to scarce managerial resources - from shedding plants rises less quickly for high-productivity firm.

The major problem with firms' organizational capability theory is motivated by an empirical observation. In planning an expansion, firms consider 3 principal channels of expansion – internal expansion, greenfield investment and mergers and acquisitions (as shown in figure 1.1 of Chapter 1). Each one of these expansion paths provides firms with different revenue streams and different costs. However, the theory discussed above fails to accommodate all 3 forms of expansion, implicitly treating greenfield investment and mergers and acquisition as equivalent[8]. This theory therefore fails to account for all 3 expansion paths available to firms wishing to expand their productive capacity. There are similar limitations with using this theory to motivate all 3 channels of contraction – internal contraction, plant closure and plant sale. As a result, we incorporate ideas from another theory - capital reallocation theory – to motivate how firms systematically choose between the 3 forms of expansion and contraction.

2.2.1.2 Capital Reallocation Theory

There has been a long tradition in corporate investment of examining firms' choice between different modes of expansion. This literature generally does not distinguish between internal expansion and greenfield investment, referring to them as new capital (or new investment or asset). Similar to the firms' organizational capability theory, capital reallocation theory generally assumes that firms differ in

[8] While greenfield investment and mergers and acquisition both represent expansion in firm's scope, the latter form of expansion often provide firms with an established variety but also requires a substantial transaction cost that must be paid upfront (e.g., Jovanovic and Rousseau 2002; and Spearot, 2012).

their organizational capital and organizational efficiency. Capital (or plant) is required as new technologies emerge with the potential to reduce labour cost and increase profit. There are substantial transaction costs (i.e., negotiation, brokerage, legal, etc.) associated with acquiring capital through mergers and acquisitions as well as further conversion cost; assuming capital is reallocated from less efficient to more efficient firms. However, firms must weigh these costs against the advantages of mergers and acquisition over greenfield investment. The first advantage stems from the assumption that existing plants are less costly than new plants, perhaps due to depreciation. Secondly, it usually takes several periods for new machinery and structures to become productive, while acquisition of another firm's plant can be achieved in a relatively short time. Thirdly, mergers and acquisition may provide firms with access to established variety and established market assuming these come with acquired plant[9]. As a result, purchasing existing plants from other firms for use in a new technological climate and/or to serve new markets can be less costly, less time consuming and/or more profitable than building a new plant. However, firms must pay the aforementioned transaction and conversion costs upfront before they can enjoy additional benefit from mergers and acquisitions.

The pioneering work of Jovanovic and Rousseau (2002) was the first to theoretically model this idea. They extend Hayashi (1982) Q-model of investment to accommodate mergers and acquisitions and analyse the effect of technological changes on firms' decision to seek new or existing capital. Jovanovic and Rousseau (2002) allow firms to differ in their organizational capital and technological adaptability choosing different levels of capital stock when there is a change in technological possibilities. Changes in technological climate lead firms to expand and contract as their profitability changes. Firms with low organizational capital and organizational efficiency i.e., low-profitability firms can improve their average productivity of capital by selling plants. However, in response to improved profitability, firms with high organizational capital and organizational efficiency have the option of expanding through greenfield investment or mergers and acquisitions. Mergers and acquisition involves a substantial transaction cost but the relative price of acquired plants is cheaper than newly built plants. Therefore, firms with improved profitability must weigh the additional transaction costs of mergers and acquisition against the cost savings from purchasing cheaper plants. Firms with the highest improved profitability seek proportionate increase in their capital stocks that are large enough to overcome the transactions costs associated with mergers and acquisition. When this happens, these high-profitability firms, being the

[9] These advantages reflects the difference in prices (Jovanovic and Rousseau 2002; and Warusawitharana, 2008), timing (Kydland and Prescott, 1982; and Koeva, 2000) and product attribute (Sweeting, 2010; and Spearot, 2012) in different forms of capital investment.

ones with the best organizational capital and organizational efficiency, can pass down their management skills and technological adaptability to their target's plant; thereby facilitating their transition back to the technology frontier.

Warusawitharana (2008) extends Jovanovic and Rousseau (2002) idea to show that firm size, in addition to profitability is a key determinant to asset purchases and sales. The author assumed that transaction costs associated with mergers and acquisitions vary with the size of the capital purchased from other firms. As firms purchase a larger amount of capital (plants) from other firms, the unit transaction cost declines (i.e., a transaction cost function that displays economies of scale). The concave transaction cost and the relative price of purchasing plants from other firms impact the optimal choice of capital. Following a positive demand shock, firms with low improved profitability will seek low levels of investment and build plants because for low levels of investment, the concave transaction costs associated with mergers and acquisitions exceeds the cost savings from purchasing existing plants. For firms with high improved profitability seeking to make high levels of investment can do so by purchasing existing plants from other firms, as the cost savings from purchasing such plants exceeds the transaction costs involved. Thus, high-profitability firms are more likely to purchase existing plants from other firms. However, large firms take better advantage of increased demand and profitability by acquiring more existing assets since they are better at integrating existing assets than small firm (this is similar to the assumption that inframarginal cost effect from additional plants increases less quickly for high efficiency firms in Breinlich and Niemann, 2011a, model).

Spearot (2012) also reached a similar conclusion by allowing firms to differ in productivity levels as they operate at different demand elasticity and assuming that firms can invest in both process innovation – the reduction of marginal cost on existing varieties – and product innovation – the addition of new varieties. In these settings, firms are recognized as brands and varieties within a brand are closer substitutes than varieties across brands i.e., MacBook laptop is a closer substitute for MacBook Pro than for Sony Vaio. This implies that expansion within the firm cannibalizes demand for existing products while expansion in another variety mitigates such cannibalization allowing firms to make additional profit from added variety. Additional established variety attached to plants acquired from other firms reduces the cannibalization effect, implying that profit from mergers and acquisition exceeds profit from greenfield investment. However, the profit differential is heightened for high productivity firms because they operate on the less elastic portion of the demand curve by making varieties that are imperfectly substitutable within the firm.

By contrast, Breinlich and Niemann (2011a) build a model that predicts that the most efficient firms are more likely to use greenfield investment over mergers and acquisition. There are 2 premises in their model. The first is that 'acquired' capital in relatively more profitable in the mergers and acquisition market than 'new' capital because existing output is attached to the former while new capital contains no output. As a result, purchasing existing capital from a mergers and acquisition market is more profitable than capital from greenfield investment, as the former comes with additional output. The second premise is that, in a mergers and acquisition market, an acquiring firm must incur a capital conversion cost of converting inferior technology in acquired capital into technology that is in line with its existing capital[10]. An expanding firm must therefore, weigh the additional output from acquired capital against the cost of converting inferior technology in such capital[11]. Following a positive shock that increases profit-maximizing output level, firms are more likely to acquire capital (or plant) if the revenue from additional output in acquired plant exceeds the cost of converting its technology. However, the new profit maximizing output level differs between firms with different efficiency level with less efficient firms requiring more plants to reach the new profit-maximizing output level. Therefore, less efficient firms will seek more plants from the mergers and acquisition market since plants in this market are cheaper (or possess additional output) than greenfield plant. Furthermore, less efficient firms seeking to acquire plants in the mergers and acquisition market operate plants with closer technological frontier to target's plants such that these less efficient acquirers need to spend less on conversion cost. It follows, therefore, from Breinlich and Niemann (2011a) model that less efficient firms are more likely to acquire plants.

The capital reallocation theory of Jovanovic and Rousseau (2002) and Warusawitharana (2008) also predict that less-efficient firms are more likely to engage in plant sales than more-efficient firms. Indeed, Jovanovic and Rousseau (2002) predict that in response to reduced profitability, least profitable (i.e., low-productivity) firms would seek proportionate reduction in their capital stock and engage more strongly in plant sales because, for large capital sales, the proceeds from such sales exceeds the transaction cost associated with searching for and negotiating with suitable buyers. Warusawitharana (2008) also reached a similar conclusion, however, the author also showed that, following such negative

[10] This stems from the assumption that acquirer's capitals are superior to targets capital.

[11] Their model also assumes that a firm cannot expand and contract simultaneously. Instead, firms receive different shocks that separate them into expanding and contracting firms with each category faced with the decision of whether to participate in a merger and acquisition market or expand (contract) via greenfield investment (plant closure)

demand shock, large firms are more likely to find themselves with too many plants than optimal and are therefore, more likely to engage in plant sales than small firms.

The existence of capital conversion cost may induce potential acquirers in the mergers and acquisition to seek plants that are of recent vintage; making it difficult for low-productivity firms to sell their plants. For instance, Han and Rousseau (2009) argue that there are conversion costs associated with adding plants to firm's operation which reduces the gains from additional plants (i.e., from added variety) to a point where an acquisition is forgone when there is a large difference between an acquirer's technology and its potential target. As a result, an acquiring firm may only seek to buy plants that have vintage technology and are closer to their technological frontier in order to avoid the substantial cost of converting plants with inferior technology into one that is in line with their operated plants. Indeed, Breinlich and Niemann (2011a) show that acquirers are always seeking plants with closer technology frontier to their own, such that they would need to spend less on integrating technology in acquired plant. An implication of such prediction is that it is the more productive firms with vintage plants that potential acquirers are looking to buy, that are more likely to sell plants in the mergers and acquisition market.

2.2.1.3 Summary and Hypothesis

In this section, we review the firm organizational capability and capital reallocation theory to generate testable hypotheses on how firms choose between the different paths of adjustment. Firms must choose the path of adjustment with the best overall profit subject to different adjustment paths characterized with different revenue streams and most importantly, different costs. According to the firms' organizational capability theory, there are fixed and inframarginal costs associated with adding and shedding plants, which implies that unless firms experience a substantial and persistent increase/reduction in demand or fall/increase in costs, internal adjustment will remain a preferred mode of adjustment. Thus, only ample productivity and/or demand shocks that make external adjustment profitable would see a firm increase/reduce its number of plants. When this occurs, firms that were previously more efficient take better advantage of the increased (reduced) demand or fall (increase) in cost by adding (shedding) more plants because for these firms, inframarginal cost (benefit) from adding (shedding) plants rises less quickly. In the event of weighing further transaction and/or conversion costs associated with acquired plants in the mergers and acquisition market against the additional output (proceeds) in acquired (sold) plant, the relationship between firms' choice of external adjustment and their productivity levels may be ambiguous. These costs and productivity implication lead us to our first 2 hypotheses:

Hypothesis 1: More efficient firms are more likely to expand through greenfield investment and mergers and acquisition – the 2 forms of external expansion. However, it is difficult to predict, a priori, whether the most efficient firms are more/less likely to choose greenfield investment over mergers and acquisition or vice versa.

Hypothesis 2: More efficient firms are more likely to contract through plant closure and plant sale – the 2 forms of external contraction. However, it is difficult to predict, a priori, whether the most efficient firms are more/less likely to choose plant closure over plant sale or vice versa.

Crucial to the theoretical models reviewed above is the assumption of productivity heterogeneity across firms but not across the plants belonging to a firm. When heterogeneity occurs across firms and plants, there is no simple productivity-based rule for predicting expansion and contraction paths (e.g., Whinston, 1988; Gibson and Harris, 1996). For instance, Maksimovic and Phillips (2002) build a model in which productivity heterogeneity exists across firms as well as across the plants belonging to a firm. In their model, firms differ in both organizational capital and efficiency and, plants that are operated in a firm's core business are more productive than plants that are operated in its peripheral division. A profit-maximizing firm optimizes size by choosing to operate number of plants at the point where the marginal product of operating the marginal plant is equal to the opportunity cost of selling and/or closing the plant. A positive industry shock has 2 effects on a firm. First, it increases the productivity of each plant in the industry. Second, it increases the opportunity cost of running marginal plant for less efficient firms because plants can be redeployed elsewhere more profitably. Therefore, following a positive industry shock that makes firms' marginal plant productivity to exceed their opportunity cost, firms must acquire/build plants until their optimal size is established.

However, the same industry shock has a greater effect on the plant productivity (opportunity cost) of firms who are initially more (less) productive. As a result, the more productive firms will add a larger proportion of plants to their core business because the increase in the productivity of plants that operate in their core business is higher relatively to less efficient firms operating plants in the same industry. Furthermore, firms that are less efficient in operating marginal plants have less incentive to increase their number of plants because plants are better utilized elsewhere. By contrast, if the positive industry shock occurs in the industry where the more productive firm is operating plants in its peripheral division – i.e., it is less efficient at managing a larger number of plants in this division even though it is overall, more productive - the more productive firm will add a smaller proportion of plants to its operation. This implies that more efficient firms are more (less) likely to increase their number of plants in their core (peripheral) business than less efficient firms. Such prediction (alongside the ones above) become more complicated if, in addition to firm heterogeneity, we allow plant heterogeneity that extends beyond the classification of core and peripheral division.

2.2.2 Theoretical Motivation for the Impact of Expansion Channels on Productivity

Sections 2.2.1 offered a number of different theoretical explanations as to why firms choose different forms of expansion. It shows that firms' decision to choose a path of expansion that maximizes profit is based the different revenue streams and costs associated with each path of expansion as well as firm productivity levels. This section turns to the consequences of choosing different expansion paths on productivity. We argue that the endogenous sorting of firms across different paths of expansion is a major determinant of productivity.

The ability of firms to expand to rising demand or falling cost is an important factor that affects their organizational efficiency (or productivity)[12]. The gain or loss in organizational efficiency in turn, depends on the path (or mix) of expansion chosen. Internal (or workforce) expansion raises productivity from higher labour quality (assuming productive workers are hired and the standard labour input in the production function specification does not capture this). However, the existence of information asymmetry between firms and workers may lead to continuous reshuffling before productive workers are found. Such reshuffling is likely to involve significant costs, not least because of the potential stringent labour laws that may prevent employers from terminating and/or negotiating labour contracts with employees. Mergers and acquisition, on the other hand, can be used to redraw boundaries by discarding unproductive workers to reduce cost, upgrading skills of existing workers and hiring new worker whose skills better suit the new organization. Similarly, a greenfield plant that requires the implementation of new production process would likely increase firm's demand for educated workers, because highly-educated workers are likely to have a comparative advantage in helping the firm adapt new technology. When this happens, the newly adapted technology in greenfield plants should lead to an increase in firm-level productivity. Ultimately, the overall contribution of expansion to the changes in

[12] The most basic producer theory says that profit maximizing firms minimizes their costs of producing their chosen quantity.

firm-level productivity depends on the path of expansion chosen, given the different efficiency gains and costs associated with each path of expansion.

Although in no integrated setting, there are theoretical models that offer explanation to the varying consequences of expansion choice on productivity. Broadly speaking, these explanations can be categorized into 2 distinct strands – the “matching” theory and “vintage capital” theory. The matching theory literature uses the notion of ‘fit’ to argue that differences in labour quality and thus, productivity, between internal and external expansion is due to the existence of incomplete information in labour market. This theory is therefore concerned with offering explanation for the disparity in productivity performance between internal and external expansion, whereby the latter refers to greenfield investment and/or mergers and acquisition. The vintage capital theory, on the other hand, distinguishes the productivity performance of greenfield investment and mergers and acquisition. However, vintage capital theory often ignores the productivity impact of internal expansion. Consequently, neither the matching theory nor vintage capital theory accommodates all 3 forms of expansion in one integrated setting. Despite their difference in details, we use insights from each theoretical study to provide lessons on how to empirically estimate the impact of expansion channels on productivity.

2.2.2.1 Matching Theory

There has been a long tradition in labour economics of examining the impact of worker-firm match on worker turnover. Early theoretical works were particularly concerned with how job matching was related to labour productivity, and thus wages and career potentials. According to this view, workers are well suited to a certain job or firm and if they are matched to jobs that best suit their skills, they receive higher wages and are less likely to quit their jobs. This idea was first theoretically modelled by Jovanovic (1979). Jovanovic (1979) assumed worker-firm match as an experienced good, whose characteristics are initially uncertain and are gradually revealed over time by output performance. The model hinges on 3 main assumptions. The first is that each worker performs different jobs with different productivities. The same is true for employer – for each task that the employer needs to assign, different workers have different productivities. The second assumption is that employers and workers can bargain over wage contract on an individual basis, with employers that are satisfied with their match willing to pay a worker relatively more than employers that are unsatisfied. This creates a reward structure that provides signal for the attainment of optimal matches. The third assumption is that both employers and workers have imperfect information about the exact location of the most productive match. As employers and/or workers continuously observe the output performance of a particular match, they incorporate this information into wages, and reassess it against alternative opportunities offered by the market. Thus, the model predicts that if a worker is employed in the right job or organization, a good match will result with positive consequences for both the organization and the worker's career.

Taking this approach further, Lichtenberg and Siegel (1987) outlined a matching theory of ownership change that focuses on how the quality of the fit between heterogeneous plant sellers and acquirers is reflected in the productivity of the acquirer. Similar to the Jovanovic (1979) model, acquirers have incomplete information about the true levels of efficiency of heterogeneous plants before acquisition with more precise information about the quality of the plant developing as the acquirer operates the plant. As acquirers continuously observe the true productivity of a given plant, they incorporate this information to determine whether to maintain or abandon the ownership of the plant. In other words, if a plant is matched with the right acquirer, a good match will result with improvement in the acquirer's productivity. In a modified framework, Homes and Schmitz (1990) included a human capital dimension that is related to the quality of the manager to show how high-quality managers acquire firms that would implement high quality projects based on new ideas.

None of these studies explicitly consider the impact of choosing external expansion – greenfield investment and/or mergers and acquisition - over internal expansion, on productivity. However, we can extend the logic of this theory to generate a testable hypothesis. Consider a firm facing increased demand or fall in cost with the overall aim of expanding its workforce and improving efficiency. Internal expansion may be used to employ new productive workers as well as layoff unproductive ones, thereby increasing the firm's overall workforce and improve efficiency level. However, an implication of the matching theory is that firms have incomplete information about potential employees' productivities which could result in continuous reshuffling before the right match is found. Such reshuffling is likely to involve significant costs, not least because of the potential stringent labour laws that may prevent employers from terminating and/or negotiating labour contracts with employees. On the other hand, external expansion such as mergers and acquisition presents an opportunity for acquirers to improve the sorting and matching of existing workers across plants. The change in corporate ownership that often follows merger and acquisition can be used as a mechanism to upgrade skills of existing workers, match those skills with appropriate plants and discard unproductive workers. Mergers and acquisition therefore, constitutes an opportunity to avoid the hiring and retrenchment costs associated with internal expansion because it matches existing employees to jobs that best suit their skills. This discussion suggests that external expansion, in particular, mergers and acquisition should result in higher productivity than internal expansion, due to the former resulting to a less costly worker-firm match.

2.2.2.2 Theory of Vintage Capital

In the previous section, we used the existence of incomplete information in labour market to motivate the disparity in productivity performance between internal expansion and mergers and acquisition. In this section, we turn to capital vintage theory for an explanation for disparity in the productivity performance between greenfield investment and mergers and acquisition. While greenfield investment may also involve significant reshuffling cost associated with the process of matching workers into greenfield plant, we draw instead, on the possible variation in capital vintages to separate the productivity performance between greenfield investment and mergers and acquisition.

To make predictions about the relative productivity levels of greenfield investment and mergers and acquisition, it is helpful to consider the motive of the firm when undertaking such investments. Firms have 2 options – greenfield investment or mergers and acquisition – when seeking to expand externally. As shown extensively in section 2.2.1.2, firms' choice of external expansion depends on the relative costs and revenues of both expansion paths and firm-level productivity. Specifically, we use the capital reallocation theory of Jovanovic and Rousseau (2002), Warusawitharana (2008), Spearot (2012) to show that more efficient firms are more likely to acquire existing plants than build a new one when there is a technological shock that allows plant to be used more efficiently. However, these firms will acquire plants with superior productivity levels and technological characteristics that are closer to their own. Otherwise, they face excessive costs in modifying and adapting technology in acquired plants that are far more inferior to the plants they operate. As such, plants acquired through mergers and acquisition will be a self-selected group of the population of plants. When this happens, these high productivity firms, being the ones with the best organizational capital and efficiency, can pass down their management skills and technological adaptability to acquired plants; thereby facilitating their transition back to the technology frontier. This implies that mergers and acquisition may well lead to higher productivity levels than greenfield investment.

If, however, the technologies in existing plants are far too inferior to the plants operated by potential acquirers, they may seek greenfield plants with better technology that are closer to their operated plants (e.g., Breinlich and Niemann, 2011a; Han and Rousseau, 2009). Similarly, a technological shock that is associated with new technology that increases capital use and is embedded in greenfield plants, may induce firms to choose greenfield investment over mergers and acquisition (e.g., Van Biesebroeck 2003)[13]. This implies that greenfield plants may well have higher productivity than acquired plants because the former increases capital use and capital-biased technical change.

2.2.2.3 Summary and Hypothesis

In this section, we review the matching theory and vintage capital theory to generate a testable hypothesis on the consequences of choosing different paths of expansion on productivity. Beginning with the overall aim of expanding capacity and improving efficiency, firms must choose the path of expansion that increases efficiency with the lowest possible cost. There is organizational efficiency associated with higher labour quality (assuming productive workers are hired and the standard labour input in the production function specification does not capture this) from using internal expansion. However, according to the matching theory, there are significant costs associated with the matching process of internal expansion because it involves the continuous reshuffling of workers before an appropriate match can be found. Mergers and acquisition, on the other hand, can be used to avoid the substantial reshuffling cost associated with internal expansion by matching existing employees to plants that best suit their skills. Firms may acquire plants for different reasons to those that motivate greenfield investment (in terms of whether a technological shock is associated with new technology that is embedded in greenfield plant or if there is a technological shock that allows existing plants to be used more efficiently). These differences in motives are likely to play an important role in determining firm-level productivity. For instance, a technological shock that allows existing plants to be used more efficiently is likely to lead to a mergers and acquisition, which in turn increases firm-level productivity. On the other hand, if a technological shock is associated with new technology that is embedded in greenfield plants, firms are more likely to use greenfield investment, which should result in higher firm-level productivity. This leads us to our third hypothesis:

Hypothesis 3: The productivity performance from external expansion, in particular, mergers and acquisition should be higher than that of internal expansion. However, it is difficult, to predict, a priori, if a particular path of external expansion leads to a better or worse productivity impact.

[13] Van Biesebroeck (2003) showed that new capital will be preferred when firms seek to shift to 'lean' technologies that uses capital more intensively and is characterized by easier substitution between capital and labour i.e. it has a larger elasticity of substitution between capital and labour. This coincides with the notion that, in the automobile industry, lean technology is more flexible and relies less on standardization.

2.2.3 Theoretical Motivation for Impact of Contraction Channels on Productivity

The previous section theoretically motivates the consequences of choosing different expansion paths on productivity. This section turns to the productivity impact of alternative forms of contraction. It draws on a number of literatures on downsizing and plant closure to provide predictions on the productivity impact of choosing a particular path of contraction over another.

The ability of firms to contract to falling demand or rising cost is an important factor that affects their organizational efficiency (or productivity). The gain or loss in organizational efficiency in turn, depends on the path of contraction chosen. Internal (or workforce) contraction will lead to loss of output. However, if the loss of labour input falls faster than the loss of output, then (labour) productivity will increase. Internal contraction that involves the elimination of unproductive workers and unnecessary levels of management (delayering) and leads to loss no useful output will result in productivity increase. However, the threat of job loss during the weeding process of who should remain and who should leave may have an adverse effect on workers' behaviour and attitude. If employees feel that their future employment is insecure, they may react by reducing job involvement commitment and effort, all of which reduces organizational efficiency (e.g., Rosenblatt and Ruvio, 1996; McFarlane Shore and Tetrick, 1991; Littler et al., 2003a). Internal contraction could also reduce firm efficiency due to low morale and commitment from employees that remain in the organization after the process of downsizing – survivor syndrome (cf. Brockner 1988, 1992). Plant closure, on the other hand, can be used to set clear goals that are defined by a closedown process which involves a notice period and a countdown period. This removes the uncertainty associated with firms' downsizing decisions and creates an environment that is more conducive to the cognitive process of forming new goals. Similarly, a plant sale that involves a deal announcement would likely reduce any prolonged uncertainty about job loss. When this happens, workers can operate in an environment that is free of uncertainty which in turn, allows them to increase commitment and effort. Ultimately, the overall contribution of contraction to the changes in firm-level productivity depends on the path of contraction chosen, given the different efficiency gains and costs associated with each path of contraction.

A handful of theoretical ideas have been set out to explain the varying consequences of contraction choice on productivity, but none in an integrated setting. Broadly speaking, these theoretical ideas can be categorized into 2 separate strands – the theory of uncertainty during organization decline and the theory of firm boundary under comparative advantage. From the theory of uncertainty during organization decline, this thesis uses the notion of 'uncertainty' to argue that differences in productivity impact between internal and external contraction is due to the certainty of job loss that is associated with plant closure and/or plant sale which contrasts with the uncertainty of job loss that internal contraction imprints. This theory is therefore, used to offer explanation for the disparity in productivity performance between internal and external contraction, whereby the latter often refers to plant closure. On the other hand, the theory of firm boundary under comparative advantage is used to offer explanation for the productivity difference between plant closure and plant sale (both external contraction). However, this theoretical idea ignores the productivity impact of internal contraction. Consequently, neither the theory of uncertainty during organization decline nor the theory of firm boundary under comparative advantage accommodates all 3 forms of contraction in one integrated setting. In spite of their difference in details, we use insights from both theoretical ideas to provide lessons on how to empirically estimate the impact of contraction channels on productivity.

2.2.3.1 Uncertainty During Organizational Decline

In a standard organization decline literature, the impact of an organizational downsizing on their post-restructuring performance depends upon workers reactions to employment conditions during and after the organizational change. Early researchers were particularly concerned with how workers react to threats of losing their jobs. According to this view, workers react to the threat of job insecurity following firms' downsizing decisions and their reactions have consequences for organizational efficiency. This idea was motivated by Sverke et al. (2002). Although, less formalized into a theoretical model, Sverke et al. (2002) assume that employees perceive certainty of job loss differently to the uncertainty of job insecurity which influences employees' reactions and behaviour towards the organization. Their theory hinges on the assumption that unlike job insecurity, actual job loss is immediate and it relieves workers from the major stress of uncertainty. In other words, uncertainty separates job insecurity from actual job loss. Employees who feel that their future employment is insecure during corporate downsizing, reduce job involvement (e.g., Rosenblatt and Ruvio, 1996; Grunberg et al., 1998) and organizational commitment and efforts (e.g., McFarlane Shore and Tetrick, 1991; Armstrong-Stassen, 1993; Littler et al., 2003a) which in turn, has a negative effect on organizational performance. Even workers, who retain their jobs following corporate downsizing, are not spared as such activity may increase their workload thereby reducing morale, commitment and job satisfaction (cf. Brockner 1988, 1992). Thus, this theoretical idea predicts that there are negative corporate performances associated with employees' perception of job insecurity that involves prolonged uncertainty about the future. There are similar negative performance outcome among survivors due to a variety of psychological states and behaviour (i.e., guilt, anger and relief) exhibited by workers who remain in the firm after the process of downsizing – survivor syndrome.

Although, the theoretical idea discussed above does not explicitly consider the impact on productivity, of choosing external contraction – plant closure and/or plant sale - over internal contraction, we use the details to generate a testable hypothesis. Consider a firm facing reduced demand and/or rise in cost with the overall aim of contracting its workforce and improving efficiency. Internal contraction may be used to deploy unproductive workers as well as eliminate unnecessary levels of management (delayering) such that overall workforce is reduced and efficiency level improves. However, an implication of the theory of uncertainty under organizational decline is that employees react negatively to the uncertainty caused by the weeding process of who should remain and who should leave. Such uncertainty associated with employees' perception of job insecurity often leads to lower performance following the process of internal contraction (e.g., Sverke et al., 2002). Internal contraction can lead to further negative performance outcome due to low morale and commitment exhibited by employees who remain in the organization after the process of downsizing – survivor syndrome (e.g., Cameron et al., 1993; Littler et al., 2003b; Littler and Innes, 2004). In comparison, external contraction such as plant closure often constitute clear goals that are defined by a closedown process which involves a notice period and a countdown period. During the closedown process, negotiation occurs in which the workforce seeks to achieve redundancy and other benefits with high certainty of job loss outcome which may create an environment that is more conducive to the cognitive process of creating new goals.

Researchers have also pointed to the diminished management control during a closedown period as a main driver for performance improvement. During the process of plant closure, managers become busy in running negotiations with labour unions, government, and the municipality etc., therefore, reducing control over daily operations. Such diminished management control in the day-to-day operation of the firm increases operative space for workers which in turn, allows worker to go beyond previously established routines and procedures (cf. Hansson, 2008, 2011). Central to this argument is that reduced management control that gives employees unrestricted autonomy allows employees to practise their innovative skills and improve their work methods. Productivity, therefore, increases as a result of enhanced worker innovativeness and efforts. These ideas thus, suggests that external contraction, in particular, plant closure should result in higher productivity than internal contraction, due to the negotiations that follow the certainty of job loss thereby, creating a better environment for employees to improve and innovate.

2.2.3.2 Theory of Firm Boundary Under Comparative Advantage

The previous section explains the existence of disparities in productivity performance between internal and external contraction. It shows that the productivity impact of external contraction should be higher than internal contraction because the former creates a perception of job insecurity among employees which reduces employees' morale and commitment. Although, the uncertainty of job loss during organizational decline can be used to provide support for the disparity in productivity performance between internal and external contraction, it cannot be used to account for any productivity difference between plant closure and plant sale (both external contraction). To argue for a disparity in the productivity performance between plant closure and plant sale, this section uses the theory of firm boundary under comparative advantage.

The theory of firm boundary under comparative advantage as proposed by Maksimovic et al. (2011) states that, firms retain plants in which they have a comparative advantage in operating and sell or close other plants after a merger. The main reason for this boundary resetting is that mergers and acquisitions requires the acquisition of 'bundled' plants each with varying degrees of fit with the acquirers' core competence – a variety in which the marginal cost of production is lowest. Thus, firms must acquire 'bundled' plants even if they are ex-ante interested in a subset of plants acquired. After the acquisition of 'bundled' plants, firms can then disassemble plants and decide whether to retain, sell or close acquired plants. Firms will work down the pecking order by first retaining plants that operate in its core business as these plants are the ones with the lowest marginal cost and thus highest expected profit. Then the firm will move on to selling plants that operate in its peripheral divisions –plants with high marginal cost of production - but have high market price or are worth more as part of another organization than as part of the owned organization (e.g., John and Ofek, 1995). Finally, the firm will close plants that are peripheral to its operations and command no market price. This theory therefore, predicts that following a merger and acquisitions, firms dispose plants that operate in its peripheral divisions. However, among the cohort of plants that are disposed, firms sell plants that command a market price and close those without a market value or where their market value is below the search and transaction cost of selling them.

Although the theory discussed above was considered in the context of post-merger restructuring, we extend the idea to make predictions about disparity in the productivity performance between plant closure and plant sale. Consider a firm facing a substantial fall in demand and/or rise in cost such that it needs to carry out a large disinvestment by disposing plants with reduced profitability i.e., plants that operate in its peripheral division[14]. An implication of the theory of firm boundary under comparative advantage is that firms will dispose of plants by selling those that command a market price and closing those without a market value or where the cost of searching and transacting with potential buyers exceeds the market value. This theory thus, suggest that when a firm is looking to dispose some of its plants due to low profitability, it works down the pecking order by selling plants with low profitability but high market price and closing plants with low profitability and low/no market price. According to this theory, one would expect plants sold to be more efficient than plants closed since the former has a higher market value than the latter. Therefore, selling plants should result in lower productivity than closing plants since plants sold are more efficient than plants closed. However, this may fail to hold if potential sellers are not willing to hand their rivals a competitive advantage by selling plants with recent vintage to their competitors. Even when a plant has a high market value, a firm may choose to close the plant if there is no secondary market for the plant (i.e., Clark and Wrigley, 1997).

2.2.3.3 Summary and Hypothesis

In this section, we review 2 theoretical ideas – the theory of uncertainty under organizational decline and the theory of firm boundary under comparative advantage - to generate a testable hypothesis on the effect on productivity, of choosing different paths of contraction. We Begin with the overall aim of contracting capacity and improving efficiency, firms must choose the path of contraction that increases efficiency with the lowest possible cost. Internal contraction can be used to eliminate unproductive workers and unnecessary levels of management (delayering) such that overall workforce is reduced and efficiency level increases. However, an implication of the theory of uncertainty under organizational decline is that employees react negatively to the uncertainty caused by the weeding process of who should remain and who should leave.

Plant closure, on the other hand, often constitutes clear goals that are defined by a closedown process which involves a notice period and a countdown period. During the closedown process, negotiation occurs in which the workforce seeks to achieve redundancy and other benefits with high certainty of job loss outcome. When this happens, a new working environment that allows cognitive process of creating new goals and for employees to improve is created. This suggests that external contraction, in particular, plant closure, should result in higher productivity than internal contraction due to the

[14] This is equivalent to the post-merger restructuring of Maksimovic et al. (2011) where firms suddenly find themselves operating more plants than they require after a merger and they have to redraw their boundaries by selling and/or closing some plants.

negotiations that follow the certainty of job loss during a closedown process, which in turn, creates a better environment for employees to improve and innovate. Assuming there is a negative demand and/or supply shock that requires a firm to dispose some plants with reduced profitability. The firm will do so by selling plants with low profitability but high market price and close plants with low profitability and low/no market price. This implies that plants sold, being the ones with higher efficiency level and therefore, higher market price, will lead to lower ex-post productivity of the firm than plants closed. If, however, firms do not find a secondary market for their less profitable but efficient plants, they may decide to close plants with high market value and efficiency. This leads to our fourth and final hypothesis:

Hypothesis 4**:** The productivity performance from external contraction, in particular, plant closure should be higher than that of internal contraction. However, it is difficult to predict, a priori, if a particular path of external contraction leads to a better or worse productivity impact.

2.3 Empirical Literature Review

This section will survey previous empirical literature that has attempted to address the determinants of firms' choice of adjustment and their impact on productivity. It is therefore, divided into 2 main parts. The first part will discuss key factors that are frequently documented in the literature to determine firms' choice of adjustment. The second part will discuss the impact on productivity of each path of adjustment that has been documented in literature.

2.3.1 Major Determinants of Adjustment Paths in Literature

According to Jovanovic and Rousseau (2002), Breinlich and Niemann (2011) and Warusawitharana (2008), firms chosen path of adjustment are determined completely by a combination of adjustments (fixed and variable) costs and firm-level productivity. In empirical counterparts to this, a set of firm-level characteristics such as size and ownership structure have been used to examine firm's choice of adjustment. These firm-level variables can act as proxies for productivity and the various thresholds required for a firm to have positive discounted expected profits from using a particular path of adjustment. These variables could also be close associated with firms' choice of adjustment. While there are differences in the exact path of adjustment considered in literature (i.e., whether firms' choice is between greenfield investment or mergers and acquisition or between plant closure and plant sale) results are for most part robust. Firm-level variables are often related to their chosen path of adjustment. Of these firm-level variables, this section focuses on the most frequently documented in the literature: firm size, adjustment size, age, R&D, ownership and other factors.

2.3.1.1 Firm Size

Firm size has long been recognised to exert a strong influence on their chosen path of expansion. There are several reasons for this. The first explanation lies with firms' growth life cycle. If, as Penrose (1959) assumes, there is a maximum rate at which a firm can hire and train managers, then the opportunities for internal growth will become limited or at least, less profitable for firms as they grow further along their life cycle and become large. Therefore, large firms that might have exhausted their managerial resources and thus, internal growth opportunities may prefer to expand through mergers and acquisition, since acquired firms/plants come with their cadre of managers. As Penrose (1959:126) pointed out "acquisition can be a means of obtaining the productive services and knowledge that are necessary for a firm to establish itself in a new field". Thus, by the time a firm begins to expand externally particularly, through mergers and acquisition, it has already grown to a large firm status by virtue of exhausting its internal managerial resources and capturing a large market share that requires an external expansion. A second reason for a relationship between firm size and their choices of expansion lies with firms' ability to integrate acquired plants. Managers of large firms are more likely to possess the appropriate managerial resources required to integrate acquired units into their business. This idea that larger firms integrate new units more easily than smaller firms has been recently formalized into theoretically models by Jovanovic and Rousseau (2002), Warusawitharana (2008) and Breinlich and Niemann (2011a).

Despite the widespread appeal of Penrose (1959) argument that larger firms are more likely to grow through mergers and acquisition, little empirical work has been undertaken to explicitly test her ideas. Instead, much attention has been focused on her unintentional contribution to resource based view rather than her firm growth theory. The only paper that has empirically examined the relationship between firm size and all 3 forms of expansion paths is by Breinlich and Niemann (2011a). Using a UK dataset created from the Business Structure Database (BSD), the authors employed a multivariate fractional logit regression to study the impact of firm size on their choices of expansion between 1997 and 2005. The authors separated the impact of firm size from expansion size and any sectorial differences in greenfield investment and mergers and acquisition activity such as differences in market concentration. Their results showed that internal expansion declines in importance with firm size while greenfield investment and mergers and acquisition increase in importance with the size of a firm. Their results also revealed that firm size has a larger positive effect on greenfield investment than on mergers and acquisition when comparing the relative coefficient magnitudes between the 2 forms of external expansion. This paper thus, reveals that large firms rely more on external expansion. However, when choosing between the 2 forms of external expansion, large firms rely more on greenfield investment than on mergers and acquisition.

A similar paper by Warusawitharana (2008) uses a panel of firm-level data to explore the relationship between firm size and profitability and their chosen path of external adjustment in US between 1984 and 2004. Warusawitharana (2008) empirical implementation uses multinomial logit regression to test his theoretically predictions that large firms with high profitability are more likely to acquire asset while large firms with low profitability are more likely to sell assets and small firms neither buy nor sell assets. His result showed that size has strong impact on firms' choice of external adjustment with large and profitable firms more like to acquire assets. Although Warusawitharana (2008) failed to distinguish between internal expansion and greenfield investment and thus, did not explicitly consider the impact of firm size on all 3 paths of expansion, it can be inferred from their result that larger firms are more likely to use mergers and acquisition over internal expansion and/or greenfield investment. This contrasts with Breinlich and Niemann (2011a) findings that large firms are more likely to rely on greenfield investment over mergers and acquisition, when choosing between the 2 forms of external expansion.

Firm size is also associated with their chosen path of contraction. Using the firms' growth argument, a large troubled firm is more likely to be further along in its life cycle and therefore, more likely to exhaust its internal contraction option faster than a small firm. As a result, large firms are more likely to use external forms of contraction than small firms (e.g., Penrose, 1959). Furthermore, large firms are more likely to hold a wide range of plants that would stretch their managerial resources and would need to be occasionally reshuffled since the synergies between the various plants are likely to evolve over time following changes in market environment and technological possibilities. For instance, Penrose (1959) argued that the extent to which assets are efficiently managed falls with the diversity of activity undertaken by a firm. Indeed, John and Ofek (1995) showed that over diversification that leads to negative synergies between various assets are likely to be reflected in poor operating performance of a firm. Therefore if, as Berger and Ofek (1995) suggested that firm size may be viewed as a proxy for greater diversification, then large firms are more likely to be over diversified than small firms and size should be positively related with the intensity of external contraction. Finally, large firms may also contract externally as a means of disposing unwanted parts of larger acquisitions (Maksimovic et al., 2011) or as part of a reduction in the scale of their investments when demand fails to meet expectations (Warusawitharana, 2008).

Breinlich and Niemann (2011a) were the first to provide supporting evidence for the relationship between firm size and the 3 paths of contraction. Using BSD data from the UK and employing a multivariate fractional logit regression, they found that large firms rely more on external contraction than small firms. However, the authors found that firm size has no influence on their chosen path of external contraction i.e., the relative coefficient magnitudes between plant sales and plant closure were economically negligible. Other studies have separately analysed the role of firm size in explaining internal contraction (or employee layoff or downsizing), plant sales (or divestment or asset sales) and plant closure (or plant shutdowns or plant deaths). For instance, Hallock (1998) found a positive relationship between firm size and layoff announcement, using a sample of 550 US firms with layoff announcement between 1987 and 1995. Also, Kang and Shivdasani (1997) found that the probability of employee layoffs was significantly higher among larger firms that experienced performance decline between 1988 and 1990 in Japan. Others such as Wagar (1997) and Coucke et al. (2007) have found a similar positive relationship between firm size and the propensity to implement workforce reduction in Canada and Belgium respectively. In contrast, Perry and Shivdasani (2005) and Yu and Park (2006) found no significant relationships between the size of a firm and employee layoffs in US and Korea respectively.

Conflicting findings also characterize the relationships between firm size and the probability of plant closure. Although, Deily (1991) provide evidence of a negative relationship between firm size and the probability of exit, Lieberman (1990) found that increasing firm size raises the probability of plant closure by multi-plant firms but had no effect on single-unit firms. Gibson and Harris (1996) found that plants that shutdown during the period of trade liberalisation in New Zealand were smaller, younger, high costs and were owned by diversified multi-plant firms. This led the authors to argue that plant costs, not firm size, is more important for explaining plant closure behaviour since diversified multi-plant firms were more likely to close (high-cost) plants. There is, however, greater consensus on the relationship between firm size and the probability of plant sales with most studies indicating that plant sales is more prevalent among larger firms. For instance, Warusawitharana (2008) showed that large unprofitable firms are more likely to sell plants than an average firm in his sample, using SDC platinum mergers and acquisition data from the US. On a similar note, Hillier et al. (2009) found that the probability of selling plants increases with the size of a firm in UK. Lastly, Haynes et al. (2003) documented a positive relationship between firm size and the frequency and intensity of selling plants to other firms in UK. In sum, existing literature linking firms' chosen path of adjustment with their size typically report that large firms increasingly rely on external forms of adjustment – greenfield investment and mergers and acquisition for expansion and; plant closure and plant sale for contraction. However, the results from empirical literature relating firm size to their chosen path of external adjustment are mixed.

2.3.1.2 Adjustment Size

External expansion such as mergers and acquisition allow firms to take advantage of economies of scale (scope) by eliminating duplicated indivisible tasks across 2 firms and spreading fixed cost of production across more units of (differentiated) outputs. This argument is frequently used to defend a proposed merger. However, to realise economies-of-scale through mergers and acquisition, firms must first pay upfront sunk-costs of acquiring and integrating firms/plants into their operations. It follows therefore, that the minimum amount of expansion planned by firms will have to be substantially large to cover the upfront sunk-cost of external expansion. For such large expanding output and/or employment, a firm can also achieve lower (average) cost of production by using mergers and acquisition over internal expansion. Vintage technology in greenfield plants may also result in a similar average cost reduction benefit for large expanding output, but firms must first overcome the high fixed costs associated with building new plants. Thus, the inclusion of adjustment size in modelling firm's choice of expansion path can be justified because it acts as proxy for high fixed costs associated with the use of external expansion. Researchers such as Breinlich and Neimann (2011a) and Warusawitharana (2008) have theoretically modelled the idea.

Consistent with this argument, Breinlich and Neimann (2011a) found that internal expansion declines as the overall size of an expansion increases in the UK, using turnover as a proxy for expansion size. Breinlich and Neimann (2011a) also found that external expansion - both greenfield investment and mergers and acquisition - increased in importance with the size of an expansion. However, expansion size was found to have a stronger impact on mergers and acquisition than on greenfield investment, implying that the largest expansions are more likely to be carried out through mergers and acquisition. Warusawitharana (2008) also provide some evidence to support this view. Using profitability as a proxy for required investment and thus, expansion size, Warusawitharana (2008) showed that firms with higher profitability are more likely to seek external growth through mergers and acquisition. The author went on to argue that an increase in profitability leads to a corresponding increase in the optimal size and required investment of a firm, such that there is a profitability threshold above which the firm buys/acquire plants and a profitability threshold below which the firm invests in new plants. These findings are consistent with the presence of large fixed costs associated with using external forms of expansion particularly, mergers and acquisition.

Another strand of related literature seeks to understand the relationship between expansion size and firms' mode of expansion into foreign markets. This approach is based on the notion of "enhancement or development of capabilities" (Madhok, 1997). Essentially, firms have limited human resource endowment, which can be augmented by cross-border investment in mergers and acquisition. However, firms must overcome the sunk cost of expanding into foreign markets. A large empirical literature exists in this vein which tests whether relative expansion size (often measured as a relative number of employees between a subsidiary and a parent company) has an impact on how firms decide to expand into foreign markets i.e., through exports, greenfield foreign direct investment, cross-border mergers and acquisition or joint venture. For example, using a sample of 136 Japanese manufacturing firms in Western Europe, Brouthers and Brouthers (2000) found that firms prefer cross-border mergers and acquisition over greenfield foreign direct investment when investments are relatively large. A similar paper by Hennart and Reddy (1997) found that joint ventures are preferred over cross-border mergers and acquisition when the target size is large, as large firms with 'indigestible' plants are difficult to integrate. Finally, Cho and Padmanabhan (1995) found no relationship between investment size and mode of entry for Japanese firms.

Large contractions are also often associated with plant closures and plant sales – both external contractions. Firms are likely to downsize in response to poor operating performance. From the viewpoint of scale or scope (dis)economies, a poor performing firm may be able to reduce its workforce as well as shed plants that interferes with its other operations to improve the average cost of production of the remaining plants. Firms may suffer from performance decline due to excessive diversification (John and Ofek, 1996), failure to meet targeted demand (Warusawitharana, 2008) or previous overinvestment in mergers and acquisition (Maksimovic et al., 2011). By reducing the amount of invested capital, a firm may be able to eliminate any negative synergy that emanates from poor performing plants. Selling plants could also allow firms to recover the value of excess plants that are undermining the profitability of their operations. However, using external contraction would cost the firm a substantial amount of money to search for and negotiate with suitable plant buyers (e.g., Warusawitharana, 2008) or to disassemble, dismantle and rehabilitate the space occupied by plants that are to be closed (e.g., Clark and Wrigley, 1997). As a result, firms be willing to carry out large and strategic contraction in employment and/or output to use external contraction. Such large contraction in output and/or employment can also be used to achieve average cost savings from using external contraction. Indeed, Breinlich and Neimann (2011a) theoretically modelled this idea to show that firms would only use external contraction when the average cost savings from such contraction and/or proceeds from plant sales exceed the fixed cost of carrying out such activity.

Relatively few empirical studies have been conducted on the impact of contraction size on firms' path of contraction. Only Breinlich and Niemann (2011a) have considered the relationship between contraction size and all 3 paths of contraction. Using turnover as a proxy for the size of contraction, the authors found that both plant closure and plant sale are increasing in importance as the size of an overall contraction increases, while internal contraction declines with the size of a contraction in the UK. Their paper also revealed that the size of a desired contraction does not influence firms' choice of external contraction i.e., the relative coefficient magnitudes between plant sales and plant closure were similar. In contrast, Warusawitharana (2008) found that the profitability of firms strongly impacts their choice to sell plants. The author showed that firms that sold plants demonstrated low realized return on assets prior to plant sales, implying that firms that needed to carry out large contraction due to low profitability were more likely to sell plants in the US between 1984 and 2004. In sum, contraction size has been generally found to be positively related to external forms of contraction, whereas the relationship between the size of a desired contraction and firms' choice of a path of external contraction, is mixed.

2.3.1.3 Firm-level Variables

From the capital reallocation theory (discussed extensively in section 2.2.1.2 of this chapter), firms that invest in external forms of adjustment i.e., greenfield investment and/or mergers and acquisition, following a positive demand or supply shock, are often the ones better at managing capital (plant). The key economic idea is that large external adjustment costs (cost of buying and integrating additional plants) keep firms from adding plants until the additional profit from such activity exceeds the cost. However, when this occurs, firms that were previously more efficient at integrating and managing plants take better advantage of the increased demand or fall in cost by adding more plants because the cost of integrating and managing an additional plant is lower for these firms. Firm-level productivity is therefore an important theme of this type of approach. However, these neoclassical models of mergers and acquisition often assume that a firm's productivity is exogenous. According to the resource-based theory of the firm, put forward by Penrose (1959), firms can invest in intangible assets such as R&D to generate/upgrade knowledge internally and therefore become more productive, innovative and competitive (e.g., Bustos, 2009). As a result, efforts have recently been made to endogenize firm-level productivity and show that firms engage in productivity enhancing investment prior to their expansion activities. The empirical counterparts of this type of studies have used firm-level variables such as R&D to examine the relationship between innovation and mergers and acquisition. These firm-level variables can have an indirect effect (through productivity) or a direct effect on firms' choices of adjustment. For instance, a large firm may increase its spending on R&D to boost productivity prior to making an acquisition or, it may reduce its R&D spending and acquire a small innovative (through R&D) firm to gain access to new technology.

Technological innovation is increasingly recognized as one of the motives for mergers and acquisition. Firms can invest in innovative activities such as R&D to increase their productivity, which in turn increases a firms' propensity to acquire other firms/plants. Indeed, Cohen and Levinthal (1989) suggested that there are 2 main channels through which R&D can contribute to higher productivity within a firm. The first is through the development of absorptive capacity that enables a firm to identify, assimilate, exploit and absorb external innovation made by other firms, which is likely to lead to indirect improvements in productivity (see, for instance, Zahra and George, 2003). The second channel is through the generation of product and process improvements that allows new and existing products to be produced with greater efficiency and is likely to lead to a direct increase in productivity. The resulting improvement in production efficiency from R&D enables firms to expand their productive capacity by acquiring less productive firms/plants and transferring their superior productivity level to acquired firms/plants (e.g., Maksimovic and Phillips, 2001).

In contrast, Phillips and Zhdanov (2013) theoretically showed that (large) firms invest less in innovative activities prior to acquiring another firm and they engage in acquisition activities to gain access to new technology. In their model, a (large) profit-maximizing firm can either invest in R&D to innovative internally or acquire a small firm that has successfully innovated. Increased competition from many (small) R&D firms reduces the likelihood of a successful innovation but, increases the pool of potential successful innovators from which a large firm can acquire from. Acquiring innovation through mergers and acquisition is therefore, a less expensive and a more efficient path for large firms to obtain innovation because they can optimally outsource R&D to smaller firms and then subsequently acquire those that have successfully innovated. Their model thus, predicts that the prospect of acquiring successfully innovative small firms reduces internal innovative activities by large firms and their spending on R&D.

Using a US sample of 84,471 Compustat firm-year observation, Phillips and Zhdanov (2013) empirically examined the prediction of their model. The authors found that firm's R&D expenditure (scaled by sales) responds positively to industry acquisition activity (captured by an industry's mergers and acquisition activities in the past), but less so for large firms. The authors showed that (after controlling for the endogeneity of mergers and acquisition activity and interacting it with firm size) undertaking R&D is smaller for large firms than small firms in industries with high acquisition activity. Similarly, Hall (1988), using a sample of 2,519 US firms in Compustat between 1976 and 1985, found evidence of a negative relationship between firm's R&D intensity (R&D expenditure divided by sales) and the probability of acquiring another firm. Thus, Phillips and Zhdanov (2013) and Hall (1988:3) showed evidence for reduced R&D spending before an acquisition, which is consistent with their argument that R&D and acquisition are substitutes – "an increase in the attractiveness of acquisition opportunities would depress spending on internal investment, including R&D".

Many more authors have studied the relationship between mergers and acquisition activities and the different stages of the development of innovation – innovation input or unrealized innovation in form of R&D and innovation output or realized innovation in form of legally enforceable patents. For instance, Bena and Li (2013) examined the effect on R&D expenses and patent portfolios on firms' participation in mergers and acquisition. Using a US economy-wide patent-merger dataset from 1984 to 2006, the authors found that both acquirers and targets are actively involved in innovation activities, but have different innovation-related characteristics. Specifically, acquirers tend to have low-R&D expenditure and large patent portfolios while targets tend to have high-R&D expenditure and slow growth in patentable innovation. Zhao (2009) reaches the opposite conclusion that neither R&D expenditure nor the number of patents is related to firms' acquisition decision. Instead, Zhao (2009) found that firms with smaller number of citations (proxy for lack of internal innovation success) are more likely to be acquirers. Finally, Sevilir and Tian (2012) showed that firms with limited ability to innovate internally are more likely to acquire innovative firms to enhance their post-merger innovative output. Thus, this literature has shown some evidence for reduced innovation activity (i.e., R&D expenditure) or unsuccessful internal innovation by acquirers, prior to them acquiring another firm.

Another channel through which productivity might influence firms' propensity to acquire another firm/plant, is learning-by-doing effect associated with the age of the firm. As firms grow older, they discover what they are good at and learn how to do things better, all of which can improve their productivity – i.e., learning-by-doing (e.g., Jovanovic and Nyarko, 1996). Moreover, since better firms are the ones that survive, their survival over time might indicate that they are the best among their cohort of firms (e.g., Jovanovic, 1982). This implies that productivity increases as firms grow older and that more-productive old firms are more likely to seek (external) productive opportunities through mergers and acquisition than less-productive young firms. In contrast, older firms might be less efficient because they are less likely to employ the latest technology that allows them to produce with greater efficiency (e.g., Jensen et al., 2001). When this happens, we would expect young firms to be more likely to make an acquisition than old firms. Another explanation for a positive relationship between firm's age and their propensity to acquire another firm is that returns from internal activities decreases (i.e., decreasing returns-to-scale from internal expansion) as firms grow, which lead them to seek new productive opportunities. Gomes and Livdan (2004:508) formalized this idea by showing that slow-growing mature firms use mergers and acquisition "to explore attractive new productive opportunities". Moreover, firms are more likely to make diversifying acquisitions later in their life cycle when their cash flow exceeds their internal growth opportunities and managers are reluctant to pay excess cash flow to shareholders – i.e., agency theory of acquisition (Mueller, 1972; Jensen, 1982; Denis et al., 1997).

Empirically, Arikan and Stulz (2016) found evidence that both learning-by-doing and vintage effects are important in determining firm's rate of acquisition using a US sample of 7,506 initial public offering (IPO) data from 1975 to 2008. Specifically, the authors found that the acquisition rate of firms is a U-shaped function of their age (time since IPO) and young firms acquire at the same rate as old firms. They argued therefore that, firms with better productive opportunities are likely to make acquisitions irrespective of their life cycle stage. Although not the focus of their paper Celikyurt et al. (2010) and Hovakimaian and Hutton (2010) have found mixed effect. Using a similar IPO data from 1985 to 2004, Celikyurt et al. (2010) found that the odds of becoming an acquirer increases with IPO years. The authors showed that 77% of firms between 0 and 4 (IPO) years carried out at least one acquisition, while only 31% of firms become acquirers in the same year of their IPO. Hovakimaian and Hutton (2010), on the other hand, documented a negative relationship between a firm's age and the likelihood of becoming an acquirer. Using a logit regression, Hovakimaian and Hutton (2010) found that the probability of an acquisition declines with firm's (IPO) age.

A third channel through which productivity might influence firms' propensity to acquire another firm/plant, is economies of scale effect associated with operating several plants. Firstly, multi-plant firms may benefit from economies of scale if they can specialize by diving production between plants and/or they are able to centralize services involving spreading risk, raising capital, procuring inputs at lower prices because of bulk buying, supporting R&D and engaging in sales promotion activities (c.f. Harris, 1989). If multi-plant firms benefit from these economies of scale and, are therefore more efficient, they are more likely to increase their number of plants than single-plant firms in response to a substantial and persistent increase in demand or fall in operating cost (see, for instance, Breinlich and Neimann, 2011a). Conversely, a multi-plant firm may be less efficient if it suffers from X-inefficiency caused by a lack of competitive pressure (Leibenstein, 1966). This is more likely to occur when the principal-agent problem is more severe in a multi-plant firms than a single-unit enterprise (where the manager is more likely to be the owner). Furthermore, single-plant enterprises with the attributes of 'smaller' in terms of their organizational and managerial structure have greater flexibility and are therefore, more responsive to change than multi-plant firms. As Dhawan (2001:271) argued "efficiency of smaller firms is the result of their leaner organizational structure that allows them to take strategic actions to exploit emerging market opportunities and to create a market niche position for themselves". When this happens, we would expect multi-plant firms to be less likely to increase their number of plants than single-plant firms.

Finally, productivity can influence firms' acquisition behaviour through the (foreign) ownership structure of the firm. To make it worthwhile for foreign multinationals to invest abroad, they must possess characteristics that gives them a cost advantage over domestic firms (Hymer, 1976). These characteristics may include better management or marketing capabilities and specialized knowledge about production by virtue of the firms' link to the home country of the multinational (Pfaffermayr, 1999; Caves, 1996). Once the choice to invest abroad has been made, foreign firms can purchase an existing plant or build a new one. The decision between greenfield entry and mergers and acquisition will depend on transaction costs and on firm-specific advantage (i.e., managerial capabilities). If a firm chooses to enter a foreign market through a greenfield subsidiary, it must incur the costs of replicating its structure and processes, building business networks and coordinating with business units abroad. Acquisition of technical know-how, on the other hand, requires the cost of integrating and adapting acquired units to the firm's operation. These differences in transaction costs and capability requirements between mergers and acquisition and greenfield investment have been identified in literature to influence multinationals choice of foreign entry mode.

Hennart and Park (1993) argue that if a firm-specific advantage is associated with the management of its workforce (and assuming a foreign firm can bring its own managerial practice and avoid domestic trade unions), then a greenfield entry may be preferred due to less organizational control than mergers and acquisition. In contrast, mergers and acquisition would be preferred if the foreign firm has little previous experience of producing in the host country or if the combined value of acquired and existing plants outweighs the cost of integrating acquired plants (e.g., Nocke and Yeaple, 2007). An extension of this argument is that, for foreign firms to expand via external expansion – i.e., greenfield investment and/or mergers and acquisition - they must possess the aforementioned cost advantages over domestic firms. However, the choice of acquisition is likely to rise with lack of experience in the foreign market, cost advantage associated with adapting local plants and if local plants have greater value when combined with foreign assets than they do in the hands of local rivals. In sum, R&D, age, multi-plant and foreign-ownership need to enter the model that considers the productivity-expansion path relationship at the micro-level.

The role of firm-level productivity in determining firm's path of contraction was also established in section 2.2.1.2 of this chapter. Specifically, we showed that high-productivity (troubled) firms are more likely to find themselves with too many plants following a negative demand and/or supply shock and are therefore, more likely to shed plants and put their scarce (managerial) resources back to its best use (e.g., Warusawitharana, 2008). Moreover, high-productivity firms with presumably vintage plants are more likely to find it easier to sell their plants in the mergers and acquisition market because acquirers are looking to avoid large integration cost associated with buying inferior plants from low-productivity firms (e.g., Rhodes-Kropf et al., 2005; Rhodes-Kropf and Robinson, 2008; Breinlich and Niemann, 2011a). However, these arguments often treat productivity as exogenous and they fail to capture various firm-level characteristics that might affect firms' productivity-level and thus, their contraction choice.

Firms can invest in innovative activities such as R&D to increase their productivity and the prospect of becoming an acquisition target. Indeed, Phillips and Zhdanov (2013) model showed that small firms would tend to invest more on R&D to increase the odds of a successful innovation (due to increased competition from many small firms) and the odds of being acquired by a large firm. Specifically, their model predicts that when there is a higher chance of being a target, small firms are incentivised to increase their spending on R&D and innovate because innovation strengthens their bargaining power during a negotiation with an acquirer, which in turn leads to greater acquisition surplus for the target firm. Empirical evidence in support of such a relationship between (small) firms increased R&D spending and the greater probability of becoming a target was also provided by Phillips and Zhdanov (2013). Using a probit regression, the authors found that firm's R&D investment responds positively to the probability of being a target. Their result also showed that firms invest more in R&D when there is greater bargaining power (captured by merger gains by target firms in previous years) and this effect is larger for small firms. In a related innovation-development-stage study, Bena and Li (2013) found that R&D-intensive (i.e., high-innovation input) firms with slow growth in patentable innovation (i.e., low-innovation output) are more likely to be acquired. However, Hall (1998), using a sample of 2,519 US manufacturing firms between 1976 and 1985, found no significant relationship between the R&D intensity of a firm and the likelihood of becoming an acquisition target.

Given the earlier discussion that age is a major determinant of firm-level productivity, the productivity-contraction path relationship is also likely to be driven by age. If an old firm is more-productive (due to learning-by-doing or survival effect) and it is facing a performance decline, it can reduce the scale of previous overinvestment and free up management time that can be redeployed to higher value operations (e.g., Maksimovic and Phillips, 2002) and; plant sales should indeed increase with firm's age. However, old firms are more likely to operate plants with older technology that are unattractive to acquirers because of high cost of integration. When this happens, plant sales would drop with firm's age as potential acquirers seek vintage plants that are likely to be operated by younger firms. An alternative explanation as to why older firms are more likely to sell plants is because of higher organizational rigidities in old firms. As firms get older, they focus primarily on serving production and marketing goals (Holmstrom, 1989). In the process of pursuing these goals, organizational rules are created that induces bureaucratization and hampers innovation which in turn, leads to operational rigidities. These rigidities make it difficult for old firms to create and exploit growth opportunities outside their core business. Instead, it allows them to focus their efforts on managing plants that are in place and to spend less time in exploring external growth opportunities. Under this view, maintaining current profitability (not lack of profitability) drives old firms' decision to sell plants to free up management time that can redeployed to their core competences (Loderer et al., 2016). However, the same operational 'rigidities' could render old firms increasingly difficult to integrate into another organization therefore, making them an unattractive target (Loderer and Waelchli, 2015).

Only recently have some papers started to examine the role of age in explaining firms' decision to sell plants. Berchtold et al., (2014) used a sample of 70,220 firm-year observation from 1985 to 2010 to investigate the relationship between firm's age and their propensity to sell plants in the US. The authors found that the probability of selling plants increases with firm's age. Specifically, they found that, a 1 standard deviation increase in a firm's age increases the odd ratio of a plant sale by 18%. The positive relationship remained after controlling for synergistic values of acquisition (i.e., firm size, demand shock, profitability, diversifying acquisition) that have been found in literature to drive firms' plant selling decisions. Finally, the authors found that plant sale activity intensifies when managers are faced with a high degree of organizational rules and process (proxied by firm's selling, general and administrative expenses); when managers feel more competitive pressure (proxied by industry median R&D expenditures, normalized by assets) and; when a firm operates more plants in its peripheral division, all of which supports their hypothesis that old (operationally-rigid) firms are more likely to sell plants to free up management time and focus on their core competences.

By contrast, Loderer and Waelchli (2015) found that probability of being acquired declines with firm's age, using a sample of 83,790 firm-year observations in the US between 1978 and 2009. Using delisting codes to distinguish between different forms of firm's exit (i.e., takeover, failure and 'other reasons') and implementing a multinomial logistic regression, their marginal effects result revealed that the takeover hazard of a 25-year-old firm can be as much as 32% lower than the takeover hazard of a 5-year-old firm. According the authors, the underlying driver of such a negative relationship between a firm's age and the probability of being acquired is the high cost of integrating old firms with operational rigidities into a different organization. Indeed, using firms' cost structure, investment policy, product portfolio and organizational structure as proxies for operational rigidities, they showed that older firms with accumulated operational rigidities and thus, higher merger integration cost, have lower takeover hazard.

Age can also influence a firms' decision to close plants. According to Jovanovic (1982), older firms are less likely to close plants mainly because firms experiment less uncertainty about their productivity type in the latter stages of their life. In Jovanovic's (1982) model, firms are uncertain about their productivity levels, but they know the distribution of such parameter. Based on the estimate of their productivity-level, firms choose their output level and if profits are larger than expected at the end of the period, a firm can infer that it is more productive than it had estimated in the preceding period. When this happens, firms update their estimate and increase their output. Over time, firm's estimate of productivity becomes more precise as they continuously update their estimate based on observed actual productivity. Firms close plants when the estimate of their productivity falls below a threshold. Since, older firms are more likely to set their productivity levels closer to their 'true productivity' level, the probability of a plant closure should fall with age. Further, if younger firms have higher scrap value for their newer vintage plants, then we would expect older firms to be less likely to close plants than young firms (i.e., Baden-Fuller, 1989). However, Deily (1991) predicts that older firms operating plants that embody old inefficient technologies would have to make reinvestment decisions that involves plant closure.

Another firm-level variable that can influence firms' decision to close plants is the number of plants they operate. If a multi-unit enterprise is more productive than a single-plant firm (due to the earlier discussed economies-of-scale effect) then the probability of a plant closure should be negatively related to a larger number of plants operated by a firm. This is because a more-productive (multi-plant) firm is more likely to operate high-productivity plants that would enable the firm to have positive discounted future profits that is greater than its liquidation (or scrap) value over future periods (Harris and Moffat, 2011). Furthermore, a more productive (multi-plant) firm that can easily shift resources within the firm and/or has access to external sources of capital might be able to avoid a plant closure during a negative demand shock such as a temporary drop in demand for one of its product. However, the ability to shift production to another plant following a negative demand shock might increase the probability of plant closure by multi-plant firms since they can transfer production to another plant without exiting the market. In contrast to the single-plant enterprise, a plant closure in a multi-unit firm does not mean a complete withdrawal from the manufacturing activities in the market or complete shutdown of the enterprise (Colombo and Delmastro, 2000). As a result, if the sunk cost of creating a firm differs from the sunk cost of creating a plant, then a single-plant enterprise would incur a higher cost of re-entry than a multi-unit firm and the former is less likely to close a plant (Bernard and Jensen, 2007).

Indeed, a positive association between the probability of a plant closure and the number of plants operated by the firm was found in Bernard and Jensen (2007). First, using a panel of 236,092 plant-year observation and an unconditional (univariate) probit model specification, the authors found that plants owned by multi-unit firms have a 3.4 percentage point reduction in their probability of death. However, the authors also showed that plants that are part of a multi-unit firm are older, larger, more-productive and more capital-intensive than stand-alone plants – plant attributes that have been previously found to improve plant survival. Once they controlled for these plant attributes that reduces the probability of plant death (and ran a multivariate conditional probit regression), they found that multi-plant firms are indeed more likely to close comparable plants than single-plant enterprises. In a similar plant-level analysis in the UK, Disney et al. (2003) found that, when single-plant enterprises are conditioned on the average characteristics of group (multi-unit) establishments, plants that belong to the former are more likely to survive than plants that are part of the latter group. For New Zealand, Gibson and Harris (1996) showed that the probability of plant closure increased with the number of plants operated by a firm. Thus, these studies conclude that multi-unit firms are more likely to close plants, particularly if the plant has a relatively different cost structure (or productivity) to the rest of the firm. By contrast, Dunne et al. (1989) found that large multi-unit firms are less likely to close plants than large single-unit firms, using a US sample with about 200,000 plants over the period 1967-1977.

Lastly, productivity can also influence plant closure behaviour through the (foreign) ownership structure of a firm. On one hand, multinationals may acquire firms with higher level of productivity (see, for instance, Harris and Robinson, 2002 and; McGuckin and Nguyen, 1995 for empirical evidence) with features that make them less likely to close plants. Furthermore, if multinationals share their superior technology and/or propriety asset with their foreign subsidiaries, this would reduce the probability of plant closure in host countries (Harris and Li, 2007). On the other hand, multinationals may have higher plant shutdown probabilities because of their inability to integrate acquired domestic plants into their operations (e.g., due to lack of understanding between the management of a multinational and labour attitudes in host country, argued in, for instance, Dunning, 1988). Additionally, a multinational with little or no experience in a foreign market may be more inclined to close its foreign subsidiaries if its operation abroad impedes the plants owned by the multinational. It is therefore not clear whether foreign-owned firms are less or more likely to close plants.

The empirical evidence is also inconclusive. Gibson and Harris (1996) found that being owned by a foreign firm leads to a 4.7 percentage point reduction in the probability of plant closure, during the period of trade liberalisation in New Zealand. This is in contrast to their original expectation that multinationals are more likely to close plants because they can probably meet domestic demand through lower cost imports during the period of trade liberalization that reduces import barriers. By contrast, Bernard and Jensen (2007) found that plants owned by US multinationals (defined as a firm with at least 10% of its assets outside the US in 1987) have a 4.5 percentage point increase in their probability of death, once the authors controlled for plant attributes known to reduce the probability of plant closure. Bernard and Jensen (2007) argued that their finding supports the notion that multinationals have greater flexibility of moving their operations to another country which raises the probability that they may close one of their domestic plants.

2.3.1.4 Industrial Effects

Going hand in hand with the impact of adjustment size (discussed in section 2.3.1.2) is the existence of industry effects, in terms of variation in the fixed cost of external adjustment amongst different sectors. If external adjustments are unattractive because they are costlier to implement (proxied by the size of an adjustment), one would expect these forms of adjustment to be particularly unappealing in industries with higher fixed cost. This argument follows from a simple cost-benefit analysis of adjustment, as expected benefits (i.e., from economies of scale) are more likely to fall below the fixed cost of using external adjustment in industries with higher fixed costs. Therefore, if adjustment size is a proxy for fixed cost associated with using external adjustment, we would expect that the issue of adjustment size should be more prevalent in industries with high fixed cost of external adjustment. In other words, industrial factors would capture the fixed cost advantages and disadvantages over and above any fixed cost associated with using external forms of adjustment.

The only paper that has empirically examined industry differences in the adjustment size-path relationship is by Breinlich et al. (2010). Using frequencies, the authors showed that firms operating in high fixed cost industries use external forms of adjustment less frequently, but undertake large adjustment when they do. Specifically, they showed that the external forms of expansion (contraction) account for over 25% (50%) of aggregate turnover adjustment in manufacturing, utilities and mining sector, but they account for around 3% (4%) in the agricultural sector. They went on to argue that sectors with high fixed costs of adjustment such as manufacturing, utilities and mining, rely less frequently on external forms of adjustment, but will tend to undertake a relatively large adjustment when they do. In a somewhat similar vein, Loderer and Waelchli (2015) found a further negative relationship between integration costs (proxied by firm's age) and takeover probability after controlling for industry effects. In particular, the authors found that while old firms have lower takeover probability because of the high cost associated with integrating them, industry distress (proxied by negative industry median sales growth and median stock return below -30%) further reduces the takeover hazard of older firms. The authors argued that firms with high integration cost (old firms) would have lower takeover probability, particularly, at times of industry distress when the gains to takeover drops.

2.3.2 Effects of Alternative Forms of Expansion on Productivity

In section 2.2.2, we used 2 theoretical ideas – matching theory and the theory of vintage capital - to hypothesize that external expansion, particularly, mergers and acquisition should lead to higher productivity levels than internal expansion. Central to this prediction is that mergers and acquisition can be used to avoid hiring costs (which are significant because of the hiring process) because workers from acquired plants will be better matched to their jobs than new worker that need to be taken on through internal expansion. Despite this theoretical appeal, we are not aware of any empirical research that has attempted to estimate the causal impact of choosing alternative forms of expansion on firm-level productivity. Instead, much attention has been focused on analysing the role of plant-level adjustments i.e., opening/closure of plants and reallocation of resources towards highly-productive continuing plants, in explaining aggregate productivity growth (e.g., Disney *et al.*, 2003; Harris and Moffat, 2013).

Relatedly, the only paper that has examined the contribution of alternative forms of expansion – internal expansion, greenfield investment and mergers and acquisition - to aggregate productivity growth is by Breinlich et al. (2012). Using a dataset that was created by merging ARD into the BSD, the authors employ the Foster et al. (2006) method to decompose labour and total factor productivity growth between 1997 and 2005 in UK agricultural and manufacturing sector. This allows them to identify the share of the growth of aggregate productivity attributable to each path of expansion. Their result show that, amongst the 3 channels of expansion, internal expansion is the largest contributor to labour productivity, while the contribution to TFP growth comes primarily from mergers and acquisition. Specifically, they found that internal expansion, greenfield investment and mergers and acquisition account for 11.85%, 0.28% and 4.03% of the growth in labour productivity respectively, while the same channels of expansion account for 4.87%, 1.25% and 15.48% of TFP growth respectively.

Breinlich et al. (2012) reveals the proportion of UK productivity growth that is attributable to each path of expansion. However, and as stated above, no study has attempted to estimate the causal impact of alternative forms of expansion on firm-level productivity. Some studies such as Maksimovic and Phillips (2002) have focused on the impact of a particular path of adjustment (e.g., mergers and acquisition) on productivity, but these impacts are never compared to the effect of alternative forms of expansion (e.g., internal expansion and/or greenfield investment). The remainder of this section reviews such studies (grouped according to each path of expansion) to allow for comparisons of our empirical results in chapter five.

2.3.2.1 Effect of Internal Expansion

Workforce (or internal) expansion is expected to have an impact on firm-level productivity through 2 main channels. Most obviously, hiring new employees (or managers) with higher efficiency parameters should lead to greater productivity levels – i.e., the managerial skill model of Jovanovic (1982). This is because, a skilled workforce is more likely to use a firm's tangible inputs in the most effective way as well as act as compliments to organizational practices and improved technologies (e.g., Battu et al., 2003). Literature on human capital has tied several factors to such higher efficiency parameters including education, skills, training and experience, which lead to greater productivity performance. For instance, Holland et al. (2013) found that a 1 per cent increase in the share of the workforce with a university degree raises the level of productivity in the UK by 0.2-0.5 per cent in the long-run. The second channel is through the "Penrose effect" (Penrose, 1959). This effect is based on the notion that there is a maximum growth rate above which productivity declines if a firm tries to hire new workers. Hiring new employees' above a firm's maximum growth rate places additional demand on the firm's managerial resources as managers redirect their attention to training and internalizing new employees. As such, productivity declines from internal expansion that is above a firms' maximum (internal) growth rate[15]. Indeed, productivity may also decline or at least remain the same in the long-run if internal expansion involves hiring skilled workers in large firms i.e., due to diminishing returns to skill in Lucas (1978). In such a situation, a firm can only improve productivity by investing in additional capital.

Ample evidence has been provided at the macroeconomic level, regarding the linkage between a country's productivity growth and changes in its workforce composition. These studies have mostly shown that productivity growth is positively related to upskilled workforce (often proxied by higher level of education, skills and experience). For instance, Mason et al (2012) decompose improvement in labour quality into 2 components – higher educational attainment and on-the-job training and experience – and find these factors to be positively related to productivity growth. Others that have found a similar positive relationship between productivity growth and higher labour quality include: Jorgenson et al. (1987), O'Mahony (2012), Van Reenen (2013) and Holland et al. (2013). The intuition behind such findings is that "if the total number of hours worked stayed the same, but they were increasingly worked by more intelligent and able workers, which are presumed more efficient, this would result in increased output" (Rincon-Aznar et al., 2015:53). Thus, these studies have shown that higher labour quality leads to improvement in productivity even though they fail to adequately quantify this effect at the firm-level.

[15] This argument is similar to standard economic theory that an increase in labour leads to an increase in output, until diminishing marginal returns to labour occurs. At this point, only high-quality labour would lead to a faster increase in output.

In contrast, empirical evidence at the firm- or plant-level provide a rather different and unique perspective to disentangle the labour quality-productivity relationship, taking into account the heterogeneity of productivity amongst firms with different labour input quality. Such studies often interact the fields of industrial and labour economics by carefully merging employer-employee datasets to provide some evidence of the importance of labour quality in explaining productivity difference between firms. Haltiwanger et al. (1999) do exactly this using US matched worker-firm data to show that productivity (the natural log of sales per employee) increases in worker's skills. They used worker's education as a proxy for labour quality to show that firms with more-educated workers are more productive than their counterparts with less-educated workers, having controlled for firm characteristics (i.e., firm size and ownership structure) and other workforce composition (i.e., worker's age, gender and place of birth). The authors remarked that their finding is not only consistent with the argument that higher quality workforce make firms more productive but also that there is sorting and matching amongst firms and employees which leads to higher productivity outcome. Haltiwanger et al. (1999) finding is echoed in Abowd et al. (1999) investigation with similar French data. Specifically, Abowd et al. (1999) find a positive relationship between worker's skill (measured from employer/employee wage equations) and labour productivity. Further empirical evidence that more productive firms have high-skilled workforce is provided in Haskel et al., (2005) for UK; Iranzo et al. (2008) for Italy; Ilmakunnas et al (2004) for Finland; and Fox and Smeets (2011) for Denmark.

The studies reviewed above focus mainly on contemporaneous association between human capital and firm- or plant-level productivity, and therefore neglect any dynamic considerations affecting the relationship between internal expansion and productivity (i.e., diminishing returns to skills). The only study that has considered such dynamic relationship is by Coad and Broekel (2012). Using a unique panel of 6,715 French firms from 1996 to 2004, Coad and Broekel (2012) studied the relationship between employment growth and firm-level productivity growth. They focused on internal expansion by excluding firms that have undergone any kind of structural modification such as mergers and acquisition in their sample and used a vector autoregression (VAR) model to study relationships. First, the authors find that employment growth is positively related with subsequent growth of labour productivity while it is negatively related with subsequent TFP growth. They attributed this contrasting result to the fact that, unlike labour productivity, TFP takes into account the efficiency with which capital is utilized. Second, they find that the negative relationship between employment growth and TFP growth persist with firm size (i.e., the negative coefficient on employment growth persists even after splitting their sample into different size groups). Overall, their result is consistent with the "Penrose effect" of productivity decline from internal expansion. The authors also argued that their result is in accordance with the notion of adjustment cost (e.g., Cooper and Haltiwanger, 2006) associated with investment in human capital.

2.3.2.2 Effect of Greenfield Investment

There are 2 main channels through which new 'greenfield' investment (i.e., in recent capital vintages) may affect firm-level productivity. First, greenfield plants may embody the latest technology that allow firms to produce existing products and/or new products with greater efficiency. Indeed, in many vintage models, new plants enter industries with improved technology embedded in their capital and often outperform existing plants operating in the same industry - an assumption that is frequently referred to as machine-embodied technical change (e.g., Cooley et al., 1994; Campbell, 1998). Thus, greenfield investment with plant-embodied technical change should result in higher productivity levels for the firm - a vintage effect. The second channel through which greenfield investment may affect firm-level productivity is the technology-specific human capital required for adopting new technology. Following an immediate switch to new technology, firms may need to learn about the given technology before they can realize higher levels of productivity (e.g., learning-by-doing in Jovanovic and Nyarko, 1994). In fact, following such technological switch, firm-level productivity may fall below its previous level due to delayed learning of how to adopt new technology in greenfield plant (e.g., Andolfatto and MacDonald, 1993; Jovanovic and MacDonald, 1994). However, as firms become more knowledgeable about the greenfield technology, productivity would increase – a learning-by-doing effect.

In terms of empirical evidence, several studies have tried to carefully construct measures of capital-embodied technological progress within 'new' and 'old' existing plants and compare their productivity levels to see whether new plants produce with better technology and greater efficiency than old plants. Jensen et al. (2001) do exactly this by comparing the relative productivity of plants with different entry years. Using US manufacturing plant-level data from 1963 to 1992, they find that more-recent entrants enter with higher productivity levels than earlier entrants (i.e., when compared to the cohort of plants that entered the US manufacturing industry in 1963, productivity is 47% higher in the cohort of plants that entered in 1992). The authors suggested that newer plants bring with them the latest technology that contributes substantially to labour productivity growth in the US manufacturing industry. However, Jensen et al. (2001) find that existing plants become more productive over time contributing also to overall productivity growth in manufacturing industry. Indeed, Jensen et al. (2001:11) report that productivity increases in plant age, indicating "the possibility that these surviving plants undertake large investments that effectively allow them to retool and replicate the latest capital". Thus, Jensen et al.

(2001) result suggests that both investment in new 'greenfield' plant and old 'existing' plant can lead to productivity improvements at the firm-level. Van Biesebroeck (2003) using dataset from the US automobile industry, found a similar contribution to industry-level productivity growth of both entry of new 'lean' plants and the transformation of earlier 'mass' plants. However, Van Biesebroeck (2003) reported that changes in lean production plants dominated the growth in the US automobile labour productivity between 1980 and 1996.

Focusing on existing plants, Power (1998) find that new investment, in for instance capital vintage, is not associated with an increase in subsequent plant-level productivity. In particular, Power (1998) use plant-level data in the US manufacturing industry and found that high-levels of 'recent' investment in existing plants is not related to high-levels of productivity (after controlling for plant fixed effects and age). Thus, contrary to Jensen et al. (2001) conjecture, this result suggests no productivity improvement following periods of large investments in existing plants. However, Power (1998) argue that their result could be due to expansion investment occurring in the US manufacturing industry over their sample period - i.e., large investments in US manufacturing plants are carried out by successful plants to expand capacity rather than update their vintage technology with more productive capital. In contrast, Sakellaris and Wilson (2004), using a similar measure of investment history, find that productivity is 12% higher in plants that carried out 'new' investment, when compared to plants with previous investment. They report that these investments in new equipment accounted for as much as two-thirds of the TFP growth in the US manufacturing industry between 1972 and 1996.

2.3.2.3 Effect of Mergers and Acquisition

Existing arguments on the role of mergers and acquisition in explaining firm-level productivity offers 2 very different views. The key distinction between these 2 arguments is managerial motive for mergers and acquisition. On the one hand, the 'free cash flow' hypothesis from Jensen (1986) suggest that opportunistic managers may acquire another firm that they are unable to operate efficiently, if there is excess cash available to do so. Thus, under this view, mergers and acquisition are driven by managerial (empire-building) objectives that leads to a decline in post-merger productivity. On the other hand, economic theory recognizes that some firms have valuable scarce resources that allows them to manage multiple plants more efficiently than others. These neoclassical models of firm organization (i.e., Maksimovic and Phillips, 2002; Jovanovic and Rousseau, 2002) often use demand/supply shock in one industry to show how firms with different efficiency levels trade plants. Specifically, industry shock changes firm's payoff/profit of operating marginal plants and trade occurs until the payoff is equalized.

When this occurs, plants flow from less efficient firms to more efficient firms and productivity increases in latter firms due to the better management of acquired plants. Thus, under this view, mergers and acquisition should generate improvement in productivity that is driven by managerial incentive to maximize profit.

To test which of these arguments predominates, several studies have used plant-level data to examine the productivity of plants before and after ownership changes[16]. Findings, however, have been mixed. For instance, Lichtenberg and Siegel (1987) compared productivity of US manufacturing plants before and after an acquisition and found that between 1972 and 1981, productivity in acquired plants declined years before acquisition, but productivity improved afterwards until eventually there was no productivity gap between acquired and unacquired plants. However, Lichtenberg and Siegel (1990) distinguished between different types of mergers and acquisition and found that while there was a general positive impact on productivity of mergers and acquisition, productivity grew faster in plants that underwent a leveraged and management buyout (LBOs and MBOs) than the productivity of plants that underwent other types of mergers. Similarly, McGuckin and Nguyen (1995) using plant-level data on US food manufacturing industry, found that while acquired plants enjoyed higher productivity growth than their unacquired counterparts several years after a change in ownership, productivity grew faster in larger unacquired plants than larger acquired plants. By contrast, Ravenscraft and Scherer (1987, 1989) found that acquired plants were highly profitable/efficient before acquisition with little or no gain in the acquiring plant post-acquisition. In sum, these earlier studies have provided inconclusive evidence regarding the impact of mergers and acquisition on the productivity of acquired plants.

In contrast to earlier studies, majority of recent studies have found evidence of improvement in plant-level efficiency following mergers and acquisition. For instance, Maksimovic and Phillips (2001) found that productivity in US manufacturing plants fell before an acquisition, but rose afterwards. The extent of this ex-post increase in productivity depends on the ex-ante productivity of the seller and buyer and on the type of division (i.e., main or peripheral) that is selling and/or buying the plants. A similar paper by Schoar (2002) found that mergers and acquisition has a positive impact on the productivity of newly

[16] There is of course an enormous literature on mergers and acquisition, far too large to cover here, that has tied this activity to firm performance including share prices, discount value etc. Much of this work in corporate finance has focused on shareholder’s wealth as outcome of interest. A smaller set of studies has focused on the productivity impact of mergers and acquisition.

acquired plants, even when the acquisition is a diversifying one. Maksimovic et al. (2011) also reported a productivity increase in acquired plants that are subsequently retained (as opposed to acquired plants that are latter closed or sold off), particularly for plants that operate in the acquirer's main industry. Other recent studies that have found a positive relationship between an ownership change and the productivity of the transferred plants include: Gugler et al. (2003), Ollinger et al. (2006) and Li (2013). Hence, by showing improvements in the productivity of transferred plants, these recent studies support profit maximizing hypothesis as explanations for mergers and acquisition.

In addition, the acquisition of new plants might also affect the productivity of the acquirer's existing plants. On one hand, a shift in managerial focus from acquirer's existing plants to newly acquired plants might reduce the productivity of existing plants. Indeed, Schoar (2002) observed that acquirer's existing plants suffer productivity losses following the acquisition of new plants, and since firms have on average many more existing than new plants (that experience an increase in productivity), the aggregate effect of mergers and acquisition on firm-level productivity is negative – referred to as a "new toy" effect. On the other hand, the further restructuring that often follows mergers and acquisition (i.e., the closure and sales of inefficient plants) might improve the match between the remaining 'existing' plants and the firm's main ability, leading to an increase in the productivity of existing plants. This argument is supported by Maksimovic et al. (2011) findings that acquirer's existing plants (alongside newly acquired plants) increased in productivity, when compared to an average plant in the industry, Thus, while recent studies have often concluded that mergers and acquisition has a positive effect on transferred plants, the evidence on the productivity effect of the same activity on acquirer's existing plants is mixed. It is therefore not clear from the literature whether mergers and acquisition should be expected to have a positive or negative effect on firm-level productivity.

2.3.3 Effects of Alternative Forms of Contraction on Productivity

The previous section reviewed empirical papers that have attempted to estimate the causal impact of different forms of expansion on productivity. In this section, we turn to a number of literatures that have examined the productivity impact of choosing alternative forms of contraction. The productivity impact of different forms of contraction was theoretically motivated in section 2.2.3. We hypothesized, using 2 theoretical ideas - the theory of uncertainty under organizational decline and the theory of firm boundary under comparative advantage – that external contraction, particularly, plant closure should lead to higher productivity level than internal contraction. The underlying idea used to generate such prediction is that plant closure, unlike internal contraction, often removes the uncertainty associated with firms' downsizing decisions and creates an environment that allows employees to improve and innovate. However, we are not aware of any empirical research that has tested this predictiion. Instead, researcher have focused much of their attention on the role plant-level adjustment play in explaining aggregate productivity growth.

Relatedly, Breinlich et al. (2012) also examined the contribution of alternative forms of contraction – internal contraction, plant closure and plant sale - to aggregate productivity growth in the UK. They found that plant closure is the largest contributor to labour productivity and TFP growth; this was followed by internal contraction and plant sale. Indeed, their result show that plant closure, internal contraction and plant sale account for 34.16%, 27.26% and 22.41% of labour productivity growth respectively, while the same channels of contraction account for 32,98%, 24.87% and 19.53% of TFP growth respectively. This paper reveals the proportion of aggregate productivity growth that is accounted for by the different forms of contraction. It does not attempt to estimate the causal impact of these alternative forms of contraction on firm-level productivity.

2.3.3.1 Effect of Internal Contraction

Employee downsizing (or internal contraction) has long been perceived as a cost cutting activity that is often used to improve productivity (or performance) during organizational decline. As Freeman and Cameron (1993:12) put it "the objective of downsizing is to improve the organizational efficiency, productivity and/or competitiveness". The key economic idea is that firms downsize to eliminate unnecessary levels of management, reduce bloated bureaucracy within the organization, reduce operating labour costs and streamline operations. The resulting elimination of redundancies improves (labour) productivity by reducing input worker hours that falls faster than the loss of output. Thus, internal contraction that is used to shed fat and lose no useful output should lead to an improvement in organizational efficiency. However, critics of employee downsizing have argued that such productivity benefits from downsizing may be minimal or non-existent, if the process involved in downsizing is not managed effectively. For instance, it has been argued that ineffective downsizing process, characterized by the uncertainty on where the axe will fall next, can lead to increased resistance to change (e.g., Brockner et al., 1992; Morris et al., 1999), increased absences or propensity to leave (e.g., Littler et al., 2003a, 2003b), reduced trust and loyalty (e.g., Cameron, 1994) and reduce morale and commitment (e.g., Cameron et al., 1993) among downsizing survivors. These negative responses from downsizing survivors can lead to productivity decline. A further typical negative effect of internal contraction is that it can erode key employees' skill, knowledge and experiences when they are moved into a new role or leave the firm entirely (Hitt et al., 1994). There are therefore reasons to expect employee downsizing to have both negative and positive impact on organizational efficiency.

Several studies have sought to examine whether downsizing leads to improvement in organizational efficiency. However, findings have been mixed. Chen et al. (2001) is one of the first studies to empirically show that there is a positive relationship between employee layoffs and firm-level productivity. The authors employed a sample of 349 layoff announcements in the US between 1990 and 1995 and compared labour productivity in layoff firms to those of similar firms (based on 2-digits SIC codes, book value of assets and return on assets in the year prior to the layoff) that did not downsize i.e., control firms. Using a Wilcoxon sign rank test, Chen et al. (2001) showed that, relatively to non-layoff firms, labour productivity (sales per employee) increased faster in layoff firms, especially in the 3-year post layoff period. Similarly, Chalos and Chen (2002) observed increased labour productivity, following firms' downsizing announcement. Using a sample of employees downsizing in 365 Fortune 500 firms between 1993 and 1995, and employing a univariate t-test, Chalos and Chen (2002) found that different forms of downsizing (revenue-refocusing and cost-cutting) resulted in improved labour productivity, in the ensuing 3-year post layoff period relatively to the 3-year period prior to downsizing. Other related studies such as Kang and Shivdasani (1997), Espahbodi et al. (2000) and Perry and Shivdasani (2005) have found that employee layoffs lead to improvements in operating performance, particularly 2 to 3 years after downsizing, emphasizing the view that benefits from layoffs are experienced only in the long term.

By contrast, Mishra and Mishra (1994) reported that downsizing firms had lower labour productivity than non-downsizing firms in the North American automotive industry. Using a survey data that comprised of 511 managers at 91 business units (representing 43 firms in the North American automotive industry), Mishra and Mishra (1994) found that workforce reduction had a negative impact on labour productivity in 1991. In Canada, Zatzick and Iverson (2007) also found that workforce reduction led to lower labour productivity, particularly, in high-involvement workplaces. Indeed, Zatzick and Iverson (2007) combined employee layoffs and high involvement work practices (HIWP) to show that firms with greater HIWP experienced lower labour productivity (log of revenues minus expenditures per employee) as a consequence of employee layoff. The authors argued that the negative effect of layoffs on labour productivity is particularly damaging in firms where employees' skills and motivation are crucial for sustained productivity i.e., firms that use HIWP more extensively. Others have found no significant relationship between downsizing and labour productivity. For instance, Said et al. (2007)

showed that there is no statistical difference in labour productivity between downsizers and non-downsizers, using a sample of 239 (140 downsizers and 99 non-downsizers) US and Canadian firms. Similarly, using 258 publicly traded firms in Korea between 1997 and 1999, Yu and Park (2006) found that layoff has no effect on productivity (neither sales per employee nor value added per employee).

2.3.3.2 Effect of Plant Closure

Although there is limited economic literature on how plant closure affects firm-level productivity, some key findings have emerged. For one, economic studies generally support the notion that plant closure is a major contributor to country- and industry-level productivity growth. In particular, studies by Oulton (2000), Disney et al. (2003) and Harris and Moffat (2013b) have all found that one of the major contributors to labour productivity and TFP growth is the exit of less productive establishments that are often replaced by more productive entrants in the UK – a market selection process. Bartelsman and Dhrymes (1998) and Foster et al. (2001) have found similar results in the US. However, these productivity-decomposition-type studies are often speculative in explaining the mechanism through which firm-level productivity improvements from plant closure arises. For instance, Disney et al. (2003) speculated that firms achieve productivity growth by closing plants because of the emergence of new technologies that requires new plants or new workers and therefore, the closure of old existing plants.

In contrast, the mechanism through which plant closure improves plant-level productivity has been extensively researched in the management literature. These studies often link productivity improvements at the plant planning to shutdown to human efforts, instead of being driven by capital investment – labelled as 'Closedown effect' in Bergman and Wigblad (1999). 2 sets of studies belong to this stream of research. One set suggest that productivity improvements arises from reduced management control that provides greater operative space for workforce to practice their innovative skills and improve their work methods. Wigblad et al. (2012) offer one of the most comprehensive studies relating such worker's job autonomy to improved productivity. The authors surveyed 11 managers, 8 labour union representatives and 85 shop-floor workers from 3 plants in Sweden. Surveys were conducted via formal interviews focusing on changes that occurred after the closure announcement compared to the period before the announcement. Wigblad et al. (2012) documented that the countdown period (i.e., the period between advanced notice of the closure and the final day) was characterized by increased labour productivity (output per employee and time unit) in all 3 establishments. More importantly, their result showed that worker's job autonomy was responsible for such improvement in productivity (i.e., there was a 10 to 15 minutes reduction between batches and start-up times in a particular establishment after the previously tight controls of management was relaxed). Other studies such as Bergman and Wigblad (1999) and Hansson and Wigblad (2006) have found similar positive relationship between greater workforce control and improvement in productivity.

The second set of studies uses 'goal theory' to argue that plant closure often constitutes clear goals that is characterized by high certainty of job loss thereby creating a new working environment that is more conducive to the cognitive process of generating new goals. The only empirical paper that exists in this vein is by Häsänen et al. (2011). Using questionnaires, Häsänen et al. (2011) surveyed 275 employees in a large medical manufacturing company in Sweden to examine whether goal setting during the process of a plant closure increases worker's performance. The authors found that productivity increased by 8 percent within 13 months from the period of implementation of a goal setting programme. Häsänen et al. (2011) argued that it is possible to maintain a goal setting programme during a closedown process without hindering employees' motivation. Limitation of these studies is the primary focus on single facilities where the closure occurs therefore, failing to consider the consequences of plant closure at the firm-level. Thus, there is no comparison between a closure in a multi-unit firm and the ex-post productivity effect in the remaining organization.

2.3.3.3 Effect of Plant Sale

An argument that is frequently used to motivate plant sales (or corporate divestiture) is the elimination of negative synergies within an organization. Whether through the pursuit of self-serving managerial goals (e.g., Jensen, 1986) or through previous investment mistakes such as unsuccessful mergers and acquisition (e.g., Maksimovic et al., 2011), firms may find themselves with excessive diversification such that their managerial capabilities are insufficient to cope with the range of business activities being undertaken[17]. Such firms may sell unrelated plants (or plants that operate in their peripheral division) and refocus managerial resources on fewer and less diverse operations to improve efficiency. Firms may generate similar positive synergies by closing unrelated plants. However, plant sale is a preferred option when the plant has a better fit and is worth more as part of another organization than it is as part of the current organization (John and Ofek, 1995).

Indeed, a positive association between plant sale that appeared to narrow the focus of firm's activities, and their ex-post performance level was provided in John and Ofek (1995). Using a sample of 321 US

[17] Schoar (2002) notes that diversified firms are not bad per se, but that it is the very act of diversifying into new line of business that reduces firm productivity. Put differently, managerial resources become stretched with each diversifying move and it is this move that leads to productivity disadvantage.

divestitures (each worth $100 million or more) from 1986 to 1988, the authors first show that there is often a significant increase in focus of the seller's operation i.e., the average number of lines of business reported by plant sellers declined during the year of divestiture. Further, they show that, after divestiture, profitability increases in the remaining plants - using 3 different accounting measures namely; earnings before interest, taxes and depreciation (EBITD) to sales ratio, EBITD to book value of assets and EBITD to market value of assets. Finally, the authors ran a regression and found that focus-increasing plant sales (as measured by change in the number of segments, change in Herfindahl index and a dummy variable that equals one if the sold segment's main 4-digit SIC code is different from the seller's main SIC code, and zero otherwise) has a positive impact on seller's operating margins (measured as change in seller's EBITD/sales from year 0 to *t* minus the median change in the industry). Their findings are consistent with the argument that diversification-reducing or focus-increasing plant sales improves performance level in the remaining organization.

A similar study is by Bergh (1995). The author examined the impact of selling unrelated plants on the post-sell-off performance of 112 parent companies in US that undertook a plant sale between 1986 and 1990. Using hierarchical multiple regression, the authors found that relatedness of plant sold (measured by a dummy variable that equals one if the sold unit's main 2-digit SIC code matches the parents main SIC code, and zero otherwise) is negatively associated with seller's post-sell-off performance (as measure by the seller's post-sell-off return on assets). His result indicates that firms that sell related plants lose part of their distinctive competencies and, therefore, have a poor performance record after such plant sales. Other studies such as Rosenfeld (1984), Jain (1985), Montgomery and Thomas (1988), Markides (1992), Haynes et al. (2002) and Hillier et al. (2009) have found a positive relationship between plant sales and seller's post-sell-off performance. However, the resulting findings often fail to show the channel through which the improvement in seller's post-sell-off performance occurs.

2.4 Conclusion

The first part of this chapter reviewed what predictions are available from the theoretical literature concerning the empirical analyses of chapters four and five. In relation to how firms systemically choose between the different paths of adjustment, the theoretical literature appears to suggest that more productive firms are more likely to use external forms of adjustment – greenfield investment and mergers and acquisition for expansion and, plant closure and plant sale for contraction - than less productive firms. With respect to the productivity impacts of alternative forms of adjustment, theory also suggests that external forms of adjustment should lead to higher productivity performance than internal adjustments.

The key factors that are frequently documented in the literature to determine firms' choice of adjustment include firm size, adjustment size, firm-level factors (R&D, age, multi-plant and foreign ownership) and industry structure. Firm size has been found to have positive and significant effect on external forms of adjustment i.e., large firms are more likely to choose external forms of adjustment than small firms. However, empirical studies have provided mixed evidence regarding the impact of firm size on a particular channel of external adjustment. With regards to adjustment size (usually used as a proxy for sunk cost of adjustment), researchers such as Breinlich and Neimann (2011a) have found that external forms of adjustment tend to increase in importance with the size of an adjustment with stronger impact on mergers and acquisition. In terms of firm-level variables, empirical literature generally provides mixed results. For instance, Berchtold et al. (2014) found that older firms are more likely to sell plants, while Loderer and Waelchli (2015) reported that probability of being acquired declines with firm's age. Lastly, in relation to industry structure, Breinlich et al. (2010) found that firms operating in high fixed cost industries tend to rely less frequently on external forms of adjustment, but will undertake a relatively large adjustment when they do.

In terms of the productivity impact of alternative forms of adjustment, empirical studies often focus on a particular path of adjustment (e.g., mergers and acquisition) without comparing this impact to the effect of other forms of adjustment (e.g., internal expansion and/or greenfield investment). Additionally, these empirical papers offer ambiguous evidence concerning what may be expected from the chapter that examines the impact of alternative forms of adjustment on productivity. For instance, Coad and Broekel (2012) find that internal expansion has a positive effect on labour productivity while the same channel of expansion has a negative effect on TFP growth. Schoar (2002) observe a similar positive and negative effect of mergers and acquisition on acquirer's 'purchased' and 'existing' plants respectively. Jensen et al. (2001) also report that both investment in new 'greenfield' plant and old 'existing' plant lead to productivity improvements. Similar mixed effects on the productivity impact of different channels of contraction have also been found: negative effects were reported in for instance, Mishra and Mishra (1994) and Bergh (1995) and, positive effects in Chen et al. (2001) and John and Ofek (1995).

3 Data and Descriptive Statistics

3.1 Introduction

The dataset that will be used in the empirical analyses of chapters four and five is created by merging Business Enterprise Research and Development (BERD) and Annual Inquiry into Foreign Direct Investment (AFDI) into Annual Respondents Database/Annual Business Survey (ARD/ABS). The BERD and AFDI are panel data covering information on business research and development and foreign direct investment respectively. The ARD/ABS is a longitudinal business micro dataset that contains key financial information such as factor inputs and outputs. All these data are collected by the Office of National Statistics (ONS). Successfully linking all datasets is crucial as failure to include key variables such as R&D and FDI will undermine the results in our empirical analyses. The work undertaken to merge all datasets builds on that of Harris (2005). First, a firm- and plant-level dataset on manufacturing and marketable services is constructed using the ARD/ABS database. This dataset is then linked with other panel data covering business research and development (BERD data) and information on foreign direct investment (AFDI data).

The chapter is structured as follows: The next section describes our key database – The Annual Respondent database/Annual Business Survey; the third section explains the method used to classify firms and plants into different adjustment categories. The fourth and fifth sections provide descriptive statistics for different sub-categories within net expanding and net contracting firms respectively. The sixth section concludes.

3.2 The Annual Respondents Database/Annual Business Survey (ARD/ABS)

The Annual Respondents Database (ARD, currently available from 1973 to 2008)[18] is a longitudinal business micro data for the UK. It is constructed by combining information from the Inter-Departmental Business Register (IDBR) named ‘indicative data’ with more comprehensive information collected from the Annual Business Inquiry (ABI) termed ‘returned data’. The IDBR, introduced in 1994, is a comprehensive list of UK businesses that covers the names, addresses, ownership structure, industrial classification and employment of businesses in all parts of the economy; except some very small businesses (those without employees and self-employed with turnover below the tax threshold) and some non-profit making organisations. There are over 2 million businesses on the IDBR; covering 99 per

[18] The annual business survey (ABS) has since replaced the ARD and it is available up until 2016.

cent of UK economy activity (by turnover) and it serves as the main sampling frame for most business surveys carried out by government departments, including the Office for National Statistics (ONS).

The more detailed information in the ARD is constructed from the Annual Business Inquiry (ABI) from 1998 onwards and other previous source surveys before that, such as the Annual Census of Production (ACOP, from 1974 to 1997) and Annual Census of Construction (ACOC, from 1991 to 1997)[19]. The ABI is a compulsory business survey that compiles the most comprehensive financial information of businesses in the UK, such as turnover, capital expenditure, employment costs and level, purchases, ownership, industry, location etc. To carry out the ABI, the ONS selects a sample of businesses from the IDBR each year. Plants are organised into reporting unit, local unit, enterprise and enterprise group in the IDBR. ONS (2012) defines an enterprise group as an "association of enterprises bound together by legal and/or financial links" while an enterprise is defined as "the smallest combination of legal units, which have a certain degree of autonomy within an enterprise group". ONS (2012) also defines a local unit as "an enterprise or part thereof (e.g., a workshop, factory, warehouse or office) situated in a geographically identified place".

A reporting unit which questionnaires are sent to is the smallest unit that can provide the full comprehensive information for the ABI. Often, the reporting unit is the same as the enterprise and can provide full information on the enterprise (except for a minority of larger businesses or businesses which have a more complex structure). If the reporting unit is unable to provide full information on the enterprise, it will report for parts of the enterprise identified by lists of local units. As a result, ABI reporting unit counts are presented as enterprise counts. An enterprise may consist of one or more local units i.e., the head office for a group of shops. Therefore, an enterprise may have local units at different geographical locations, and may operate at different industries.

Reporting units are selected for surveying in the ABI based on employment data in the IDBR with the sampling frame skewed towards the largest businesses. From 1998, 100 per cent of businesses with 250 or more employees are surveyed; the proportion of businesses with employees between 100 and 249 that were surveyed varies by industry from 100 to less than or equal to 50 per cent; 50 per cent of businesses with between 10 and 99 employees are surveyed while 25 per cent of businesses with fewer

[19] Note that the ACOP, ACOC, Annual Distribution and Services Inquiry (ADSI) and, Purchase Inquiry (PI) were all combined in 1998 to become the Annual Business Inquiry (ABI) which was then replaced by the Annual Business Survey in 2009.

than 10 employees are surveyed in the ABI (Oulton, 1997 and; Barnes and Martin, 2002). Given this sampling frame, weights must be applied to obtain statistics that are representative of the population.

When the ONS dispatches questionnaires for the ABI, it uses different form-types, often categorized into either short or long form-type. The short form-types are sent to businesses with fewer than 250 employees requesting for totals i.e., total turnover. The long form-types, on the other hand, are sent to businesses with 250 or more employees and to a proportion of selected businesses with lower employment asking for more detailed breakdowns. The data are collected in 2 parts: Part 1 (or ABI, Part 1) collects employment record as soon as possible after 12th December of each year. Part 2 (or ABI, Part 2) collects financial information, which may be submitted up to 12 months after each financial year end. This survey is designed to generate statistics for calculating the national income accounts and Gross Domestic Product (GDP). In 2009, the ARD was renamed the Annual Business Survey. The ABS now contains the financial information of businesses covering the production, construction, distribution and service industries, which represents about two-thirds of the UK economy in terms of the GVA

3.3 Adjustment Classification

Upon entry into the IDBR, the ONS assigns 3 unique identification numbers to each plant, identifying its status as a local unit, enterprise and enterprise group. These unique reference numbers allow the analysis of demographic events over time. Since the local unit is the lowest level of aggregation for which we have the information to identify the different demographic events over time, we start our classification by focusing on the local unit unique identifier. If between 2 census years, a new local unit identifier appears, we code this as a plant entry. Likewise, if one disappears, we code this as a plant exit. Thirdly, if a local unit identifier survives between 2 census years, we check to see if the enterprise identifier associated with the local unit identifier also survived between the same census years. If the enterprise identifier survives and there is a change in employment, we code this as internal expansion for positive changes and internal contraction for negative changes. Secondly, if the enterprise identifier survives and there is no change in employment between the 2 census years we code this 'No change'. Thirdly, if the enterprise identifier changes between the 2 census years, we code this as ownership changes. The local unit identifier associated with the new enterprise identifier is coded as mergers and acquisition; while the local unit identifier associated with the old enterprise identifier is coded as plant sold. Because adjustment decisions are made at the level of the firm (i.e., enterprise level), we aggregate these classifications to that level for our analysis. We can of course distinguish between plants that enter/exit, but are part of a surviving firm (i.e., an enterprise identifier that survives between 2 census years) from those that belong to an entering or exiting firm (i.e., an enterprise identifier that appears or disappears between 2 census years). The same can be done for plants that are acquired and sold.

Taken together, firms can use one or more of the aforementioned adjustment strategies to adjust their overall (net) employment. Indeed, a continuing firm[20] that wants to raise its overall employment may choose to increase employment at existing plants (internal expansion); create new plants (greenfield investment) or acquire existing plants from other firms (mergers and acquisition). The same firm may choose to combine some/all of the 3 expansion (and contraction) paths in order to raise its net employment. There are 53 potential path combinations (and a total of 56 expansion paths including the 3 major expansion paths) available to continuing firms that wish to expand their net employment. Net contracting firms have 56 similar contracting paths available to them. Continuing firms could sometimes use some/all of the adjustment paths without changing their net employment[21]. We regard to such firms as 'No change'. If between 2 census years, a continuing firm fails to use any adjustment path, it is also classified as a 'No change' firm[22]. Finally, for entry (exiting) firms, they may only access (leave) domestic market through greenfield investment (plant closure) or mergers and acquisition (plant sale) or both.

Table 3.1 presents some basic descriptive statistics on the employment changes and number of firms carrying out such changes under different sub-categories. This table separates net expanding firms (Panel A) from net contracting firms (Panel B) and classify all firms into 5 broad categories. The first 4 categories are those using either internal expansion (internal contraction); greenfield investment (plant closure); mergers and acquisition (plant sale) or 'No change'. For firms using combinations of expansion and contraction paths (106 combinations for net expanding and contracting firms), we collapse them into the 4 categories; according to the path that is used as a dominating strategy[23].

[20] A continuing firm is one that existed in period *t* and *t-1*, an entrant is a firm that existed in period *t* but not t-*1*, and; an exitor is a firm that existed in period *t-1* but not *t*.

[21] For instance, a firm with 100 employees in period *t-1*, may in period *t*, employ 10 new workers in some existing plants (internal expansion) and deploy 10 existing workers in other existing plants (internal contraction), so that the net employment in this particular firm remains at 100 employees in *t* even though the firm has both expanded and contracted internally between periods *t-1* and *t*.

[22] We also include firms with employment changes of less than 5 employees into the 'No change' category as these represents small changes in employment possibly reflecting other things than expansion/contraction.

[23] Detailed information on all 106 combinations is given in sections 3.4 and 3.5 respectively.

Table 3-1: Employment change and number of firms; averages per year, 1997-2012

	Employment change	percent of employment change		Number of firms	Percent of number	
		Total	Sub-group		Total	Sub-group
Panel A: Expanding firms						
All firms	**2,139,151**	100		**1,447,009**	100	
Greenfield investment	1,129,537		52.8	217,017		15.0
Internal expansion	671,664		31.4	31,359		2.2
Mergers and acquisition	281,800		13.2	1,575		0.1
At least 2 dominant	1,582		0.1	62		0.0
No change	54,569		2.6	1,196,996		82.7
Continuing firms	**1,264,292**	59		**1,234,122**	85	
Greenfield investment	342,601		27.1	4,866		0.4
Internal expansion	671,664		53.1	31,359		2.5
Mergers and acquisition	193,989		15.3	841		0.1
At least 2 dominant	1,468		0.1	60		0.0
No change	54,569		4.3	1,196,996		97.0
Entrants	**874,860**	41		**212,887**	15	
Greenfield investment	786,936		89.9	212,151		99.7
Mergers and acquisition	87,810		10.0	734		0.3
At least 2 dominant	*		*	*		*
Panel B: Contracting firms						
All firms	**2,048,754**	100		**1,417,233**	100	
Plant closure	1,154,381		56.3	194,933		13.8
Internal contraction	516,722		25.2	22,630		1.6
Plant sale	322,078		15.7	2,620		0.2
At least 2 dominant	1,003		0.0	54		0.0
No change	54,569		2.7	1,196,996		84.5
Continuing firms	**890,006**	43		**1,224,044**	86	
Plant closure	265,584		29.8	4,164		0.3
Internal contraction	516,722		58.1	22,630		1.8
Plant sale	52,350		5.9	205		0.0
At least 2 dominant	780		0.1	49		0.0
No change	54,569		6.1	1,196,996		97.8
Exitors	**1,158,748**	57		**193,189**	14	
Plant closure	888,797		76.7	190,769		98.7
Plant sale	269,728		23.3	2,415		1.2
At least 2 dominant	*		*	*		*

Notes: All categories include firms that expanded/contracted by 5 or more employees; whereas 'No change' category includes firms with employment changes between 0 and 4 employees. A continuing firm is one that existed in period *t* and *t-1*, an entrant is a firm that existed in period *t* but not t-*1*, and; an exitor is a firm that existed in period *t-1* but not *t*.
(*) Exact annual average values cannot be reported due to disclosure restriction (Number of observations underlying the cell is less than 10).
Source: Authors' own calculations using the Annual Respondent Database/Annual Business Survey (ARD/ABS).

For instance, if a firm expands employment by 100 employees in an existing plant (internal expansion) and contracts employment by closing another plant with 10 employees (plant closure), such a firm is clearly using internal expansion as a dominating strategy. As such, it will be classified under the internal expansion category. We compute the employment changes and number of firms which at any stage continued operation, entered or exited. The table shows annual averages.

As shown in the first row of panel A, on average each year there were around 2,140,000 employment expansions carried out by almost 1,450,000 firms over the period considered. Of the total employment expansions, 60 per cent were carried out in continuing firms while 40 per cent were due to firm entry. The next 3 rows of panel A show that 97 per cent of the employment expansions were carried out via greenfield investment (52.8 per cent), internal expansion (31.4 per cent) and mergers and acquisition (13.2 per cent), even though firms using these expansion paths only account for 17 per cent of the total numbers of firms. About two-third of greenfield investment expansion was due to firm entering through the creation of new plants[24]. Turning now to net contracting firms. The first row of panel B shows that on average around 2,050,000 employment contractions was carried out each year by almost 1,420,000 firms. 43 per cent of the total employment contractions were carried out in continuing firms while 60 per cent were due to firm exit. The next 2 rows of panel B show that 82 per cent of the employment contractions were carried out via plant closure (56.3 per cent) and internal contraction (25.2 per cent), even though firms using these contraction paths only account for 15 per cent of the total number of firms. About three quarter of plant closure contraction was due to firm exiting through the closure of existing plants.

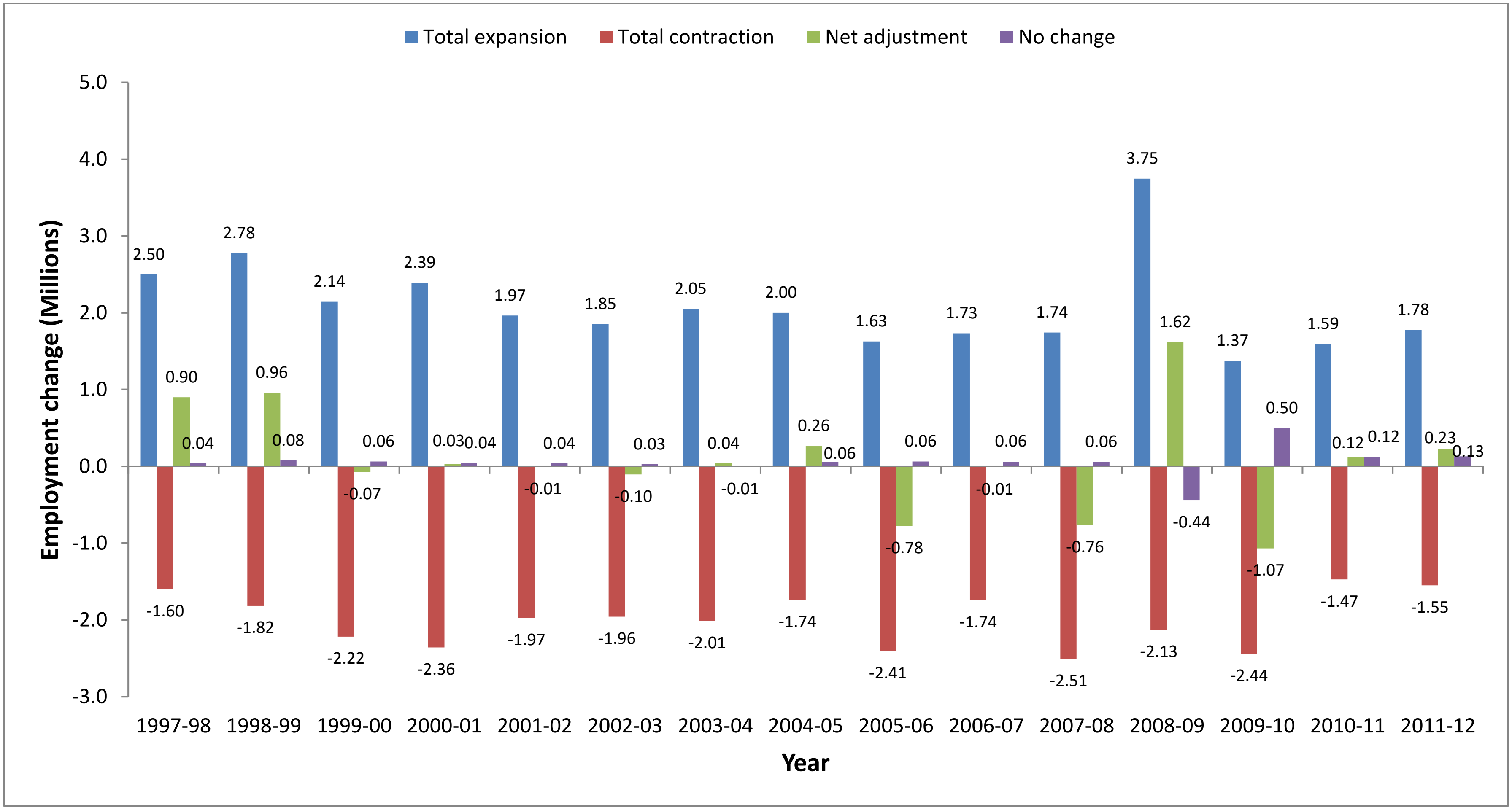
The averaged data in Table 3.1 may hide important differences across years. Figure 3.1 shows employment changes for each year between 1997 and 2012. The employment numbers between 2008 and 2009 should be treated with caution as, due to the replacement of the ARD with ABS, the ONS may have largely updated the employment figures in the IDBR (which goes into the ABS) to make sure that their employment-size sampling frame for the then new ABS was adequate in 2009. As is clear in Figure 3.1, employment expansion has fluctuated considerably between 1997 and 2008. Dramatic rise and fall in employment expansion was witnessed between 2008 and 2010, due to the aforementioned replacement of the ARD with ABS in 2009. However, after the 2008/2009 period, employment expansion has displayed an upward trend. Turning to employment contraction, there is no obvious trend

[24] Note that by construction; only continuing firms can use either internal expansion or internal contraction.

across years. Employment contraction was however in its highest during the global financial crisis of 2007/08. Compared to employment expansion i.e., net adjustment, again, there is no obvious trend between the periods 1997 to 2012.

Figure 3.2 shows the number of firms carrying out the adjustments displayed in Figure 3.1. Most firms fall into the 'No change' category. For expanding firms, there is no clear trend across years. More interestingly, the dramatic rise and fall in employment expansion between 2008 and 2010 cannot be accounted for by the change in number of firms. While the number of firms expanding employment between 2008 and 2010 increased and fell, these changes were not as dramatic as the employment expansion itself. Finally, the trend in the number of firms contracting follow a similar pattern to employment contraction.

Figure 3-1: Employment change in United Kingdom by year, 1997-2012



Notes: Total expansion and total contraction includes only firms that expanded/contracted by 5 or more employees; whereas 'No change' includes firms with employment changes between 0 and 4. Net adjustment is calculated as total expansion minus total contraction. The number above each bar represents total employment change for each year.
Source: Authors' own calculations using the Annual Respondent Database/Annual Business Survey (ARD/ABS).

Figure 3-2: Number of firms in the United Kingdom by year, 1997-2012

Notes: Total expansion and total contraction includes only firms that expanded/contracted by 5 or more employees; whereas 'No change' includes firms with employment changes between 0 and 4. Net adjustment is calculated as total expansion minus total contraction. The number above each bar represents total number of firms for each year.
Source: Authors' own calculations using the Annual Respondent Database/Annual Business Survey (ARD/ABS).

3.4 Descriptive Statistics for Net Expanding Firms

As discussed in the previous section, firms were classified into 5 major expansion categories - 'No change', internal expansion 'only', greenfield investment 'only', mergers and acquisition 'only' and a mix of adjustment path used to achieve net expansion.

Table 3-2: Employment expansion by major[a] expansion path; average per year, 1997-2012

Expansion path	Employment expansion per year[b]	Number of firms per year[c]	Employment expansion per firm[d]
Panel A: All firms			
Greenfield investment only	785,701	212,375	4
Greenfield investment dominant	343,836	4,642	74
Internal expansion only	440,987	28,731	15
Internal expansion dominant	230,678	2,628	88
Mergers and acquisition only	81,080	985	82
Mergers and acquisition dominant	200,720	590	340
At least 2 dominant	1,582	62	25
Total expansion	**2,084,582**	**250,013**	**629**
Total contraction[e]	**1,994,185**	**220,237**	**777**
No change (0-4)[f]	**54,569**	**1,196,996**	**0.05**
Panel B: Continuing firms			
Greenfield investment only	17,626	260	68
Greenfield investment dominant	324,975	4,606	71
Internal expansion only	440,987	28,731	15
Internal expansion dominant	230,678	2,628	88
Mergers and acquisition only	29,333	303	97
Mergers and acquisition dominant	164,656	538	306
At least 2 dominant	1,468	60	25
Total expansion	**1,209,723**	**36,867**	**601**
Panel C: Entrants			
Greenfield investment only	768,075	212,115	4
Greenfield investment dominant	18,861	35	535
Mergers and acquisition only	51,747	682	76
Mergers and acquisition dominant	36,064	52	695
At least 2 dominant	*	*	*
Total expansion	**874,860**	**212,887**	**1,354**

[a] The 53 gross expansion (and contraction) path combinations in Table 1 has been collapsed into 3 major expansion paths according to the expansion path used as the dominating strategy. If a firm uses more than one expansion path as a dominating strategy, it is classified into the 'At least 2 dominant' group.

[b] Employment expansion of each of the expansion path summed over the period 1997-2012 divided by the number of years.

[c] Number of firms using each of the expansion path summed over the period 1997-2012, divided by the number of years.

[d] Employment expansion per year divided by number of firms per year.

[e] Employment contraction, number of firms and employment contraction per firm for all contraction path summed over the period 1998-2012, divided by the number of years.

[f] Employment change, number of firms and employment change per firm for all firms with no adjustment summed over the period 1997-2012, divided by the number of years. 'No change' includes firms with employment changes between 0 and 4 employees.

Source: Authors' own calculations using the Annual Respondent Database/Annual Business Survey (ARD/ABS).

Firms that used a combination of adjustment paths were further classified into 4 categories, according to the path of adjustment that was used as a dominating strategy – i.e., internal expansion 'dominant', greenfield investment 'dominant', mergers and acquisition 'dominant' and at least 2 'dominant'. The 'dominant' and 'only' expansion paths were merged to show the aggregate figures in panel A of table 3.1 (i.e., Greenfield investment = Greenfield investment 'only' + Greenfield investment 'dominant'). In this section, we separate the 'dominant' from 'only' expansion paths to provide more detailed information.

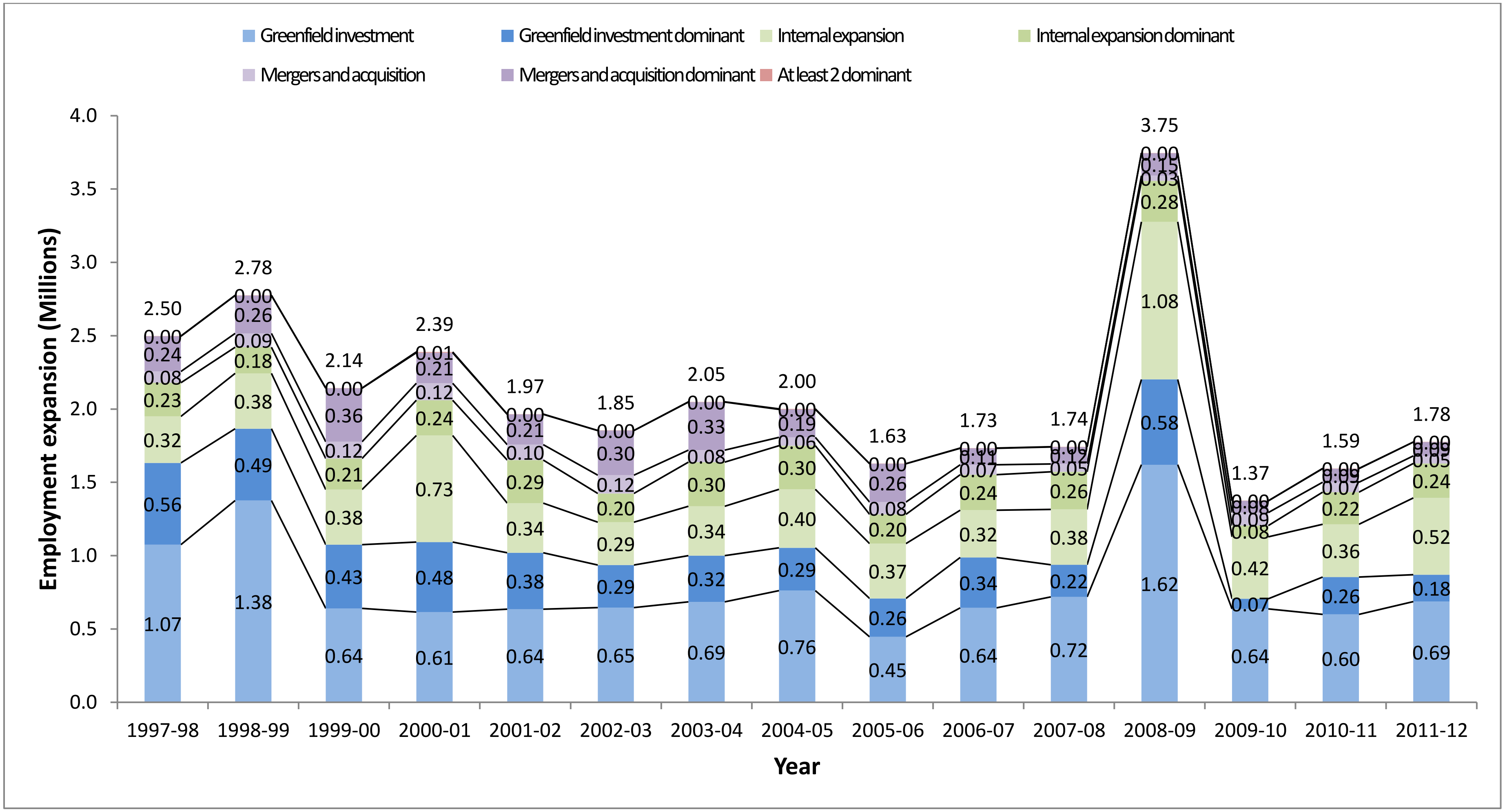
Table 3.2 provide some basic information on employment expansion and number of firms for each of the 'dominant' and 'only' expansion paths. The table shows that although the dominating categories are rare events, firms using greenfield investment as a dominating strategy, account as major contributors to employment expansion. This expansion path is also the most frequently used out of the 4 'dominant' categories. However, on average, when used, mergers and acquisition 'dominant' strategy is used to carry out a larger expansion in employment than all other 6 expansion paths. The importance of mergers and acquisition 'dominant' path is persistent when we separate continuing firms from starters (See panels B and C of table 3.2).

The averaged data in Table 3.2 may hide important differences across years. As a result, we present figures 3.3 and 3.4 to show year-on-year differences, according to the 7 paths of expansion. Figures 3.3 and 3.4 are mirror images (the top half of the x-axis) of figures 3.1 and 3.2 respectively, with the expansion bar in the latter figures broken down into 7 expansion paths. Like in Figure 3.1, there is no obvious trend in all the 7 expansion paths. However, across all years, greenfield investment (and greenfield investment dominant amongst the dominant paths) is the largest contributor to employment expansion. It is also clear from figure 3.3 that the dramatic rise and fall in employment shown in figure 3.1 was largely due to the substantial rise and fall in employment expansion via greenfield investment and internal expansion. Figure 3.4 shows that while the number of firms using internal expansion tripled in 2008/09 (the period in which there was a dramatic rise in employment), the number of firms using greenfield investment fell over the same period. This suggests that while the substantial rise in employment via internal expansion can be accounted for through the huge rise in the number of firms using internal expansion; the big rise in employment that is due to greenfield investment cannot be explained by the number of firms using this path. To better illustrate this, Figure 3.5 shows the employment expansion per firm[25] for each year, according to the 7 channels of expansion.

Figure 3.5 shows that internal expansion per firm remains steady for the entirety of the period so that, the substantial rise in internal employment expansion in 2008/09 is accommodated for by the huge rise in the number of firms using this path of expansion. On the hand, greenfield investment per firm, experienced a dramatic increase in 2008/09, which means that the substantial rise in greenfield employment expansion cannot be explained by fall in the number of firms using this path. In moving from ARD to ABS in 2009, the ONS updated a lot of the employment figures for continuing firms with continuing plants, so that both internal employment expansion and the number of firms using internal expansion would increase in the 2008/09 period. The big rise in greenfield investment per firm in 2008/09 suggests that even though fewer firms used greenfield investment in 2009 (the year ABS was introduced), those that used it, carried a larger expansion in employment compared to previous years. The dramatic rise in greenfield investment in 2008/09 can only be attributed to the switch from ARD to ABS in 2009.

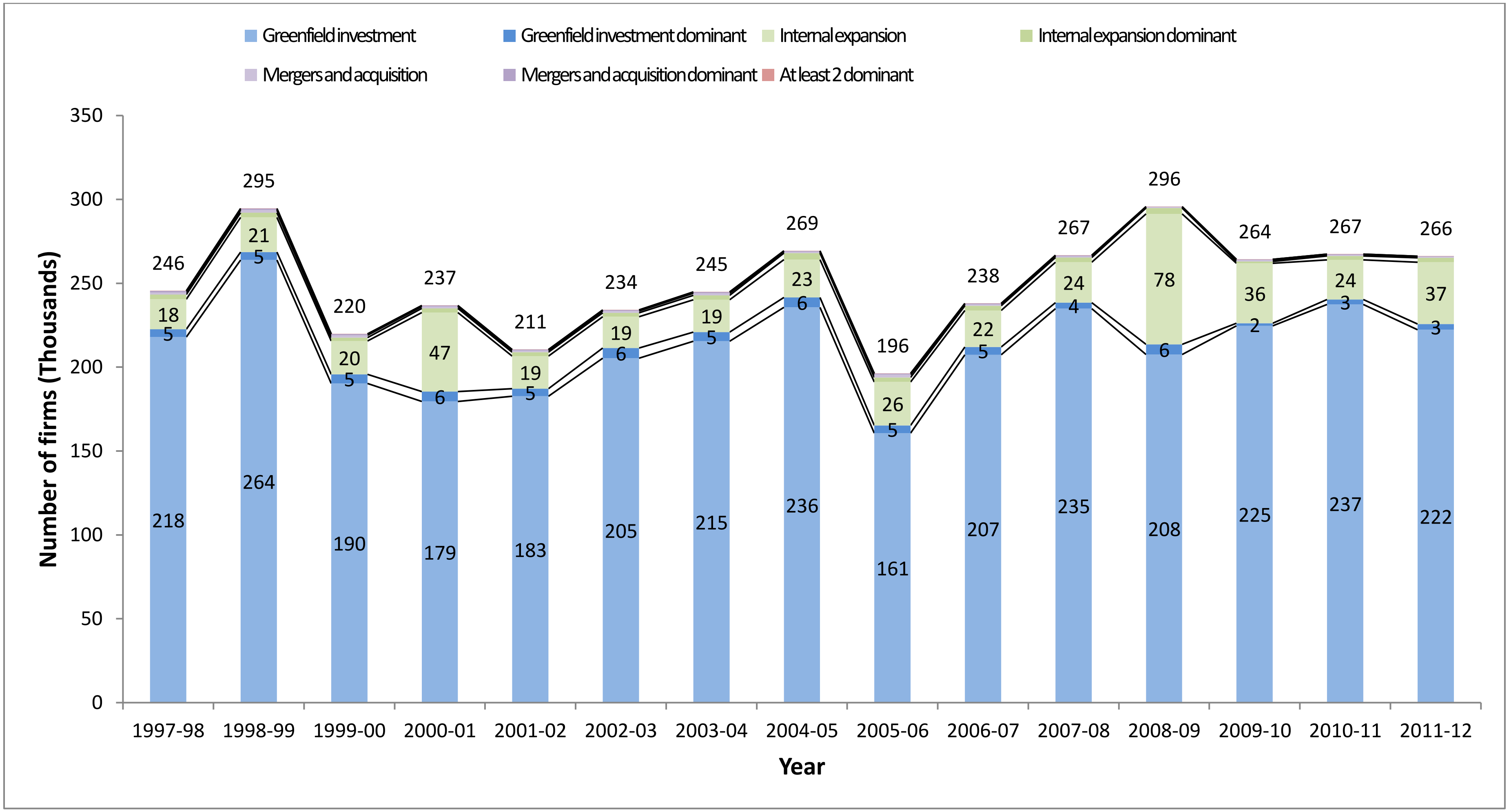
[25] The numbers in Figure 3.5 are calculated by dividing the numbers in Figure 3.3 (employment expansion per expansion path per year) by the numbers in Figure 3.4 (number of firms using each expansion path yearly).

Figure 3-3: Employment expansion by expansion path by year, 1997-2012



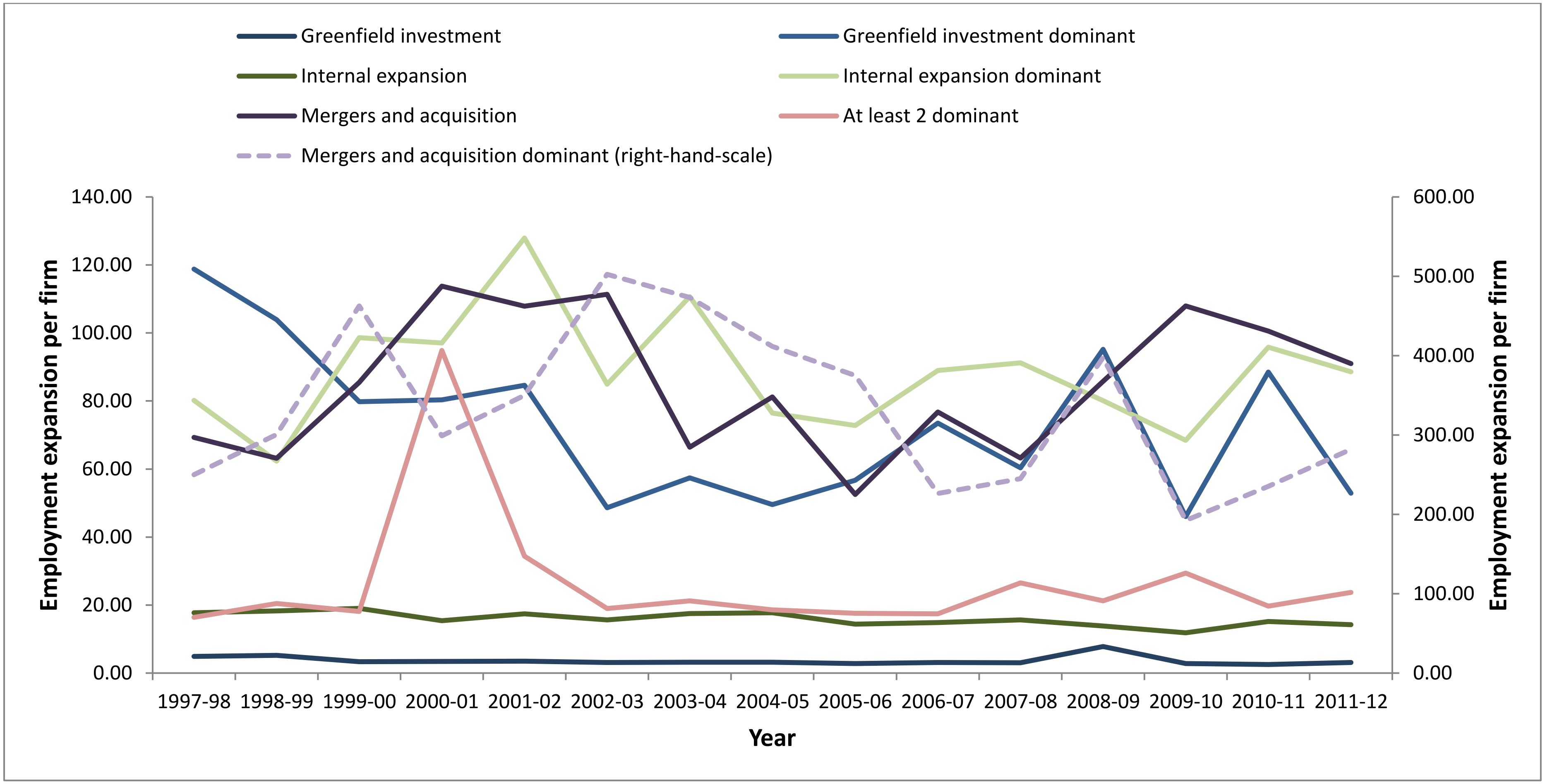
Notes: Each expansion path includes firms that expanded (and contracted) by 5 or more employees. The number above each bar represents total employment expansion between 2 years.
Source: Authors' own calculations using the Annual Respondent Database/Annual Business Survey (ARD/ABS).

Figure 3-4: Number of firms using each expansion path by year, 1997-2012



Notes: Each expansion path includes firms that expanded (and contracted) by 5 or more employees. The number above each bar represents total number of firms between 2 years.
Source: Authors' own calculations using the Annual Respondent Database/Annual Business Survey (ARD/ABS).

Figure 3-5: Employment expansion per firm by expansion path by year, 1997-2012



Notes: Numbers are calculated by dividing employment expansion per expansion path per year (Figure 3.3) by number of firms using each expansion path yearly (Figure 3.4).
Source: Authors' own calculations using the Annual Respondent Database/Annual Business Survey (ARD/ABS).

For completeness, we further disaggregate the ‘dominant’ expansion paths to show how firms combine different paths of adjustment to attain a net expansion. Table 3.3 presents all the 53 possible combinations of adjustment and the 3 ‘only’ expansion path (making a total of 56 expansion paths). Between 1997 and 2012, most of the 56 available options are used at least once (see third column of table 3.3). The 3 main expansion channels – Internal expansion ‘only’, greenfield investment ‘only’ and merger and acquisition ‘only’ – were used in about 97 per cent of overall employment expansion in the UK economy, with the clear majority occurring via greenfield investment ‘only’ (85 per cent). On average, greenfield investment also accounts as the major contributor (about 38 per cent) to employment expansion. Combining gross expansion (and contraction) path into overall net expansion are rare events; used in only about 3 per cent of employment expansions in the UK economy between 1997 and 2012. However, on average, the 53 gross expansion (and contraction) path combinations account for a large share – one-third – of the economy-wide employment expansion between 1997 and 2012. Indeed, when they occur, these gross expansion (and contraction) path combinations are major events as shown in the fourth column of table 3.3. The average gross expansion (and contraction) path combination employment expansion per firm is 150 times bigger than the average greenfield investment employment expansion per firm.

The most obvious lesson from tables 3.2 and 3.3 is that gross expansion (and contraction) path combinations account for a large fraction of overall employment expansion despite their infrequent occurrence. Therefore, it would seem reasonable to include these gross expansion (and contraction) path combinations into our empirical analyses. However, examining how firms choose between 7 or 56 different channels of expansion (as in tables 3.2 and 3.3) and their impacts on firm-level productivity can be very complex, particularly when we come to using multinomial logit/probit to empirically model the unordered multiple firms’ choice of using different expansion paths to increase output/employment. As a result, we merged the different gross expansion (and contraction) combinations into the Internal expansion ‘only’, greenfield investment ‘only’ and mergers and acquisition ‘only’ categories. In other words, we used the categorisation in panel A of table 3.1 to carry out our empirical analyses in chapters four and five.

Table 3-3: Employment expansion by expansion path; averages per year, 1997-2012

Expansion path	Employment expansion per year[a]	Number of firms per year[b]	Employment expansion per firm[c]
1 = Greenfield investment only	785,701	212,375	4
2 = Internal expansion only	440,987	28,731	15
3 = 1 + Internal expansion + Internal contraction + Plant closure	155,736	593	263
4 = 1 + 2 + Mergers and acquisition + Internal contraction + Plant closure	105,004	106	993
5 = Greenfield investment + Mergers and acquisition	81,744	123	665
6 = Mergers and acquisition only	81,080	985	82
7 = Greenfield investment + Plant closure	78,989	2,811	28
8 = Greenfield investment + Internal expansion + Internal contraction	57,886	702	82
9 = Greenfield investment + Internal expansion	44,508	767	58
10 = Internal expansion + Internal contraction	35,054	1,011	35
11 = 1 + 2 + Mergers and acquisition + Internal contraction	*	*	*
12 = Greenfield investment + Mergers and acquisition + Plant closure	18,318	48	380
13 = Greenfield investment + Internal expansion + Plant closure	17,640	196	90
14 = Internal expansion + Internal contraction + Plant closure	17,340	175	99
15 = Greenfield investment + Internal contraction	15,954	405	39
16 = Internal expansion + Plant closure	15,314	336	46
17 = Mergers and acquisition + Plant closure	12,029	193	62
18 = Internal expansion + Mergers and acquisition	10,799	80	135
19 = 2 + Mergers and acquisition + Internal contraction	10,105	54	187
20 = 1 + 2 + 6 +Internal contraction + Plant closure + Plant sale	*	*	*
21 = Greenfield investment + Internal expansion + Mergers and acquisition	9,218	24	382
22 = 2 + Mergers and acquisition + Internal contraction + Plant closure	*	*	*
23 = Greenfield investment + Mergers and acquisition + Internal contraction	*	*	*
24 = 1 + Internal expansion + Mergers and acquisition + Plant closure	*	*	*
25 = 1 + 2 + Internal contraction + Plant closure + Plant sale	*	*	*
26 = 1 + Mergers and acquisition + Plant closure + Plant sale	*	*	*
27 = Mergers and acquisition + Internal contraction	5,587	64	87
28 = 1 + Mergers and acquisition + Internal contraction + Plant closure	*	*	*
29 = Greenfield investment + Internal contraction + Plant closure	3,745	50	75
30 = Internal expansion + Mergers and acquisition + Plant closure	*	*	*
31 = 1 + 2 + Mergers and acquisition + Internal contraction + Plant sale	*	*	*
32 = Greenfield investment + Plant closure + Plant sale	*	*	*
33 = Greenfield investment + Mergers and acquisition + Plant sale	*	*	*
34 = Mergers and acquisition + Internal contraction + Plant closure	*	*	*
35 = 1 + Internal expansion + Internal contraction + Plant sale	*	*	*
36 = 2 + Mergers and acquisition + Internal contraction + Plant sale	*	*	*
37 = 1 + Internal expansion + Mergers and acquisition + Plant sale	*	*	*
38 = Greenfield investment + Plant sale	*	*	*
39 = 1 + 2 + Mergers and acquisition + Plant closure + Plant sale	*	*	*
40 = Mergers and acquisition + Plant sale	*	*	*
41 = Greenfield investment + Internal expansion + Plant sale	*	*	*
42 = Mergers and acquisition + Plant closure + Plant sale	*	*	*
43 = 2 + 6 + Internal contraction + Plant closure + Plant sale	*	*	*
44 = Internal expansion + Internal contraction + Plant sale	*	*	*
45 = Mergers and acquisition + Internal contraction + Plant sale	*	*	*
46 = 1 + Internal contraction + Plant closure + Plant sale	*	*	*
47 = Internal expansion + Plant sale	*	*	*
48 = Internal expansion + Internal contraction + Plant closure + Plant sale	*	*	*
49 = Greenfield investment + Internal expansion + Plant closure + Plant sale	*	*	*
50 = Greenfield investment + Internal contraction + Plant sale	*	*	*

Expansion path	Employment expansion per year[a]	Number of firms per year[b]	Employment expansion per firm[c]
51 = Internal expansion + Mergers and acquisition + Plant sale	*	*	*
52 = 2 + Mergers and acquisition + Plant closure + Plant sale	*	*	*
53 = Internal expansion + Plant closure + Plant sale	*	*	*
54 = 1 + Mergers and acquisition + Internal contraction + Plant sale	*	*	*
55 = 1 + 6 + Plant closure + Internal contraction + Plant sale	*	*	*
56 = 6 + Internal contraction + Plant closure + Plant sale	*	*	*
Total expansion	**2,084,582**	**250,013**	**29,078**
Total contraction[d]	**1,994,185**	**220,237**	**32,576**
No change[e]	**54,569**	**1,196,996**	**0.05**

[a] Employment expansion of each of the expansion path summed over the period 1997-2012 divided by the number of years.

[b] Number of firms using each of the expansion path summed over the period 1997-2012, divided by the number of years.

[c] Employment expansion per year divided by number of firms per year.

[d] Employment contraction, number of firms and employment contraction per firm for all contraction path summed over the period 1997-2012, divided by the number of years.

[e] Employment change, number of firms and employment change per firm for all firms with no adjustment summed over the period 1997-2012, divided by the number of years. 'No change' includes firms with employment changes between 0 and 4 employees.

Notes: (*) Exact annual average values cannot be reported due to disclosure restriction (Number of observations underlying the cell is less than 10).

Source: Authors' own calculations using the Annual Respondent Database/Annual Business Survey (ARD/ABS).

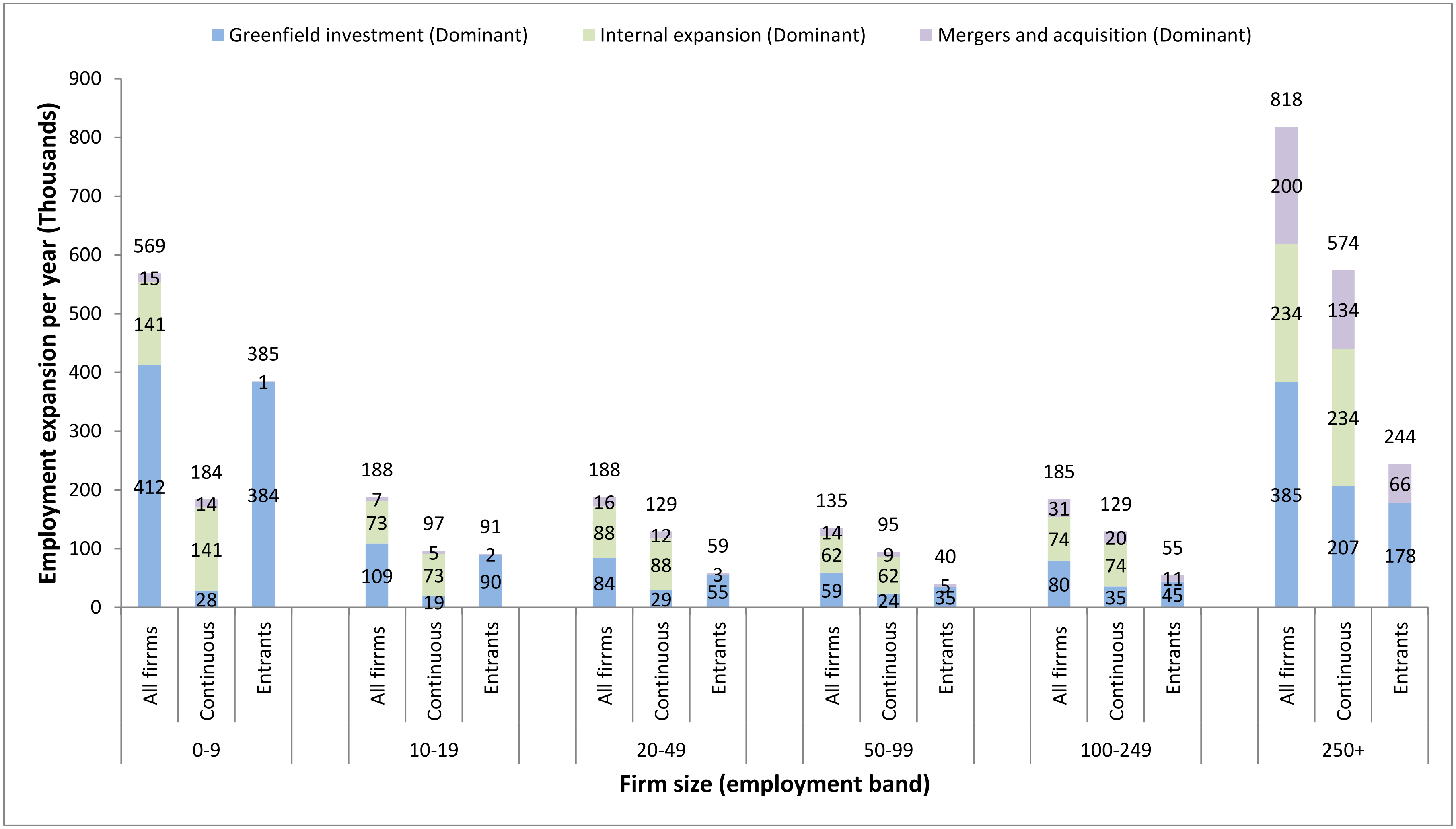
Because of theoretical predictions on firms' adjustment choice (as discussed in chapter two of this thesis), Figures 3.6 and 3.7 focus on some key firm-level variables which may determine the choice of adjustment channel. Firm size has figured prominently in the theoretical works of Jovanovic and Rousseau (2002), Warusawitharana (2008) and Breinlich and Neimann (2011). Their models have predicted that following a positive demand- or supply-side shock, large firms (those with lower marginal costs and/or better organizational capabilities) are more likely to expand through greenfield investment and mergers and acquisition. However, when choosing between greenfield investment and mergers and acquisition, Jovanovic and Rousseau (2002) and Warusawitharana (2008) show that large firms rely more on the latter path. Figure 3.6 provide some initial evidence on how firm size (based on employment band) correlates with the choice of expansion channel. The figure shows that greenfield investment (Dominant)[26] accounts for the largest share of the employment expansion for 4 out of the 6

[26] Because the number of firms underlying some cells in Figure 3.6 are less than 10 (i.e., less than the threshold required for disclosure restriction) we have combined greenfield investment with greenfield investment dominant and now refer to it as greenfield investment (Dominant). The same has been done to internal expansion and internal expansion dominant as well as mergers and acquisition and mergers and acquisition dominant.

firm size categories. However, when we separate continuous firms from entrants, Figure 3.6 shows that the importance of greenfield investment for continuing firms rises steadily with firm size. A similar pattern arises when we look at mergers and acquisition. For the smallest firms (those with employees between 0 and 9) mergers and acquisition only account for about 3 per cent of overall employment expansion. As firm size increases, however, mergers and acquisition become increasingly more important. For the largest firms (those with employees of at least 250), around 25 per cent of overall employment expansion is achieved via mergers and acquisition.

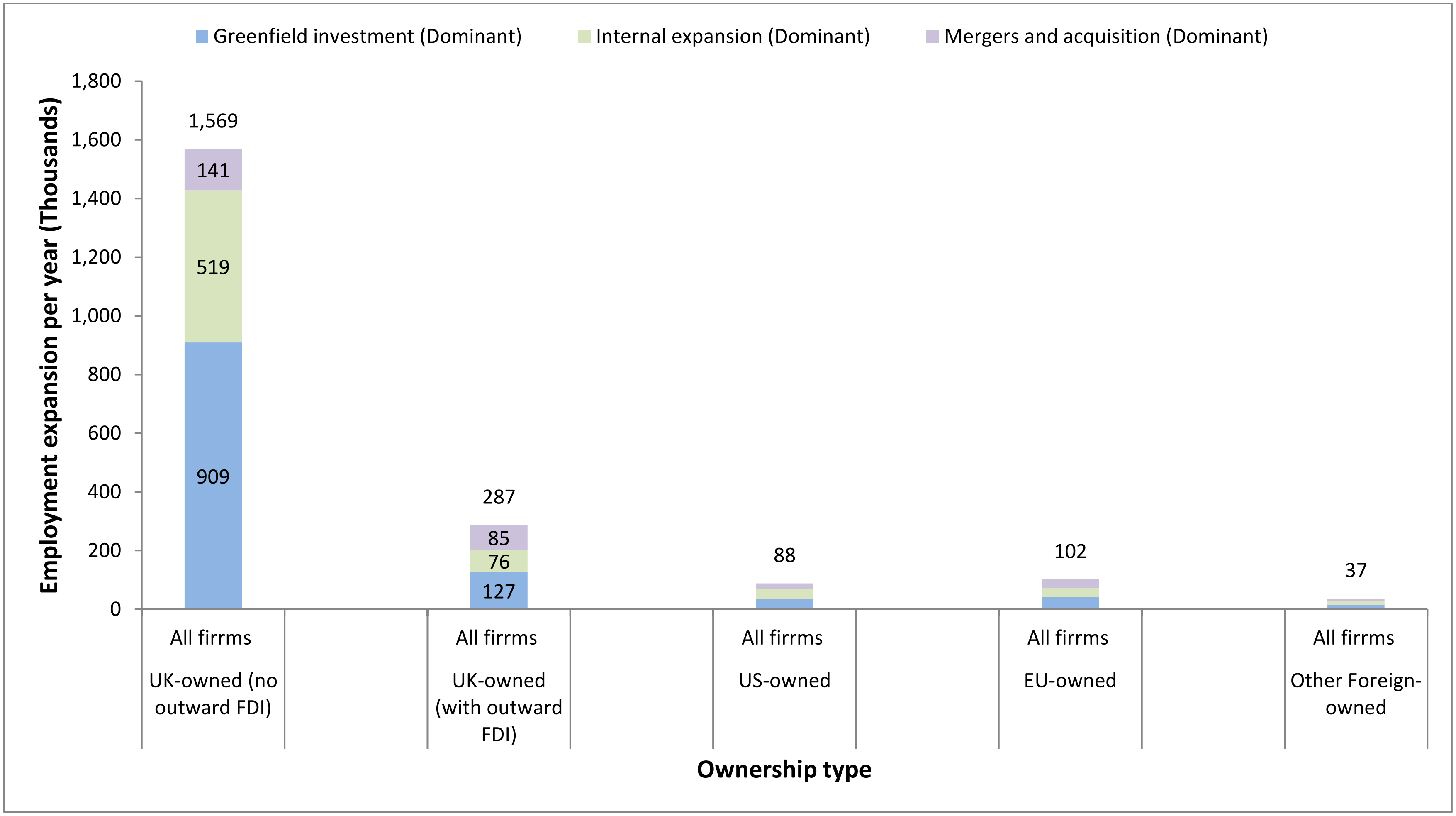
Ownership type has also figured extensively in the works of Hymer (1976), Harris and Robinson (2003) and Harris and Moffat (2012). For foreign firms to enter into a domestic market and incur the sunk cost of setting up or acquiring a plant, the foreign firms must possess superior characteristics such as specialized knowledge about production that gives them a cost advantage over domestic firms (Hymer, 1976). However, such superior characteristics may disappear as domestic firms learn to emulate the foreign firms as a result of knowledge spillover (Harris and Robinson, 2003). Figure 3.7 show how firm ownership-type correlates with the choice of expansion path. The Figure shows that greenfield investment and mergers and acquisition account for the largest share of employment expansion for UK-owned firms (91 per cent for UK-owned firms without FDI and 71 per cent for UK-owned firms with outward FDI). For Foreign-owned firms (US-owned, EU-owned and Other Foreign-owned) greenfield investment and mergers and acquisition account for about two-thirds of overall employment expansion. One shortcoming of the descriptive approach in Figures 3.6 and 3.7 is the failure to accommodate a multivariate relationship between for instance, a combination of firm size and ownership-type and firms' choice of expansion. Thus, it is unclear whether the correlations displayed in Figures 3.6 and 3.7 are driven by firm size, ownership-type or a combination of both.

Figure 3-6: Employment expansion by expansion path by firm size; average per year, 1997-2012



Notes: Each expansion path includes firms that expanded/contracted by 5 or more employees. The number above each bar represents annual average from 1997 to 2012.
Source: Authors' own calculations using the Annual Respondent Database/Annual Business Survey (ARD/ABS).

Figure 3-7: Employment expansion by expansion path by ownership type; average per year, 1997-2012



Notes: Each expansion path includes firms that expanded/contracted by 5 or more employees. The number above each bar represents annual average from 1997 to 2012.
Source: Authors' own calculations using the Annual Respondent Database/Annual Business Survey (ARD/ABS

3.5 Descriptive Statistics for Net Contracting Firms

Turning to net contracting firms, this section provides detailed information on the gross contraction (and expansion) path combinations. Specifically, we separate the 'dominant' from 'only' contraction paths – shown in panel B of table 3.1 as internal contraction, plant close and plant sale - to provide more comprehensive information.

Table 3-4: Employment contraction by major[a] contraction path; average per year, 1997-2012

Contraction type	Employment contraction per year[b]	Number of firms per year[c]	Employment contraction per firm[d]
Panel A: All firms			
Plant closure only	883,469	191,018	5
Plant closure dominant	270,912	3,914	69
Internal contraction only	298,326	20,239	15
Internal contraction dominant	218,397	2,391	91
Plant sale only	163,117	2,307	71
Plant sale dominant	158,961	313	508
At least 2 dominant	1,003	54	19
Total contraction	**1,994,185**	**220,237**	**777**
Total expansion[e]	**2,084,582**	**250,013**	**629**
No change[f]	**54,569**	**1,196,996**	**0.05**
Panel B: Continuing firms			
Plant closure only	15,631	314	50
Plant closure dominant	249,953	3,850	65
Internal contraction only	298,326	20,239	15
Internal contraction dominant	218,397	2,391	91
Plant sale only	3,254	45	72
Plant sale dominant	49,096	160	307
At least 2 dominant	780	49	16
Total contraction	**569,853**	**22,884**	**501**
Panel C: Exitors			
Plant closure only	867,839	190,705	5
Plant closure dominant	20,958	64	328
Plant sale only	159,863	2,262	71
Plant sale dominant	109,865	153	719
At least 2 dominant	*	*	*
Total contraction	**1,158,748**	**193,189**	**1,162**

[a] The 53 gross contraction (and expansion) path combinations in Table 1 has been collapsed into 3 major contraction paths according to the contraction path used as the dominating strategy. If a firm uses more than one contraction path as a dominating strategy, it is classified into the 'At least 2 'dominant' group.

[b] Employment contraction of each of the contraction path summed over the period 1997-2012 divided by the number of years.

[c] Number of firms using each of the contraction path summed over the period 1997-2012, divided by the number of years.

[d] Employment contraction per year divided by number of firms per year.

[e] Employment expansion, number of firms and employment expansion per firm for all expansion path summed over the period 1998-2012, divided by the number of years.

[f] Employment change, number of firms and employment change per firm for all firms with no change summed over the period 1997-2012, divided by the number of years. 'No change' includes firms with employment changes between 0 and 4 employees.

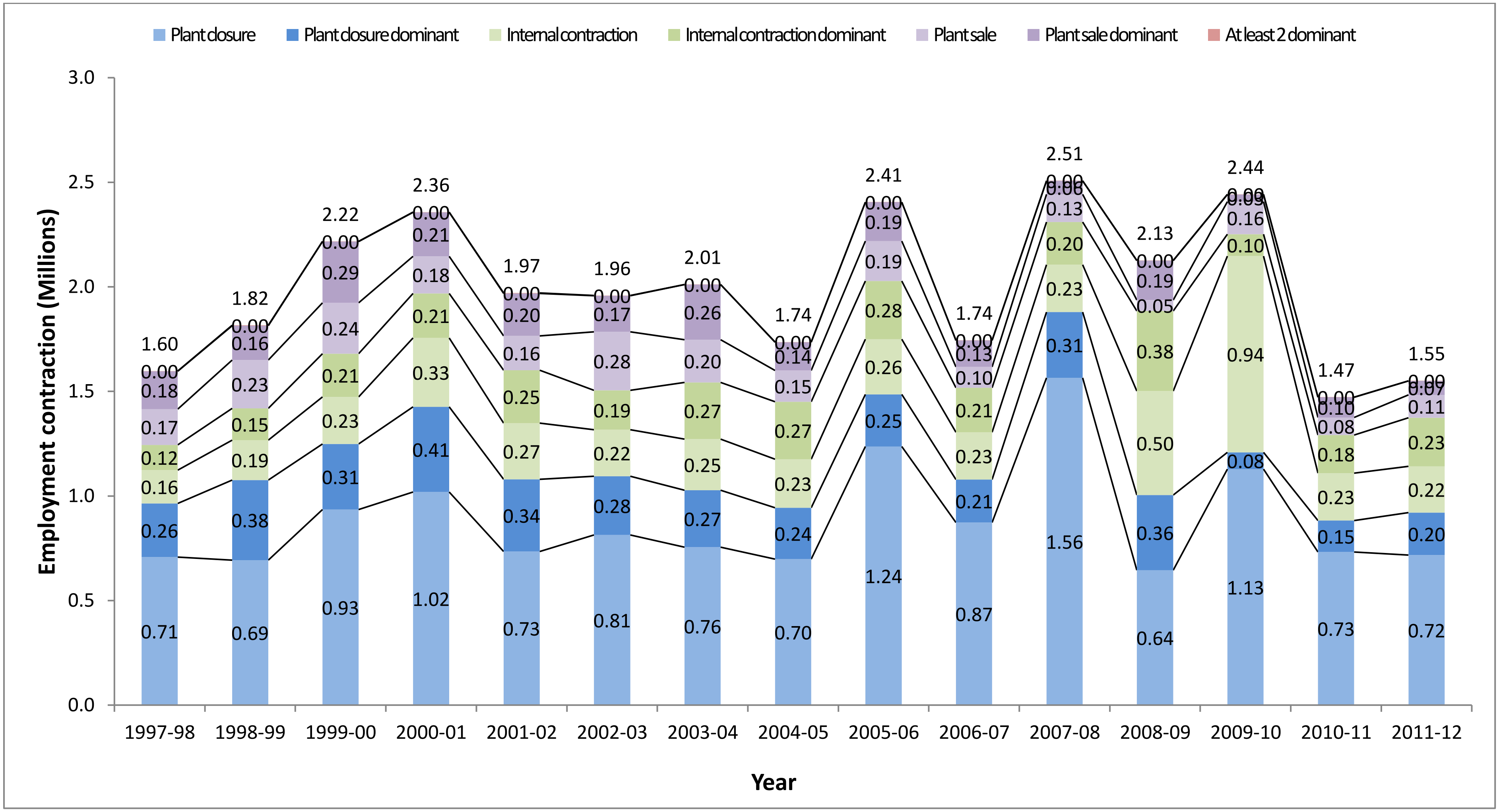
Notes: Panel A focuses on all firms while panel B and C focuses on continuing firms and entrants respectively.

Source: Authors' own calculations using the Annual Respondent Database/Annual Business Survey (ARD/ABS).

Table 3.4 provide some basic information on employment contraction and number of firms for each of the ‘dominant’ and ‘only’ contraction path. The table shows that although, the dominating categories rare events, firms using plant closure as a dominating strategy account as major contributors to employment contraction. Out of the 4 ‘dominant’ strategy, plant closure ‘dominant’ is the most frequently used. However, on average, plant sale ‘dominant’ strategy is used to carry out a larger contraction in employment than all other 6 contraction paths. The importance of plant sale ‘dominant’ path is persistent when we separate continuing firms from exitors (see panels B and C of Table 3.4).

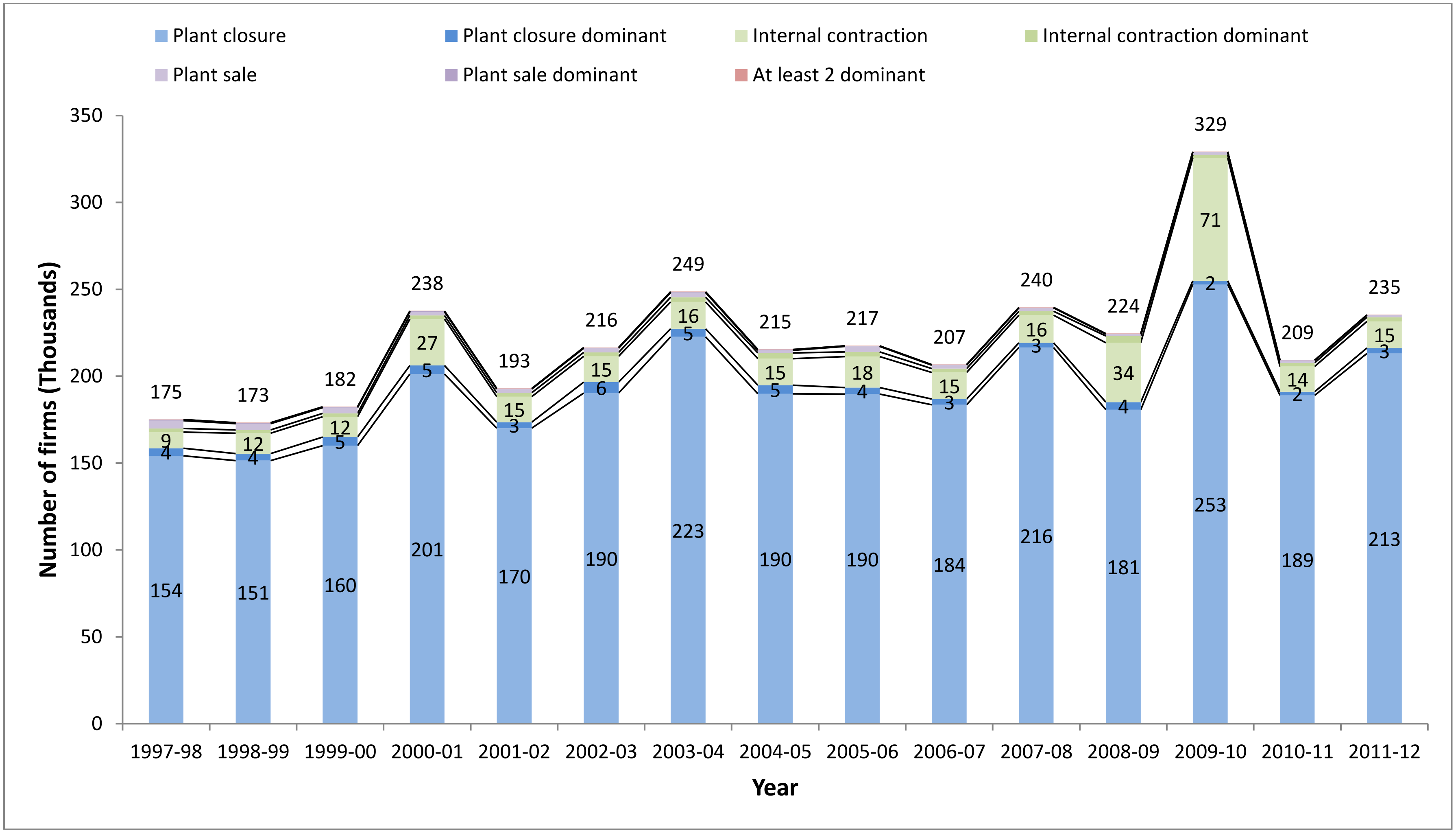
The averaged data in Table 3.4 may hide important differences across years. As a result, we present figures 3.8 and 3.9 to show yearly differences, according to the 7 paths of contraction. Figures 3.8 and 3.9 are mirror images (the bottom half of the x-axis) of figures 3.1 and 3.2 respectively, with the contraction bar in the latter figures broken down into 7 contraction paths. Like Figure 3.1, there is no obvious trend in all 7 paths of contraction. However, across all years, plant closure (and plant closure dominant amongst the dominant paths) is the largest contributor to employment contraction. Figure 3.8 also shows that the substantial rise in employment contraction during the global financial crisis of 2007/08 was largely due to plant closure. The number of firms that closed plants over the same period also rose, but not in proportion with the employment contraction via plant closure (see figure 3.9). As a result, Figure 3.10 shows a slight increase in plant closure per firm in 2007/08 period. Furthermore, Figure 3.8 reveals a sudden rise in employment contraction via internal contraction in 2009/10 followed by a substantial fall in 2010/2011. In Figure 3.9, the number of firms using internal contraction increased and then fell in proportion with the employment contraction via internal contraction. As a result, internal contraction per firm remains steady between 2009 and 2010. Like in expansion paths, the updating of employment figures that was carried out when the ONS moved from ARD to ABS has caused the sudden changes in internal contraction.

Figure 3-8: Employment contraction by contraction path by year, 1997-2012



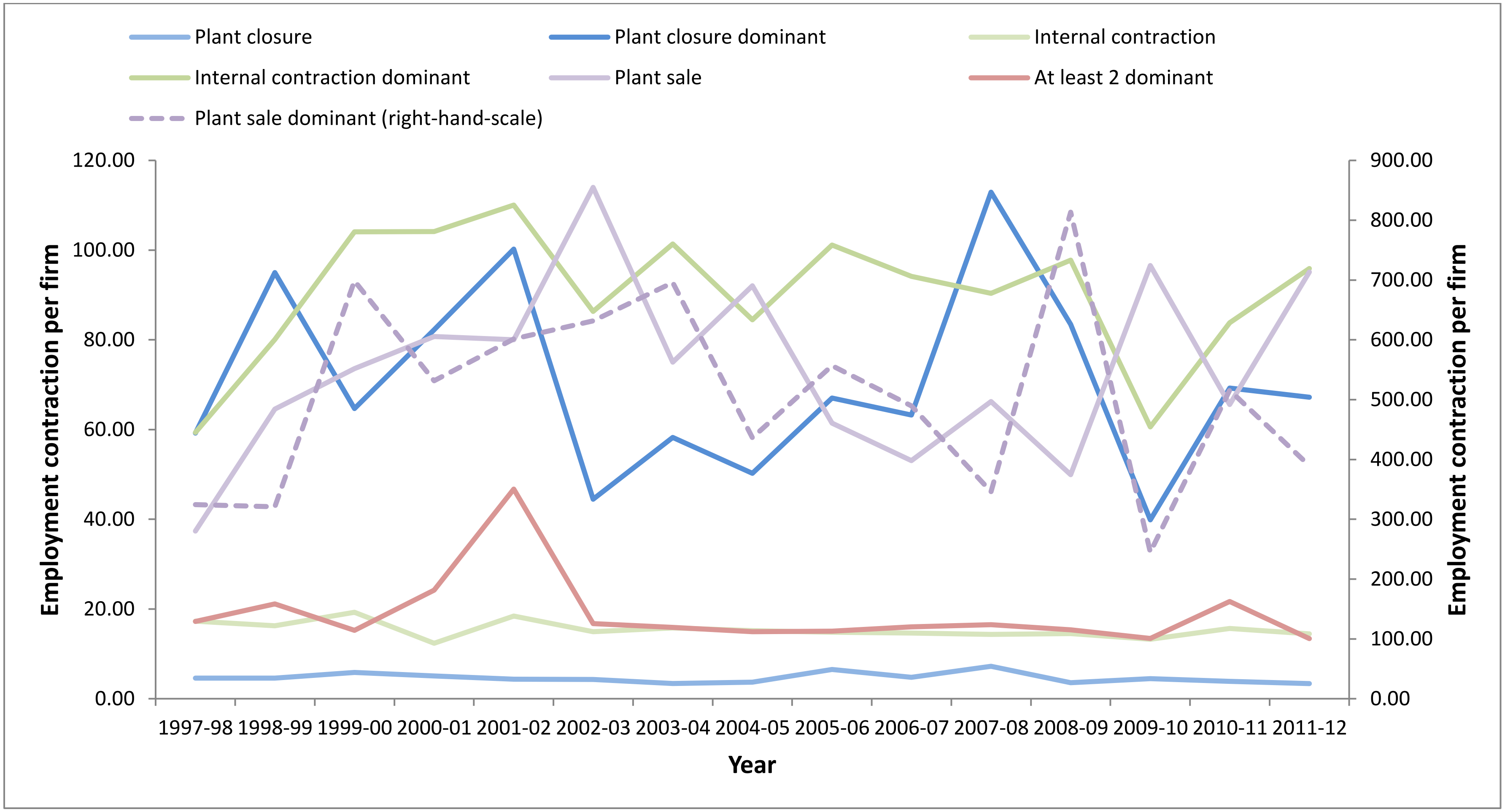
Notes: Each contraction path includes firms that contracted/expanded by 5 or more employees. The number above each bar represents total employment contraction between 2 years.
Source: Authors' own calculations using the Annual Respondent Database/Annual Business Survey (ARD/ABS).

Figure 3-9: Number of firms using each contraction path yearly, 1997-2012



Notes: Each contraction path includes firms that contracted (and expanded) by 5 or more employees. The number above each bar represents total number of firms between 2 years.
Source: Authors' own calculations using the Annual Respondent Database/Annual Business Survey (ARD/ABS).

Figure 3-10: Employment contraction per firm by contraction path by year, 1997-2012



Notes: Numbers are calculated by dividing total employment contraction per year by total number of firms per year.
Source: Authors' own calculations using the Annual Respondent Database/Annual Business Survey (ARD/ABS).

We further disaggregate the ‘dominant’ contraction paths to show how firms combine different paths of adjustment to achieve a net contraction. Table 3.5 presents all the 53 possible combinations of adjustment and the 3 ‘only’ contraction path (making a total of 56 contraction paths). On average, between 1997 and 2012, most of the 56 available options are used at least once. The 3 major contraction path – Internal contraction, plant closure and plant sale – were used in about 97 per cent of overall employment contraction in the UK economy, with the clear majority occurring via plant closure (87 per cent). On average, plant closure also accounts as the major contributor to employment contraction (about 44 per cent). Combining gross contraction (and expansion) paths into overall net contraction are rare events; used, on average, in only about 3 per cent of employment contractions in the UK economy between 1997 and 2012. However, on average, the 53 gross contraction (and expansion) path combinations account for a large share – 33 per cent – of the economy-wide employment contraction between 1997 and 2012. Indeed, when they occur, these gross contraction (and expansion) path combinations are major events as shown in the fourth column of table 3.5. The average gross contraction (and expansion) path combination employment contraction per firm is 120 times bigger than the average plant closure employment contraction per firm.

It is clear from Table 3.5 that gross contraction (and expansion) path combinations account for a large share of overall employment contraction despite their infrequent occurrence. As a result, it would seem reasonable to include these gross contraction (and expansion) path combinations into our empirical analyses. However, examining how firms choose between 7 or 56 different paths of contraction (as in tables 3.4 and 3.5) and their impacts on firm-level productivity can be very complex, particularly when we come to using multinomial logit/probit to empirically model the unordered multiple firms’ choice of using different contraction paths to reduce output/employment. As a result, we merged the different gross contraction (and expansion) combinations into the Internal contraction ‘only’, plant closure ‘only’ and plant sale ‘only’ categories. In other words, we used the categorisation in panel B of table 3.1 to carry out our empirical analyses in chapters four and five

Table 3-5: Employment contraction by contraction path; average per year, 1997-2012

Contraction type	Employment contraction per year[a]	Number of firms per year[b]	Employment contraction per firm[c]
1 = Plant closure only	883,469	191,018	5
2 = Internal contraction only	298,326	20,239	15
3 = Plant sale only	163,117	2,307	71
4 = Plant closure + Plant sale	134,675	232	581
5 = 1 + Internal contraction + Greenfield investment + Internal expansion	116,673	465	251
6 = Plant closure + Internal contraction + Internal expansion	76,743	662	116
7 = Plant closure + Greenfield investment	51,308	2,061	25
8 = Plant closure + Internal contraction	44,185	852	52
9 = Internal contraction + Internal expansion	36,919	940	39
10 = 1 + 2 + Greenfield investment + Internal expansion + Mergers and acquisition	*	*	*
11 = 1 + 2 + Plant sale + Greenfield investment + Internal expansion	*	*	*
12 = Plant closure + Internal expansion	15,673	456	34
13 = Plant closure + Internal contraction + Greenfield investment	13,035	156	84
14 = Internal contraction + Greenfield investment	12,923	307	42
15 = Plant closure + Internal contraction + Plant sale + Internal expansion	*	*	*
16 = 1 + 2 + 3 + Greenfield investment + Internal expansion + Mergers and acquisition	*	*	*
17 = Internal contraction + Greenfield investment + Internal expansion	9,227	125	74
18 = Plant closure + Plant sale + Greenfield investment	*	*	*
19 = 1 + Internal contraction + Internal expansion + Mergers and acquisition	*	*	*
20 = Plant closure + Internal contraction + Plant sale	*	*	*
21 = Plant closure + Mergers and acquisition	3,789	61	62
22 = Plant closure + Plant sale + Greenfield investment + Mergers and acquisition	*	*	*
23 = Internal contraction + Plant sale + Internal expansion	*	*	*
24 = Internal contraction + Plant sale	3,343	34	99
25 = Plant closure + Greenfield investment + Internal expansion	3,340	45	75
26 = Plant sale + Greenfield investment	3,333	33	101
27 = Plant closure + Internal contraction + Plant sale + Greenfield investment	*	*	*
28 = Plant closure + Plant sale + Internal expansion	*	*	*
29 = 1 + Internal contraction + Greenfield investment + Mergers and acquisition	*	*	*
30 = 1 + 2 + Plant sale + Internal expansion + Mergers and acquisition	*	*	*
31 = Plant sale + Internal expansion	1,870	30	62
32 = Plant closure + Greenfield investment + Mergers and acquisition	*	*	*
33 = Plant closure + Plant sale + Greenfield investment + Internal expansion	*	*	*
34 = 2 + Greenfield investment + Internal expansion + Mergers and acquisition	*	*	*
35 = Plant sale + Greenfield investment + Mergers and acquisition	*	*	*
36 = Internal contraction + Mergers and acquisition	*	*	*
37 = Plant closure + Internal contraction + Mergers and acquisition	*	*	*
38 = Internal contraction + Plant sale + Greenfield investment + Internal expansion	*	*	*
39 = Internal contraction + Internal expansion + Mergers and acquisition	*	*	*
40 = Plant sale + Mergers and acquisition	*	*	*
41 = Internal contraction + Plant sale + Internal expansion + Mergers and acquisition	*	*	*
42 = Internal contraction + Greenfield investment + Mergers and acquisition	*	*	*
43 = Internal contraction + Plant sale + Greenfield investment	*	*	*

Contraction type	Employment contraction per year[a]	Number of firms per year[b]	Employment contraction per firm[c]
44 = Plant closure + Internal contraction + Plant sale + Mergers and acquisition	*	*	*
45 = 1 + Greenfield investment + Internal expansion + Mergers and acquisition	*	*	*
46 = 3 + Greenfield investment + Internal expansion + Mergers and acquisition	*	*	*
47 = Plant closure + Internal expansion + Mergers and acquisition	*	*	*
48 = Plant closure + Plant sale + Mergers and acquisition	*	*	*
49 = 1 + 3 + Greenfield investment + Internal expansion + Mergers and acquisition	*	*	*
50 = Plant sale + Greenfield investment + Internal expansion	*	*	*
51 = 2 + Plant sale + Greenfield investment + Mergers and acquisition	*	*	*
52 = Internal contraction + Plant sale + Mergers and acquisition	*	*	*
53 = Plant sale + Internal expansion + Mergers and acquisition	*	*	*
54 = Plant closure + Plant sale + Internal expansion + Mergers and acquisition	*	*	*
55 = 2 + 3 + Greenfield investment + Internal expansion + Mergers and acquisition	*	*	*
56 = 1 + 2 + Plant sale + Greenfield investment + Mergers and acquisition	*	*	*
Total contraction	**1,994,185**	**220,237**	**32,576**
Total expansion[d]	**2,084,582**	**250,013**	**29,078**
No change[e]	**54,569**	**1,196,996**	**0.05**

[a] Employment contraction of each of the contraction path summed over the period 1997-2012 divided by the number of years.

[b] Number of firms using each of the contraction path summed over the period 1997-2012, divided by the number of years.

[c] Employment contraction per year divided by number of firms per year.

[d] Employment expansion, number of firms and employment expansion per firm for all expansion path summed over the period 1997-2012, divided by the number of years.

[e] Employment change, number of firms and employment change per firm for all firms with no change summed over the period 1997-2012, divided by the number of years. 'No change' includes firms with employment changes between 0 and 4 employees.

Notes: (*) Exact annual average values cannot be reported due to disclosure restriction (Number of observations underlying the cell is less than 10).

Source: Authors' own calculations using the Annual Respondent Database/Annual Business Survey (ARD/ABS).

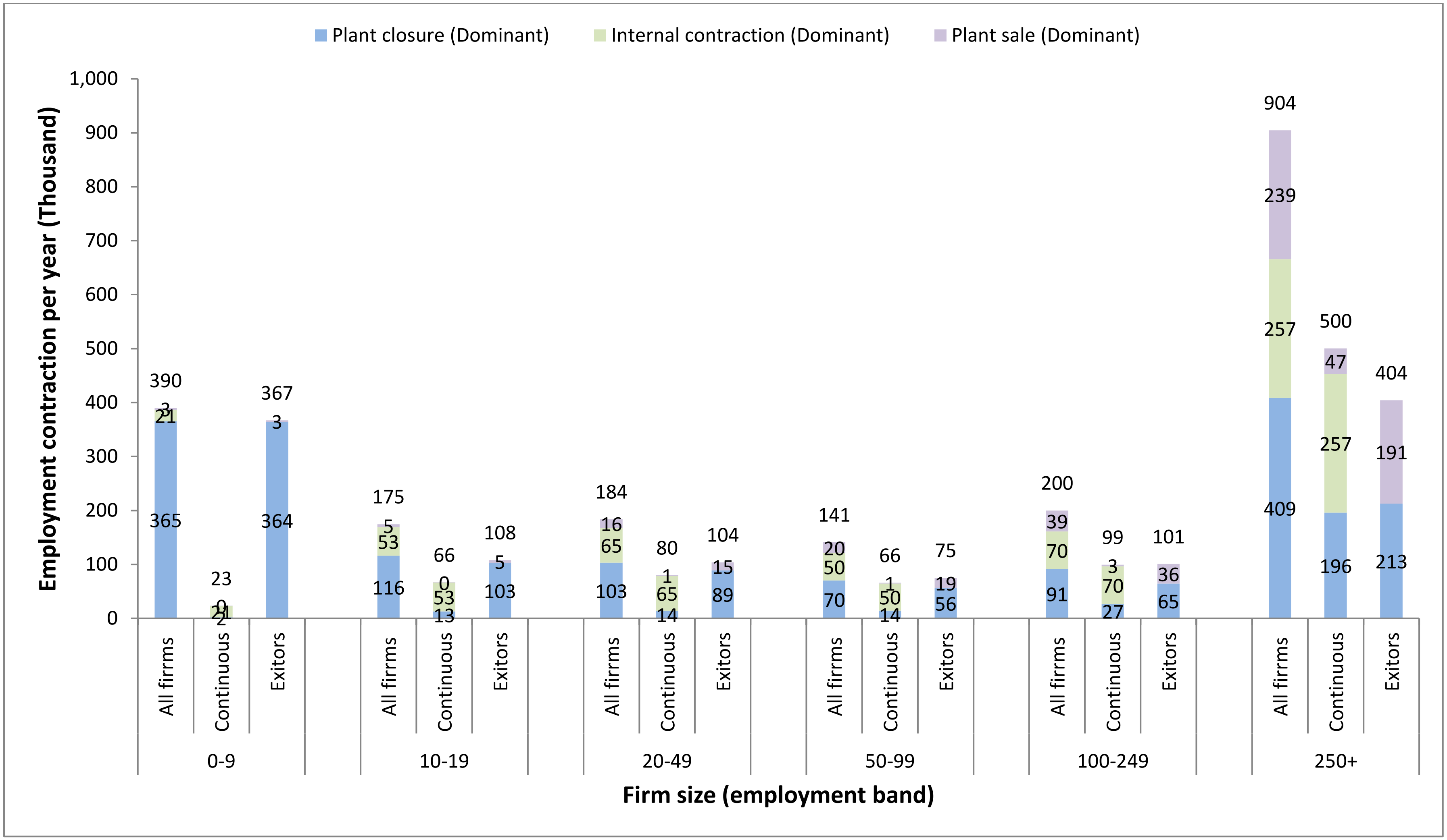
Following the theoretical predictions of Jovanovic and Rousseau (2002), Warusawitharana (2008) and, Breinlich and Neimann (2011) and the empirical work of Hymer (1976), Harris and Robinson (2003) and Harris and Moffat (2012), Figures 3.11 and 3.12 focus on some key firm-level variables which may determine the choice of adjustment channel. Figure 3.11 shows that plant closure (Dominant)[27] accounts for the largest share of the employment expansion for all 6 firm size categories. When we separate continuous firms from entrants, Figure 3.11 shows that the importance of plant closure for continuing firms rises steadily with firm size. A similar pattern arises when we look at plant sale. For the

[27] Because the number of firms underlying some cells in Figure 3.11 are less than 10 (i.e., less than the threshold required for disclosure restriction) we have combined plant closure with plant closure dominant and now refer to it as plant closure (Dominant). The same has been done to internal contraction and internal contraction dominant as well as plant sale and plant sale dominant.

smallest firms (those with employees between 0 and 9) plant sale only account for about 5 per cent of overall employment contraction. However, as firm size increases, plant sale become increasingly more important. For the largest firms (those with employees of at least 250), around 28 per cent of overall employment expansion is achieved via plant sale.

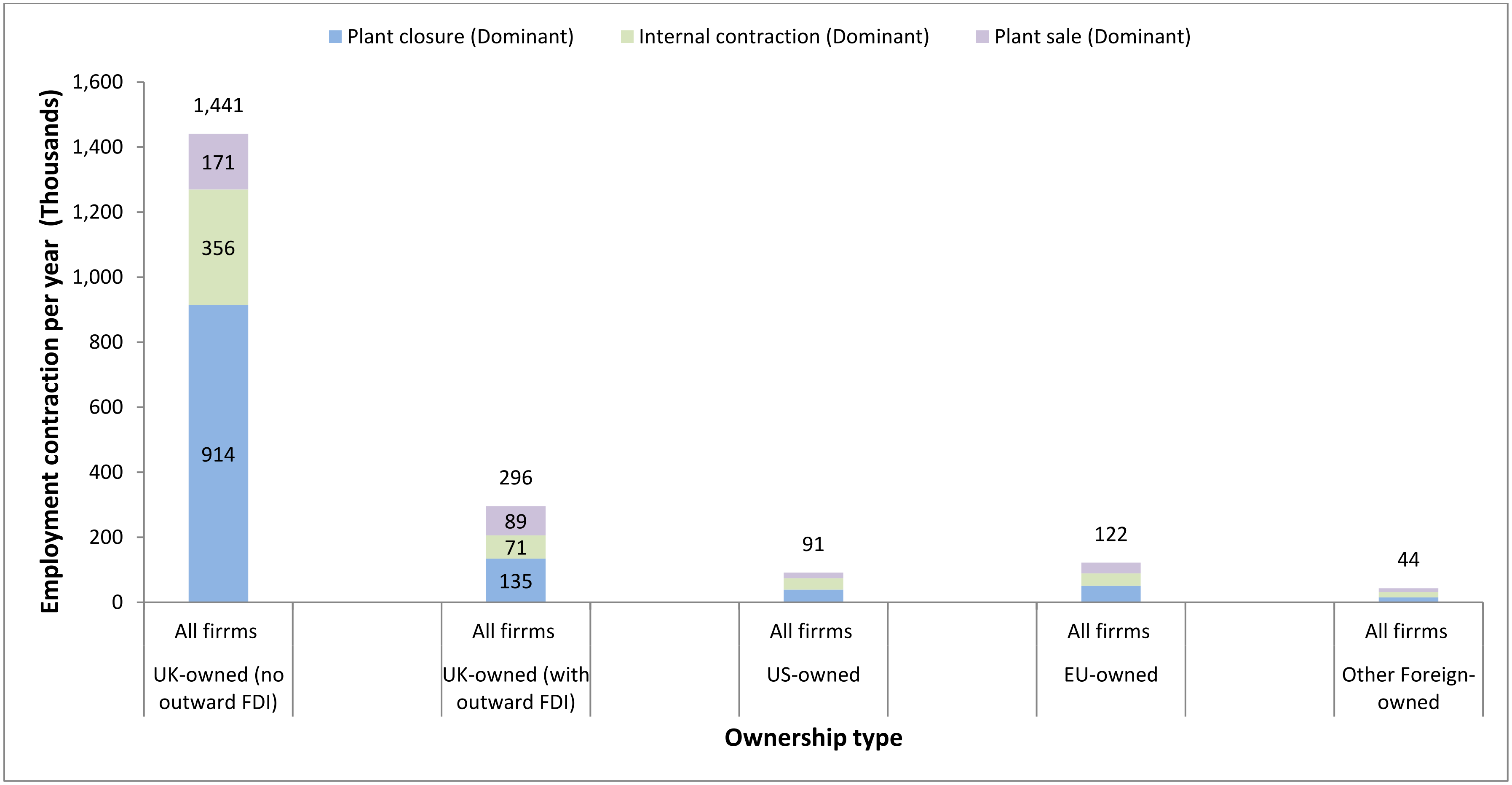
Turning to the correlation between firm ownership-type and their choice of contraction path, Figure 3.12 displays come initial evidence. The Figure shows that plant closure and plant sale account for the largest share of employment contraction for UK-owned firms (88 per cent for UK-owned firms without FDI and 70 per cent for UK-owned firms with outward FDI). For Foreign-owned firms (US-owned, EU-owned and Other Foreign-owned) plant closure and plant sale account for about 66 per cent of overall employment contraction. However, Figures 3.11 and 3.12 have similar shortcomings to those of Figure 3.6 and 3.7. The descriptive approach in Figures 3.11 and 3.12 fail to accommodate a multivariate relationship between for instance, a combination of firm size and ownership-type and firms’ choice of contraction. Thus, it is unclear whether the correlations displayed in Figures 3.11 and 3.12 are driven by firm size, ownership-type or a combination of both.

Figure 3-11: Employment contraction by contraction path by firm size; average per year, 1997-2012



Notes: Each contraction path includes firms that contracted (and expanded) by 5 or more employees. The number above each bar represents annual average from 1997 to 2012.
Source: Authors' own calculations using the Annual Respondent Database/Annual Business Survey (ARD/ABS).

Figure 3-12: Employment contraction by contraction path by ownership type; average per year, 1997-2012



Notes: Each contraction path includes firms that contracted (and expanded) by 5 or more employees. The number above each bar represents annual average from 1997 to 2012.
Source: Authors' own calculations using the Annual Respondent Database/Annual Business Survey (ARD/ABS).

3.6 Conclusion

The chapter has described the data that will be employed in the empirical analyses of chapters four and five. It began by explaining our key data source – the Annual Respondent database/Annual Business Survey (ARD/ABS). The next section explains how firms are classified into different adjustment categories. The process involves using local unit and enterprise unit (plant and firm respectively) unique identifiers in the ARD to capture demographic events which led to 112 adjustment classifications (56 for net expanding firms and 56 for net contracting firms). However, examining how firms choose between 56 different channels of expansion and contraction and their impacts on firm-level productivity can be very complex. As a result, we collapsed the 112 adjustment classification into 12 categories, according to the path that is used as a dominating strategy (see section 3.3 for a detailed description of our adjustment classification). A description of each path of adjustment was then provided. In addition, we provided a comparison between some key firm-level variables and the different channels of adjustment. This showed that firms that rely on external forms of adjustment - greenfield investment and mergers and acquisition for expansion and, plant closure and plant sales for contraction – tend to be larger and UK-owned. A limitation of this descriptive approach used is that it fails to accommodate a multivariate relationship between several firm-level variables and firms' choice of adjustment. As a result, we employ econometrics techniques to study such multivariate relationships in subsequent chapters.

4 The Determinants of Firms' Choice of Expansion and Contraction

4.1 Introduction

This chapter empirical examines the determinants of firms' choice of adjustment. As shown in chapter 1.1 of this thesis, a firm can increase or decrease its productive capacity through 3 main channels. On the one hand, firms seeking to increase output may do so at existing plants (internal expansion), create new plants (greenfield investment) or acquire existing plants from other firms (mergers and acquisition). On the other hand, firms can reduce their productive capacity by cutting employment at existing plants (internal contraction), closing existing plants (plant closure) or selling existing plants (plant sale). Each path, if chosen, is likely to be fundamentally related to firms' characteristics such as firm-level productivity as motivated in the theoretical models of firm organizational capability (e.g., Breinlich and Niemann, 2011a) and capital reallocation theory (e.g., Jovanovic and Rousseau, 2002).

Indeed, in chapter 2.2.1, we show that firms' chosen path of adjustment depends fundamentally on their prospects for profits, and this in turn is dependent on their productivity level and the sunk cost of adjustment. Theory has shown that there are large sunk costs associated with using external forms of adjustment – greenfield investment and mergers and acquisition for expansion, and plant closure and plant sale for contraction – such that a firm must be (ex-ante) more productive to overcome such costs. As such, firms that use external forms of adjustment are likely to be more productive than firms that use internal forms of adjustment. Theory is, however, less clear in its prediction on how firms choose between the different channels of external adjustment. For instance, Jovanovic and Rousseau (2002) show that high-productivity firms are more likely to choose mergers and acquisition over greenfield investment when there is a technological shock that requires the reallocation of existing plants from less-efficient producers to more-efficient firms. However, when the technological gap between a potential (high-productivity) acquirer and (low-productivity) target is too large such that the cost of converting the inferior technology is target's plant exceeds any benefits from say, additional product variety, a potential acquirer may favour greenfield investment over mergers and acquisition (e.g., Breinlich and Niemann, 2011a).

In empirical counterparts to this, a set of firm-level characteristics have been used to examine the relationship between these firm-level variables and different paths of adjustment. We adopt a similar approach in this thesis. However, this is the most comprehensive and up-to-date of its kind for United Kingdom; and, in particular, provides empirical evidence to how firms systematically choose between alternative forms of adjustment. With respect to our econometrics modelling, we employ the multinomial logit model because the dependent variable takes the value 0, 1 and 2 depending on whether a firm expands internally (contracts internally), creates a new plant (closes an existing plant), or acquires an existing plant (sell an existing plant) respectively. However, marginal effects are computed to provide an interpretable measure of the relationship between explanatory variables and the dependent variable.

The next section will set out the multinomial logit model used, in which the probability of firms' choice of adjustment is explained by variables described in chapter 2.3.1. The third section will describe how the multinomial logit is estimated; the issues that complicate the interpretation of multinomial logit model coefficients and discuss marginal effects estimator which is one way of interpreting the relationship between an explanatory variable and the dependent variable in a multinomial logit model. The fourth section presents the results and the fifth section concludes.

4.2 Econometric Model and Variables Used

This section sets out the model of firms' decision to expand internally, create a new plant or acquire an existing plant. For contracting firms, the choices are whether to contract internally, close an existing plant or sell an existing plant. The dependent variable in this model therefore takes the value 0, 1 and 2 depending on whether a firm expands internally (contracts internally), creates a new plant (closes an existing plant), or acquires an existing plant (sells an existing plant) for expanding (contracting) firms respectively. The model can be expressed as:

$$p_{ij} = \Pr(y_{it} = j \mid X_{it}) = \frac{\exp(X_{it}\beta_j)}{\sum_{j=0}^{2} \exp(X_{it}\beta_j)} \qquad j = 0, 1, 2. \tag{4.1}$$

This is the probability that firm *i* will select alternative *j* (*j* = 0, 1, 2), X_{it} is a vector of observed variables (*i* = 1, . . . , *k*; *t* = 1, . . . , *T*), thought to explain firms' choice of adjustment[28] and β_j is a vector of coefficients that contains the intercept β_{0j} and the slope coefficients β_{kj}. Thus, there is one set of coefficients for each choice alternative. The model in equation 4.1 has 3 (*J*) equations of which only 2 (*J* – 1) can be estimated. This is because the probabilities of mutually exclusive and exhaustive events must sum to one i.e. $\sum_{j=0}^{2} p_{ij} = 1$. In other words, if we determine any 2 probabilities, then the third probability is automatically determined, therefore, we cannot estimate the third probability independently. The common practice in multinomial logit model is to set β_j to zero for one of the categories and interpret coefficients with respect to that category. Therefore, β_j is set to zero for internal expansion for expanding firms and internal contraction for contracting firms. The coefficients of other alternatives are interpreted in reference to the base group – internal expansion for expanding firms and internal contraction for contracting firms. Setting $\beta_0 = 0$ when $y_0 = 0$ (i.e.,

[28] The independent variables have been extensively reviewed in Chapter 2.3.1.

when a firm uses internal expansion for expansion and internal contraction for contraction) and computing the probabilities yields:

$$p_{ij} = \Pr(y_{it} = j \mid X_{it}) = \frac{\exp(X_{it}\beta_j)}{1 + \sum_{j=1}^{2} \exp(X_{it}\beta_j)} \qquad j = 1, 2. \qquad \beta_0 = 0 \qquad (4.2)$$

And for the baseline category – internal expansion/internal contraction, the probability is:

$$p_{ij} = \Pr(y_{it} = 0 \mid X_{it}) = \frac{1}{1 + \sum_{j=1}^{2} \exp(X_{it}\beta_j)} \qquad j = 1, 2. \qquad \beta_0 = 0 \qquad (4.3)$$

The variables included in X_{it} are frequently documented variables (reviewed in chapter 2.3.1) that determine firms' choice of adjustment. These variables include firm size, adjustment size and firm-level variables (R&D, age, multi-plant ownership and foreign ownership). Table 4.1 sets out the list of these variables, along with the sources of data.

Firm size is defined as a set of dummy variables that indicate whether a firm belongs to one of the following 6 size bands: 0-9, 10-19, 20-49, 50-99, 100-249 or 250+ employees. Adjustment size is the relative employment ratio at the firm level between 2 consecutive years. Age represents the number of years a firm has been in operation. R&D represents a set of dummy variables that indicate whether a firm has no R&D expenditure or whether a firm has a positive R&D expenditure and belongs to one of the 4 equal percentiles. A single-plant enterprise dummy, equal to one if a firm owns only one plant and zero otherwise. Foreign ownership is a vector of dummy variables that indicate whether firms are UK-owned without outward FDI, UK-owned with outward FDI, SE Asia-owned, EU-owned, USA-owned, Australia/Canada/South Africa-owned and other-foreign owned.

Also included in equation (4.1) is set of dummy variables that capture the path of adjustment that a firm chooses in period, *t-1*, in an attempt to test for entry (sunk) costs of adjustment. For instance, in trade literature, Roberts and Tybout (1997) and Bernard and Jensen (2004) have shown that hysteresis in exports is due to sunk costs associated with entering the exports market. By extension, a firm that seeks to expand either through greenfield investment or mergers and acquisition would need to spend considerable time looking for suitable plants or creating a new one. This can be thought of as a learning cost associated with external forms of adjustment. Typically, there would be legal and administrative costs associated with creating or buying plants as well as possible restructuring costs associated with adapting built or acquired plants with the firm (see, for instance, Warusawitharana, 2008). Learning-by-adjustment captures these sunk costs and allows for

Table 4-1: Variable definitions used in ARD/ABS/IDBR/BERD panel dataset for 1997-2012

Variables	Definitions	Source
Firm size		
0 -9 employees	Dummy coded 1 if firm employs fewer than 10 people	ABS
10 -19 employees	Dummy coded 1 if firm employs 10-19 people	ABS
20 - 49 employees	Dummy coded 1 if firm employs 20-49 people	ABS
50 - 99 employees	Dummy coded 1 if firm employs 50-99 people	ABS
100 - 249 employees	Dummy coded 1 if firm employs 100-249 people	ABS
250+ employees	Dummy coded 1 if firm employs 250 or more people	ABS
Adjustment size		
Employee ratio	Number of employees in the firm at period, t divided by number of employees at period, t-1	ABS
Firm-level variables		
Age	Number of years firm has been in operation based on year of entry	IDBR
R&D band 1	Dummy coded 1 if firm has no R&D expenditure	BERD
R&D band 2	Dummy coded 1 if firm has positive R&D expenditure and lies in the first percentile	BERD
R&D band 3	Dummy coded 1 if firm has positive R&D expenditure and lies in the second percentile	BERD
R&D band 4	Dummy coded 1 if firm has positive R&D expenditure and lies in the third percentile	BERD
R&D band 5	Dummy coded 1 if firm has positive R&D expenditure and lies in the fourth percentile	BERD
Single-plant firm	Dummy coded 1 when firm has a single plant	ABS
UK-owned firm (Without FDI)	Dummy coded 1 if firm is UK-owned by those not involved in outward FDI	ABS
UK-owned firm (With FDI)	Dummy coded 1 if firm is UK-owned by those involved in outward FDI	ABS
SE Asia-owned firms	Dummy coded 1 if a firm is SE Asia-owned	ABS
EU-owned firms	Dummy coded 1 if a firm is EU-owned	ABS
USA-owned firms	Dummy coded 1 if a firm is USA-owned	ABS
AUS/CAN/SA-owned firms	Dummy coded 1 if a firm is Australian- Canadian- and SA-owned	ABS
Other Foreign-owned firms	Dummy coded 1 if firm is owned by other countries	ABS
Other variables		
Internal expansion$_{t-1}$	Dummy coded 1 if firm expanded internally at period, t-1	ABS
Greenfield investment$_{t-1}$	Dummy coded 1 if firm created plant at period, t-1	ABS
Mergers and acquisition$_{t-1}$	Dummy coded 1 if firm acquired an existing plant at period, t-1	ABS
Internal contration$_{t-1}$	Dummy coded 1 if firm contracted internally at period, t-1	ABS
Plant closure$_{t-1}$	Dummy coded 1 if firm closed plant at period, t-1	ABS
Plant sale$_{t-1}$	Dummy coded 1 if firm sold plant at t-1	ABS
Region	Dummies coded 1 if firm is in one of 11 Government Office regions	ABS
City	Dummies coded 1 if firm is in a major GB city (defined by NUTS3 code)	ABS
Industry	Dummy coded 1 depending on 1992 SIC of firm (used at 2-digit level)	ABS
2008 Onwards	Dummy coded 1 from 2008 onwards	ABS

continuing external expanders to have a lower adjustment cost than first time expanders. There may be similar lower cost of adjustment for firms that continue to contract externally, as they are able to learn from previous contractions.

A time dummy that takes the value of one if the year is 2008 onwards, and zero otherwise, is also included in equation (4.1). This dummy variable is included to capture the effect of uncertainty created by the 2008 financial crisis. The a priori expectation is that the uncertainty created by the 2008 economy-wide shock would adversely affect firm-level investment behaviour. In particular, this economy-wide shock might be expected to be more important in firm's external adjustment decision as these forms of adjustment are the costliest. For instance, Harris and Moffat (2016) found that the probability of plant closure in the UK has reduced post-2007 financial crisis. Thus, firms are expected to be less likely to (dis)invest in external forms of adjustment, post-2007. Lastly, regional and city dummies are included in equation (4.1) to control for variation in regional industrial structure and other regional and city characteristics. The dummies are equal to one when a firm is located within a government office region and a major Great Britain city (defined by NUTS3 code)[29]. Our expectation is that firms located in regions and cities where it is costly to build a greenfield plant or acquire and existing one i.e., firms located in south east region such as London, are less likely to use external forms of adjustment. Recent work in economic geography have highlighted the importance of regional industrial structure in explaining plant closure and survival (e.g., Duranton and Puga, 2000).

In order to account for the industrial effect discussed in chapter 2.3.1.4, equation (4.1) is estimated separately for 8 industrial sectors (defined in Table 4.2 by the sophistication of technology used; following Harris and Moffat, 2011, 2016a, 2016b)[30]. We also include a full set of 2-digit (SIC92) Industrial dummies in all our specifications. These dummies are included to capture cost differences even within well-defined industry sub-groups. For instance, the cost of greenfield investment for a pharmaceutical firm and an aircraft and spacecraft manufacturing firm would likely differ even though they both operate in the high-tech manufacturing sector.

---

[29] For firms operating plants at different cities/region, we select the region/city with the highest level of employment i.e., the dominant region/city.

[30] The results for all 8 industrial sectors for expansion and contraction are separately presented in Appendices 4.7.1 and 4.7.2 with analysis restricted to continuing firms.

Table 4-2: Definitions of industrial sub-sectors (1992 standard industrial classification)

High-tech manufacturing	Pharmaceuticals (SIC244); Office machinery and computers (SIC30); Radio, TV and communications equipment (SIC32); Medical and precision instruments (SIC33); Aircraft and spacecraft (SIC353)
Medium high-tech manufacturing	Chemical (SIC24 exc. Pharmaceuticals SIC244); Machinery and equipment (SIC29); Electrical machinery (SIC31); Motor Vehicles (SIC34); Other transport equipment (SIC35 exc. Ships and boats, SIC351, and Aircraft and spacecraft, SIC353)
Medium low-tech manufacturing	Coke and petroleum (SIC23); Rubber and plastics (SIC25); Other non-metalic (SIC26); Basic metals (SIC27); Fabricated metals (SIC28); Ships and boats (SIC351)
Low-tech manufacturing	Food and beverages (SIC15); Tobacco (SIC16); Textiles (SIC17); Clothing (SIC18); Leather goods (SIC19); Wood products (SIC20); Paper products (SIC21); Publishing, printing (SIC22); Furniture and other manufacturing (SIC36); Recycling (SIC37)
High-tech knowledge-intensive (KI) services	Telecoms (SIC642); Computer and related (SIC72 exc. Maintenance and repair, SIC725); R&D (SIC73); Photographic activities (SIC7481); Motion pictures (SIC921); Radio and TV activities (SIC922); Artistic and literary creation (SIC9231
KI services	Water transports (SIC61); Air transport (SICSIC62); Legal, accountancy and consultancy (SIC741 exc. Management activities of holding companies, SIC7415); Architecture and engineering (SIC742); Technical testing (SIC743); Advertising (SIC744)
Low KI services	Hotels and restaurants (SIC55); Land transport (SIC60); Support for transport (SIC63); Real estate (SIC70); Renting machinery (SIC71); Maintenance and repair of office machines (SICSIC725); Management activities of holding companies (SIC7415); Labour recruitment (SIC745); Investigation services (SIC746); Industrial cleaning (SIC747); Packaging (SIC7482); Secretarial services (SIC7483); Other business services (SIC7484); Sewage and refuse (SIC90); Sales and repairs of motor vehicles (SIC50); Wholesale (SIC51); Retail (SIC52)
Other low KI services	Postal services (SIC641); Membership organization (SIC91); Other entertainment services (SIC923 exc. Artistic and literary creation, SIC9231); News agencies (SIC924); Sporting activities (SIC926); Other recreational activities (SIC927); Other services (SIC92)

Note: Equation 4.1 was estimated separately for each of these sub-groups. The groups chosen are based on common levels of technology being used.
Source: Harris and Moffat (2013a)

Table 4-3: Mean and standard deviation of variables by sector, 1997-2012

Variables	All firms			Manufacturing firms			Non-manufacturing firms		
	N (Thousands)	Mean	SD	N (millions)	Mean	SD	N (millions)	Mean	SD
Internal expansion$_{t-1}$	3,389	0.209	0.407	0.395	0.224	0.417	2.994	0.208	0.406
Greenfield investment$_{t-1}$	3,389	0.135	0.342	0.395	0.102	0.302	2.994	0.137	0.344
Mergers and acquisition$_{t-1}$	3,389	0.002	0.041	0.395	0.004	0.060	2.994	0.001	0.039
Internal contration$_{t-1}$	2,824	0.132	0.339	0.346	0.161	0.367	2.478	0.129	0.335
Plant closure$_{t-1}$	2,824	0.005	0.070	0.346	0.010	0.097	2.478	0.004	0.066
Plant sale$_{t-1}$	2,824	0.000	0.018	0.346	0.001	0.030	2.478	0.000	0.015
0 -9 employees	20,180	0.807	0.394	2.164	0.663	0.473	18.016	0.820	0.384
10 -19 employees	20,180	0.074	0.261	2.164	0.117	0.321	18.016	0.070	0.255
20 - 49 employees	20,180	0.035	0.185	2.164	0.081	0.273	18.016	0.030	0.172
50 - 99 employees	20,180	0.011	0.103	2.164	0.030	0.171	18.016	0.009	0.092
100 - 249 employees	20,180	0.006	0.079	2.164	0.020	0.139	18.016	0.005	0.068
250+ employees	20,180	0.067	0.249	2.164	0.089	0.284	18.016	0.067	0.250
Adjustment size	19,835	1.758	86.22	2.138	2.995	73.45	17.697	1.609	87.64
Age	20,172	6.086	4.818	2.156	7.176	6.592	18.016	5.955	4.543
R&D band 1	20,161	0.991	0.094	2.161	0.964	0.187	18.000	0.994	0.075
R&D band 2	20,161	0.002	0.046	2.161	0.005	0.074	18.000	0.002	0.041
R&D band 3	20,161	0.002	0.047	2.161	0.007	0.082	18.000	0.002	0.041
R&D band 4	20,161	0.002	0.048	2.161	0.011	0.102	18.000	0.001	0.036
R&D band 5	20,161	0.002	0.049	2.161	0.013	0.115	18.000	0.001	0.033
Single-plant firm	18,918	0.966	0.182	2.000	0.946	0.227	16.918	0.967	0.179
UK-owned firm (Without FDI)	20,181	0.919	0.272	2.164	0.892	0.310	18.016	0.920	0.272
UK-owned firm (With FDI)	20,181	0.010	0.100	2.164	0.013	0.112	18.016	0.010	0.099
SE Asia-owned firms	20,181	0.001	0.026	2.164	0.001	0.038	18.016	0.001	0.024
EU-owned firms	20,181	0.004	0.063	2.164	0.009	0.096	18.016	0.003	0.058
USA-owned firms	20,181	0.002	0.048	2.164	0.006	0.080	18.016	0.002	0.043
AUS/CAN/SA-owned firms	20,181	0.000	0.020	2.164	0.001	0.027	18.016	0.000	0.019
Other Foreign-owned firms	20,181	0.001	0.025	2.164	0.001	0.029	18.016	0.001	0.024
2008 Onwards	20,181	0.323	0.468	2.164	0.278	0.448	18.016	0.318	0.466

Table 4.3 presents some basic descriptive statistics for the variables in X_{it}', broken down into manufacturing and non-manufacturing sector (excluding agricultural sector). It is clear from Table 4.3 that mergers and acquisition (plant sale) are rare events; used, on average, in only about 0.2% (0.1%) by previous adjusters. Internal adjustment, on the other hand, is prevalent among previous adjusters. With regard to firm size, Table 4.3 shows that almost 81% of the firms in our sample are small firms (firms with 0-9 employees) with these firms representing 66% of the firms in the manufacturing sector and 82% in the non-manufacturing sector. In general manufacturing firms

were carrying out larger (relative) adjustments and were often older than non-manufacturing firms. No R&D was undertaken in about 99% of the firms in our sample, making R&D an uncommon event. Around 97% of the firms in our sample own only one plant with little variation between manufacturing and non-manufacturing firms. Around 92% (89% for manufacturing and 92% for non-manufacturing) of firms in our sample were UK owned and were not engaged in outward FDI. Lastly, 32% of firms in our sample existed sometime after 2007

4.3 Estimation Strategy

This section is divided into 2 parts. The first briefly describes how multinomial logit model of the form of equation 4.1 can be estimated using maximum likelihood. It will then discuss the issues that complicate the interpretation of the coefficients in a multinomial logit model. To overcome those issues, marginal effect is explained in the second part.

4.3.1 Maximum Likelihood Estimation

Estimation of unknown parameters in the multinomial logit model is done using the method of maximum likelihood. Since, statistical programs such as STATA used in this study provide 'point and click' routines to estimate multinomial logit model, we do not dwell on the details of the numerical methods used to obtain maximum likelihood estimates (see Greene, 2002 for extensive discussion). However, in this section, we provide a brief explanation as to how the method of maximum likelihood is used to estimate the unknown parameters in the multinomial logit model. First, one must determine the form of the likelihood function of the model. Once determined, the estimates are then derived by maximizing the likelihood function. This involves setting the first derivatives of the natural logarithm of the model's likelihood function to zero and solving for the coefficients. To illustrate, let d_{ij} = 1 if alternative j (j = 0, 1, 2) is chosen by firm i, and zero if not. Then for each firm i, one and only one of the d_{ij}'s is 1. The log-likelihood function takes the form[31]

$$\ln L = \sum_{i=1}^{n} \sum_{j=0}^{j} d_{ij} \ln \Pr(Y_i = j) \qquad (4.4)$$

The first order conditions for maximization require

[31] For binary models, each observation is assumed to be an independent Bernoulli trial with success probability Pr (y = 1 | x) = F (x'β) and the failure probability Pr (y = 0 | x) = [1 − F (x'β)]. For a sample of n observations, the likelihood function takes the form:

$$L = \prod_{i=1}^{n} [F\,(X'\beta)]^{y_i}\ [1 - F\,(X'\beta)]^{1-y_i}$$

$$\frac{\partial \ln L}{\partial \beta_j} = \sum_i [d_{ij} - P_{IJ}] X_i = 0 \qquad for\ j = 1, \ldots, J. \tag{4.5}$$

In general, the first derivative equations are non-linear, so an exact analytical solution for the coefficients cannot be obtained. As a result, the beta coefficients that maximize the natural logarithm of the model's likelihood function are obtained using an iterative numerical method (c.f. Greene, 2002).

4.3.2 Multinomial Logit Model Coefficients and Interpretations

2 main issues complicate the interpretation of multinomial logit model coefficients. First, the direction (sign) of an estimated coefficient cannot be used to ascertain the relationship between the explanatory variables and the probability of choosing a particular path of adjustment. Instead, the sign on a single coefficient only tells us about the contrast among the categories, making it difficult to see the implication for each category from the estimated coefficient. For instance, a negative sign on a coefficient in a multinomial logit model does not necessarily mean that an increase in the independent variable corresponds to a decrease in the probability of choosing a particular path of adjustment. Second, the relationship between the independent variables and the probability of choosing a particular path of adjustment is non-linear; β therefore, cannot be interpreted as the coefficient of marginal effect. Consequently, this thesis uses another means of interpretation namely; marginal effects which indicates the effect of each explanatory variable on the probability of belonging to a particular path of adjustment. The marginal effect estimation is described below.

4.3.3 Marginal Effects Estimation

One way of interpreting the relationship between an explanatory variable and the dependent variable in a multinomial logit model is by computing the marginal effects. Marginal effects indicates the effect of a change in variable X_{it} on the probability that alternative j is chosen. For a continuous variable X_{it} the marginal effects are:

$$ME_{ij} = \frac{\partial P_{ij}}{\partial X_{ik}} = \frac{\partial \Pr(y_i = j|x_i)}{\partial X_{ik}} = P_{ij}(\beta_{kj} - \bar{\beta}_i) \tag{4.6}$$

Where $\bar{\beta}_i = \sum_{m=1}^{2} \beta_{km} \Pr(y_i = m|x_i)$ is a probability weighted average of the coefficients for different choices. As can be seen in equation 4.6, marginal effects are non-linear and would vary across values of all the explanatory variables in the model. Further, the sign of the marginal effect may change across the range of each predictors i.e., it may be positive $(\beta_{kj} > \bar{\beta}_i)$ for some values of X_{ik} and negative $(\beta_{kj} < \bar{\beta}_i)$ for others.

There are 2 main ways in which equation 4.6 can be calculated. The first is to set the values of all predictors to their sample mean resulting to "marginal effects at the mean". However, the major downside to this method is that it is unlikely that there is any firm in the sample that has the average of all model variables. As a result, this thesis presents averaged marginal effects (AME) which relies on actual values of the predictors. AME involves estimating the marginal effect for all firm-year observations and then taking the average as shown below.

$$AME = \frac{1}{n}\sum_{i=1}^{n} P_{ij}(\beta_{ij} - \bar{\beta}_i) \tag{4.7}$$

4.4 Firm-level Results for Net Expanding Firms

As stated in the introduction, the focus of this chapter is to examine the crucial factors that are likely to determine firms' choice of expansion and contraction in the UK. We carry out separate analysis for expanding and contracting firms (discussed in the subsequent section of this chapter). To avoid imposing common coefficients across industries operating with potentially distinct cost structure and technologies, estimation is performed separately for 8 industrial sectors (defined in Table 4.2 by the sophistication of technology used; following Harris and Moffat, 2011, 2016a, 2016b)[32]. The coefficients obtained at the 8 industrial sectors level[33] are then aggregated into one table by taking the weighted average (based on number of observation) to provide a broad overview of results. Table 4.4 shows the aggregated result for expanding firms, as well as separately for the 8 industrial sectors in Appendix 4.7.1. In this section, we discuss our results by grouping variables into those that are related to firm size, adjustment size, firm-level variables (R&D, age, multi-plant and foreign ownership) and other factors (industry and geography and, persistence and crisis).

In order to probe the robustness of the results in table 4.4 and that results are not sensitive to measurement issues; we recode each expansion category and repeat the exercise in the preceding paragraph. Internal expansion was recoded from internal expansion 'only' + internal expansion 'dominant' to internal expansion 'only'. Greenfield investment and mergers and acquisition were recoded to a similar 'only' path. This led to a fourth category of firms that used a combination of various adjustment methods to achieve a net expansion – referred to as expansion dominant - internal expansion 'dominant' + greenfield investment 'dominant' + mergers and acquisition 'dominant'. The results (presented in table 4.22 in appendix 4.7.3) are qualitatively similar to those presented in table 4.4.

[32] The results for all 8 industrial sectors for expansion and contraction are separately presented in Appendices 4.7.1 and 4.7.2 with analysis restricted to continuing firms.
[33] This also allows brevity of results presented.

Table 4-4: Marginal effects from multinomial logit model of determinants of expansion path in UK[a]

Variables	Internal expansion $\partial p/\partial x$	Greenfield investment $\partial p/\partial x$	Mergers and Acquisition $\partial p/\partial x$
Firm size			
10 -19 employees	-0.055	0.048	0.006
20 - 49 employees	-0.090	0.081	0.009
50 - 99 employees	-0.104	0.093	0.011
100 - 249 employees	-0.123	0.111	0.013
250+ employees	-0.240	0.224	0.016
Adjustment size			
$\ln(employment_t \vert employment_{t-1}$	-0.032	0.028	0.004
Firm-level variables			
R&D band 2	0.013	-0.013	0.000
R&D band 3	0.017	-0.017	0.000
R&D band 4	0.027	-0.028	0.001
R&D band 5	0.038	-0.039	0.001
ln Age	0.003	-0.003	0.000
Single-plant firm	-0.004	0.007	-0.003
UK-owned firm (With FDI)	0.025	-0.027	0.002
SE Asia-owned firms	0.021	-0.023	0.002
EU-owned firms	0.022	-0.024	0.002
USA-owned firms	0.023	-0.025	0.002
AUSCANSA-owned firms	0.021	-0.024	0.003
Other Foreign-owned firms	0.019	-0.022	0.003
Region			
North-East	-0.003	0.003	0.000
Yorkshire-Humberside	-0.001	0.001	0.000
North-West	-0.001	0.001	0.000
West Midlands	-0.001	0.001	0.000
East Midlands	0.000	0.001	-0.001
South-West	0.000	0.001	0.000
Eastern	0.000	0.000	0.000
London	0.004	-0.004	-0.001
Scotland	-0.023	0.022	0.000
Wales	-0.017	0.017	-0.001
Tyneside	0.007	-0.008	0.000
Northern Ireland	-0.022	0.029	-0.007
Major UK Cities			
Manchester	0.005	-0.005	0.001
Liverpool	0.001	-0.001	0.000
Birmingham	0.003	-0.003	0.000
Coventry	0.000	0.001	-0.001
Leicester	0.004	-0.003	-0.001
Nottingham	0.008	-0.007	-0.001
Bristol	0.002	-0.002	0.000

Variables	Internal expansion $\partial p/\partial x$	Greenfield investment $\partial p/\partial x$	Mergers and Acquisition $\partial p/\partial x$
Glasgow	0.009	-0.008	-0.001
Edinburgh	0.003	-0.004	0.001
Cardiff	0.006	-0.006	0.000
Persistence and crisis			
Internal expansion$_{t-1}$	-0.006	0.007	-0.001
Greenfield investment$_{t-1}$	-0.065	0.069	-0.004
Mergers and acquisition$_{t-1}$	-0.010	-0.034	0.043
2008 Onwards	0.037	-0.033	-0.003

[a] Weighted coefficients from tables 4.6 to 4.13.

4.4.1 Firm Size

The results in table 4.4 shows that firm's size affects internal expansion in 2 ways. First, larger firms are less likely to use internal expansion, vis-à-vis the baseline group (i.e., firms that employ less than 10 people), as shown by the negative coefficients on the size dummies. Second, the probability of using internal expansion declines with firm size. This implies that large firms are not only less likely to use internal expansion, the probability of using this form of expansion grows increasingly negative with firm size. Indeed, table 4.4 shows that moving from the smallest firms (i.e., firms that have less 10 employees) to firms with 10-19 employees reduces the probability of using internal expansion by 5.5%; a reduction in the probability by 10.4% in the 50-99 employees group and up to a reduction of about 24% for firms with 250 employees or more. The underlying coefficients associated with table 4.4 are negative and economically significant across all 8 industrial sectors, as shown in tables 4.6 - 4.13 (in Appendix 4.7.1). However, the size of the coefficients varies substantially across sectors. For instance, the impact of size on internal expansion is highest in the low-tech KI service sector where the largest firms are 31% less likely to use internal expansion, and lowest in the KI-service sector where the same firms are 11% less likely to use internal expansion than the smallest firms.

Conversely, table 4.4 shows that firm size has a positive impact on the 2 forms of external expansion - greenfield investment and mergers and acquisition. Our result indicates that the probability of choosing external forms of expansion increase with firm's size, with the largest firms being the most likely to use these forms of expansion. All estimates associated with table 4.4 are statistically significant at the 1% level (i.e., all the coefficients on firm size in 4.6 - 4.13 of Appendix 4.7.1). When comparing magnitudes, table 4.4 also shows that firms within the same size category have higher probability of choosing greenfield investment over mergers and acquisition. For instance, the largest firms (i.e., 250 employees or more) are 22.4% more likely to use greenfield investment, whereas the same firms are only 1.6% more likely to use mergers and acquisition, when compared to the smallest firms. This implies that that although, greenfield investment and mergers and acquisition increase in importance with firm size, large firms tend to rely more on greenfield investment than on mergers and acquisition. The gap in the probabilities is particularly large in the low-tech KI service sector (where the largest firms are 28.4% more likely to use greenfield investment compared to 1.2% for mergers and acquisition), but quite small in the medium high-tech manufacturing sector (where the largest firms are 8.7% more likely to use greenfield investment compared to 5.7% for mergers and acquisition), as shown in tables 4.6 - 4.13. Nonetheless, it remains evidently clear that large firms rely more on greenfield investment than mergers and acquisition across all sectors

In sum, our result shows that the probability of using internal (external) form of expansion declines (increases) with firm's size. However, large firms are more likely to rely on greenfield investment than on mergers and acquisition, when choosing between the 2 forms of external expansion. This is in line with Breinlich and Niemann (2011a) model, which predicts that high-productivity (large) firms are more likely to expand externally, and they do so by relying more on greenfield investment than on mergers and acquisition. The authors also found empirical evidence in support of their theoretical prediction. Our result also shows that the gap between greenfield investment and mergers and acquisition varies substantially across sectors, ranging from 3% (8.7% - 5.7%) in the medium high-tech manufacturing sector to 27.2% (28.4% - 1.2%) in the low-tech KI service sector. In general, manufacturing sectors with higher percentage of large firms (as shown in table 4.3) tend to rely closely on the 2 forms of external expansion. This suggest that there might be lower cost of capital conversion associated with using mergers and acquisition in industries with large firms such that there is little difference in the economies of scale benefits from using the 2 forms of external expansion.

4.4.2 Adjustment Size

The result obtained for adjustment size in table 4.4 shows that firms are less likely to rely on internal expansion when the desired size of expansion is large. Specifically, it shows that a one standard deviation increase in desired expansion reduces the likelihood of choosing internal expansion by 3.2%. This variable is statistically significant (at the 1% level) in every sector, however there is substantial sectorial variation, as shown in tables 4.6 - 4.13. The tables show that the impact of adjustment size on internal expansion is highest in medium high-tech manufacturing sector (5.5%), followed by high-tech manufacturing (5%), low-tech manufacturing (4.3%) and medium low-tech manufacturing (4.2%), and generally lower in the service sectors (ranging from 2.5% to 3.2%). This suggests that firms in the manufacturing sectors tend to rely less on internal expansion (relatively to firms in the service sectors) when the desired size of expansion is large.

As to the impact of adjustment size on external forms of expansion, table 4.4 shows that the former has a positive impact on greenfield investment and mergers and acquisition. However, the impact of expansion size on external expansion is largest for greenfield investment. Indeed, table 4.4 shows that a one standard deviation increase in desired expansion increases the probability of using greenfield investment and mergers and acquisition by 2.8% and 0.4% respectively. The primary coefficients associated with table 4.4 are statistically significant across all 8 industrial sectors, with little sectorial variation. When the desired size of expansion is large, firms in the manufacturing sectors tend to rely more on the 2 forms of external expansion (3.2%-3.7% for greenfield investment, and 0.9%-1.6% for mergers and acquisition) than firms in the service sectors (2.2%-2.9% for greenfield investment, and 0.3%-0.4% for mergers and acquisition).

Overall, table 4.4 shows that firms are more (less) likely to rely on external (internal) expansion, particularly, greenfield investment when the desired size of expansion is large. This is partly, consistent with the empirical finding of Breinlich and Niemann (2011a), that firms are more likely to rely on external forms of expansion for large expansion. However, our finding that firms rely more on greenfield investment than on mergers and acquisition, is in contrast with the results in Breinlich and Niemann (2011a) and Warusawitharana (2008). One important reason for our contrasting result may be the way in which expansion size is measured in this paper, which is different from measure used in Breinlich and Niemann (2011a) and Warusawitharana (2008). The size of an expansion is empirically not observable. In fact, there is no item on the financial data that tells us if, and the extent to which, a firm is carrying out a large expansion. However, there is a specificity associated with expansion size that one should expect to be reflected in a good measure i.e., it should be firm specific. For instance, adding an addition worker to a firm with one employee is very different from doing the same to a firm with 1,000 employees. Such expansion could be considered as a large expansion for the former as it is doubling its workforce whereas; the same action represents only a 0.1% increase in the workforce of the latter firm.

Therefore, a large expansion in one firm might represent a small expansion in another and; using different thresholds to arbitrarily define adjustment size as done in Breinlich and Niemann (2011a) and Warusawitharana (2008) may be flawed. To capture what we believe to be firm-specific adjustment size, we use relative employment ratio at the firm-level between 2 consecutive years. This represents an attempt to capture future profits as firms will generally increase their workforce as perception of future profit improves. Finally, our appendix result indicates that firms operating in high fixed cost industries (i.e., manufacturing sectors) are more likely to rely on the 2 forms of external expansion, when the desired size of expansion is large. This is consistent with our argument (in section 2.3.1.4) that the issue of adjustment size should be more prevalent in industries with high fixed cost as expected benefits (i.e., from economies of scale) from using external expansion are more likely to fall below their fixed cost in these industries. Breinlich and Niemann (2010) found a similar result that external expansion accounts for over 25% of aggregate turnover expansion in manufacturing, utilities and mining sector, but they account for around 3% in the agricultural sector.

4.4.3 Firm-level Variables

As reviewed in chapter 2.3.1.3, the key firm-level variables that are frequently documented to determine firms' expansion behaviour include R&D, age, multi-plant and foreign ownership. This section discusses the relationship between these firm-level variables and firms' choice of expansion. The result obtained for the first of our firm-level variables shows that all the firms with positive R&D spending are more likely to expand internally, vis-à-vis the baseline group (i.e., firms with no R&D expenditure). Further, the probability of using internal expansion is increasing in firm's R&D expenditure. Thus, internal expansion is not only positively related with R&D activity, it is also increasing in such activity – firms with high-R&D expenditure have a relatively higher probability of using internal expansion. In terms of sectorial result in the appendix, the coefficients on the R&D dummies are generally positive and economically significant except for other low-tech Ki service sector where there is no statistically significant relationship between any of the R&D dummies and the probability of using internal expansion. The effect of R&D on internal expansion is particularly strong in the low-tech KI service sector where all the coefficients on the R&D dummies are economically significant and positive.

With regards to the effect of firm's R&D on the probability of choosing external forms of expansion, table 4.4 shows that greenfield investment is negatively related to firm's R&D expenditure and it is increasing in such expenditure. Indeed, table 4.4 shows that firms with the largest R&D expenditure (i.e., R&D band 5) are 4% less likely to use greenfield investment, when compared to firms with zero R&D stock. The disaggregated coefficients are generally negative and significant across industrial sectors except for other low-tech KI service sector where there is no statistically significant relationship between any of the R&D dummies and the probability of using greenfield investment. This result suggests that firms that engage less in innovative activities such R&D are more likely to use greenfield investment to gain access to new technology, which is unsurprising given the nature of vintage technology that is often embodied in greenfield plants.

By contrast, table 4.4 shows that the firms that engage in R&D activity are somewhat more likely to use mergers and acquisition – i.e., firms with the largest R&D expenditure are 0.1% more likely to use mergers and acquisition, vis-à-vis firms with no R&D expenditure. This contrasts with the theoretical prediction and empirical findings of Phillips and Zhdanov (2013) that large firms spend less on R&D prior to acquiring another firm, and they later engage in acquisition activities to gain access to new technology. However, most of the coefficients on the R&D dummies are statistically insignificant at the industrial sectors. Furthermore, the signs on the R&D coefficients are mixed in sectors where there is at least one statistically significant R&D coefficient (5 out of the 8 industrial sectors). Indeed, the tables in the appendix show that the impact of R&D expenditure on the probability of using mergers and acquisition is negative in medium high-tech manufacturing sector, low-tech manufacturing sector and other low-tech KI service sector; and it is positive in high-tech KI service sector and KI service sector.

Turning to our second firm-level variable - firm's age - table 4.4 shows that firms are more likely to rely on internal expansion as they grow older. Precisely, table 4.4 shows that a one standard deviation increase in firm's age increases the probability of using internal expansion by 0.3%. The underlying coefficients associated with this variable are positive and economically significant (at the 1% level) in all industrial sectors except for the low-tech Ki service sector where there is a negative relationship between firm's age and the likelihood of using internal expansion (shown in tables 4.6 - 4.13). In terms of sectorial variation, tables 4.6 - 4.13 show that there is little variation across industrial sectorial. The impact of age on the probability of using internal expansion ranges from 0.6% in the low-tech manufacturing and high-tech KI service sectors to 1.7% in the other low-tech KI service sector. In sum, our result suggests that old firms tend to rely more on internal expansion than young firms, and this is consistent across 7 (out of 8) industrial sectors.

In contrast, table 4.4 shows that old firms are less likely to rely on greenfield investment than young firms. A one standard deviation increase in age reduces the likelihood that a firm uses greenfield investment by 0.3%. The coefficients on age are also statistically significant and negative in all sectors except for low-tech KI service sector where there is a positive relationship between firm's age and the probability of using greenfield investment. When comparing sectorial coefficients, tables 4.6 - 4.13 show little variation across sectors – ranging from 0.5% in the low-tech manufacturing and high-tech KI service sectors to 1.6% in the other low-tech KI service sector. Lastly, we find that firm's age is significantly related to the probability of using mergers and acquisition in all sectors, but these coefficients are negligible (i.e., they are close to zero). Our result is somewhat like that of Arikan and Stulz (2016) who found that older firms use mergers and acquisition at the same rate as young firms, and that the acquisition rate of firms is a U-shaped function of their age.

As to the third firm-level variable, our result shows that single-plant enterprises are less likely to expand via internal expansion. Indeed, table 4.4 shows that single-plant enterprises are some 0.3%

less likely to use internal expansion, when compared to multi-unit firms. However, the tables in the appendix (i.e., tables 4.6 - 4.13) shows that we obtain a largely positive and statistically significant coefficient across the industrial sectors except for low-tech KI service sector where the sign of the coefficient is negative. Table 4.4 shows a negative relationship between single-plant enterprises and the probability of using internal expansion because it represents aggregated result based on the number of observations in tables 4.6 - 4.13, and around 63% of our total number of observations are in the low-tech KI service sector – the only sector with a negative coefficient. In general, tables 4.6 - 4.13, show that single-plant enterprises in the manufacturing sector are the most likely to use internal expansion (from 4.9% in the low-tech manufacturing sector to 6.8% in the medium high-tech manufacturing sector), compared to the same enterprises in the service sector (from 1.1% in the KI service sector to 4.5% in the other low-tech KI service sector). This suggests that, in response to a positive demand and/or supply shock, single-plant enterprises are more likely to explore the internal expansion option ahead of multi-unit firms, which is unsurprising given that external forms of expansion are often associated with large sunk costs and managerial commitment.

Table 4.4 also shows that, in contrast to the general result in our appendix (all statistically different from zero), there is a positive relationship between single-plant enterprises and the probability of using greenfield investment. This is again, due to the positive coefficient associated with single-plant enterprises in the low-tech Ki service sector - the only sector (out of the 8 sectors) that has a positive coefficient and represents 63% of our total number of observations. As for the other industrial sectors, our results in tables 4.6 - 4.13 show that single-plant enterprises in the manufacturing sector are the least likely to use greenfield investment (from 4.5% in the low-tech manufacturing sector to 6.3% in the medium high-tech manufacturing sector), compared to the same enterprises in the service sector (from 0.8% in the KI service sector to 4.2% in the other low-tech KI service sector). Tables 4.6 - 4.13 also show that, compared to multi-unit firms, single-plant enterprises are less likely to acquire existing plants (ranging from 0.3% in KI service, low-tech KI service and other low-tech KI service sector to 0.7% in high-tech manufacturing sector). Thus, our result shows that single-plant enterprises tend to rely less on external forms of expansion, particularly on, greenfield investment. This suggests that there may be economies of scale benefit associated with owning more than one plant that makes multi-unit firms more productive than single-plant enterprises, and in turn, more likely to use external forms of expansion (e.g., Breinlich and Neimann, 2011a).

With regards to the fourth firm-level variable - foreign ownership – our result in table 4.4 shows that all foreign-owned firms (including UK multinational firms) are more likely to expand internally, vis-à-vis the baseline group (i.e., UK firms without foreign investment). However, this result is driven mainly by the positive and economically significant coefficients in low-tech KI service sector. In this sector, all foreign-owned enterprises (including UK multinationals) are between 3.3% and 3.8% more likely to use internal expansion, when compared to UK firms. As for the other industrial sectors, our results in tables 4.6 - 4.13 are mixed. Firstly, we find that UK multinationals are less likely to use internal expansion in most sectors except for high-tech and other low-tech KI service sectors (all the coefficients on this variable are statistically significant at the 1% level). For other economically significant coefficients, firms owned by SE-Asia are 3.2 and 1.8% more likely to use internal expansion in the high-tech and low-tech manufacturing sectors respectively; while EU-owned firms are 1.9 % and 1.0% less likely to use the same form of expansion in the medium high-tech and low-tech manufacturing sectors respectively. US-owned firms are 2.2%, 1.4% and 0.8% less likely to expand internally in the high-tech manufacturing, medium high-tech manufacturing and KI service sectors respectively. Lastly, the probability of using internal expansion is 6.2% lower for the other foreign-owned firms in the medium high-tech manufacturing sector.

In a similar vein, the negative relationship between foreign ownership and the probability of using greenfield investment, shown in table 4.4 is driven mainly by the results in the low-tech KI service sector. Foreign-owned firms in this sector are between 3.5% and 4.1% less likely to build new plants, when compared to UK firms (all the coefficients on this variable are statistically significant at the 1% level). For economically significant coefficients in other sectors, tables 4.6 - 4.13 show that UK multinationals are more likely to use greenfield investment in 4 sectors (medium high-tech manufacturing, medium low-tech manufacturing, low-tech manufacturing and KI service sectors) while the same firms are less likely to use greenfield investment in 2 sectors (high-tech KI service sector and other low-tech KI service sector). In the high-tech manufacturing industry, firms owned by SE Asia countries are 2.2% less likely to expand via greenfield investment. Finally, EU-, US- and other foreign-owned companies are more likely to build new plants in the medium high-tech industry. Perhaps more interestingly, tables 4.6 - 4.13 show that foreign-owned firms are generally more likely to acquire an existing domestic plant than UK firms. Although generally lower in magnitude than greenfield investment, these coefficients are broadly statistically significant in most sectors. This result is in line with our argument (in section 2.3.1.3) that foreign-owned firms are more likely to acquire a domestic plant if they lack experience in their host market; have a cost advantage associated with adapting local plants or if local plants have greater value when combined with foreign assets than they do in the hands of local rivals.

4.4.4 Other Factors

Further to the well-documented variables discussed in previous sections, we also examine the links between the decision to expand in *t-1* and the decision to expand in *t*. These lagged values of expansion are included in equation (4.1) to test for entry sunk costs of expansion discussed in section 4.2. The result in table 4.4 shows that previous internal expanders are less likely to use the same form of expansion in the next period - firms that used internal expansion in period, *t-1*, are 0.6% less likely to use the same form of expansion in period *t*. These coefficients are negative and statistically significant across all sectors (as shown in tables 4.6 - 4.13). Tables 4.6 - 4.13 also show that previous internal expanders in the manufacturing sector are the least likely to use internal expansion in the next period (from -2.1% in the medium high-tech manufacturing sector to -2.5% in the high-tech and medium low-tech manufacturing sector), compared to the same enterprises in the service sector (from -0.2% in the low-tech KI service sector to -1.0% in the KI service and other low-tech KI service sector). This suggests that, the sunk cost from using internal expansion is very low such that there is no learning cost that allows for continuing internal expanders to have a lower adjustment cost than first time internal expanders. This result is also unsurprising given that internal expansion can lead to diminishing returns from the continuous increase in workforce without a corresponding increase in capital.

On the other hand, table 4.4 shows that past participation in greenfield investment increases the probability that a firm will continue to use the same form of expansion by 6.9%. The underlying coefficients associated with this variable are positive and economically significant (at the 1% level) in all industrial sectors except for 2 service sectors (Ki service is statistically insignificant and; other low-tech sector is statistically significant) where there is a negative relationship between greenfield investment in period *t-1* and greenfield investment in period *t*. Table 4.4 also shows a positive relationship between mergers and acquisition in period t-1 and mergers and acquisition in period t – past participation in mergers and acquisition increase the likelihood that a firm will continue to acquire another firm/plants by 4.3%. These coefficients are positive and economically significant in all sectors with large variation across sectors – from 0.2% in the KI service sector to 6.5% in the low-tech KI service sector. As these variables are in the model to proxy for sunk cost that allows for continuing external expanders to have a lower expansion cost than first time external expanders, it is not surprising that we find that previous users of external forms of expansion are more likely to rely on similar paths of expansion.

A time dummy that takes the value of one if the year is 2008 onwards, and zero otherwise, was also included in equation (4.1) to test for the uncertainty that was created by the 2008 economy-wide shock. The result obtained for this variable in table 4.4 shows that firms are more likely to expand internally post-2007. Indeed, firms in the UK are some 3.7% more likely to use internal expansion between the period 2008 and 2012. The underlying coefficients associated with this variable are positive and economically significant (at the 1% level) in all industrial sectors, as shown in tables 4.6 - 4.13. This implies that, between the period 2008 and 2012, firms were more likely to use internal expansion in every industrial sector. Tables 4.6 - 4.13also show that there is little industrial variation – the higher probability of using internal expansion ranges from 2.8% in the KI service sector to 4.0% in the low-tech KI service sector. In sum, our result suggests that expanding firms tend to rely more on internal expansion post-2007 and this is consistent across all the 8 industrial sectors.

In contrast, table 4.4 shows that expanding firms are less likely to rely on the 2 forms of external expansion – greenfield investment and mergers and acquisition. Specifically, table 4.4 shows that, post-2007, firms in the UK are some 3.3% and 0.3% less likely to build a new plant and acquire an existing one respectively. The coefficients obtained for this dummy variable are negative and economically significant in every industrial sector shown in tables 4.6 - 4.13 – implying that, since the 2008 recession, expanding firms are less likely to rely on external forms of expansion in all sectors. There is also little industrial variation shown in tables 4.6 - 4.13. The lower probability of using greenfield investment ranges from -2.0% in the high-tech manufacturing sector to -3.7% in the low-tech KI service sector and; that of using mergers and acquisition ranges from -0.2% in the other low-tech KI service sector to -0.9% in the high-tech manufacturing sector. In general, our result provides support for the adverse effect uncertainty caused by the 2008 financial crisis has on firm-level investment behaviour, particularly, firms' external expansion decision.

With regards to regional rankings, table 4.4 shows that firms located in most government office region are less likely to use internal expansion, vis-à-vis the baseline group (i.e., firms located in the South-Eastern region of England). The impact of being located in a particular region on the probability of choosing internal expansion is economically significant in at least one sector except for firms located in the North-Western part of England, as shown in tables 4.6 - 4.13. Overall, tables 4.6 - 4.13 show that firms based in Scotland, Wales and Northern Ireland are the least likely to expand internally (around 3.1-8.5% lower in the high-tech KI service sector and 2.5-7.3% in the other low-tech KI service sector). The coefficients associated with these regions are statistically significant in all the service sectors as well as in the low-tech manufacturing sector.

On the other hand, table 4.4 shows that firms located in most government office region are more likely to build plants, vis-à-vis the baseline group (i.e., firms located in the South-Eastern region of England). The coefficients associated with these regional dummies are statistically significant in at least one industrial sector except for firms located in the East-midlands, as shown in tables 4.6 - 4.13. Tables 4.6 - 4.13 also show that firms located in Scotland, Wales and Northern Ireland are the most likely to use greenfield investment (around 2.6-7.5% higher in the other low-tech KI service sector and 3.0-11.6% in the high-tech KI service sector). These coefficients are also economically significant across all the service sectors as well as in the low-tech manufacturing sector. In terms of mergers and acquisition, our result in tables 4.6 - 4.13 shows that the impact of being located in a particular region on mergers and acquisition is generally insignificant and numerically unimportant. Overall, regional impacts are partly in accord with expectations that there are high (sunk) costs associated with building new plants in the South-East Region, which make firms in this region less likely to rely on greenfield investment.

As to differences based on cities, it is not possible to consider, say, negative coefficient in isolation since there is a need to consider simultaneously the impacts of the region in which the city is located. Table 4.4 shows that the parameter estimates on the city dummies are positively related to internal expansion for all the major cities in Britain. These coefficients are particularly significant in the low-tech KI service sector, as shown in table 4.12. In this sector, the positive coefficient associated with the city dummies are matched by similar negative coefficients on their respective regions. This implies that positive 'cities' estimates are mostly offset by negative 'region' estimates, and that there is little difference in the probability of choosing internal expansion in most of the major cities vis-à-vis the South-East region. For greenfield investment, the negative city coefficients are also matched by similar positive coefficients on their respective regions. The city coefficients on mergers and acquisition are generally insignificant and numerical negligible, as shown in tables 4.6 - 4.13. In effect, what is apparent from our results is that, there is little difference in the likelihood of choosing internal expansion or greenfield investment in most of the major cities vis-à-vis the South-East region

Lastly, as to industrial variation (not shown in Table 4.4[34] but, available in the tables 4.6 - 4.13), our results shows that there is sectorial variation even within well-defined industrial sectors. We find that firms operating in high fixed cost sectors tend to rely less (more) on greenfield investment and mergers and acquisition (internal expansion) relative to firms operating in low fixed cost sectors. The probability of choosing internal expansion is generally higher for firms operating in a higher fixed cost sectors when compared to the baseline group of firms operating in lower cost industries (Pharmaceutical for high-tech manufacturing; Chemicals for medium high-tech manufacturing; Coke

[34] This is because our 2-digit industrial dummies vary across the 8 technologically defined industries and since Table 4.4 contains weighted average coefficients obtained at the 8 industrial sectors level, we can only present variables that are common across sectors.

and petroleum for medium low-tech manufacturing; Food and beverages for low-tech manufacturing; Telecoms for high-tech KI service; Water transport for KI service sector; Hotels and restaurants for low-tech KI service; and Postal services for other low-tech KI service). On the other hand, firms tend to rely less on greenfield investment and mergers and acquisition when they operate in a high fixed cost industry, as shown in tables 4.6 - 4.13. In general, results in Tables 4.6 - 4.13 tend to confirm that firms operating in high fixed cost sectors tend to rely less on external forms of adjustment as predicted by the "Q-theory of Mergers" (Jovanovic and Rousseau, 2002). For instance, Table 4.6 shows that when compared to firms operating in the pharmaceutical industry, firms in the aircraft and spacecraft industry are 1.6% less likely to build a new plant; even though they both operate in the high-tech manufacturing sector.

4.5 Firm-level Results for Net Contracting Firms

In this section, we interpret results for contracting firms. Similar to expanding firms, estimation is performed separately for 8 industrial sectors (defined in table 4.2 by the sophistication of technology used; following Harris and Moffat, 2011, 2016a, 2016b)[35] to avoid imposing common coefficients across industries operating with potentially distinct structure and technologies. The coefficients obtained at the 8 industrial sectors level[36] are then aggregated into one table by taking the weighted average (based on number of observation). In this section, we discuss our results by grouping variables into those that are related to firm size, adjustment size, firm-level variables (R&D, age, multi-plant and foreign ownership) and other factors (industry and geography and, persistence and crisis).

As a robustness, we recode each contraction category and repeat the exercise in the preceding paragraph. Internal contraction was recoded from internal contraction 'only' + internal contraction 'dominant' to internal contraction 'only'. Plant closure and plant sale were recoded to a similar 'only' path. This led to a fourth category of firms that used a combination of several adjustment paths to achieve a net contraction – referred to as contraction dominant - internal contraction 'dominant' + plant closure 'dominant' + plant sale 'dominant'. The results (presented in table 4.23 in appendix 4.7.3) are qualitatively similar to those presented in table 4.5.

[35] The results for all 8 industrial sectors for expansion and contraction are separately presented in Appendices 4.7.1 and 4.7.2 with analysis restricted to continuing firms.
[36] This also allows brevity of results presented.

Table 4-5: Marginal effects from multinomial logit model of determinants of contraction path in UK

Variables	Internal contraction $\partial p/\partial x$	Plant Closure $\partial p/\partial x$	Plant Sale $\partial p/\partial x$
Firm size			
10 -19 employees	-0.045	0.044	0.001
20 - 49 employees	-0.046	0.044	0.002
50 - 99 employees	-0.040	0.038	0.002
100 - 249 employees	-0.040	0.038	0.002
250+ employees	-0.049	0.046	0.003
Adjustment size			
$\ln(employment_t \mid employment_{t-1})$	0.042	-0.040	-0.002
Firm-level variables			
R&D band 2	0.001	0.000	0.000
R&D band 3	0.009	-0.010	0.001
R&D band 4	-0.003	0.002	0.000
R&D band 5	0.000	0.000	0.000
ln Age	0.012	-0.012	0.000
Single-plant firm	0.229	-0.218	-0.012
UK-owned firm (With FDI)	-0.003	0.002	0.001
SE Asia-owned firms	0.003	-0.003	0.000
EU-owned firms	-0.008	0.007	0.000
USA-owned firms	-0.005	0.006	0.000
AUSCANSA-owned firms	-0.016	0.016	0.000
Other Foreign-owned firms	-0.010	0.010	0.000
Region			
North-East	0.009	-0.008	0.000
Yorkshire-Humberside	0.004	-0.004	0.000
North-West	0.005	-0.005	0.000
West Midlands	0.004	-0.004	0.000
East Midlands	0.004	-0.004	0.000
South-West	0.003	-0.002	0.000
Eastern	0.002	-0.002	0.000
London	0.001	-0.001	0.000
Scotland	0.000	0.000	0.000
Wales	-0.002	0.002	0.000
Tyneside	-0.004	0.004	0.000
Northern Ireland	0.060	0.084	-0.144
Major UK Cities			
Manchester	0.003	-0.003	-0.001
Liverpool	0.005	-0.004	-0.001
Birmingham	0.001	-0.001	0.000
Coventry	0.006	-0.004	-0.002
Leicester	0.008	-0.007	-0.001
Nottingham	0.001	0.004	-0.005

Variables	Internal contraction $\partial p/\partial x$	Plant Closure $\partial p/\partial x$	Plant Sale $\partial p/\partial x$
Bristol	0.004	-0.001	-0.003
Glasgow	0.001	0.000	0.000
Edinburgh	-0.005	0.005	-0.001
Cardiff	0.010	0.013	-0.022
Persistence and crisis			
Internal contraction$_{t-1}$	0.003	-0.004	0.000
Plant closure$_{t-1}$	-0.001	0.001	0.000
Plant sale$_{t-1}$	-0.027	0.025	0.002
2008 Onwards	0.033	-0.033	-0.001

[a] Weighted coefficients from tables 4.14 to 4.21.

4.5.1 Firm Size

It is evident from table 4.5 that the large firms are less likely to use internal contraction than the smallest firms (i.e., firms that employ less than 10 people). However, unlike our result for expanding firms, the probability of using internal contraction does not decline with firm size. Indeed, table 4.5 shows that the probability of using internal contraction initially increased with firm size (i.e., an increase from -4.6% to -4.0% when moving from 20-49 employees to 50-99 employees) and later reduced for higher values of firm size (i.e., a reduction from -4.0% to -4.9% when moving from 100-249 employees to 250+ employees). Note that the initial increase does not mean that the probability of using internal contraction is getting higher, but simply that the rate of reducing probability is slowing down. The primary coefficients associated with these dummies are negative and economically significant across 7 industrial sectors (the exception being high-tech manufacturing where none of the size dummies are statistically significant). The tables in appendix 4.7.2 (tables 4.14 - 4.21) show little variation in the estimated coefficients. For instance, the largest firms are between 2.0% (in medium low-tech manufacturing sector) and 5.1% (in other low-tech KI service sector) less likely to use internal contraction, when compared to the smallest firms. Our finding that large firms are less likely to rely on internal contraction contrasts those of Hallock (1998) and Kang and Shivdasani (1997).

Large firms, on the other hand, are more likely to rely on plant closure and plant sale – the 2 forms of external contraction. Table 4.5 shows that although, the probability of plant closure does not increase with firm size, the largest firms (i.e. those with 250 employees or more) are still the most likely to close plants. The same firms are also the most likely to sell plants with plant sale increasing in firm size. Most of the estimates associated with table 4.5 are statistically significant (at the 1% level) across sectors with the exception of high-tech manufacturing where none of the size dummies are statistically significant for plant closure and plant sale. In terms of magnitudes, table 4.5 also shows that firms within the same size category are more likely to close plants than sell plants. For instance, the largest firms are 4.6% more likely to close plants while, the same firms are only 0.3% more likely to sell plants. It thus, seems that large firms are more like to rely on external forms of contraction, particularly, on plant closure. The gap in the probabilities is particularly large in the low-tech KI service sector (where the largest firms are 5.3% more likely to close plants compared to 0.2% for plant sales), but quite small in the medium low-tech manufacturing sector (where the largest firms are 0.5% more likely to close plants compared to 0.4% for plant sales), as shown in tables 4.14 - 4.21. Nevertheless, it remains evidently clear that large firms rely more on plant closure than plant sales across all sectors.

In summary, our result shows that large firms are less (more) likely to rely on internal (external) forms of contraction. This is in line with the theoretical prediction and empirical findings of Breinlich and Niemann (2011a), who showed that large firms rely more on external contraction than small firms. Our result also indicates that large firms are more likely to close plants when choosing between the 2 forms of external contraction. This is at odds with the theoretical model of Warusawitharana (2008) which predicts that troubled large firms are more likely to sell plants. One explanation for such contrasting result is that additional factors may play a role in firms' decision of contraction path, which is absent from Warusawitharana (2008) model. For instance, a firm may not be willing to sell some of its plants to actual or potential competitors but instead, choose to close those plants in order not to give competitive advantage to its competitors. In other words, large firms may only be willing to contemplate the plant sale option if there are active secondary markets for its plants that would have no adverse effect on future profit from selling those plants.

4.5.2 Adjustment Size

Regarding the adjustment size variable, table 4.5 shows that firms are more likely to rely on internal contraction when the desired size of contraction is large. Indeed, it shows that a one standard deviation increase in desired contraction increases the probability of using internal contraction by 4.2%. The coefficients associated with this variable are positive and economically significant (at the 1% level) in every sector. There is also little sectorial variation, as shown in tables 4.14 - 4.21. The values of the marginal effects ranges from 3.2% in high-tech KI service sector to 6.7% in high-tech manufacturing sector. However, when the desired size of contraction is large, firms in the manufacturing sector tend to rely more on internal contraction (range from 4.6% to 6.7%) than firms in the service sector (range from 3.2% to 4.1%).

By contrast, table 4.5 shows that there is a negative relationship between the size of a contraction and the probability of using plant closure. A 1 standard deviation increase in desired contraction reduces the probability of choosing to close plant by 4%. The disaggregated coefficients in tables 4.14 - 4.21 are negative and statistically significant across all industrial sectors. Tables 4.14 - 4.21 also show that, when the desired size of contraction is large, firms in the manufacturing sector tend to rely less on plant closure (range from -4.3% to -6.2%) than firms in the service sector (range from -3.2% to -4.0%). Lastly, we find that contraction size is negatively and significantly related to the probability of selling plants in all sectors; but these coefficients are quite small – ranging from -0.1% to -0.5%. Further, the probability of selling plants is lower in the manufacturing sectors (range from -3.0% to -5.0%) than the probability of closing plants (range from -0.1% to -0.2%), when firms need to carry out a large contraction.

Overall, our result shows that firms are less (more) likely to rely on external (internal) forms of contraction, when the desired size of contraction is large. One explanation, which is admittedly favourable to our result, is that an adverse shock on a firm is likely to affect all the plants under the control of that firm, particularly, if the plants are being operated at close to, if not the same efficiency level. Assuming such firm receives a negative firm-level (and not plant-specific) shock, it is more likely to contract its operation at all existing plants i.e., internal contraction instead of closing the operation of a particular plant i.e., external contraction, even for large contractions. For instance, a firm that owns 10 plants with 10 employees in each plant wishing to downsize its workforce by 10% might find it optimal to reduce its workforce by one employee in each plant rather than closing the operation of a specific plant. Our result also shows that, when choosing between the 2 forms of external contraction, firms are more likely to carry out large contractions via plant closure. This is at odds with Breinlich and Niemann (2011a) result that found no relationship between contraction size and firms' choice of external contraction. Our contrasting result might again be due to the different measure of contraction size used in this thesis.

4.5.3 Firm-level Variables

We now turn to the firm-level variables reviewed in section 2.3.1.3 of this thesis. The result obtained for the first of our firm-level variables shows that positive R&D has a minor impact on the probability of using internal contraction; vis-à-vis the baseline group (i.e., firms with no R&D expenditure), moving to R&D band 1 increase the probability of undertaking internal contraction by 0.1%, an increase in the probability by 0.9% in the R&D band 2 group, a reduction in the probability by 0.3% in the R&D band 3 group and a negligible increase for firms in the R&D band 4 group. However, the coefficients associated with these dummies are barely statistically significant across the industrial sectors. With regards to the effect of firm's R&D on the probability of choosing external forms of contraction, table 4.5 shows that there is a positive relationship between firm's R&D expenditure and the probability of closing and selling plants (with the exception of firms in R&D band 3 category on plant closure). However, most of the coefficients associated with these dummies are close to zero and often statistically insignificant across sectors. Nonetheless, our finding that firms that engage in R&D activity are somewhat more likely to sell plant is similar to that of Phillips and Zhdanov (2013).

As to the second firm-level variable – firm's age - table 4.5 shows that older firms are more likely to rely on internal contraction than young firms. Specifically, table 4.4 shows that a one standard deviation increase in firm's age increases the probability of using internal contraction by 1.2%. The underlying coefficients associated with this variable are positive and economically significant (at the 1% level) in all industrial sectors, as shown in tables 4.14 - 4.21. Tables 4.14 - 4.21 also show that there is little variation across sectors – the impact of age on the probability of using internal contraction ranges from 0.7% in the high-tech KI service sector to 1.3% in the medium high-tech manufacturing and other low-tech KI service sectors. Thus, our result suggests that old firms tend to rely more on internal contraction than young firms, which is unsurprising given that old firms are more likely to exhaust their internal growth opportunities faster than young firms, and would seek to contract internally to improve their profitability during a downturn.

In contrast, table 4.5 shows that old firms are less likely to close plants than young firms. A one standard deviation increase in age reduces the probability that a firm closes plant by 1.2%. The effect of age on plant closure remains negative and statistically significant across all sectors, as shown in tables 4.14 - 4.21. Tables 4.14 - 4.21 also show that there is little variation across the 8 industrial sectors - the impact of age on the probability of plant closure ranges from -0.7% in the high-tech KI service sector to -1.3% in the medium high-tech manufacturing and other low-tech KI service sectors. This result is consistent with the argument that older firms are more likely to set their efficiency levels closer to the 'true' level of efficiency which should in turn lead to a negative relationship between a firm's age and the probability of a plant closure, as argued, for example, by Jovanovic (1982). Finally, table 4.5 shows that firm's age has no impact on the probability of selling plants. Indeed, tables 4.14 - 4.21 shows that these estimates are close to zero in all industrial sectors. Thus, we found no evidence to suggest that older firms with operational rigidities and therefore, higher cost of integration, have lower takeover hazard (e.g., Loderer and Waelchli, 2015); or in contrast, that older firm with operationally rigidities are more likely to sell plants to free up management time and focus on their core competences (e.g., Berchtold et al., 2014). Instead, our result suggests that these 2 effects offset one another so that all firms have similar probabilities of selling plants, irrespective of their age.

As regards to our third firm-level variable, table 4.5 shows that single-plant enterprises are more likely to contract internally. When compared to multi-unit firms, single-plant enterprises are 22.9% more likely to contract internally, as shown in table 4.5. The coefficients associated with this variable show that (in Tables 4.14 - 4.21) we obtained positive and statistically significant relationships across all the industrial sectors. However, we find some variation across sectors – single-plant enterprises in the manufacturing sectors tend to rely more on internal expansion (range from 29.4% to 34.6%) than the same firms in the service sectors (range from 18.4% to 22.5%). Nevertheless, our result shows ample evidence to suggest that single-plant enterprises are more likely to explore the option of contracting internally as they may find it harder to implement a plant closure or plant sale which would involve a complete withdrawal from manufacturing or service activities.

In contrast, table 4.5 shows that single-plant enterprises are less likely to close plants. This table shows that single-plant enterprises are 21.8% less likely to close plants than multi-unit firms. The disaggregated coefficients associated with this variable are negative and statistically significant across all industrial sectors, as shown in tables 4.14 - 4.21. Tables 4.14 - 4.21 also show that single-plant enterprises in the manufacturing sectors tend to rely less on plant closure (range from -28.7% to 33.7%) than the same firms in the service sectors (range from -17.6% to -21.1%). This result is similar to that of Bernard and Jensen (2007) and Disney et al. (2003) that conclude that multi-unit firms are more likely to close plants, particularly if the plant has a relatively different cost structure to the rest of the firm. It also supports the argument that multi-unit firms are more likely to close plants because they can easily transfer production from one plant to another without ceasing operation or exiting the market. Lastly, table 4.5 shows that single-plant enterprises are 1.2% less likely to sell plant than multi-unit firms. These coefficients associated with this variable are negative, economically significant, and they range from -0.7% to -1.4% in all industrial sectors. This suggests that single-unit enterprises might have personal links with the plant and/or community in which they operate such that they are unwilling to sell their plants to another firm.

With regards to our fourth firm-level variable - foreign ownership – table 4.5 shows that most foreign-owned firms (except for SE Asia-owned firms) are less likely to use internal contraction, vis-à-vis the baseline group (i.e., UK firms without foreign investment). Results in table 4.5 show that foreign-owned firms are between 0.3% and 1.6% less likely to contract internally than UK-owned firms. The coefficients associated with these dummies are mostly negative and statistically significant across all sectors, as shown in tables 4.14 - 4.21. In particular, each foreign ownership dummy is statistically significant in at least one sector (out of the possible 8) with UK multinational dummy and EU-owned dummy statistically significant in 6 sectors. In general, our results in tables 4.14 - 4.21 indicate that most foreign-owned firms are less likely to contract internally.

On the other hand, foreign-owned enterprises are more likely to close plants (with the exception of SE Asia-owned firms), when compared to UK-owned firms. Table 4.5 shows that foreign-owned firms are between 0.2% and 1.6% more likely to close plants than their UK-owned counterpart. The coefficients associated with these dummies are largely positive and statistically significant across all sectors, as shown in tables 4.14 - 4.21. Specifically, each foreign ownership dummy is statistically significant in at least one sector (out of the possible 8) with EU-owned dummy statistically significant in 6 sectors. Overall, our result is in line with that of Bernard and Jensen (2007), who found that US multinationals are more likely to close domestic plants. Lastly, we find a similar positive relationship between foreign ownership and the probability of plant sales, however these coefficients are close to zero; implying a negligible impact of foreign ownership on the probability of selling plants.

4.5.4 Other Factors

Like in expanding firms, we also consider the links between lagged contraction values, the 2008 economy-wide shock, regional and city rankings and industry effect and, firms' decision to contract in period *t*. The result in table 4.5 shows that previous internal contractors are more likely to use the same form of contraction in the next period - firms that used internal contraction in period, *t-1*, are 0.3% more likely to use the same form of contraction in period *t*. These coefficients are statistically significant in 4 industrial sectors (medium high-tech manufacturing, low-tech manufacturing, high-tech KI service and low-tech KI service) and they are positive in these sectors – ranging from 0.4% to 0.8%, as shown in tables 4.14 - 4.21. This result is unsurprising given that there are redundancies payment often associated with internal contraction such that a firm using this form of contraction for the first time would pay more than a firm that had previously contracted internally.

Table 4.5 also shows that past participation in plant closure increases the probability that a firm will use the same form of contraction by 0.1%. The underlying coefficients associated with this variable are only statistically significant in 2 industrial sectors (low-tech manufacturing and high-tech KI service) and the signs are mixed. Firms that closed plants in period *t-1* are 1.2% more likely to do the same in period *t*, in the low-tech manufacturing sector while the same firms are 1.1% less likely to close plants in period *t*, in the high-tech KI service sector. For plant sale, there is a similar positive relationship between plant sale in period *t-1* and period *t*, shown on table 4.5. Indeed, table 4.5 shows that firms that sold plants in period *t-1* are 0.2% more likely to use the same form of contraction the following year. These coefficients are economically significant in 4 industrial sectors and positive in 3 out of these 4 sectors. Overall, our result suggests a similar sunk cost effect found in expanding firms, however, this effect is not quite as pronounced for contracting firms, possibly due to the difference in the cost of external expansion and external contraction. For instance, the cost of building a plant could be much higher than the cost of closing one.

The result obtained for the time dummy, 2008-2012, shows that firms are more likely to contract internally over this period. Indeed, table 4.5 shows that firms in the UK are some 3.3% more likely to lay off workers over the period 2008-2012. The underlying coefficients associated with this dummy variable are positive and economically significant (at the 1% level) in every sector, as shown in tables 4.14 - 4.21. This implies that, between the period 2008 and 2012, firms were more likely to use internal contraction in every industrial sector. Tables 4.14 - 4.21 also show little industrial variation - the higher probability of using internal contraction ranges from 2.0% in the other low-tech KI service sector to 3.8% in the low-tech KI service sector. In sum, our result suggests that contracting firms tend to rely more on internal contraction post-2007 and this is consistent across all the 8 industrial sectors.

In contrast, table 4.5 shows that contracting firms are less likely to rely on the 2 forms of external contraction – plant closure and plant sale – over the 2008-2012 period. Specifically, table 4.5 shows that, post-2007, firms in the UK are some 3.3% and 0.1% less likely to close and sell plants respectively. The coefficients obtained for this dummy variable are negative and economically significant in every industrial sector shown in tables 4.14 - 4.21 – implying that, since the 2008 recession, contracting firms are less likely to rely on external forms of contraction in all sectors. There is also little industrial variation shown in tables 4.14 - 4.21. The lower probability associated with plant closure ranges from -1.9% in the other low-tech Ki service sector to -3.8% in the low-tech KI service sector and; that of selling plants ranges from -0.1% to -0.4%. In general, this result provides support for Dixit (1989) model which shows that under considerable uncertainty about future market condition, firms may decide to keep plants even when output price is significantly lower than the average variable costs of running plants. In other words, a substantial fall in demand or rise in operation costs that occurred during the financial crisis of 2008 may not serve as enough reason for firms' willingness to shed plant as any future improvements in market conditions will see them avoid the sunk costs of rebuilding and/or repurchasing plants (e.g., Harris and Moffat, 2016).

Turning to regional rankings, table 4.5 shows that firms located in most government office region are more likely to contract internally, vis-à-vis the baseline group (i.e., firms located in the South-Eastern region of England). The impact of being located in a particular region on the likelihood of using internal contraction is economically significant in at least one industrial sector, as shown in tables 4.14 - 4.21. In terms of industrial variation, firms located in Scotland (in the high-tech manufacturing sector) are the most likely to use internal contraction while firms located in Northern Ireland (in the low-tech KI service sector) and the least likely to use the same form of contraction. By contrast, table 4.5 shows that firms located in most government office region are less likely to close plants, vis-à-vis the baseline group (i.e., firms located in the South-Eastern region of England). Again, the underlying coefficients associated with these regional dummies are statistically significant in at least one industrial sector with the coefficient signs generally negative (shown in tables 4.14 - 4.21). Lastly, there are negligible impacts of being located in a particular region on the probability of selling plants. Overall, our result suggests that, while it may be expensive opening a new plant in South East of England, closing an existing plant may not be so expensive in the same region.

As to differences based on cities, Table 4.5 shows that the parameter estimates on the city dummies are positively related to internal contraction, for all the major cities in Britain. These coefficients are statistically significant in at least one industrial sector, as shown in tables 4.14 - 4.21. However, the signs on the statistically significant coefficients are mixed – negative for 8 coefficients and positive for 11 coefficients. There are similar mixed coefficient signs at industry level for plant closure and plant sale. In effect, it is difficult to conclude that firms operating in major cities outside the South-Eastern region of England are more or less likely to use a particular path of contraction.

Finally, as to industrial variation (not shown in table 4.5 but, available in the tables 4.14 - 4.21), our results shows that there is sectorial variation even within well-defined industrial sectors. We find that firms operating in high fixed cost sectors tend to rely less (more) on plant closure and plant sales (internal contraction), when compared to firms operating in low fixed cost sectors. The probability of choosing internal contraction is generally higher for firms operating in a higher fixed cost sectors when compared to the baseline group of firms operating in lower cost industries (Pharmaceutical for high-tech manufacturing; Chemicals for medium high-tech manufacturing; Coke and petroleum for medium low-tech manufacturing; Food and beverages for low-tech manufacturing; Telecoms for high-tech KI service; Water transport for KI service sector; Hotels and restaurants for low-tech KI service; and Postal services for other low-tech KI service). On the other hand, firms tend to rely less on plant closure and plant sale when they operate in a high fixed cost industry, as shown in tables 4.14 - 4.21. Our finding is similar to that of expanding firms and supports the “Q-theory of Mergers” (Jovanovic and Rousseau, 2002).

4.6 Summary and Conclusion

This chapter has sought out to examine the crucial factors that are likely to determine firms’ choice of expansion and contraction in the UK. Using a multinomial logit model, it considers the role of the following 4 determinants: firm size, adjustment size, firm-level variables (R&D, age, multi-plant and foreign ownership) and other factors (persistence, time, geography and industrial effect). Our sample was disaggregated into manufacturing and services and by technology to avoid imposing common coefficients across industries operating with potentially distinct cost structure and technologies. This exercise was done separately for expanding and contracting firms.

In terms of expanding firms, we find that large firms tend to rely on external forms of expansion, particularly, on greenfield investment than small firms. Expansion size is generally positively related to external expansion, implying that firms tend to rely more on external expansion when the desired size of expansion is large. The results obtained for our firm-level variables are mixed. The first of such result shows that undertaking R&D is negatively associated with external expansion in most sectors, implying that high-productivity (innovative) firms engage less in internal innovation, instead they use greenfield investment and mergers and acquisition to gain access to new technology. Second, firm age is generally positively related to greenfield investment but has a negligible impact (i.e., coefficients that are close to zero) on mergers and acquisition. Third, single-plant enterprises tend to rely less on external forms of expansion, particularly, on greenfield investment across most sectors, which implies that there may be economies of scale benefit associated with owning more than one plant. Fourth, foreign ownership is positively related to mergers and acquisition while there is no obvious relationship between the former and greenfield investment. Turning to the other determinants, our result shows that past participation in external expansion increases the probability of using the same form of expansion across most sectors. Our measure of the impact of 2007 financial crisis shows that expanding firms tend to rely less on external forms of expansion post-2007. Lastly, we find that there are regional, city and sectorial differences in the use of expansion paths, particularly for external forms of expansion.

Turning now to contracting firms, our result shows that large firms tend to rely more on external forms of contraction than small firms and this is consistent across all industrial sectors. Our measure of contraction size is negatively related to external forms of contraction, implying that firms rely less on these forms of contraction, when the desired size of contraction is large. Regarding our first firm-level variables, we find that that undertaking R&D is positively related to external contraction. However, most of the coefficients associated with our R&D dummies are close to zero and often statistically insignificant across sectors. Our second firm-level variable shows that old firms are less likely to close plants than young firms, while firm age is unrelated to plant sales across all industrial sectors. The third firm-level variable indicates that there is a negative relationship between single-plant enterprises and plant closure and plant sales. For the fourth firm-level variable, we find that foreign ownership is positively associated with plant closure while the impact of foreign ownership on probability of plant sale is close to zero across all sectors. As regards to the other determinants, our result reveals that past participation in external contraction increases the probability of using the same form of contraction across most sectors, although this is less for pronounced for contracting firms. Across all sectors, contracting firms tend to rely less on external forms of contraction, post-2007. Finally, we also find that there are regional, city and sectorial differences in the use of contraction paths, particularly for external forms of contraction.

4.7 Appendix

4.7.1 Net Expanding Firms

Table 4-6: Marginal effects from multinomial logit model of determinants of expansion path in UK high-tech manufacturing, 1997-2012

	Internal expansion		Greenfield investment		Mergers and Acquisition	
Variables	$\partial p/\partial x$	**z-value**	$\partial p/\partial x$	**z-value**	$\partial p/\partial x$	**z-value**
Persistence						
Internal expansion$_{t-1}$	-0.025	-5.97	0.026	6.45	-0.001	-0.50
Greenfield investment$_{t-1}$	-0.020	-3.09	0.019	3.13	0.001	0.31
Mergers and acquisition$_{t-1}$	-0.073	-3.42	0.059	2.90	0.013	1.97
Firm size						
10 -19 employees	-0.080	-14.76	0.062	13.02	0.018	5.52
20 - 49 employees	-0.110	-19.99	0.080	16.17	0.030	9.64
50 - 99 employees	-0.105	-15.48	0.073	11.69	0.032	9.32
100 - 249 employees	-0.120	-16.61	0.080	12.03	0.040	10.96
250+ employees	-0.144	-17.23	0.100	12.92	0.044	10.88
Adjustment size						
$\ln(employment_t \mid employment_{t-1})$	-0.050	-23.03	0.037	18.73	0.013	14.61
Internal and external knowledge						
ln Age	0.013	6.44	-0.012	-6.15	-0.001	-1.57
R&D band 2	0.017	0.90	-0.021	-1.33	0.004	0.37
R&D band 3	0.021	1.50	-0.023	-1.95	0.002	0.21
R&D band 4	0.015	1.94	-0.011	-1.48	-0.004	-1.25
R&D band 5	0.006	1.36	-0.006	-1.41	0.000	-0.08
Multi-plant economies of scale						
Single-plant firm	0.064	8.70	-0.056	-7.91	-0.007	-3.20
Ownership-type						
UK-owned firm (With FDI)	-0.013	-2.04	0.008	1.41	0.004	1.77
SE Asia-owned firms	0.032	3.17	-0.022	-2.29	-0.009	-3.35
EU-owned firms	-0.011	-1.31	0.007	0.91	0.004	1.08
USA-owned firms	-0.022	-2.68	0.013	1.64	0.010	2.58
AUSCANSA-owned firms	-0.041	-1.49	0.022	0.87	0.019	1.37
Other Foreign-owned firms	0.001	0.04	-0.005	-0.28	0.004	0.45
Region						
North-East	0.012	1.07	-0.014	-1.24	0.001	0.23
Yorkshire-Humberside	0.015	1.94	-0.013	-1.79	-0.002	-0.61
North-West	0.004	0.54	-0.004	-0.67	0.001	0.18
West Midlands	-0.001	-0.16	-0.001	-0.12	0.002	0.59
East Midlands	0.004	0.58	-0.004	-0.63	0.000	0.01
South-West	0.013	2.12	-0.012	-2.07	-0.001	-0.41
East	0.002	0.44	-0.004	-0.74	0.001	0.54
Scotland	-0.010	-1.40	0.012	1.91	-0.002	-0.71
Wales	0.010	1.16	-0.009	-1.14	-0.001	-0.22

Variables	Internal expansion $\partial p/\partial x$	z-value	Greenfield investment $\partial p/\partial x$	z-value	Mergers and Acquisition $\partial p/\partial x$	z-value
Northern Ireland	0.026	0.81	-0.008	-0.29	-0.019	-0.81
Major UK Cities						
London	-0.002	-0.26	-0.003	-0.43	0.004	1.40
Manchester	-0.022	-1.00	0.020	0.99	0.002	0.20
Birmingham	-0.008	-0.51	0.008	0.57	0.000	-0.05
Glasgow	-0.017	-0.95	0.015	0.95	0.002	0.20
Tyneside	-0.021	-0.84	0.012	0.47	0.010	1.08
Edinburgh	-0.031	-1.57	0.030	1.79	0.001	0.06
Bristol	0.013	0.51	-0.017	-0.68	0.004	0.39
Cardiff	0.018	0.66	-0.026	-0.99	0.008	1.00
Liverpool	0.053	1.02	-0.069	-1.31	0.016	1.48
Nottingham	0.104	0.47	0.036	0.71	-0.140	-0.53
Leicester	-0.012	-0.49	0.012	0.51	0.000	0.04
Coventry	0.051	0.63	0.017	0.68	-0.068	-0.73
Industry sector (SIC 1992 2-digit)						
office machinery and computers	0.005	0.83	-0.010	-1.73	0.004	1.07
Radio, TV and communication equipment	0.005	0.78	-0.007	-1.35	0.002	0.78
Medical and precision instruments	0.004	0.70	-0.010	-1.85	0.006	1.98
Aircraft and spacecraft	0.012	1.74	-0.016	-2.77	0.004	1.04
Years						
2008 Onwards	0.029	8.79	-0.020	-6.40	-0.009	-6.67
Number of observations	25,599					
Pseudo-R^2	0.137					
Log-likelihood	-6,447.59					

Table 4-7: Marginal effects from multinomial logit model of determinants of expansion path in UK medium high-tech manufacturing, 1997-2012

	Internal expansion		Greenfield investment		Mergers and Acquisition	
Variables	$\partial p/\partial x$	**z-value**	$\partial p/\partial x$	**z-value**	$\partial p/\partial x$	**z-value**
Persistence						
Internal expansion$_{t-1}$	-0.021	-7.59	0.023	8.57	-0.002	-1.57
Greenfield investment$_{t-1}$	-0.027	-5.97	0.019	4.66	0.008	3.38
Mergers and acquisition$_{t-1}$	-0.076	-5.45	0.059	4.43	0.017	3.96
Firm size						
10 -19 employees	-0.076	-21.15	0.051	16.83	0.024	10.44
20 - 49 employees	-0.101	-27.23	0.066	20.62	0.035	14.89
50 - 99 employees	-0.095	-20.69	0.054	13.03	0.041	15.97
100 - 249 employees	-0.114	-23.26	0.065	14.91	0.048	17.73
250+ employees	-0.143	-24.73	0.087	16.36	0.057	18.77
Adjustment size						
$\ln(employment_t \mid employment_{t-1})$	-0.055	-36.50	0.039	28.94	0.016	24.11
Internal and external knowledge						
ln Age	0.009	7.21	-0.010	-8.21	0.001	1.16
R&D band 2	0.012	0.89	-0.003	-0.23	-0.009	-1.79
R&D band 3	0.021	2.96	-0.025	-4.34	0.004	0.82
R&D band 4	0.025	5.99	-0.019	-5.10	-0.005	-2.74
R&D band 5	0.005	1.38	-0.006	-1.73	0.001	0.77
Multi-plant economies of scale						
Single-plant firm	0.068	13.80	-0.063	-13.00	-0.005	-3.86
Ownership-type						
UK-owned firm (With FDI)	-0.016	-3.23	0.011	2.25	0.005	2.94
SE Asia-owned firms	0.012	1.35	-0.010	-1.22	-0.002	-0.50
EU-owned firms	-0.019	-3.52	0.013	2.50	0.006	2.98
USA-owned firms	-0.014	-2.59	0.011	2.00	0.004	1.89
AUSCANSA-owned firms	-0.008	-0.44	0.013	0.69	-0.004	-0.83
Other Foreign-owned firms	-0.062	-2.38	0.059	2.31	0.004	0.46
Region						
North-East	0.010	1.49	-0.007	-1.18	-0.003	-0.87
Yorkshire-Humberside	0.000	0.01	0.000	0.05	0.000	-0.12
North-West	0.003	0.67	-0.003	-0.64	0.000	-0.16
West Midlands	0.002	0.40	0.001	0.19	-0.002	-1.15
East Midlands	0.005	1.02	-0.005	-1.13	0.000	0.06
South-West	0.002	0.38	0.001	0.34	-0.003	-1.37
East	-0.004	-0.90	-0.001	-0.13	0.004	2.23
Scotland	-0.020	-4.09	0.025	5.73	-0.005	-1.77
Wales	-0.015	-2.81	0.014	2.93	0.001	0.23
Northern Ireland	0.003	0.19	0.019	1.46	-0.023	-1.47
Major UK Cities						
London	-0.002	-0.38	0.001	0.23	0.001	0.34
Manchester	-0.026	-1.92	0.026	2.10	0.000	0.07

Variables	Internal expansion $\partial p/\partial x$	z-value	Greenfield investment $\partial p/\partial x$	z-value	Mergers and Acquisition $\partial p/\partial x$	z-value
Birmingham	0.002	0.26	-0.012	-1.53	0.010	3.25
Glasgow	-0.007	-0.53	0.006	0.49	0.001	0.17
Tyneside	0.006	0.46	-0.006	-0.47	0.000	-0.03
Edinburgh	0.022	0.79	-0.038	-1.45	0.017	1.79
Bristol	0.001	0.09	0.007	0.58	-0.009	-0.82
Cardiff	-0.006	-0.37	0.007	0.45	0.000	-0.05
Liverpool	0.011	0.54	-0.009	-0.51	-0.001	-0.13
Nottingham	-0.004	-0.25	0.002	0.14	0.002	0.29
Leicester	-0.021	-1.60	0.021	1.66	0.001	0.13
Coventry	0.006	0.47	-0.009	-0.71	0.003	0.45
Industry sector (SIC 1992 2-digit)						
Machinery and equipment	0.011	3.87	-0.010	-3.71	-0.001	-0.93
Electrical machinery	0.012	3.92	-0.008	-2.99	-0.003	-2.65
Motor Vehicles	0.016	4.84	-0.010	-3.43	-0.005	-4.04
Other transport equipment	-0.019	-2.52	0.019	2.67	0.000	0.00
Years						
2008 Onwards	0.031	14.42	-0.023	-11.50	-0.008	-8.43
Number of observations	59,709					
Pseudo-R^2	0.143					
Log-likelihood	-15,058.4					

Table 4-8: Marginal effects from multinomial logit model of determinants of expansion path in UK medium low-tech manufacturing, 1997-2012

	Internal expansion		Greenfield investment		Mergers and Acquisition	
Variables	$\partial p/\partial x$	z-value	$\partial p/\partial x$	z-value	$\partial p/\partial x$	z-value
Persistence						
Internal expansion$_{t-1}$	-0.025	-12.32	0.025	13.20	-0.001	-1.34
Greenfield investment$_{t-1}$	-0.022	-7.13	0.019	6.30	0.004	2.96
Mergers and acquisition$_{t-1}$	-0.067	-5.51	0.054	4.57	0.014	4.34
Firm size						
10 -19 employees	-0.062	-28.41	0.047	23.98	0.015	12.58
20 - 49 employees	-0.081	-34.28	0.060	28.03	0.021	16.70
50 - 99 employees	-0.080	-25.67	0.051	17.69	0.029	19.96
100 - 249 employees	-0.084	-22.88	0.053	15.37	0.031	19.84
250+ employees	-0.119	-25.17	0.081	18.00	0.038	21.15
Adjustment size						
$\ln(employment_t \mid employment_{t-1})$	-0.043	-41.32	0.033	34.37	0.010	25.61
Internal and external knowledge						
ln Age	0.008	8.99	-0.007	-7.88	-0.001	-4.06
R&D band 2	0.018	2.49	-0.017	-2.47	-0.002	-0.47
R&D band 3	0.015	2.88	-0.014	-2.84	-0.001	-0.50
R&D band 4	0.002	0.58	-0.003	-0.79	0.001	0.60
R&D band 5	0.002	0.37	-0.003	-0.66	0.001	1.05
Multi-plant economies of scale						
Single-plant firm	0.055	13.52	-0.051	-12.64	-0.004	-4.49
Ownership-type						
UK-owned firm (With FDI)	-0.020	-4.45	0.013	3.03	0.007	4.91
SE Asia-owned firms	0.015	1.17	-0.015	-1.25	0.000	0.02
EU-owned firms	0.003	0.65	-0.005	-1.23	0.002	1.57
USA-owned firms	-0.006	-1.03	0.002	0.40	0.004	2.10
AUSCANSA-owned firms	-0.005	-0.33	-0.006	-0.36	0.011	1.69
Other Foreign-owned firms	-0.006	-0.41	0.008	0.57	-0.002	-0.62
Region						
North-East	0.003	0.73	-0.001	-0.29	-0.002	-1.08
Yorkshire-Humberside	0.004	1.38	-0.002	-0.80	-0.002	-1.47
North-West	0.003	0.97	-0.002	-0.78	-0.001	-0.55
West Midlands	0.005	1.84	-0.006	-2.31	0.001	0.88
East Midlands	0.005	1.68	-0.002	-0.76	-0.003	-2.20
South-West	0.003	0.80	0.000	-0.03	-0.002	-1.69
East	0.000	-0.09	0.001	0.45	-0.001	-0.75
Scotland	-0.021	-6.40	0.020	6.66	0.001	0.43
Wales	-0.008	-2.18	0.010	2.88	-0.002	-1.15
Northern Ireland	0.001	0.16	0.008	1.07	-0.009	-1.89
Major UK Cities						
London	0.008	1.95	-0.004	-1.07	-0.004	-1.99
Manchester	-0.001	-0.11	0.004	0.30	-0.002	-0.41

Variables	Internal expansion		Greenfield investment		Mergers and Acquisition	
	$\partial p/\partial x$	z-value	$\partial p/\partial x$	z-value	$\partial p/\partial x$	z-value
Birmingham	0.005	0.86	-0.004	-0.83	0.000	-0.16
Glasgow	0.008	0.94	-0.010	-1.23	0.002	0.53
Tyneside	0.003	0.33	-0.005	-0.58	0.002	0.60
Edinburgh	0.004	0.29	-0.003	-0.20	-0.002	-0.23
Bristol	-0.005	-0.50	0.006	0.70	-0.001	-0.28
Cardiff	0.006	0.51	-0.004	-0.44	-0.001	-0.23
Liverpool	0.001	0.06	0.001	0.10	-0.002	-0.30
Nottingham	0.009	0.62	0.002	0.15	-0.010	-0.93
Leicester	0.006	0.63	-0.009	-0.88	0.002	0.54
Coventry	0.010	1.04	0.003	0.31	-0.013	-2.09
Industry sector (SIC 1992 2-digit)						
Rubber and plastics	0.010	1.34	-0.010	-1.37	0.000	-0.15
Other non-metallic	0.001	0.12	0.000	0.00	-0.001	-0.44
Basic metals	0.000	-0.03	0.000	-0.01	0.000	0.15
Fabricated metal	0.011	1.34	-0.011	-1.29	-0.001	-0.39
Ships and boats	0.007	0.90	-0.005	-0.58	-0.003	-1.33
Years						
2008 Onwards	0.033	22.88	-0.027	-20.42	-0.005	-9.25
Number of observations	106,690					
Pseudo-R^2	0.129					
Log-likelihood	-22,907.6					

Table 4-9: Marginal effects from multinomial logit model of determinants of expansion path in UK low-tech manufacturing, 1997-2012

Variables	Internal expansion		Greenfield investment		Mergers and Acquisition	
	$\partial p/\partial x$	z-value	$\partial p/\partial x$	z-value	$\partial p/\partial x$	z-value
Persistence						
Internal expansion$_{t-1}$	-0.024	-15.29	0.024	16.08	0.000	-0.88
Greenfield investment$_{t-1}$	-0.017	-7.46	0.015	6.61	0.003	3.11
Mergers and acquisition$_{t-1}$	-0.051	-5.33	0.044	4.69	0.007	3.64
Firm size						
10 -19 employees	-0.068	-38.42	0.054	33.6	0.014	14.96
20 - 49 employees	-0.088	-45.14	0.066	36.8	0.022	22.64
50 - 99 employees	-0.081	-29.95	0.054	21.16	0.027	24.1
100 - 249 employees	-0.088	-29.41	0.058	20.18	0.031	25.93
250+ employees	-0.119	-33.57	0.082	24.14	0.037	28.09
Adjustment size						
$\ln(employment_t \mid employment_{t-1})$	-0.042	-52.38	0.032	43.31	0.009	32.06
Internal and external knowledge						
ln Age	0.006	7.45	-0.005	-6.99	-0.001	-2.15
R&D band 2	0.025	5.15	-0.023	-4.98	-0.003	-1.23
R&D band 3	0.020	4.73	-0.017	-4.25	-0.003	-1.95
R&D band 4	0.015	4.61	-0.016	-5.04	0.001	0.71
R&D band 5	0.002	0.41	-0.003	-0.67	0.001	1.03
Multi-plant economies of scale						
Single-plant firm	0.049	15.28	-0.045	-14.31	-0.004	-5.15
Ownership-type						
UK-owned firm (With FDI)	-0.019	-4.52	0.015	3.69	0.004	3.78
SE Asia-owned firms	0.018	1.66	-0.017	-1.56	-0.002	-0.51
EU-owned firms	-0.010	-2.06	0.007	1.42	0.003	2.54
USA-owned firms	-0.003	-0.49	0.003	0.56	0.000	-0.28
AUSCANSA-owned firms	-0.001	-0.1	-0.007	-0.61	0.008	2.21
Other Foreign-owned firms	-0.001	-0.05	-0.003	-0.27	0.004	1.06
Region						
North-East	-0.002	-0.55	0.003	0.92	-0.001	-0.77
Yorkshire-Humberside	0.001	0.4	0.000	-0.02	-0.001	-0.96
North-West	0.002	0.95	-0.002	-1.01	0.000	0.02
West Midlands	0.001	0.54	-0.003	-1.3	0.002	1.76
East Midlands	0.004	1.64	-0.004	-1.64	0.000	-0.22
South-West	0.001	0.46	-0.001	-0.46	0.000	-0.06
East	0.006	2.15	-0.005	-2.13	0.000	-0.32
Scotland	-0.025	-9.18	0.024	9.49	0.001	0.72
Wales	-0.013	-4.15	0.015	5.32	-0.002	-1.69
Northern Ireland	-0.020	-2.73	0.030	5.04	-0.010	-2.06
Major UK Cities						
London	0.005	2.34	-0.007	-3	0.001	1.25

Variables	Internal expansion $\partial p/\partial x$	Internal expansion z-value	Greenfield investment $\partial p/\partial x$	Greenfield investment z-value	Mergers and Acquisition $\partial p/\partial x$	Mergers and Acquisition z-value
Manchester	-0.007	-1.07	0.006	0.99	0.001	0.33
Birmingham	-0.002	-0.34	0.001	0.25	0.001	0.25
Glasgow	0.005	0.86	-0.003	-0.51	-0.002	-0.82
Tyneside	-0.003	-0.36	-0.003	-0.36	0.006	2.04
Edinburgh	-0.003	-0.39	0.003	0.44	0.000	-0.02
Bristol	-0.001	-0.13	0.003	0.4	-0.002	-0.56
Cardiff	0.000	0.01	0.000	-0.05	0.000	0.08
Liverpool	-0.003	-0.39	0.002	0.24	0.001	0.44
Nottingham	0.003	0.35	-0.003	-0.38	0.000	0.04
Leicester	0.004	0.77	-0.002	-0.55	-0.001	-0.62
Coventry	0.006	0.53	0.005	0.56	-0.011	-1.49
Industry sector (SIC 1992 2-digit)						
Tobacco	-0.072	-1.49	0.069	1.48	0.003	0.36
Textiles	0.005	2.33	-0.007	-3.16	0.001	1.46
Clothing	0.012	4.9	-0.011	-4.78	-0.001	-1.07
Leather goods	-0.001	-0.19	0.004	0.71	-0.003	-1.63
Wood products	0.014	7.31	-0.013	-6.91	-0.002	-2.07
Paper products	0.009	3.3	-0.013	-5.14	0.004	3.24
Publishing and printing	0.009	5.27	-0.011	-6.79	0.002	2.68
Furniture and other manufacturing	0.006	3.6	-0.005	-2.75	-0.002	-2.66
Recycling	0.006	1.7	-0.004	-1.39	-0.001	-0.92
Years						
2008 Onwards	0.035	30.97	-0.031	-28.52	-0.005	-10.53
Number of observations	175,645					
Pseudo-R^2	0.124					
Log-likelihood	-39,765.6					

Table 4-10: Marginal effects from multinomial logit model of determinants of expansion path in UK high-tech knowledge-intensive (KI) service, 1997-2012

Variables	Internal expansion $\partial p/\partial x$	Internal expansion z-value	Greenfield investment $\partial p/\partial x$	Greenfield investment z-value	Mergers and Acquisition $\partial p/\partial x$	Mergers and Acquisition z-value
Persistence						
Internal expansion$_{t-1}$	-0.006	-4.91	0.008	6.84	-0.002	-7.79
Greenfield investment$_{t-1}$	-0.001	-0.69	0.003	1.74	-0.002	-4.77
Mergers and acquisition$_{t-1}$	-0.046	-4.35	0.043	4.12	0.003	2.54
Firm size						
10 -19 employees	-0.061	-42.50	0.056	40.16	0.006	10.91
20 - 49 employees	-0.100	-62.63	0.090	58.18	0.010	19.42
50 - 99 employees	-0.095	-38.22	0.083	34.02	0.012	19.45
100 - 249 employees	-0.105	-35.35	0.091	31.36	0.014	19.71
250+ employees	-0.125	-35.39	0.108	31.34	0.016	21.46
Adjustment size						
$\ln(employment_t \vert employment_{t-1})$	-0.025	-43.47	0.022	38.91	0.003	23.85
Internal and external knowledge						
ln Age	0.006	8.40	-0.005	-7.33	-0.001	-4.75
R&D band 2	-0.010	-1.12	0.006	0.70	0.004	1.15
R&D band 3	-0.012	-2.11	0.010	1.86	0.002	0.92
R&D band 4	0.005	1.22	-0.006	-1.70	0.001	1.04
R&D band 5	0.005	2.30	-0.007	-3.02	0.001	2.66
Multi-plant economies of scale						
Single-plant firm	0.015	5.49	-0.011	-4.02	-0.004	-6.22
Ownership-type						
UK-owned firm (With FDI)	0.006	2.83	-0.007	-3.51	0.001	2.28
SE Asia-owned firms	-0.001	-0.13	0.000	-0.01	0.001	0.59
EU-owned firms	0.001	0.36	-0.003	-0.87	0.002	1.95
USA-owned firms	-0.003	-1.06	0.000	0.02	0.003	3.97
AUSCANSA-owned firms	-0.011	-1.26	0.004	0.49	0.007	2.51
Other Foreign-owned firms	-0.001	-0.16	-0.004	-0.48	0.006	1.86
Region						
North-East	-0.005	-1.16	0.006	1.40	-0.001	-0.53
Yorkshire-Humberside	-0.006	-2.71	0.005	2.29	0.001	1.66
North-West	0.001	0.25	-0.001	-0.49	0.000	0.72
West Midlands	-0.005	-2.45	0.004	2.03	0.001	1.57
East Midlands	0.000	0.12	0.000	0.11	-0.001	-0.67
South-West	-0.003	-1.34	0.003	1.61	0.000	-0.64
East	0.001	0.34	-0.001	-0.58	0.000	0.75
Scotland	-0.031	-13.72	0.030	13.86	0.001	1.31
Wales	-0.026	-9.03	0.026	9.45	0.000	0.20
Northern Ireland	-0.085	-1.64	0.116	9.73	-0.031	-0.50
Major UK Cities						
London	0.004	3.25	-0.004	-3.32	0.000	-0.07
Manchester	-0.005	-1.03	0.004	0.93	0.001	0.46

Variables	Internal expansion		Greenfield investment		Mergers and Acquisition	
	$\partial p/\partial x$	z-value	$\partial p/\partial x$	z-value	$\partial p/\partial x$	z-value
Birmingham	0.009	1.81	-0.007	-1.52	-0.002	-1.09
Glasgow	0.009	1.99	-0.005	-1.23	-0.004	-1.97
Tyneside	0.005	0.66	-0.006	-0.91	0.002	0.77
Edinburgh	0.005	1.08	-0.003	-0.84	-0.001	-0.76
Bristol	0.002	0.34	-0.002	-0.48	0.001	0.40
Cardiff	0.006	1.02	-0.002	-0.34	-0.004	-1.41
Liverpool	0.002	0.28	0.000	0.05	-0.002	-0.94
Nottingham	0.004	0.63	-0.004	-0.55	-0.001	-0.31
Leicester	-0.004	-0.40	0.011	1.39	-0.007	-1.09
Coventry	-0.001	-0.18	0.002	0.31	-0.001	-0.36
Industry sector (SIC 1992 2-digit)						
Computer and related	0.013	7.71	-0.014	-8.31	0.001	1.49
Research and Development	0.014	6.11	-0.012	-5.57	-0.001	-3.06
Photographic activities	0.011	4.93	-0.011	-5.08	0.000	-0.33
Motion pictures	0.006	2.73	-0.007	-2.99	0.000	0.37
Radio and TV activities	0.001	0.32	-0.003	-1.34	0.002	2.43
Artistic and literary creation	0.006	3.40	-0.006	-3.53	0.000	-0.10
Years						
2008 Onwards	0.034	38.09	-0.031	-35.93	-0.003	-11.29
Number of observations	242,875					
Pseudo-R^2	0.119					
Log-likelihood	-46,421.3					

Table 4-11: Marginal effects from multinomial logit model of determinants of expansion path in UK knowledge-intensive (KI) service, 1997-2012

	Internal expansion		Greenfield investment		Mergers and Acquisition	
Variables	$\partial p/\partial x$	**z-value**	$\partial p/\partial x$	**z-value**	$\partial p/\partial x$	**z-value**
Persistence						
Internal expansion$_{t-1}$	-0.010	-10.83	0.012	13.15	-0.002	-8.29
Greenfield investment$_{t-1}$	0.003	2.75	-0.001	-1.30	-0.002	-5.70
Mergers and acquisition$_{t-1}$	-0.055	-6.53	0.053	6.38	0.002	1.76
Firm size						
10 -19 employees	-0.055	-52.57	0.049	48.53	0.007	17.29
20 - 49 employees	-0.085	-70.23	0.075	64.40	0.010	24.79
50 - 99 employees	-0.089	-47.54	0.077	42.27	0.012	23.14
100 - 249 employees	-0.097	-44.37	0.083	39.05	0.014	24.16
250+ employees	-0.113	-42.98	0.095	37.34	0.017	27.34
Adjustment size						
$\ln(employment_t \mid employment_{t-1})$	-0.028	-63.36	0.024	57.53	0.004	32.97
Internal and external knowledge						
ln Age	0.013	26.44	-0.012	-25.67	-0.001	-5.58
R&D band 2	0.017	2.67	-0.016	-2.46	-0.002	-1.03
R&D band 3	0.022	5.19	-0.020	-4.91	-0.002	-1.52
R&D band 4	0.004	0.94	-0.006	-1.54	0.002	1.87
R&D band 5	0.007	1.96	-0.008	-2.11	0.000	0.49
Multi-plant economies of scale						
Single-plant firm	0.011	7.31	-0.008	-5.49	-0.003	-6.90
Ownership-type						
UK-owned firm (With FDI)	-0.009	-3.09	0.006	2.25	0.003	3.65
SE Asia-owned firms	0.002	0.24	-0.010	-1.24	0.008	1.98
EU-owned firms	-0.004	-0.98	0.001	0.40	0.002	2.18
USA-owned firms	-0.008	-2.04	0.006	1.60	0.002	2.05
AUSCANSA-owned firms	-0.008	-0.77	0.008	0.80	0.000	-0.03
Other Foreign-owned firms	-0.010	-1.05	0.007	0.82	0.002	0.86
Region						
North-East	-0.006	-2.27	0.005	2.13	0.001	0.69
Yorkshire-Humberside	-0.001	-0.78	0.002	1.12	0.000	-0.85
North-West	-0.002	-1.49	0.002	1.62	0.000	-0.20
West Midlands	-0.002	-1.34	0.002	1.51	0.000	-0.30
East Midlands	-0.001	-0.50	0.001	0.63	0.000	-0.29
South-West	0.000	-0.09	0.000	0.16	0.000	-0.19
East	-0.002	-1.19	0.002	1.38	0.000	-0.39
Scotland	-0.026	-17.56	0.025	17.46	0.001	2.63
Wales	-0.021	-10.52	0.021	11.06	0.000	0.20
Northern Ireland	-0.043	-9.53	0.046	12.16	-0.003	-0.89
Major UK Cities						
London	0.008	6.90	-0.007	-6.61	-0.001	-1.64
Manchester	0.008	2.49	-0.009	-2.91	0.001	1.29

Variables	Internal expansion $\partial p/\partial x$	z-value	Greenfield investment $\partial p/\partial x$	z-value	Mergers and Acquisition $\partial p/\partial x$	z-value
Birmingham	0.003	0.80	-0.004	-1.33	0.002	1.66
Glasgow	0.014	4.62	-0.012	-3.99	-0.003	-2.32
Tyneside	0.007	1.57	-0.006	-1.27	-0.002	-1.06
Edinburgh	0.010	3.37	-0.010	-3.28	-0.001	-0.67
Bristol	0.000	-0.11	-0.001	-0.35	0.002	1.62
Cardiff	0.005	1.11	-0.006	-1.41	0.001	0.68
Liverpool	0.008	1.74	-0.008	-1.82	0.000	0.09
Nottingham	0.003	0.55	-0.004	-0.74	0.001	0.60
Leicester	-0.004	-0.69	0.004	0.70	0.000	0.08
Coventry	0.013	1.96	-0.014	-2.11	0.001	0.35
Industry sector (SIC 1992 2-digit)						
Air transport	0.010	2.78	-0.008	-2.08	-0.003	-4.56
Legal, accountancy and consultancy	0.021	6.19	-0.020	-6.12	-0.001	-0.95
Architecture and engineering	0.013	4.92	-0.013	-5.10	0.000	-0.21
Technical testing	0.010	3.43	-0.010	-3.70	0.000	0.09
Advertising	0.013	5.30	-0.014	-6.03	0.001	0.56
Years						
2008 Onwards	0.028	42.05	-0.024	-38.14	-0.004	-17.34
Number of observations	398,886					
Pseudo-R^2	0.107					
Log-likelihood	-73,512					

Table 4-12: Marginal effects from multinomial logit model of determinants of expansion path in UK low-tech knowledge-intensive (KI) service, 1997-2012

Variables	Internal expansion $\partial p/\partial x$	z-value	Greenfield investment $\partial p/\partial x$	z-value	Mergers and Acquisition $\partial p/\partial x$	z-value
Persistence						
Internal expansion$_{t-1}$	-0.002	-3.85	0.002	5.34	-0.001	-5.66
Greenfield investment$_{t-1}$	-0.101	-111.26	0.108	113.85	-0.007	-27.88
Mergers and acquisition$_{t-1}$	0.015	5.92	-0.080	-34.15	0.065	27.79
Firm size						
10 -19 employees	-0.051	-102.96	0.046	93.63	0.005	32.15
20 - 49 employees	-0.090	-153.08	0.083	142.59	0.007	40.74
50 - 99 employees	-0.112	-127.66	0.104	118.41	0.009	41.05
100 - 249 employees	-0.138	-135.62	0.128	126.69	0.010	43.56
250+ employees	-0.309	-461.09	0.296	453.77	0.012	67.98
Adjustment size						
$\ln(employment_t \mid employment_{t-1})$	-0.032	-170.77	0.029	158.03	0.003	79.26
Internal and external knowledge						
ln Age	-0.001	-5.87	0.002	7.20	0.000	-4.64
R&D band 2	0.016	4.23	-0.015	-4.15	0.000	-0.37
R&D band 3	0.020	6.20	-0.021	-6.59	0.001	1.11
R&D band 4	0.039	14.75	-0.039	-14.85	0.000	0.15
R&D band 5	0.056	20.18	-0.057	-20.24	0.001	1.10
Multi-plant economies of scale						
Single-plant firm	-0.024	-43.88	0.027	51.20	-0.003	-16.38
Ownership-type						
UK-owned firm (With FDI)	0.038	36.18	-0.041	-39.11	0.002	7.77
SE Asia-owned firms	0.033	12.11	-0.035	-12.69	0.001	1.63
EU-owned firms	0.038	31.51	-0.039	-33.45	0.002	4.75
USA-owned firms	0.038	21.58	-0.040	-23.26	0.002	4.17
AUSCANSA-owned firms	0.037	8.18	-0.040	-8.97	0.003	1.91
Other Foreign-owned firms	0.033	9.47	-0.036	-10.51	0.003	2.40
Region						
North-East	-0.003	-2.72	0.003	2.72	0.000	0.14
Yorkshire-Humberside	0.000	-0.67	0.001	1.41	0.000	-2.48
North-West	-0.001	-1.50	0.001	2.05	0.000	-1.81
West Midlands	-0.001	-1.61	0.001	1.95	0.000	-1.05
East Midlands	-0.001	-0.72	0.001	1.41	0.000	-2.29
South-West	0.000	-0.69	0.001	1.05	0.000	-1.20
East	0.000	-0.74	0.001	0.85	0.000	-0.33
Scotland	-0.021	-29.65	0.021	29.95	0.000	0.59
Wales	-0.015	-18.81	0.016	19.99	-0.001	-2.51
Northern Ireland	-0.007	-4.11	0.012	7.92	-0.005	-5.40
Major UK Cities						
London	0.004	6.40	-0.003	-5.15	-0.001	-4.70

Variables	Internal expansion $\partial p/\partial x$	z-value	Greenfield investment $\partial p/\partial x$	z-value	Mergers and Acquisition $\partial p/\partial x$	z-value
Manchester	0.008	4.54	-0.009	-4.83	0.000	0.81
Birmingham	0.003	1.93	-0.003	-2.02	0.000	0.18
Glasgow	0.009	5.80	-0.009	-5.69	0.000	-0.69
Tyneside	0.010	4.60	-0.010	-4.56	0.000	-0.35
Edinburgh	0.003	1.75	-0.003	-2.09	0.001	1.08
Bristol	0.002	1.11	-0.002	-1.25	0.000	0.43
Cardiff	0.007	3.08	-0.008	-3.47	0.001	1.15
Liverpool	0.000	0.20	0.000	-0.24	0.000	0.12
Nottingham	0.010	3.92	-0.011	-4.40	0.001	1.70
Leicester	0.006	2.49	-0.005	-2.48	0.000	-0.21
Coventry	-0.003	-1.23	0.002	0.96	0.001	1.04
Industry sector (SIC 1992 2-digit)						
Land transport	0.018	24.17	-0.017	-22.60	-0.001	-5.88
Support for transport	0.007	7.09	-0.008	-7.78	0.001	2.43
Real estate	0.003	3.74	-0.004	-5.16	0.001	4.41
Renting machinery	0.004	3.30	-0.004	-3.49	0.000	0.70
Maint. and rep. of office machines	0.007	1.64	-0.006	-1.44	-0.001	-0.95
Managm. activities of hold. Comp.	-0.055	-18.48	0.038	13.28	0.017	14.81
Labour recruitment	0.042	62.54	-0.040	-58.57	-0.003	-18.36
Investigation services	0.027	20.49	-0.025	-19.09	-0.002	-5.99
Industrial cleaning	0.025	26.81	-0.023	-24.53	-0.002	-10.45
Packaging	0.017	5.89	-0.015	-5.46	-0.001	-1.75
Secretarial services	0.016	3.28	-0.017	-3.55	0.001	0.99
Other business services	0.011	11.16	-0.011	-11.46	0.000	0.93
Sewage and refuse	0.001	0.56	-0.001	-0.48	0.000	-0.34
Repair	-0.021	-28.36	0.020	28.22	0.000	1.54
Wholesale	-0.026	-41.70	0.026	40.96	0.001	3.91
Retail	-0.040	-69.84	0.041	72.00	-0.001	-9.34
Years						
2008 Onwards	0.040	129.06	-0.037	-120.10	-0.003	-39.03
Number of observations	2,252,790					
Pseudo-R^2	-0.687					
Log-likelihood	-462,898					

Table 4-13: Marginal effects from multinomial logit model of determinants of expansion path in UK other low-tech knowledge-intensive (KI) service, 1997-2012

Variables	Internal expansion $\partial p/\partial x$	Internal expansion z-value	Greenfield investment $\partial p/\partial x$	Greenfield investment z-value	Mergers and Acquisition $\partial p/\partial x$	Mergers and Acquisition z-value
Persistence						
Internal expansion$_{t-1}$	-0.010	-9.25	0.011	10.61	-0.001	-5.75
Greenfield investment$_{t-1}$	0.007	5.57	-0.007	-5.28	0.000	-1.78
Mergers and acquisition$_{t-1}$	-0.045	-3.63	0.040	3.31	0.005	2.42
Firm size						
10 -19 employees	-0.060	-50.69	0.056	48.87	0.004	10.44
20 - 49 employees	-0.087	-58.55	0.081	56.26	0.005	13.26
50 - 99 employees	-0.093	-38.08	0.085	35.47	0.008	14.95
100 - 249 employees	-0.102	-35.87	0.094	33.74	0.008	12.76
250+ employees	-0.123	-38.69	0.112	35.86	0.011	17.75
Adjustment size						
$\ln(employment_t \vert employment_{t-1})$	-0.032	-63.80	0.029	60.19	0.003	24.01
Internal and external knowledge						
ln Age	0.017	27.93	-0.016	-27.04	-0.001	-6.23
R&D band 2	0.002	0.14	-0.005	-0.43	0.003	0.74
R&D band 3	0.007	0.46	-0.004	-0.25	-0.003	-30.09
R&D band 4	0.005	0.44	-0.010	-0.88	0.005	1.20
R&D band 5	0.009	0.93	-0.012	-1.34	0.003	1.43
Multi-plant economies of scale						
Single-plant firm	0.045	15.29	-0.042	-14.45	-0.003	-4.92
Ownership-type						
UK-owned firm (With FDI)	0.042	46.43	-0.041	-47.36	-0.001	-4.55
SE Asia-owned firms	-0.026	-1.04	0.017	0.71	0.009	1.08
EU-owned firms	-0.011	-1.46	0.011	1.41	0.001	0.40
USA-owned firms	0.006	0.85	-0.006	-0.85	0.000	-0.15
AUSCANSA-owned firms	-0.006	-0.30	0.002	0.13	0.003	0.72
Other Foreign-owned firms	0.003	0.23	-0.011	-0.88	0.008	1.47
Region						
North-East	-0.002	-0.69	0.002	0.91	-0.001	-0.73
Yorkshire-Humberside	-0.001	-0.71	0.002	0.93	0.000	-0.75
North-West	-0.001	-0.35	0.001	0.59	0.000	-0.87
West Midlands	0.000	-0.05	0.000	-0.04	0.000	0.40
East Midlands	-0.001	-0.40	0.001	0.72	-0.001	-1.10
South-West	-0.003	-1.73	0.003	1.95	0.000	-0.64
East	-0.002	-0.94	0.001	0.90	0.000	0.23
Scotland	-0.025	-15.35	0.026	16.26	-0.001	-1.16
Wales	-0.020	-9.60	0.020	9.64	0.000	0.78
Northern Ireland	-0.073	-18.21	0.075	20.78	-0.002	-0.82
Major UK Cities						
London	0.005	3.14	-0.005	-3.20	0.000	0.01
Manchester	-0.002	-0.50	0.001	0.24	0.001	1.19

Variables	Internal expansion		Greenfield investment		Mergers and Acquisition	
	$\partial p/\partial x$	z-value	$\partial p/\partial x$	z-value	$\partial p/\partial x$	z-value
Birmingham	0.000	0.09	-0.001	-0.29	0.001	0.87
Glasgow	0.005	1.42	-0.006	-1.65	0.001	0.62
Tyneside	-0.001	-0.22	0.000	0.09	0.001	0.54
Edinburgh	-0.001	-0.40	-0.001	-0.24	0.002	2.53
Bristol	0.006	1.08	-0.006	-1.16	0.000	0.25
Cardiff	0.006	1.14	-0.007	-1.34	0.001	0.75
Liverpool	-0.004	-0.69	0.005	0.97	-0.001	-0.76
Nottingham	0.003	0.46	0.000	0.06	-0.004	-1.17
Leicester	0.012	1.69	-0.010	-1.51	-0.002	-0.75
Coventry	-0.006	-0.98	0.006	0.90	0.001	0.43
Industry sector (SIC 1992 2-digit)						
Membership organisations	0.010	5.82	-0.010	-5.58	-0.001	-1.47
Other entertainment services	0.006	2.28	-0.006	-2.53	0.000	0.65
News agency	0.001	0.15	-0.002	-0.38	0.001	0.81
Sporting activities	0.013	7.42	-0.012	-7.43	0.000	-0.70
Other recreational activities	-0.014	-5.01	0.013	4.81	0.001	1.22
Other services	-0.005	-2.97	0.005	2.99	0.000	0.17
Years						
2008 Onwards	0.029	35.91	-0.027	-33.93	-0.002	-11.15
Number of observations	293,972					
Pseudo-R^2	0.125					
Log-likelihood	-55,135.9					

4.7.2 Net Contracting Firms

Table 4-14: Marginal effects from multinomial logit model of determinants of contraction path in UK high-tech manufacturing, 1997-2012

	Internal contraction		Plant closure		Plant sale	
Variables	$\partial p/\partial x$	z-value	$\partial p/\partial x$	z-value	$\partial p/\partial x$	z-value
Persistence						
Internal contraction$_{t-1}$	-0.003	-0.66	0.000	0.06	0.003	1.99
Plant closure$_{t-1}$	-0.020	-1.95	0.016	1.57	0.004	1.54
Plant sale$_{t-1}$	-0.024	-1.00	0.015	0.63	0.009	1.65
Firm size						
10 -19 employees	-0.069	-0.06	0.011	0.02	0.059	0.03
20 - 49 employees	-0.059	-0.05	-0.002	0.00	0.060	0.03
50 - 99 employees	-0.049	-0.04	-0.015	-0.02	0.063	0.03
100 - 249 employees	-0.041	-0.04	-0.023	-0.03	0.063	0.03
250+ employees	-0.060	-0.05	-0.005	-0.01	0.065	0.04
Adjustment size						
$\ln(employment_t \vert employment_{t-1})$	0.067	25.14	-0.062	-23.77	-0.005	-9.02
Internal and external knowledge						
ln Age	0.010	5.97	-0.011	-6.76	0.001	2.05
R&D band 2	0.039	2.34	-0.039	-2.46	-0.001	-0.12
R&D band 3	-0.012	-0.70	0.017	0.98	-0.005	-10.88
R&D band 4	0.012	1.39	-0.010	-1.18	-0.002	-0.88
R&D band 5	0.006	1.30	-0.006	-1.43	0.001	0.50
Multi-plant economies of scale						
Single-plant firm	0.321	22.65	-0.312	-22.08	-0.008	-6.56
Ownership-type						
UK-owned firm (With FDI)	-0.008	-1.31	0.004	0.75	0.003	2.16
SE Asia-owned firms	0.032	3.82	-0.031	-3.67	-0.002	-0.75
EU-owned firms	-0.015	-1.98	0.014	1.87	0.001	0.55
USA-owned firms	-0.004	-0.58	0.003	0.40	0.001	0.72
AUSCANSA-owned firms	0.016	0.91	-0.012	-0.64	-0.005	-10.87
Other Foreign-owned firms	0.000	0.00	0.005	0.26	-0.005	-10.87
Region						
North-East	0.014	1.22	-0.020	-1.78	0.006	2.53
Yorkshire-Humberside	0.009	1.18	-0.010	-1.36	0.001	0.49
North-West	0.009	1.33	-0.009	-1.44	0.001	0.25
West Midlands	0.004	0.60	-0.007	-0.94	0.002	0.98
East Midlands	0.005	0.68	-0.004	-0.51	-0.001	-0.42
South-West	0.017	2.63	-0.020	-3.05	0.003	1.43
East	0.003	0.54	-0.006	-1.04	0.003	1.58
Scotland	0.022	2.78	-0.020	-2.57	-0.002	-0.76
Wales	0.011	1.38	-0.008	-1.05	-0.003	-0.84
Northern Ireland	0.787	0.38	0.393	0.33	-1.180	-0.36

Variables	Internal contraction $\partial p/\partial x$	z-value	Plant closure $\partial p/\partial x$	z-value	Plant sale $\partial p/\partial x$	z-value
Major UK Cities						
London	0.013	1.99	-0.018	-2.77	0.005	2.40
Manchester	-0.021	-0.99	0.016	0.79	0.004	0.83
Birmingham	0.021	1.31	-0.020	-1.30	0.000	-0.05
Glasgow	-0.015	-0.58	0.021	0.95	-0.007	-0.30
Tyneside	0.009	0.23	0.023	0.74	-0.032	-0.61
Edinburgh	0.014	0.56	-0.007	-0.28	-0.007	-0.90
Bristol	0.117	0.57	0.049	0.40	-0.166	-0.52
Liverpool	-0.009	-0.26	0.029	1.00	-0.020	-0.60
Nottingham	0.046	0.38	0.024	0.33	-0.070	-0.38
Leicester	-0.016	-0.61	0.008	0.30	0.008	1.38
Coventry	-0.011	-0.53	0.008	0.39	0.003	0.59
Industry sector (SIC 1992 2-digit)						
office machinery and computers	0.006	0.92	-0.003	-0.49	-0.003	-2.42
Radio, TV and communication equipment	0.007	1.12	-0.005	-0.86	-0.002	-1.17
Medical and precision instruments	0.010	1.68	-0.010	-1.67	0.000	-0.15
Aircraft and spacecraft	0.010	1.49	-0.011	-1.61	0.001	0.34
Years						
2008 Onwards	0.028	8.54	-0.024	-7.48	-0.004	-4.45
Number of observations	22,232					
Pseudo-R^2	0.284					
Log-likelihood	-4,448.9					

Table 4-15: Marginal effects from multinomial logit model of determinants of contraction path in UK medium high-tech manufacturing, 1997-2012

	Internal contraction		Plant closure		Plant sale	
Variables	$\partial p/\partial x$	**z-value**	$\partial p/\partial x$	**z-value**	$\partial p/\partial x$	**z-value**
Persistence						
Internal contraction$_{t-1}$	0.006	2.36	-0.007	-2.84	0.001	1.54
Plant closure$_{t-1}$	-0.002	-0.44	-0.003	-0.47	0.005	2.89
Plant sale$_{t-1}$	-0.003	-0.19	-0.004	-0.24	0.007	1.51
Firm size						
10 -19 employees	-0.035	-10.28	0.032	9.60	0.004	1.54
20 - 49 employees	-0.018	-4.75	0.013	3.40	0.006	2.37
50 - 99 employees	-0.008	-1.92	0.003	0.78	0.005	2.15
100 - 249 employees	-0.008	-1.80	0.002	0.42	0.006	2.66
250+ employees	-0.028	-5.74	0.019	4.06	0.009	3.60
Adjustment size						
$\ln(employment_t \mid employment_{t-1})$	0.064	37.30	-0.059	-35.07	-0.005	-14.22
Internal and external knowledge						
ln Age	0.013	12.49	-0.013	-12.32	0.000	-1.09
R&D band 2	0.014	1.14	-0.016	-1.31	0.002	0.31
R&D band 3	0.011	1.31	-0.018	-2.33	0.007	1.54
R&D band 4	0.013	2.87	-0.013	-2.85	0.000	-0.19
R&D band 5	0.004	1.38	-0.005	-1.56	0.001	0.76
Multi-plant economies of scale						
Single-plant firm	0.333	38.32	-0.320	-36.82	-0.014	-7.84
Ownership-type						
UK-owned firm (With FDI)	-0.006	-1.40	0.003	0.80	0.002	2.33
SE Asia-owned firms	0.018	2.52	-0.015	-2.02	-0.004	-3.65
EU-owned firms	-0.006	-1.54	0.006	1.46	0.000	0.36
USA-owned firms	-0.011	-2.42	0.010	2.40	0.000	0.11
AUSCANSA-owned firms	-0.016	-0.88	0.010	0.56	0.006	1.03
Other Foreign-owned firms	-0.027	-1.70	0.030	1.91	-0.003	-2.29
Region						
North-East	0.005	0.76	-0.004	-0.67	-0.001	-0.33
Yorkshire-Humberside	0.000	0.06	0.000	0.06	0.000	-0.38
North-West	0.000	0.10	0.001	0.17	-0.001	-0.86
West Midlands	0.009	2.25	-0.010	-2.42	0.001	0.52
East Midlands	0.004	0.80	-0.003	-0.59	-0.001	-0.67
South-West	0.003	0.62	-0.003	-0.69	0.000	0.20
East	0.002	0.36	-0.001	-0.24	0.000	-0.36
Scotland	-0.006	-1.15	0.005	1.03	0.001	0.42
Wales	-0.004	-0.65	0.004	0.77	-0.001	-0.34
Northern Ireland	-0.002	-0.08	-0.008	-0.36	0.009	2.52

Variables	Internal contraction		Plant closure		Plant sale	
	$\partial p/\partial x$	z-value	$\partial p/\partial x$	z-value	$\partial p/\partial x$	z-value
Major UK Cities						
London	0.013	2.49	-0.014	-2.66	0.001	0.47
Manchester	0.012	0.68	-0.004	-0.24	-0.008	-0.80
Birmingham	-0.015	-2.11	0.014	2.00	0.001	0.54
Glasgow	-0.001	-0.10	0.001	0.06	0.001	0.17
Tyneside	0.000	-0.01	-0.002	-0.13	0.002	0.58
Edinburgh	0.010	0.33	-0.003	-0.11	-0.006	-0.37
Bristol	0.038	1.72	-0.009	-0.50	-0.028	-1.10
Cardiff	-0.001	-0.07	0.000	-0.02	0.002	0.35
Liverpool	0.019	0.85	-0.016	-0.73	-0.003	-0.28
Nottingham	0.065	0.71	0.039	0.62	-0.104	-0.69
Leicester	0.000	0.03	0.002	0.16	-0.002	-0.51
Coventry	0.010	0.78	-0.008	-0.61	-0.002	-0.72
Industry sector (SIC 1992 2-digit)						
Machinery and equipment	0.004	1.61	-0.004	-1.50	0.000	-0.48
Electrical machinery	0.011	3.52	-0.008	-2.66	-0.003	-4.01
Motor Vehicles	0.006	1.83	-0.007	-1.99	0.000	0.51
Other transport equipment	-0.023	-2.99	0.025	3.23	-0.002	-1.19
Years						
2008 Onwards	0.025	11.95	-0.022	-10.30	-0.004	-7.03
Number of observations	54,516					
Pseudo-R^2	0.289					
Log-likelihood	-10,769					

Table 4-16: Marginal effects from multinomial logit model of determinants of contraction path in UK medium low-tech manufacturing, 1997-2012

	Internal contraction		Plant closure		Plant sale	
Variables	$\partial p/\partial x$	**z-value**	$\partial p/\partial x$	**z-value**	$\partial p/\partial x$	**z-value**
Persistence						
Internal contraction$_{t-1}$	0.002	1.14	-0.003	-1.60	0.001	1.72
Plant closure$_{t-1}$	-0.003	-0.54	0.001	0.29	0.001	1.20
Plant sale$_{t-1}$	-0.046	-2.47	0.044	2.37	0.002	1.04
Firm size						
10 -19 employees	-0.032	-15.99	0.030	15.26	0.002	1.98
20 - 49 employees	-0.021	-9.04	0.018	7.81	0.003	2.87
50 - 99 employees	-0.009	-3.14	0.005	1.76	0.004	3.54
100 - 249 employees	-0.011	-3.50	0.007	2.35	0.004	3.12
250+ employees	-0.020	-5.54	0.014	3.74	0.007	5.49
Adjustment size						
$\ln(employment_t \vert employment_{t-1})$	0.049	41.92	-0.045	-39.41	-0.004	-15.88
Internal and external knowledge						
ln Age	0.011	16.14	-0.012	-16.60	0.000	0.88
R&D band 2	0.009	1.09	-0.010	-1.18	0.001	0.18
R&D band 3	0.006	1.15	-0.005	-1.02	-0.001	-0.70
R&D band 4	0.010	3.00	-0.010	-3.15	0.000	0.58
R&D band 5	0.004	1.39	-0.005	-1.57	0.001	1.03
Multi-plant economies of scale						
Single-plant firm	0.346	43.09	-0.337	-41.97	-0.009	-7.42
Ownership-type						
UK-owned firm (With FDI)	-0.009	-2.53	0.008	2.36	0.001	1.07
SE Asia-owned firms	-0.006	-0.46	0.008	0.58	-0.002	-1.24
EU-owned firms	-0.002	-0.61	0.004	0.96	-0.001	-2.69
USA-owned firms	-0.002	-0.46	0.003	0.57	0.000	-0.80
AUSCANSA-owned firms	-0.030	-2.25	0.030	2.23	0.000	0.14
Other Foreign-owned firms	-0.013	-1.14	0.015	1.33	-0.002	-2.32
Region						
North-East	0.011	2.43	-0.010	-2.35	0.000	-0.41
Yorkshire-Humberside	0.005	1.68	-0.005	-1.66	0.000	-0.14
North-West	0.007	2.37	-0.006	-2.11	-0.001	-1.02
West Midlands	0.004	1.63	-0.004	-1.50	0.000	-0.54
East Midlands	0.009	2.91	-0.008	-2.75	-0.001	-0.67
South-West	0.009	2.76	-0.006	-2.10	-0.002	-2.04
East	-0.001	-0.18	0.001	0.22	0.000	-0.16
Scotland	0.005	1.57	-0.004	-1.06	-0.002	-1.69
Wales	0.008	2.13	-0.008	-2.11	0.000	-0.13
Northern Ireland	0.007	0.65	-0.007	-0.62	-0.001	-0.16
Major UK Cities						
London	0.008	2.14	-0.007	-1.92	-0.001	-0.81
Manchester	0.005	0.41	-0.001	-0.11	-0.004	-1.09

Variables	Internal contraction $\partial p/\partial x$	z-value	Plant closure $\partial p/\partial x$	z-value	Plant sale $\partial p/\partial x$	z-value
Birmingham	0.009	2.02	-0.010	-2.16	0.001	0.57
Glasgow	0.012	1.03	-0.009	-0.80	-0.003	-0.49
Tyneside	-0.012	-1.42	0.011	1.34	0.001	0.46
Edinburgh	0.025	1.33	-0.017	-0.97	-0.008	-0.50
Bristol	0.014	1.30	-0.018	-1.63	0.004	1.56
Cardiff	0.316	1.19	0.221	1.27	-0.537	-1.23
Liverpool	0.016	1.26	-0.013	-1.10	-0.002	-0.42
Nottingham	0.019	0.29	0.024	0.56	-0.042	-0.41
Leicester	0.017	1.75	-0.018	-1.80	0.000	0.14
Coventry	0.011	1.09	-0.011	-1.16	0.001	0.23
Industry sector (SIC 1992 2-digit)						
Rubber and plastics	0.015	2.68	-0.014	-2.43	-0.002	-1.80
Other non-metalic	0.011	1.93	-0.010	-1.63	-0.002	-2.66
Basic metals	0.011	1.84	-0.009	-1.53	-0.002	-3.03
Fabricated metal	0.016	2.36	-0.014	-2.03	-0.002	-2.32
Ships and boats	0.008	1.14	-0.005	-0.75	-0.003	-6.36
Years						
2008 Onwards	0.023	16.30	-0.021	-15.28	-0.002	-4.62
Number of observations	91,764					
Pseudo-R^2	0.291					
Log-likelihood	-14,805					

Table 4-17: Marginal effects from multinomial logit model of determinants of contraction path in UK low-tech manufacturing, 1997-2012

Variables	Internal contraction $\partial p/\partial x$	Internal contraction z-value	Plant closure $\partial p/\partial x$	Plant closure z-value	Plant sale $\partial p/\partial x$	Plant sale z-value
Persistence						
Internal contraction$_{t-1}$	0.004	2.84	-0.004	-2.72	0.000	-0.61
Plant closure$_{t-1}$	-0.013	-3.16	0.012	2.88	0.001	1.93
Plant sale$_{t-1}$	-0.048	-2.79	0.044	2.62	0.003	1.74
Firm size						
10 -19 employees	-0.042	-26.83	0.040	25.93	0.002	3.16
20 - 49 employees	-0.027	-13.57	0.024	12.31	0.003	3.65
50 - 99 employees	-0.020	-8.09	0.017	6.75	0.004	4.30
100 - 249 employees	-0.018	-6.71	0.014	5.21	0.004	5.02
250+ employees	-0.038	-13.07	0.032	11.13	0.006	6.99
Adjustment size						
$\ln(employment_t \vert employment_{t-1})$	0.046	49.62	-0.043	-47.27	-0.003	-16.78
Internal and external knowledge						
ln Age	0.011	18.90	-0.011	-19.41	0.000	1.18
R&D band 2	0.010	1.70	-0.009	-1.45	-0.002	-1.65
R&D band 3	0.002	0.54	-0.003	-0.65	0.001	0.56
R&D band 4	0.001	0.33	-0.002	-0.65	0.001	1.73
R&D band 5	0.002	0.62	-0.003	-0.75	0.000	0.85
Multi-plant economies of scale						
Single-plant firm	0.294	45.97	-0.287	-44.92	-0.007	-8.05
Ownership-type						
UK-owned firm (With FDI)	-0.010	-3.20	0.010	3.19	0.000	0.16
SE Asia-owned firms	0.014	1.77	-0.013	-1.61	-0.001	-1.25
EU-owned firms	-0.014	-3.34	0.014	3.37	0.000	-0.25
USA-owned firms	-0.009	-1.93	0.010	2.02	0.000	-0.84
AUSCANSA-owned firms	0.011	1.31	-0.013	-1.47	0.001	0.85
Other Foreign-owned firms	-0.005	-0.49	0.004	0.37	0.001	0.75
Region						
North-East	0.005	1.37	-0.006	-1.49	0.000	0.56
Yorkshire-Humberside	0.004	1.73	-0.004	-1.79	0.000	0.22
North-West	0.008	3.39	-0.007	-3.01	-0.001	-1.64
West Midlands	0.005	1.81	-0.005	-1.89	0.000	0.27
East Midlands	0.002	0.80	-0.001	-0.28	-0.001	-1.96
South-West	0.006	2.22	-0.006	-2.22	0.000	-0.08
East	0.002	1.00	-0.002	-1.02	0.000	0.07
Scotland	-0.001	-0.40	0.003	1.05	-0.002	-2.47
Wales	0.001	0.34	-0.001	-0.18	-0.001	-0.63
Northern Ireland	0.016	1.91	-0.015	-1.73	-0.002	-0.68
Major UK Cities						
London	0.005	2.06	-0.004	-1.87	0.000	-0.78
Manchester	0.008	1.18	-0.007	-1.08	-0.001	-0.34

Variables	Internal contraction		Plant closure		Plant sale	
	$\partial p/\partial x$	z-value	$\partial p/\partial x$	z-value	$\partial p/\partial x$	z-value
Birmingham	0.008	1.63	-0.009	-1.78	0.001	0.57
Glasgow	0.005	0.71	-0.005	-0.74	0.000	0.08
Tyneside	-0.002	-0.25	0.001	0.18	0.001	0.41
Edinburgh	0.000	0.06	-0.002	-0.32	0.002	1.17
Bristol	-0.005	-0.58	0.008	1.01	-0.003	-0.90
Cardiff	-0.004	-0.41	0.002	0.17	0.002	1.12
Liverpool	0.000	-0.01	0.001	0.09	-0.001	-0.25
Nottingham	0.000	-0.01	-0.001	-0.11	0.001	0.43
Leicester	0.012	2.49	-0.013	-2.62	0.001	0.35
Coventry	0.025	0.93	0.003	0.18	-0.028	-0.72
Industry sector (SIC 1992 2-digit)						
Tobacco	-0.010	-0.49	0.012	0.61	-0.002	-19.76
Textiles	0.003	1.32	-0.002	-1.14	0.000	-1.09
Clothing	0.010	4.36	-0.008	-3.72	-0.001	-4.31
Leather goods	0.002	0.52	0.000	-0.11	-0.002	-4.22
Wood products	0.004	1.80	-0.004	-1.65	0.000	-0.74
Paper products	-0.001	-0.21	0.000	0.17	0.000	0.26
Publishing and printing	-0.001	-0.43	0.001	0.54	0.000	-0.56
Furniture and other manufacturing	0.002	1.00	-0.001	-0.35	-0.001	-3.91
Recycling	-0.002	-0.56	0.003	0.76	-0.001	-0.96
Years						
2008 Onwards	0.024	20.51	-0.022	-19.40	-0.001	-5.87
Number of observations	148,279					
Pseudo-R^2	0.240					
Log-likelihood	-25,901					

Table 4-18: Marginal effects from multinomial logit model of determinants of contraction path in UK high-tech knowledge-intensive (KI) service, 1997-2012

	Internal contraction		**Plant closure**		**Plant sale**	
Variables	$\partial p/\partial x$	**z-value**	$\partial p/\partial x$	**z-value**	$\partial p/\partial x$	**z-value**
Persistence						
Internal contraction$_{t-1}$	0.008	5.60	-0.007	-5.54	0.000	-0.62
Plant closure$_{t-1}$	0.011	2.78	-0.011	-2.80	0.000	0.19
Plant sale$_{t-1}$	-0.085	-1.81	0.084	1.79	0.001	0.56
Firm size						
10 -19 employees	-0.048	-39.50	0.048	39.42	0.000	0.89
20 - 49 employees	-0.056	-31.92	0.055	31.72	0.000	1.67
50 - 99 employees	-0.040	-15.13	0.040	15.00	0.000	1.46
100 - 249 employees	-0.036	-12.24	0.036	12.06	0.001	2.00
250+ employees	-0.042	-12.80	0.041	12.61	0.001	2.34
Adjustment size						
$\ln(employment_t \mid employment_{t-1})$	0.032	43.91	-0.032	-43.24	-0.001	-9.15
Internal and external knowledge						
ln Age	0.007	13.00	-0.007	-13.08	0.000	0.42
R&D band 2	-0.011	-1.00	0.012	1.06	-0.001	-11.17
R&D band 3	-0.005	-0.85	0.005	0.78	0.000	0.58
R&D band 4	-0.006	-1.31	0.005	1.13	0.001	1.16
R&D band 5	0.002	0.72	-0.002	-0.81	0.000	1.08
Multi-plant economies of scale						
Single-plant firm	0.215	26.82	-0.207	-26.31	-0.008	-3.61
Ownership-type						
UK-owned firm (With FDI)	0.005	2.05	-0.005	-2.30	0.001	2.11
SE Asia-owned firms	0.002	0.28	-0.002	-0.21	-0.001	-11.17
EU-owned firms	-0.009	-2.09	0.008	1.98	0.000	1.23
USA-owned firms	-0.004	-1.30	0.004	1.30	0.000	-0.03
AUSCANSA-owned firms	0.007	0.91	-0.008	-1.07	0.001	1.15
Other Foreign-owned firms	-0.003	-0.30	0.003	0.29	0.000	0.17
Region						
North-East	0.011	2.05	-0.012	-2.12	0.000	0.69
Yorkshire-Humberside	0.000	-0.16	0.001	0.36	0.000	-1.02
North-West	0.000	-0.11	0.000	0.17	0.000	-0.30
West Midlands	-0.001	-0.54	0.001	0.60	0.000	-0.33
East Midlands	0.005	1.82	-0.005	-2.03	0.001	1.92
South-West	0.001	0.47	-0.001	-0.59	0.000	0.90
East	0.002	1.17	-0.002	-1.34	0.000	1.37
Scotland	-0.006	-1.92	0.006	1.93	0.000	-0.07
Wales	-0.012	-3.40	0.011	3.33	0.000	0.60
Northern Ireland	0.948	0.01	0.807	0.02	-1.755	-0.01
Major UK Cities						
London	-0.002	-1.21	0.001	1.08	0.000	0.93
Manchester	0.005	0.85	-0.005	-0.81	0.000	-0.25

Variables	Internal contraction $\partial p/\partial x$	z-value	Plant closure $\partial p/\partial x$	z-value	Plant sale $\partial p/\partial x$	z-value
Birmingham	0.015	2.52	-0.012	-2.14	-0.003	-0.81
Glasgow	-0.003	-0.56	0.004	0.79	-0.001	-0.79
Tyneside	-0.020	-2.47	0.021	2.63	-0.001	-0.90
Edinburgh	-0.013	-2.44	0.013	2.56	-0.001	-0.50
Bristol	0.000	-0.08	0.003	0.48	-0.002	-1.01
Cardiff	0.026	1.30	0.004	0.28	-0.030	-0.96
Liverpool	-0.001	-0.07	0.000	0.02	0.000	0.43
Nottingham	-0.017	-2.49	0.017	2.42	0.000	0.85
Leicester	0.012	1.26	-0.012	-1.29	0.000	0.46
Coventry	0.023	2.36	-0.024	-2.49	0.001	1.98
Industry sector (SIC 1992 2-digit)						
Computer and related	0.005	2.57	-0.005	-2.48	0.000	-0.88
Research and Development	0.006	1.99	-0.005	-1.95	0.000	-0.60
Photographic activities	0.012	5.28	-0.011	-5.14	0.000	-1.54
Motion pictures	0.005	2.23	-0.006	-2.46	0.001	1.28
Radio and TV activities	0.001	0.28	-0.001	-0.45	0.000	1.14
Artistic and literary creation	0.003	1.62	-0.003	-1.54	0.000	-0.73
Years						
2008 Onwards	0.034	36.86	-0.034	-36.54	0.000	-3.15
Number of observations	181,065					
Pseudo-R^2	0.179					
Log-likelihood	-28,438					

Table 4-19: Marginal effects from multinomial logit model of determinants of contraction path in UK knowledge-intensive (KI) service, 1997-2012

Variables	Internal contraction $\partial p/\partial x$	z-value	Plant closure $\partial p/\partial x$	z-value	Plant sale $\partial p/\partial x$	z-value
Persistence						
Internal contraction$_{t-1}$	-0.001	-0.49	0.001	0.54	0.000	-0.38
Plant closure$_{t-1}$	0.004	1.25	-0.004	-1.30	0.000	0.41
Plant sale$_{t-1}$	-0.015	-0.83	0.013	0.76	0.001	0.87
Firm size						
10 -19 employees	-0.041	-44.55	0.040	44.29	0.000	2.05
20 - 49 employees	-0.039	-30.27	0.038	29.87	0.001	2.91
50 - 99 employees	-0.037	-20.45	0.037	20.25	0.000	1.84
100 - 249 employees	-0.040	-19.15	0.039	19.06	0.000	1.08
250+ employees	-0.046	-18.61	0.045	18.38	0.001	2.57
Adjustment size						
$\ln(employment_t \mid employment_{t-1})$	0.041	70.00	-0.040	-68.75	-0.001	-14.36
Internal and external knowledge						
ln Age	0.011	28.65	-0.011	-28.96	0.000	1.30
R&D band 2	-0.008	-0.82	0.009	0.91	-0.001	-16.30
R&D band 3	0.004	0.59	-0.004	-0.69	0.001	0.69
R&D band 4	-0.007	-1.36	0.005	1.07	0.001	1.90
R&D band 5	-0.002	-0.38	0.002	0.35	0.000	0.40
Multi-plant economies of scale						
Single-plant firm	0.184	40.72	-0.176	-39.85	-0.008	-5.97
Ownership-type						
UK-owned firm (With FDI)	-0.011	-3.52	0.010	3.30	0.001	2.10
SE Asia-owned firms	-0.004	-0.37	0.002	0.23	0.001	0.91
EU-owned firms	-0.008	-2.06	0.008	2.07	0.000	-0.15
USA-owned firms	-0.014	-3.21	0.014	3.16	0.000	0.70
AUSCANSA-owned firms	-0.023	-1.89	0.024	1.96	-0.001	-16.33
Other Foreign-owned firms	-0.006	-0.79	0.006	0.69	0.001	0.72
Region						
North-East	0.010	3.21	-0.009	-3.16	0.000	-0.45
Yorkshire-Humberside	0.003	1.86	-0.003	-1.72	0.000	-0.98
North-West	0.001	0.74	-0.001	-0.76	0.000	0.11
West Midlands	0.005	2.59	-0.004	-2.35	0.000	-1.46
East Midlands	0.007	3.52	-0.007	-3.42	0.000	-0.69
South-West	0.000	-0.13	0.001	0.35	0.000	-1.29
East	-0.001	-0.53	0.001	0.54	0.000	-0.05
Scotland	0.003	1.55	-0.003	-1.38	0.000	-1.19
Wales	-0.004	-1.73	0.004	1.91	0.000	-1.09
Northern Ireland	-0.015	-2.62	0.014	2.40	0.001	2.51
Major UK Cities						
London	-0.001	-0.75	0.001	1.02	0.000	-1.63
Manchester	0.000	0.13	0.000	-0.08	0.000	-0.30

Variables	Internal contraction $\partial p/\partial x$	z-value	Plant closure $\partial p/\partial x$	z-value	Plant sale $\partial p/\partial x$	z-value
Birmingham	-0.005	-1.54	0.004	1.27	0.001	2.10
Glasgow	0.001	0.36	-0.002	-0.51	0.001	1.34
Tyneside	-0.002	-0.29	0.004	0.82	-0.003	-1.21
Edinburgh	-0.004	-1.00	0.003	0.92	0.000	0.63
Bristol	0.003	0.76	-0.003	-0.63	-0.001	-0.67
Cardiff	-0.011	-2.44	0.010	2.38	0.000	0.43
Liverpool	0.007	1.46	-0.007	-1.49	0.000	0.21
Nottingham	0.002	0.38	-0.002	-0.37	0.000	-0.09
Leicester	0.005	0.81	-0.006	-0.83	0.000	0.13
Coventry	-0.002	-0.34	0.003	0.41	0.000	-0.30
Industry sector (SIC 1992 2-digit)						
Air transport	0.021	7.53	-0.021	-7.33	-0.001	-3.43
Legal, accountancy and consultancy	0.025	7.11	-0.024	-6.91	-0.001	-2.02
Architecture and engineering	0.020	7.97	-0.019	-7.74	-0.001	-2.80
Technical testing	0.014	4.98	-0.014	-4.86	0.000	-1.72
Advertising	0.013	5.26	-0.013	-5.11	0.000	-2.06
Years						
2008 Onwards	0.031	43.77	-0.030	-43.10	-0.001	-5.55
Number of observations	305,672					
Pseudo-R^2	0.198					
Log-likelihood	-45,986					

Table 4-20: Marginal effects from multinomial logit model of determinants of contraction path in UK low-tech knowledge-intensive (KI) service, 1997-2012

	Internal contraction		Plant closure		Plant sale	
Variables	$\partial p/\partial x$	**z-value**	$\partial p/\partial x$	**z-value**	$\partial p/\partial x$	**z-value**
Persistence						
Internal contraction$_{t-1}$	0.004	7.31	-0.004	-7.92	0.000	3.09
Plant closure$_{t-1}$	-0.002	-1.34	0.002	1.34	0.000	0.09
Plant sale$_{t-1}$	-0.029	-3.65	0.025	3.27	0.003	3.42
Firm size						
10 -19 employees	-0.047	-102.04	0.047	100.80	0.001	5.65
20 - 49 employees	-0.051	-81.27	0.050	79.62	0.001	8.16
50 - 99 employees	-0.046	-50.13	0.045	49.15	0.001	6.26
100 - 249 employees	-0.046	-44.18	0.045	43.11	0.001	7.26
250+ employees	-0.054	-47.42	0.053	46.01	0.002	10.11
Adjustment size						
$\ln(employment_t \mid employment_{t-1})$	0.042	140.11	-0.040	-135.9	-0.002	-37.87
Internal and external knowledge						
ln Age	0.012	61.61	-0.012	-62.60	0.000	3.76
R&D band 2	0.007	1.57	-0.006	-1.50	0.000	-0.54
R&D band 3	0.010	2.69	-0.010	-2.84	0.001	0.94
R&D band 4	-0.005	-1.38	0.005	1.35	0.000	0.23
R&D band 5	0.000	-0.03	0.000	0.03	0.000	0.06
Multi-plant economies of scale						
Single-plant firm	0.225	110.64	-0.211	-107.64	-0.013	-17.11
Ownership-type						
UK-owned firm (With FDI)	-0.003	-1.94	0.002	1.54	0.001	2.94
SE Asia-owned firms	0.000	0.04	0.000	-0.10	0.000	0.47
EU-owned firms	-0.005	-2.92	0.005	2.80	0.000	0.98
USA-owned firms	-0.004	-1.57	0.004	1.64	0.000	-0.67
AUSCANSA-owned firms	-0.013	-2.04	0.014	2.19	-0.001	-2.44
Other Foreign-owned firms	-0.012	-2.46	0.012	2.45	0.000	0.12
Region						
North-East	0.008	5.69	-0.007	-5.26	-0.001	-2.43
Yorkshire-Humberside	0.005	6.09	-0.005	-5.91	0.000	-1.16
North-West	0.006	8.03	-0.006	-7.83	0.000	-1.28
West Midlands	0.004	4.78	-0.004	-4.59	0.000	-1.15
East Midlands	0.003	3.59	-0.003	-3.30	0.000	-1.58
South-West	0.003	3.49	-0.003	-3.39	0.000	-0.66
East	0.003	3.92	-0.003	-3.90	0.000	-0.21
Scotland	-0.001	-0.61	0.001	0.79	0.000	-1.08
Wales	-0.001	-1.38	0.002	1.72	0.000	-1.79
Northern Ireland	-0.029	-12.78	0.029	12.92	0.000	0.00

Variables	Internal contraction $\partial p/\partial x$	z-value	Plant closure $\partial p/\partial x$	z-value	Plant sale $\partial p/\partial x$	z-value
Major UK Cities						
London	0.001	1.75	-0.001	-1.36	0.000	-2.01
Manchester	0.004	1.92	-0.004	-1.79	0.000	-0.67
Birmingham	0.000	-0.19	0.000	0.20	0.000	-0.03
Glasgow	0.000	0.00	0.000	0.14	0.000	-0.70
Tyneside	0.000	-0.07	0.000	-0.10	0.000	0.95
Edinburgh	-0.007	-3.58	0.008	3.88	-0.001	-1.38
Bristol	0.002	0.94	-0.001	-0.59	-0.001	-1.55
Cardiff	-0.005	-1.99	0.005	1.81	0.000	1.05
Liverpool	0.005	1.80	-0.004	-1.42	-0.001	-1.58
Nottingham	0.000	0.16	0.000	-0.05	0.000	-0.48
Leicester	0.009	3.15	-0.008	-2.77	-0.001	-1.38
Coventry	0.001	0.22	-0.001	-0.33	0.000	0.61
Industry sector (SIC 1992 2-digit)						
Land transport	-0.001	-0.79	0.002	1.76	-0.001	-12.52
Support for transport	-0.017	-11.68	0.018	12.33	-0.001	-11.59
Real estate	-0.041	-39.92	0.041	40.70	-0.001	-10.71
Renting machinery	-0.015	-9.29	0.016	9.86	-0.001	-9.56
Maintenance and repair of office machines	-0.012	-2.31	0.013	2.58	-0.001	-11.37
Management activities of holding companies	-0.075	-18.86	0.075	18.98	0.000	-2.68
Labour recruitment	-0.027	-19.98	0.028	20.95	-0.001	-23.51
Investigation services	-0.011	-4.70	0.012	5.13	-0.001	-6.47
Industrial cleaning	-0.021	-13.06	0.022	13.86	-0.001	-20.13
Packaging	-0.010	-2.29	0.011	2.54	-0.001	-5.23
Secretarial services	-0.010	-1.36	0.010	1.48	-0.001	-2.08
Other business services	-0.021	-13.60	0.022	14.24	-0.001	-7.99
Sewage and refuse	-0.023	-7.00	0.024	7.30	-0.001	-6.92
Repair	-0.008	-9.58	0.009	10.02	0.000	-4.36
Wholesale	-0.015	-19.90	0.016	21.09	-0.001	-12.75
Retail	-0.017	-26.55	0.018	27.90	-0.001	-11.55
Years						
2008 Onwards	0.038	104.51	-0.038	-102.73	-0.001	-12.59
Number of observations	1,344,132					
Pseudo-R^2	0.2186					
Log-likelihood	-235,023					

Table 4-21: Marginal effects from multinomial logit model of determinants of contraction path in UK other low-tech knowledge-intensive (KI) service, 1997-2012

	Internal contraction		Plant closure		Plant sale	
	$\partial p/\partial x$	z-value	$\partial p/\partial x$	z-value	$\partial p/\partial x$	z-value
Persistence						
Internal contraction$_{t-1}$	0.001	0.75	-0.001	-0.92	0.000	0.95
Plant closure$_{t-1}$	-0.003	-0.66	0.001	0.32	0.001	2.41
Plant sale$_{t-1}$	0.022	2.11	-0.021	-2.02	-0.001	-14.61
Firm size						
10 -19 employees	-0.045	-45.79	0.044	45.48	0.000	1.92
20 - 49 employees	-0.046	-34.52	0.046	34.04	0.001	2.88
50 - 99 employees	-0.041	-19.17	0.040	18.86	0.001	2.48
100 - 249 employees	-0.040	-15.90	0.040	15.64	0.001	2.17
250+ employees	-0.051	-19.75	0.051	19.44	0.001	2.77
Adjustment size						
$\ln(employment_t \mid employment_{t-1})$	0.033	52.63	-0.032	-51.54	-0.001	-10.67
Internal and external knowledge						
ln Age	0.013	29.75	-0.013	-29.76	0.000	-0.66
R&D band 2	-0.030	-1.79	0.031	1.84	-0.001	-14.61
R&D band 3	0.028	2.94	-0.032	-3.60	0.004	0.77
R&D band 4	0.006	0.50	-0.005	-0.43	-0.001	-14.62
R&D band 5	-0.001	-0.06	0.000	-0.04	0.001	0.95
Multi-plant economies of scale						
Single-plant firm	0.208	37.80	-0.194	-37.12	-0.013	-5.68
Ownership-type						
UK-owned firm (With FDI)	0.014	7.90	-0.014	-8.38	0.001	1.37
SE Asia-owned firms	0.023	1.78	-0.022	-1.71	-0.001	-14.53
EU-owned firms	-0.018	-2.01	0.018	2.03	0.000	-0.19
USA-owned firms	-0.001	-0.17	0.002	0.29	-0.001	-14.61
AUSCANSA-owned firms	-0.050	-1.64	0.048	1.58	0.002	0.58
Other Foreign-owned firms	-0.009	-0.59	0.010	0.65	-0.001	-14.61
Region						
North-East	0.010	3.68	-0.010	-3.67	0.000	-0.11
Yorkshire-Humberside	0.001	0.82	-0.001	-0.32	-0.001	-2.33
North-West	0.003	1.83	-0.003	-1.93	0.000	0.67
West Midlands	0.004	1.96	-0.004	-2.01	0.000	0.28
East Midlands	0.003	1.54	-0.003	-1.65	0.000	0.74
South-West	0.000	0.23	0.000	0.12	-0.001	-1.81
East	0.001	0.49	0.000	-0.19	0.000	-1.73
Scotland	0.000	0.08	0.000	0.13	0.000	-1.24
Wales	0.000	0.18	0.001	0.30	-0.001	-2.23
Northern Ireland	-0.026	-5.78	0.025	5.73	0.000	0.66
Major UK Cities						
London	-0.001	-0.86	0.001	0.88	0.000	-0.11
Manchester	-0.002	-0.31	0.001	0.31	0.000	0.04

	Internal contraction		Plant closure		Plant sale	
	$\partial p/\partial x$	z-value	$\partial p/\partial x$	z-value	$\partial p/\partial x$	z-value
Birmingham	0.000	-0.12	0.002	0.41	-0.001	-1.08
Glasgow	0.000	0.01	0.001	0.17	-0.001	-0.71
Tyneside	-0.012	-2.27	0.013	2.45	-0.001	-0.74
Edinburgh	-0.004	-0.95	0.004	1.09	-0.001	-0.57
Bristol	0.001	0.19	-0.003	-0.58	0.002	4.16
Cardiff	-0.001	-0.12	0.000	0.00	0.001	0.64
Liverpool	0.009	1.65	-0.009	-1.60	0.000	-0.48
Nottingham	-0.009	-1.50	0.008	1.40	0.001	0.94
Leicester	0.001	0.10	0.008	0.90	-0.010	-0.53
Coventry	0.016	1.78	-0.011	-1.39	-0.005	-0.56
Industry sector (SIC 1992 2-digit)						
Membership organisations	0.008	4.44	-0.008	-4.27	0.000	-1.35
Other entertainment services	-0.006	-1.81	0.005	1.74	0.000	0.45
News agency	-0.010	-1.78	0.010	1.85	0.000	-0.77
Sporting activities	0.001	0.52	-0.001	-0.56	0.000	0.22
Other recreational activities	-0.008	-3.05	0.008	2.97	0.000	0.58
Other services	-0.007	-3.84	0.007	3.73	0.000	0.70
Years						
2008 Onwards	0.020	25.00	-0.019	-24.53	0.000	-3.54
Number of observations	229,915					
Pseudo-R^2	0.207					
Log-likelihood	-32,843.7					

4.7.3 Robustness Check

Table 4-22: Marginal effects from multinomial logit model of determinants of expansion path in UK

Variables	Internal expansion $\partial p/\partial x$	Greenfield investment $\partial p/\partial x$	Mergers and Acquisition $\partial p/\partial x$	Expansion dominant $\partial p/\partial x$
Firm size				
10 -19 employees	-0.059	0.044	0.006	0.010
20 - 49 employees	-0.094	0.073	0.008	0.013
50 - 99 employees	-0.108	0.084	0.010	0.014
100 - 249 employees	-0.129	0.102	0.011	0.015
250+ employees	-0.253	0.222	0.015	0.016
Adjustment size				
$\ln(employment_t \| employment_t$	-0.034	0.027	0.004	0.003
Firm-level variables				
R&D band 2	0.014	-0.014	0.000	0.000
R&D band 3	0.017	-0.018	0.000	0.000
R&D band 4	0.027	-0.028	0.001	0.000
R&D band 5	0.038	-0.039	0.001	0.000
ln Age	0.002	-0.002	-0.001	0.000
Single-plant firm	0.007	0.006	-0.003	-0.009
UK-owned firm (With FDI)	0.022	-0.025	0.003	0.000
SE Asia-owned firms	0.020	-0.022	0.002	0.000
EU-owned firms	0.020	-0.022	0.002	0.000
USA-owned firms	0.020	-0.022	0.002	0.000
AUSCANSA-owned firms	0.017	-0.021	0.003	0.001
Other Foreign-owned firms	0.019	-0.022	0.003	0.000
Region				
North-East	-0.002	0.003	0.000	0.000
Yorkshire-Humberside	-0.001	0.001	0.000	0.000
North-West	-0.001	0.001	0.000	0.000
West Midlands	-0.001	0.001	0.000	0.000
East Midlands	0.000	0.001	-0.001	0.000
South-West	0.000	0.001	0.000	0.000
Eastern	0.000	0.000	0.000	0.000
London	0.004	-0.004	0.000	0.000
Scotland	-0.023	0.022	0.000	0.000
Wales	-0.017	0.017	-0.001	0.001
Tyneside	0.007	-0.008	0.000	0.001
Northern Ireland	-0.024	0.029	-0.007	0.002
Major UK Cities				
Manchester	0.004	-0.006	0.000	0.001
Liverpool	0.002	-0.002	0.000	0.000
Birmingham	0.003	-0.002	0.000	-0.001
Coventry	0.000	0.001	-0.001	0.000

Variables	Internal expansion $\partial p/\partial x$	Greenfield investment $\partial p/\partial x$	Mergers and Acquisition $\partial p/\partial x$	Expansion dominant $\partial p/\partial x$
Leicester	0.006	-0.002	-0.003	-0.001
Nottingham	0.008	-0.007	-0.002	0.001
Bristol	0.001	-0.002	0.000	0.000
Glasgow	0.008	-0.008	0.000	0.000
Edinburgh	0.003	-0.004	0.001	0.000
Cardiff	0.006	-0.007	0.000	0.000
Persistence and crisis				
Internal expansion$_{t-1}$	-0.006	0.008	-0.001	-0.001
Greenfield investment$_{t-1}$	-0.065	0.071	-0.004	-0.002
Mergers and acquisition$_{t-1}$	-0.015	-0.036	0.051	0.000
Expansion dominant$_{t-1}$	-0.002	-0.002	0.002	0.002
2008 Onwards	0.038	-0.033	-0.003	-0.002

Table 4-23: Marginal effects from multinomial logit model of determinants of contraction path in UK

Variables	Internal contraction $\partial p/\partial x$	Plant Closure $\partial p/\partial x$	Plant Sale $\partial p/\partial x$	Contraction dominant $\partial p/\partial x$
Firm size				
10 -19 employees	-0.044	0.037	0.001	0.006
20 - 49 employees	-0.066	0.057	0.002	0.008
50 - 99 employees	-0.076	0.066	0.003	0.008
100 - 249 employees	-0.091	0.080	0.003	0.009
250+ employees	-0.197	0.183	0.005	0.010
Adjustment size				
$\ln(employment_t \vert employment_t$	-0.046	0.007	0.039	-0.001
Firm-level variables				
R&D band 2	0.011	-0.011	0.000	0.000
R&D band 3	0.013	-0.014	0.000	0.000
R&D band 4	0.022	-0.023	0.001	0.000
R&D band 5	0.034	-0.034	0.001	0.000
ln Age	0.003	-0.003	0.000	0.000
Single-plant firm	0.064	-0.038	-0.004	-0.022
UK-owned firm (With FDI)	0.022	-0.024	0.002	0.000
SE Asia-owned firms	0.016	-0.017	0.002	0.000
EU-owned firms	-0.017	0.019	-0.001	-0.001
USA-owned firms	-0.017	0.019	-0.001	0.000
AUSCANSA-owned firms	-0.016	0.019	-0.002	0.001
Other Foreign-owned firms	-0.017	0.019	-0.002	0.000
Region				
North-East	0.000	0.000	0.000	0.000
Yorkshire-Humberside	0.000	0.001	0.000	0.000
North-West	0.000	0.000	0.000	0.000
West Midlands	0.000	0.000	0.000	0.000
East Midlands	0.001	0.001	0.000	0.000
South-West	0.000	0.000	0.000	0.000
Eastern	0.000	0.000	0.000	0.000
London	0.003	-0.003	0.000	0.000
Scotland	-0.014	0.015	0.000	0.000
Wales	-0.012	0.012	-0.001	0.001
Tyneside	0.004	-0.003	-0.001	0.000
Northern Ireland	0.044	0.053	-0.108	0.011
Major UK Cities				
Manchester	0.007	-0.005	-0.003	0.001
Liverpool	0.661	0.365	-1.175	0.148
Birmingham	0.004	-0.002	-0.001	-0.001
Coventry	0.001	0.000	0.000	-0.001
Leicester	0.007	-0.006	0.000	0.000
Nottingham	0.105	0.055	0.018	-0.179

Variables	Internal contraction $\partial p/\partial x$	Plant Closure $\partial p/\partial x$	Plant Sale $\partial p/\partial x$	Contraction dominant $\partial p/\partial x$
Bristol	0.003	-0.002	0.000	0.000
Glasgow	0.008	-0.005	-0.004	0.001
Edinburgh	0.003	-0.001	-0.001	-0.001
Cardiff	0.011	-0.002	-0.009	0.000
Persistence and crisis				
Internal contraction$_{t-1}$	0.001	-0.003	0.000	0.001
Plant Closure$_{t-1}$	-0.056	0.061	-0.003	-0.002
Plant Sale$_{t-1}$	-0.002	-0.043	0.045	0.000
Contraction dominant$_{t-1}$	0.003	-0.007	0.002	0.002
2008 Onwards	0.011	-0.010	-0.001	0.000

5 The impact of Firm Adjustment on Productivity

5.1 Introduction

This chapter will examine whether choosing alternative forms of adjustment has a causal impact on firm-level productivity. In order to tackle the dynamic nature of the adjustment-productivity relationship discussed below, system GMM estimator will be employed. This estimator also helps to control for other sources of endogeneity such as endogeneity of inputs and self-selection of firms in and out of an industry, in our model. To strengthen our empirical argument, we illustrate why commonly used techniques such as OLS, fixed-effects and Levinsohn and Petrin (2003) semiparametric method may be biased and show the estimates obtained from these methods.

As discussed extensively in chapter 2.2.2, theory suggests that choosing external forms of expansion should result in higher level of productivity than internal expansion. Central to this prediction is that external expansion such as mergers and acquisition can be used to avoid substantial hiring costs that are often associated with taking on new workers i.e., internal expansion. There are similar productivity impacts when firms choose external forms of contraction. Indeed, using theoretical ideas in chapter 2.2.3, we show that external expansion such as plant closure should result in higher level of productivity than internal expansion. This is because plant closure often removes any uncertainty that is associated with firms' downsizing decisions therefore, creating an environment that allows employees to improve and innovate. However, theory is less clear in its prediction of whether choosing mergers and acquisition (plant sale) over greenfield investment (plant closure) lead to better ex-post productivity or vice versa.

Firms' decision to adjust via a particular path of adjustment may be taken on the basis of an assessment of the benefit that will accrue to the firm and this benefit will itself be a function of the characteristics of the firm. In other words, adjusting firms may possess certain characteristics such that they achieve better performance (in terms of higher productivity) vis-à-vis 'no adjusters' even when they do not adjust their productive capacity. These characteristics may include better managerial capabilities, organisational skills etc. that are associated with both productivity and the decision to choose a particular path of adjustment. Indeed, using theoretical literature, we show in chapter 2.2.1 that firms endogenously sort into different channels of adjustment i.e., more efficient firms are more likely to rely on external forms of adjustment – greenfield investment and mergers and acquisition for expansion and; plant closure and plant sale for contraction – than internal forms of adjustment.

Similarly, we found in our empirical analysis of chapter 4 that firm characteristics such as R&D, age, foreign-ownership, etc., are related to firms' choice of adjustment. While these theoretical models are not explicitly dynamic, the implication we draw from them and our empirical evidence, suggest that any empirical estimation of the effect on productivity of alternative forms of adjustment that ignores the dynamic relation between current path of adjustment and past productivity (as do OLS and traditional fixed-effects estimators) will yield inconsistent estimates. As a result, this thesis applies the system GMM estimator to account for such simultaneity. By using some combination of variables from the firm's history as valid instruments (and because it is difficult to find suitable 'external' instruments for all endogenous variables), system GMM deals with the aforementioned problem of simultaneity and endogeneity of other explanatory variables in our model.

There are 2 main measures of productivity upon which the impact of choosing alternative forms of adjustment could be measured: labour productivity or TFP. Labour productivity can be obtained by dividing output or gross value added by the number of employees in a firm. TFP (sometimes referred to as multi-factor productivity), on the other hand, is given by the ratio of output to all factor inputs adopted in the production process of a firm. TFP is our preferred measure of productivity in this thesis because, unlike labour productivity, it does not depend on factor substitution (Harris, 2005). To illustrate, consider 2 similar firms, A and B, adopting the same technology and the same production process. Firm A may report a different labour productivity if it uses its capital input more intensively. Therefore, an increase in labour productivity does not only depend on gains in efficiency and/or technological progress but also on the usage intensity of other factor inputs such as capital and intermediate inputs. As firm adjustment is a reaction to changes in market environment and technological possibilities which has efficiency improvement as its main aim, any estimated impact of firm adjustment on labour productivity will be the sum of the impact of a firm adjustment on capital, employment and TFP. It will therefore be more difficult to interpret than when TFP is used as the measure of productivity.

The rest of this chapter is structured as follows. The next section will set out the econometric model that will be estimated. The third section will lay out the theoretical basis for the biases in commonly used techniques for estimating TFP. Section three also describes our preferred approach, the system GMM estimator which is used to tackle the endogeneity of the explanatory variables. Section four presents our empirical results and the fifth section concludes.

5.2 Econometric Model

Assuming the production is Cobb-Douglas (1928).

$$Y_{it} = A_{it}K_{it}^{\beta_K}L_{it}^{\beta_L}M_{it}^{\beta_M} \tag{5.1}$$

Where Y_{it}, K_{it},, L_{it}, M_{it} represent output, capital input, labour, and intermediate input respectively, in firm *i* at time t, and A_{it} represents the Hicksian factor-neutral efficiency level (or TFP) of firm *i* at time *t*. β_K, $\beta_L$and β_M represent the elasticity of output, labour and intermediate inputs, respectively. Taking the natural logarithm of equation (5.1) gives:

$$y_{it} = \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + a_{it} \tag{5.2}$$

Where y_{it}, k_{it}, l_{it}, and m_{it} refer to the natural logarithms of output, capital, labour and intermediate inputs in firm *i* at time *t* (*i* =1,........, N; *t* = 1,........., T), respectively, and a_{it} is the natural logarithm of TFP. It is postulated that the natural logarithm of TFP can be decomposed into:

$$a_{it} = \beta_0 + \beta_x X_{it} + \beta_j J_{it} + (\nu_{it} + u_{it}) \tag{5.3}$$

Substituting (5.3) into (5.2) gives:

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \beta_x X_{it} + \beta_j J_{it} + (\nu_{it} + u_{it}) \tag{5.4}$$

The error term in equation (5.4) comprises: ν_{it}, a TFP shock and u_{it}, a measurement error which is assumed to be serially uncorrelated.

The TFP shock takes the form:

$$\nu_{it} = \alpha \nu_{it} + \varepsilon_{it} \qquad |\alpha < 1| \tag{5.5}$$

This is autoregressive if $\alpha \neq 0$.

β_0 in equation (5.4) is the average firm efficiency level and J_{it} is a vector of dummy variables taking the values of one if a firm uses any of the following 6 adjustment channel: internal expansion, greenfield investment, mergers and acquisition, internal contraction, plant closure and plant sale. These adjustment dummies are the key variables in our model thus, the vector of coefficients β_j (β_1, β_2,......., β_J) will provide the estimate of the impact of using a particular path of adjustment on TFP[37]. X_{it} in (5.4) is a vector of observed (proxy) variables that literature has shown to determine TFP. They include the firm-level variables - R&D, age, multi-plant ownership and foreign ownership – reviewed in chapter 2.3.1.3. Further to these variables, we also include multi-region dummy variable in X_{it}, in an attempt to capture economies of scale. This variable is equal to one if a firm operates plants in more than one region and zero otherwise. If there are transport costs benefits from locating plants

[37] The benchmark group for our analysis are firms that do not adjust.

presumably closer to major suppliers and/or customers then there may be organizational efficiencies associated with multi-region firms (Harris and Moffat, 2011). New trade theory and economic geography models have suggested that there may be spatial productivity effects associated with locating firms in close proximity to markets and suppliers (e.g., Fujita et al., 1999). This would imply that the coefficient on the multi-region firm dummy should be positive.

Another variable included in X_{it} is Herfindahl index calculated by summing the squared share of industry output of each firm within an industry. This measures the concentration of output across firms and therefore, of market power with larger values indicating greater market power and less competition within the industry (Herfindahl, 1950). It also serves as a measure for competition under the assumption that the elasticity of demand does not vary considerably across firms within a particular industry (see, for instance, Cabral, 2000). The theoretical model of Meyers and Vickers (1995) motivates the inclusion of Herfindahl index as a proxy for competition. In their model, competition raises managerial efforts hence, firm productivity mainly because better performing managers are rewarded with higher earnings. Meyers and Vickers (1995) assumes that investors use the knowledge of observed managerial output which depends on unobserved managers' ability, effort and productivity shocks to reward better performing managers. If unobserved productivity shocks are common across firms operating in the same industry, the existence of more firms in the industry should increase pressure for managers to perform better than their rivals. This generates the incentive for managers to increase efforts to improve efficiency. This implies that greater level of competition (involving lower Herfindahl index) requires that firms operate more efficiently. However, increased competition may also have a negative effect on productivity if monopoly rents are required for managers to invest in R&D which in turn leads to improvements in productivity (Aghion et al., 2001). Lastly, a time trend is also included in X_{it} to control for hicks-neutral (or exogeneous) technical improvements that are common to all firms.

A time dummy that takes the value of one if the year is 2008 onwards, and zero otherwise, is also included in equation (5.4). This variable is included to capture the effect of uncertainty created by the 2008 financial crisis. The expectation is that the common (exogenous) improvement in technology (captured by time trend) has slowed down since 2007 – i.e., the UK productivity puzzle in Harris and Moffat (2016a). Regional and city dummies are also included in equation (5.4) to capture the TFP advantages and disadvantages of being located in different regions and cities. The dummies are equal to one when a firm is located within a particular government office region and a major

Great Britain city (defined by NUTS3 code)[38]. There are 4 main channels through which the location of a firm may have an impact on its TFP. The first of such locational impact is knowledge spillovers of locating a firm in a major region or city with higher population density. This arises due to large and common pool of labour that would facilitate the transfer of knowledge from locating firm in a major city or region. As Borowiecki (2003) argues, the cost of transmitting knowledge rises with distance. Another benefit of locating a firm in a major city with wider pool of labour is the availability of highly skilled workers that are likely to increase the TFP of a firm (e.g., Bacolod et al., 2009; Elvery, 2010). Thirdly, a firm located in a major city can obtain important insights from its customers that are in close proximity and adapt customers' needs to its product. Finally, firms located in a major city might benefit from the high availability of business services such as financial services, accounting and legal service.

Typically, earlier productivity studies estimate (5.4) without X_{it} and J_{it} on the right-hand-side of the equation and obtain TFP as the residual. As part of a two-stage approach, TFP is then regressed on some variables in X_{it} to examine its determinants. Clearly, this two-stage approach would lead to biased estimates of the elasticities of output (and TFP) because of an omitted variables problem (Harris et al., 2005). Thus, equation (5.4) is estimated directly with the variables in X_{it} and J_{it} to avoid biased estimates of TFP. Furthermore, equation (5.4) is estimated separately for 8 industrial sectors (defined in table 4.2 of chapter 4 by the sophistication of technology used; following Harris and Moffat, 2011, 2016a, 2016b) to avoid imposing common coefficients across industries operating with potentially distinct technologies[39].

5.3 Estimation Strategy

There are several approaches that can be used and, indeed, have been used to estimate the unknown parameters in equation (5.4). This thesis uses the most commonly applied estimators in the productivity literature, allowing for comparison of estimates. In what follows, we show that using OLS to estimate parameters in (5.4) leads to biased estimates on the productivity impacts of adjustment paths, caused by endogeneity of firms' input decisions and the self-selection of firms in and out of an industry. A potential solution is to assume that the TFP shock in equation (5.4) is firm-specific but time-invariant, and remove this term by transforming equation (5.4) - a method referred to as fixed effects. However, this method requires that productivity is constant over time; an assumption that is likely to fail in practice. Another potential solution is to use a two-stage

[38] For firms operating plants at different cities/region, we select the region/city with the highest level of employment i.e., the dominant region/city.
[39] Each estimated equation includes a full set of 2-digit (SIC92) Industrial dummies to further capture technological difference even within a well-defined industry sub-groups.

procedure where TFP shock is proxied by other state variables such as firms' investment decisions (Olley and Pakes, 1996) or firms' intermediate input decisions (Levinsohn and Petrin, 2003). However, this approach relies on some strong assumptions (i.e., strict monotonicity between intermediate input demand and productivity shock) that are unlikely to hold in practice. Lastly, we show how instrumental variable (IV) and our preferred system GMM approach can be used to obtain unbiased and consistent estimates of the impacts of adjustment paths on productivity.

To further illustrate the theoretical basis for the biases that may arise when we use traditional OLS, fixed-effect or semi-parametric methods to estimate the parameters in (5.4) the rest of this section is structured as follows. In section 5.3.1, we review earlier estimation methods used in productivity literature – OLS and fixed-effects approach - with specific attention to their drawbacks when used to estimate parameters in (5.4). Section 5.3.2 explains the increasingly popular semi-parametric methods of Olley and Pakes (1996) and Levinsohn and Petrin (2003); accompanied by a discussion of the main methodological issues that arises when we use these methods to estimate parameters in (5.4). Although not used to estimate parameters in (5.4) due to the nature of identifying 'external' instruments, the instrumental variables (IV) approach is illustrated in 5.3.3. This is then followed with the description of our preferred approach of system GMM in the same section.

5.3.1 Ordinary Least Squares (OLS) and Fixed-effects (FE) Method

OLS can be used to estimate the unknown parameters in (5.4) because of its theoretical and practical advantage. However, simple OLS regression of (5.4) would produce biased and inconsistent estimates because it ignores endogeneity of input choices and firms' selection in and out of an industry. To illustrate, an OLS regression of equation (5.4) gives:

$$y_{it} = \hat{\beta}_0 + \hat{\beta}_k k_{it} + \hat{\beta}_l l_{it} + \hat{\beta}_m m_{it} + \hat{\beta}_x X_{it} + \hat{\beta}_j J_{it} + \hat{v}_{it} + \hat{u}_{it} \tag{5.6}$$

The vector, $\hat{\beta}_j$, can be interpreted as the TFP impact of the different paths of adjustment, but these estimates are unbiased and consistent only if the condition $E(v_{it}|k_{it}, l_{it}, m_{it}) = 0$ is met. For this condition to hold, inputs in (5.4) must be exogenously determined. As first pointed out by Marschak and Andrews (1944), firms are likely to make input choices based on, their characteristics, including their productivity levels. If a firm has prior knowledge of its productivity at the time input choices are made, simultaneity issue arises because the level of input that will be used for production will be partially determined by firm's productivity, which itself is also influenced by inputs choices. This would lead to a correlation between input choices and firms' unobservable productivity i.e., $E(v_{it}\ |k_{it}, l_{it}, m_{it}) \neq 0$. Ignoring this issue in the OLS estimation would lead to biased and inconsistent estimates of output elasticities and TFP (e.g., De Loecker, 2007).

Another issue that arises from using OLS to estimate (5.4) is the self-selection of firms in and out of an industry. The theoretical models of Jovanovic (1982) and Hopenhayn (1992) predicts that firm-level productivity play a major role in explaining firms' entry, growth and exit decisions. Productivity is expected to have an impact on these strategic decisions through the capital channel. If a firm knows its productivity level prior to an exit decision, this would generate a correlation between unobservable productivity and capital stock i.e., $E(v_{it} \mid k_{it}) \neq 0$, because firms with low productivity and low capital stock are more likely to exit relatively to firms with low productivity but, high capital stock (Ackerberg et al., 2007). Failure to take this into account would likely generate a negative correlation between (unobservable) firm-level productivity and their capital stock i.e., $E(v_{it} \mid k_{it}) < 0$ thus, leading to a downward bias on the capital stock coefficient, β_k.

A potential solution to the simultaneity and selection bias problem discussed above is to assume that unobservable firm productivity, v_{it} is firm-specific but time-invariant - a method referred to as fixed effects. This occurs when the productivity (unobservable to the researcher but known to the firm) that drives firms' input choices varies across firms but is constant over time. The fixed-effects method then solves the simultaneity and selection bias problem by eliminating the firm-specific, time-invariant productivity that is correlated with input choices. To illustrate, consider the time index in v_{it} removed so that equation (5.4) becomes:

$$y_{it} = \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \beta_x X_{it} + \beta_j J_{it} + (v_i + u_{it}) \quad (5.7)$$

Mean differencing (5.7) gives[40]:

$$(y_{it} - \bar{y}_i) = \beta_k(k_{it} - \bar{k}_i) + \beta_l(l_{it} - \bar{l}_i) + \beta_m(m_{it} - \bar{m}_i) + \beta_x(X_{it} - \bar{X}_i) + \beta_j(J_{it} - \bar{J}_i) + (u_{it} - \bar{u}_i) \quad (5.8)$$

v_i is eliminated in (5.8) because it does not vary over time i.e, $v_i = \bar{v}_i$ therefore, $v_i - \bar{v}_i = 0$. The resulting model (5.8) can be estimated using OLS. Provided that v_i is indeed, time-invariant, OLS estimation of equation (5.8) would result in unbiased and consistent estimates of input coefficients. Van Beveren (2012) further noted that the fixed-effects method addresses the selection bias problem if firms' entry and exit decision are determined by the time-invariant firm-specific productivity, v_i. Thus, an OLS estimation of equation (5.8) should produce unbiased coefficients on adjustment paths if indeed, v_i is time-invariant and it is the only determinant of firm's entry and exit in an industry. This method has a long tradition in the productivity literature since it was originally proposed by Mundlak (1961) and Hoch (1962). However, despite its usefulness in addressing the issue of simultaneity and selection bias, fixed effects method has been found to perform poorly in

[40] An alternative to the mean differencing transformation is the time differencing transformation. Both methods eliminate v_i since it does not vary over time.

practice. For instance, Griliches and Mairesse (1995) found that fixed effects estimator yields unreasonably low estimates of the capital coefficients as well as low estimates of returns to scale. Olley and Pakes (1996) also found that the fixed-effects method leads to widely different set of coefficients when applied to a balanced and unbalanced sample, suggesting the assumptions underlying the model are invalid. The first of such invalid assumptions is the constant productivity over time which Del Gatto et al. (2011) argues does not rest on strong theoretical grounds. Secondly, fixed-effects method as noted by Wooldridge (2009) rests on the assumption of strict exogeneity of inputs. This implies that current and future input choices are not affected by productivity, an assumption that is likely to fail in practice.

Another issue that may be of concern when using fixed-effects (or even OLS) is when $E(u_{it} \mid J_{it},\ X_{it}) \neq 0$, which implies that the factors, X_{it} that determine TFP also drive firms' choice of adjustment. Indeed, when we empirically modelled the determinants of firms' choice of adjustment in chapter 4, the variables in X_{it} were included on the right-hand-side. This is because theory suggests that firms' decision to choose a particular path of adjustment depend fundamentally on their prospects for profits, which in turn depends on their productivity levels and on the different costs and revenues associated with each path of adjustment. Therefore, fixed-effects regression of equation (5.4) would lead to biased and inconsistent estimates because, if as theory suggests, firms choose a particular path of adjustment in a given period based on their level of productivity, then while productivity may be affected by firms' choice of adjustment, the reverse will also be true – adjustment choice will also be determined by productivity. We found in chapter 4 that most of the X_{it} variables that determine productivity also drive firms' choice of adjustment, as predicted by theory.

5.3.2 Semi-parametric Methods of Olley and Pakes and Levinsohn and Petrin

An extensive discussion of this approach is provided in Van Beveren (2012) and Del Gatto et al. (2011). However, in this section we provide a brief explanation as to how the methods are set out to address the problem of simultaneity and selection bias. More importantly, we focus on the shortcomings of using these approaches and why they are not our preferred method of estimation. Olley and Pakes (1996) approach replaces equation (5.4) with:

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \nu_{it}(i_{it}, k_{it}) + u_{it} \qquad (5.9)$$

Where ν_{it} = $\nu_{it}(i_{it}, k_{it})$ = $i_{it}^{-1}(k_{it}, \nu_{it})$, which implies that unobserved productivity, ν_{it} is proxied by $\nu_{it}(.)$ and can be estimated using a higher-order polynomial in i_{it} and k_{it} to approximate for ν_{it}. Levinsohn and Petrin (2003) argue that because the monotonicity condition (i.e., firm's investment is a strictly increasing function of productivity) in Olley and Pakes (1996) which implies that only non-negative values of investment can be used when estimating equation (5.9), this could lead to a significantly loss in efficiency, particularly in data that contains a significant number of firms that report zero investment. As a result, Levinsohn and Petrin (2003) propose that intermediate inputs constitute a better proxy (since firms always report a positive value for intermediate inputs) to control for the simultaneity between input choice and productivity. Because this method is the most commonly used approach of the two and is one of the method used in this chapter, we focus more on this approach. Assuming demand for intermediate inputs depends on capital and productivity and it is strictly increasing in productivity, allowing (unobserved) productivity to be expressed as a function of observable intermediate inputs and capital; intermediate inputs and productivity can then be expressed as follows:

$$m_{it} = m_{it}(\nu_{it}, k_{it}) \qquad (5.10)$$

$$\nu_{it} = \nu_{it}(m_{it}, k_{it}) = m_{it}^{-1}(\nu_{it}, k_{it}) \qquad (5.11)$$

Substituting equation (5.11) into (5.4) and excluding X_{it} and J_{it} gives:

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \nu_{it}(m_{it}, k_{it}) + u_{it} \qquad (5.12)$$

Equation (5.12) can be estimated using a higher-order polynomial in m_{it} and k_{it}. The estimated equation results in consistent estimates of β_l (the variable factor of production), although β_k and β_m are not identified since capital and intermediate inputs enter the equation more than once. In the second stage the authors regressed output on capital and intermediate inputs. In other words, the following model is estimated:

$$y_{it}^{*} = y_{it} - \beta_l l_{it} = \beta_0 + \beta_m m_{it} + \beta_k k_{it} + \nu_{it} + u_{it} \qquad (5.13)$$

To estimate β_k and β_m Levinsohn and Petrin (2003) assume that productivity follows a first-order markov process:

$$\nu_{it} = E[\nu_{it} \mid \nu_{it-1}] + \xi_{it} \qquad (5.14)$$

Where ξ_{it} represents the innovation component of $\nu_{i,t}$ and is assumed to be uncorrelated with capital in period *t*. An estimate of $E[\nu_{it} \mid \nu_{it-1}]$ can be derived from the estimates in equation (5.12). The second stage of the estimation algorithm can therefore, be derived as:

$$y_{it}^{*} = y_{it} - \beta_l l_{it} = \beta_0 + \beta_m m_{it} + \beta_k k_{it} + E[\nu_{it} \mid \nu_{it-1}] + \xi_{it} + u_{it} \qquad (5.15)$$

Since the innovation component ξ_{it} is uncorrelated with capital, the estimated equation results in consistent estimate of β_k. However, the same does not hold for intermediate inputs which may respond to ξ_{it}. In order to produce a consistent estimate of β_m, Levinsohn and Petrin (2003) used moment condition implied by the fact that intermediate inputs in *t -1* will be uncorrelated with productivity innovation in period t. As such, all the coefficients required to compute TFP are identified.

Despite representing a better method than Olley and Pakes (1996), this method suffers from several drawbacks. The first, as pointed out by Ackerberg et al. (2006) is that some unappealing assumptions must be made for β_l to be identified in the first stage of the estimation algorithm. Ackerberg et al. (2006) argue that this approach suffers from serious collinearity problems arising from the fact that labour, like capital and intermediate inputs, needs to be allocated by the firm in some way and at a point in time. If, indeed, labour and intermediate inputs are chosen at the same time, one can assume that they are both chosen as a function of productivity and capital, so that labour can be written as:

$$l_{it} = l_{it}(v_{it}, k_{it}) \tag{5.16}$$

Substituting equation (5.11) into equation (5.16) gives:

$$l_{it} = l_{it}(v_{it}(m_{it}, k_{it}), k_{it}) = h(m_{it}, k_{it}) \tag{5.17}$$

Hence, labour is also a function of intermediate inputs and capital which implies perfect collinearity between labour and $v_{it}(m_{it}, k_{it})$ in the first stage of the estimation algorithm and, therefore, β_l is not identified in the first-stage. Secondly, this approach, together with Olley and Pakes (1996) method, only allows productivity shock and no other component of the error term that is constant but unobservable (i.e., managerial ability) to be correlated with factor inputs. As these fixed-effects are likely to be important determinants of output, omitting them presents a major drawback of the Levinsohn and Petrin (2003) approach[41]. Finally, Ackerberg et al. (2006) noted that this method requires the assumption that there must be strict monotonicity between intermediate input demand and the productivity shock. If this assumption fails, then the intermediate input function cannot be inverted and used as a function for the productivity shock.

5.3.3 Instrumental Variables (IV) and Generalized Method of Moments (GMM) Approach

Another method for achieving unbiased and consistent estimates is by instrumenting the explanatory variables that are causing the endogeneity problems – a method referred to as instrumental variable (IV) estimation. This method assumes that each of the endogenous variables contain 2 distinct parts. The first part is correlated with the TFP term v_{it} thus, causing the endogeneity problems, while the second part is uncorrelated with v_{it}. IV method then uses

[41] Including extensions by Ackerberg et al. (2006); Wooldridge (2009); Van Biesebroeck (2005); De Loecker (2007)

instruments to simulate the variation in the endogenous variables that are uncorrelated with v_{it}. However, for instruments to be valid in the IV method they must satisfy 3 main conditions (Greene, 2008). The first is that instruments should not enter directly into equation (5.4). Secondly, instruments must be correlated with the endogenous variables – instrument relevance. In fact, the more the correlation that is explained by instruments, the more information provided to explain the endogenous variables. Thirdly, instruments must be uncorrelated with the error term, u_{it} – instrument exogeneity condition. Formally, instruments vector, $Z_{it,}$ must be satisfy the following assumptions for them to be valid:

$$Cov(Z_{it}, D_{it} \mid X_{it}) \neq 0 \qquad (5.18)$$

$$Cov(Z_{it}, u_{it} \mid J_{it}, X_{it}) = 0 \qquad (5.19)$$

D_{it}, represents a vector of the endogenous variables, $k_{it},\ l_{it},\ m_{it}\ and\ J_{it}$. When such instruments are available, unbiased and consistent estimates can be obtained by applying the two-stage least squares (2SLS) approach. This is performed by first, regressing the endogenous variables on the instrumental variables to remove the parts of the former variables that are correlated with u_{it}. The second stage then involves substituting the endogenous variables in (5.4) with their fitted values (i.e., the parts that are uncorrelated with u_{it}). Intuitively, IV estimation removes the part of the endogenous (vector) variables D_{it} that are correlated with u_{it}, and uses the uncorrelated parts of the endogenous variables to estimate parameters in (5.4).

However, the major challenge of the IV approach is finding instruments that satisfy the 3 conditions in Greene (2008). The natural choice of instruments for input quantities are input and output prices. Assuming firms operate in a perfectly competitive market, input prices can be used as an instrument for input quantities because firms have no power to set the prices of input. However, when a firm has market power, input prices are likely to be set according to their quantities and firm-level productivity (Van Beveren, 2012). When this happens, input prices, just like quantities would be correlated with TFP thus, rendering them endogenous and failing the assumption in (5.19). Moreover, input prices are often unreported or they are reported with less precision by firms. For instance, in the financial statements of firms, labour costs are often calculated as average wage per worker. If such variable reflects (exogenous) labour market conditions, then this is a suitable instrument for labour quantities. However, since wages are often determined by the employees' quality and skills rather than (exogenous) labour market conditions, this would be transmitted to TFP (as labour quality), generating a correlation with wages and rendering it as an invalid instrument (Ackerberg et al., 2007). Using wages as instruments therefore result in biased and inconsistent estimates of parameters in (5.4).

Other instruments that have been suggested in literature include variables that shift demand for output or the supply of inputs. Such instruments include weather conditions or exogenous shocks on the labour markets that are likely to be more valid than input prices. However, such clear-cut instruments are relatively harder to come by in the productivity literature. Even in a case where a researcher finds such instruments, they are likely to only deal with the simultaneity bias and not selection bias or the endogeneity of adjustment choices. As a result, instrumental variables that can shift demand for output or shift the supply of inputs are rarely used in practice possibly, due to the difficulty in finding suitable 'external' instruments for all endogenous variables. Since, we face a similar difficulty in finding appropriate 'external' instruments; this thesis does not use this 2SLS approach. Instead, we use a different type of IV approach that relies on 'internal' instruments that is contained within the panel itself – the system GMM approach.

The system GMM approach developed in a series of papers by Holtz-Eakin et al. (1988), Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998) accommodates (fixed) unobserved heterogeneity and tackles the problem of simultaneity and selection bias by using lagged values (in first different and levels) of the explanatory variables as instruments. The basic estimation procedure consists rewriting equation (5.4) in dynamic form – that is, with additional lagged value of output:

$$y_{it} = \beta_0 + \alpha_y y_{it-1} + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \beta_x X_{it} + \beta_j J_{it} + (v_i + u_{it}) \qquad (5.20)$$

In equation (5.20), the time-invariant term, v_i is correlated with $y_{it-1}$and therefore, the equation cannot be estimated using OLS. Similarly, fixed effects method that involves eliminating v_i via within-transformation cannot be used because a non-zero correlation exists between the transformed lagged value of output and the transformed error term i.e., $y_{it-1} - \frac{1}{T}\sum_{t=1}^{T} y_{it-1}$ share many elements with $u_{it} - \frac{1}{T}\sum_{t=1}^{T} u_{it}$. This is because $y_{it-1} - \frac{1}{T}\sum_{t=1}^{T} y_{it-1}$ depends on $u_{it-1} - \frac{1}{T}\sum_{t=1}^{T} u_{it-1}$. Alternatively, the time-invariant term, v_i can be removed by first differencing. Thus, we can write the dynamic model of (5.20) in first-difference form:

$$\Delta y_{it} = \beta_0 + \alpha_y \Delta y_{it-1} + \beta_k \Delta k_{it} + \beta_l \Delta l_{it} + \beta_m \Delta m_{it} + \beta_x \Delta X_{it} + \beta_j \Delta J_{it} + \Delta u_{it} \qquad (5.21)$$

Despite the elimination of the time-invariant term, v_i in equation (5.21), there exists a correlation between Δy_{it-1} and Δu_{it} because they both contain the error term, u_{it-1}. As a result, OLS cannot be used to estimate parameters in equation (5.21). However, if u_{it} is assumed to be serially uncorrelated in (5.20), then the values of the output lagged by 2 or more periods (data permitting) can be used as instruments for the endogenous regressor, Δy_{it-1}. In other words, $y_{it-2}, y_{it-3}, \ldots$

., y_{it-p} can be used as instruments for Δy_{it-1} because $E[u_{it}u_{is}\,|N_{it},\ X_{it},\ J_{it}]^{42} = 0\ \ \forall\ t\ \neq s$, which implies that $Cov\{y_{it-k}, \Delta u_{it}\} = 0, for\ k = 2, 3, \dots, p$. Therefore, unbiased and consistent estimates of the parameters in equation (5.21) can be obtained by 2SLS. However, 2SLS does not exploit the complete set of moment conditions. Instead, the difference GMM estimator fully exploits all available moment condition and uses the following instrument matrix:

$$Z_i = \begin{bmatrix} y_{it-4} & 0 & \dots & \dots & 0 & \dots & 0 \\ . & . & y_{it-4} & y_{it-3} & . & \dots & . \\ 0 & 0 & 0 & \dots & y_{it-4} & y_{it-3} & y_{it-2} \end{bmatrix} \quad (5.22)$$

Where the first row contains the instrument sets for Δy_{it-3}, the second row the instrument set for Δy_{it-2} and the final row the instrument set for Δy_{it-1}. To limit instruments proliferation, equation (5.22) can be collapsed into one column:

$$Z_i = \begin{bmatrix} y_{it-4} \\ y_{it-3} \\ y_{it-2} \end{bmatrix} \quad (5.23)$$

The moment conditions are given by:

$$Cov(Z_i' \,, \Delta u_{it}\,) = 0 \quad (5.24)$$

Where $\Delta u_{it} = \ (\Delta u_{it-2}\,, \Delta u_{it-1}\,, \Delta u_{it})'$. The difference GMM estimator minimizes the following criterion:

$$J_N = \left(\frac{1}{N}\sum_{i=1}^{N} \Delta u_i'\, Z_i\right) W_N \left(\frac{1}{N}\sum_{i=1}^{N} Z_i'\, \Delta u_i\right) \quad (5.25)$$

Where the weighting matrix, W_N, is given by:

$$W_N = \left[\frac{1}{N}\sum_{i=1}^{N} Z_i' \Delta\hat{u}_i \Delta\hat{u}_i' Z_i\right] \quad (5.26)$$

Where $\Delta\hat{u}_i$ is a consistent estimate of the first-difference error taken from an initial consistent estimator. For simplicity, we have assumed so far that Δy_{it-1} is the only endogenous regressor in (5.20). However, the difference GMM can easily accommodate other endogenous regressors. Indeed, under the additional assumption that the vectors, ΔN_{it}[43] and ΔJ_{it} are endogenous and therefore, correlated with Δu_{it}, the vectors can be treated the same way as Δy_{it-1} whereby historical values of N_{it} and J_{it} i.e., $N_{it-2}, N_{it-3}, \dots, N_{it-p}$ and; $J_{it-2}, J_{it-3}, \dots, J_{it-p}$ can be used

[42] N_{it}, represents a vector of factor inputs: $k_{it},\ l_{it}\ and\ m_{it}$
[43] ΔN_{it}, represents a vector of first-difference factor inputs: $\Delta k_{it},\ \Delta l_{it}\ and\ \ \Delta m_{it}$

as instruments for ΔN_{it} and ΔJ_{it} respectively. Since, the vector, ΔX_{it}[44] is assumed to be exogenous, it can be used as its own instruments (also known as included instruments).

An important feature of the difference GMM is its use of firm historical values as instruments for our regressors. That is, in estimating equation (5.20) or the first-difference transformation of equation (5.4) in dynamic form, our instruments will be drawn from the set of lagged dependent and explanatory variables i.e., $y_{it-2}, y_{it-3}, \ldots, y_{it-p}$; $N_{it-2}, N_{it-3}, \ldots, N_{it-p}$; $J_{it-2}, J_{it-3}, \ldots, J_{it-p}$ and $X_{it-2}, X_{it-3}, \ldots, X_{it-p}$. For these instruments to be valid, they must meet 2 main criteria. First, the historical values of the dependent and explanatory variables must be uncorrelated with u_{it} in equation (5.20). This implies that the historical values must provide an exogenous source of variation for our endogenous regressors: lagged output, factor inputs and firm's choice of adjustment. As earlier discussed, under the assumption that u_{it} is serially uncorrelated in (5.20), the values of the output lagged by 2 or more periods (data permitting) can be used as instruments for Δy_{it-1} in equation (5.21). This is because the u_{it-2} in y_{it-2} for instance, is uncorrelated with $\Delta u_{it} = u_{it} - u_{it-1}$. Further, if factor inputs and firms' choice of adjustment behave in the same way as lagged output, then their historical values, 2 years or longer, can also be used as valid instruments. Since, the vector, ΔX_{it} is assumed to be exogenous and thus, uncorrelated with Δu_{it}, it can be used as its own instruments. Assuming these exogeneity conditions are valid, then we can write the following orthogonality conditions:

$$E[y_{it-s}\Delta u_{it}] = E[N_{it-s}\Delta u_{it}] = E[J_{it-s}\Delta u_{it}] = E[X_{it-s}\Delta u_{it}] = 0 \quad for \ s = 2, 3, \ldots\ldots, p \qquad (5.27)$$

The second criterion for the instruments to be valid is that the historical values of our instruments must be highly correlated with the endogenous regressors: lagged output, factor inputs and firms' choice of adjustment. In other words, they must provide a source of variation for our endogenous regressors. In our discussion on the determinants of firms' choice of adjustment in chapter 2, we established a theoretical motivation for why productivity differences across firms should influence their choice of adjustment. In addition, we found in our empirical analysis of chapter 4 that firms, indeed, choose different paths of adjustment based on their lagged values and their characteristics i.e., X_{it}. As such, we expect past values of adjustment and firms' characteristics in X_{it} to be correlated with firm's chosen path of adjustment.

However, it has been found in the productivity literature that lagged values of input tend to be only weakly correlated with input changes because inputs tend to be highly persistent over time. Moreover, using lagged inputs to instrument for changes in input in empirical practice has often led

[44] R&D is treated as endogenous with its historical values serving as instruments for the variable.

to downward bias of the capital coefficient (e.g., Blundell and Bond, 1998). Arellano and Bover (1995) thus, suggested that variables in levels may be weak instruments for first difference equations such as equation (5.21). Another drawback of estimating (5.21) is that differencing may reduce the power of our test by reducing the variation in the explanatory variables, if the original model is theoretically in levels (Beck at al., 2000). Finally, first-differencing may intensify the impact of measurement errors on the dependent variable (Griliches and Hausman, 1986).

To mitigate the aforementioned shortcoming of differenced GMM, Arellano and Bover (1995) and Blundell and Bond (1998) proposed a system GMM estimator which includes the equation in levels in the estimation procedure. The authors proposed that the shortcomings of differenced GMM can be improved by using lagged first-difference variables as instruments for the equation in levels, in addition to using lagged level variables as instruments for the equation in first-difference. The procedure involves estimating the following system:

$$\begin{bmatrix} y_{it} \\ \Delta y_{it} \end{bmatrix} = \alpha + \Pi \begin{bmatrix} y_{it-1} \\ \Delta y_{it-1} \end{bmatrix} + \beta \begin{bmatrix} N_{it} \\ \Delta N_{it} \end{bmatrix} + \gamma \begin{bmatrix} X_{it} \\ \Delta X_{it} \end{bmatrix} + \kappa \begin{bmatrix} J_{it} \\ \Delta J_{it} \end{bmatrix} + \begin{bmatrix} u_{it} \\ \Delta u_{it} \end{bmatrix} \qquad (5.28)$$

Where N_{it} represents factor inputs: capital, labour and intermediate inputs. Unfortunately, the levels equation in (5.28) includes the time-invariant term, ν_i which is correlated with y_{it-1} and potentially, correlated with other explanatory variables. To deal with this, we assume that while y_{it-1} and other control variables may be correlated with ν_i, this correlation is constant over time. This is a reasonable assumption over a relatively short period of time if ν_i proxy for factors such as unobserved managerial ability and productivity. This assumption leads to an additional set of orthogonality conditions:

$$E[\Delta y_{it-s}(\nu_i + u_{it})] = E[\Delta D_{it-s}(\nu_i + u_{it})] = E[\Delta X_{it-s}(\nu_i + u_{it})] = 0 \ for\ s > 0 \qquad (5.29)$$

System GMM is used to estimate parameters in (5.28) using the orthogonality conditions of (5.27) and (5.29). These orthogonality conditions imply that we can use lagged level variables as instruments for the differenced equation and lagged first-difference variables as instruments for the level equation[45]. As a result, the system GMM approach has an advantage over the 2SLS approach because it allows us to rely on 'internal' instruments that are contained within the panel itself. The system GMM approach also improves on OLS, fixed-effects and the semi-parametric method of Levinsohn and Petrin (2003) in at least 3 important ways. First, unlike OLS, system GMM allows us to tackle selection bias and endogeneity of factor inputs and firms' choice of adjustment by using their lagged values (in levels and first-difference) as instruments. Second, unlike fixed effects, it does not

[45] We carry out tests of the validity of the orthogonality conditions in (5.28) and (5.29).

improve the endogeneity of inputs and selection bias problem at the expense of a strong exogeneity condition. Third, unlike the semi-parametric method of Levinsohn and Petrin (2003), it allows us to include fixed effects to account for (fixed) unobserved heterogeneity among firms. This estimator therefore, has advantage over the earlier discussed estimators because it allows the inclusion of fixed-effects and tackles endogeneity of the right-hand-side variables and selection bias by using their lagged values (in levels and first-difference) as instruments.

As noted earlier, the validity of system GMM estimation hinges, at least in part, on the assumption of joint exogeneity of instruments. Because the system GMM uses multiple lags as instruments, our system is over-identified i.e., more instruments than endogenous variables, therefore, providing us with the opportunity to carry out the test of over-identification. We use the Hansen test of over-identification to check whether our instruments are valid or not. The Hansen test produces a J-statistics that tests the null hypothesis that instruments are distributed independently of the production function and are uncorrelated with the residuals. Thus, a rejection of the null hypothesis would imply that at least one of our instruments is not exogenous rendering our estimates in (5.28) invalid. However, as noted by Roodman (2009), the Hansen test is weak when there are many instruments. As a result, we carry out an additional test to check for the validity of instruments.

Recall that, the use of lagged values (in levels and first-difference) of explanatory variables as instruments depend crucially on the absence of serial correlation in the error term of the equation in levels i.e., equation (5.20). If the errors in equation (5.20) are serially correlated, then the first-difference errors i.e., the error term in equation (5.21) would be AR(2) or higher order. Therefore, by testing for serial correlation, one can ascertain the validity of instruments or otherwise. However, standard tests for serial correlation such as Durbin-Watson and Breusch-Godfrey are not appropriate for our dynamic model. Instead, we use the Arellano and Bond (1991) tests for first-order and second-order serial correlation in differenced residuals, under the null of no serial correlation. If the assumptions of our specification are valid, by construction, the residuals in first-difference (AR(1)) should be correlated while the residuals in second-difference (AR(2)) should not be correlated. This is because $\Delta u_{it} = u_{it} - u_{it-1}$ is likely to be correlated with $\Delta u_{it-1} = u_{it-1} - u_{it-2}$, as the 2 share the same error term, u_{it-1}. But, for the second-difference residual test, u_{it-1} in Δu_{it} should not be correlated with u_{it-2} in Δu_{it-2}.

5.4 Firm-level Results

As stated in the introduction, the focus of this chapter is to examine the effect of alternative forms of adjustment on TFP. To highlight the potential problems associated with ignoring fixed-effects, selection bias due to firm entry and exit, endogeneity of input and the dynamic relationship between firm adjustment and productivity, we estimate the equation (5.28) using the following models: OLS model, fixed-effects model and Levinsohn and Petrin (2003) model. However, we start by using the system GMM approach to estimate equation (5.28) because of its theoretically appeal in dealing with the aforementioned endogeneity and simultaneity issues (explained in section 5.3.3)[46].

When using system GMM to estimate equation (5.28), several alternative specifications of J_{it} were tested. In particular, we examine the question: to what extent do adjustment paths affect TFP (i.e., do adjustment paths have a short- or long-run effect on TFP, or both)? To answer this question, we start with the assumption that there is a long-run relationship between the different paths of adjustment and TFP[47]. In other words, as our baseline, we specify J_{it} as equals one in the year a firm carries out an adjustment and remains one in subsequent years (zero otherwise). We then carry out a series of test by including single-year dummies to determine whether there are short-run effects on the path to the new long-run level of productivity. For instance, mergers and acquisition may have a (positive) long-run effect on productivity, but it may take a few years to reach the new long-run level of productivity. Thus, short-run adjustment dummies are sequentially included into J_{it}, and using a F-test, we determine, each time, whether these short-run dummy variables are jointly equal to zero (i.e., whether they bring additional information into our model).

The first of such tests was carried out on the immediate effect of adjustment on productivity. In other words, we include a set of adjustment dummies that are equal to one in the year of adjustment (zero otherwise), and using the F-test, we check if the coefficients on these dummies are jointly equal to zero. Our result (not presented in this thesis because of brevity) shows that we cannot reject the null hypothesis (at the 90% level) that these dummy variables were jointly equal to zero. So, we exclude an immediate effect of adjustments on productivity and stopped the process of searching for short-run effects[48]. Since, we find that there are no short-run effects of adjustments on TFP, we proceed to checking for lag effects (i.e., does a firm wishing to close a plant experience any performance decline in terms of TFP before it closes the plant). We found that only adjustments *t-1* (which is set of dummy variables that is equals one in the year before the adjustment and, zero otherwise) have a joint effect on TFP. Hence, our statistical procedure leads to a model that captures the long-run and lag effects of using different forms of adjustments on TFP. However, we estimate

[46] This is carried out on STATA 14.2, using the xtabond command introduced by Roodman (2009)
[47] This is a reasonable assumption to make as one might expect adjustments such as greenfield investment and mergers and acquisition to have a long-run effect on firm's productivity.
[48] This exercise was performed separately for the 8 industrial sectors (defined according to table 4.2) to avoid imposing common coefficients across industries operating with potentially distinct technologies and the F-test was statistically insignificant across all sectors. As a quick check, we also include short-run adjustment dummies that are equal to one in the year after the adjustment and found the coefficients to be jointly equal to zero in all sectors.

the same model using OLS, fixed-effects and Levinsohn-Petrin approach; allowing for comparison of estimates with the system GMM approach.

Table 5-1: Returns-to-scale from system GMM, OLS, Fixed-effects and Levinsohn-Petrin estimators, Manufacturing

			System GMM					
Variables	**High-tech**	**z-value**	**Med. high-tech**	**z-value**	**Med. low-tech**	**z-value**	**Low-tech**	**z-value**
ln Intermediate inputs	0.654	5.52	0.677	9.30	0.758	13.11	0.526	3.92
ln Employment	0.243	1.91	0.206	1.95	0.114	1.27	0.298	2.74
ln Capital	0.093	1.70	0.105	1.67	0.06	1.83	0.223	2.47
Returns-to-scale	**0.990**		**0.988**		**0.932**		**1.047**	
			OLS					
Variables	**High-tech**	**t-value**	**Med. high-tech**	**t-value**	**Med. low-tech**	**t-value**	**Low-tech**	**t-value**
ln Intermediate inputs	0.21	8.32	0.182	11.65	0.201	10.37	0.190	9.27
ln Employment	0.408	13.33	0.386	17.71	0.333	13.82	0.322	11.74
ln Capital	0.004	1.08	0.011	2.95	0.006	2.36	0.011	4.09
Returns-to-scale	**0.622**		**0.579**		**0.540**		**0.523**	
			Fixed-effects					
Variables	**High-tech**	**t-value**	**Med. high-tech**	**t-value**	**Med. low-tech**	**t-value**	**Low-tech**	**t-value**
ln Intermediate inputs	0.204	4.35	0.333	11.34	0.422	8.31	0.319	20.96
ln Employment	0.438	8.93	0.416	11.93	0.403	10.83	0.355	30.31
ln Capital	0.031	2.41	0.01	1.70	0.008	1.55	0.004	2.16
Returns-to-scale	**0.673**		**0.759**		**0.833**		**0.678**	
			Levinsohn-Petrin					
Variables	**High-tech**	**t-value**	**Med. high-tech**	**t-value**	**Med. low-tech**	**t-value**	**Low-tech**	**t-value**
ln Intermediate inputs	1.14	5.79	0.699	3.28	0.717	6.06	1.078	7.14
ln Employment	0.311	15.86	0.229	19.41	0.259	27.44	0.228	31.53
ln Capital	0.000	0.00	0.073	1.87	0.047	2.93	0.029	1.28
Returns-to-scale	**1.451**		**1.001**		**1.023**		**1.335**	

Comparing all estimates across the 4 estimators would lead to a tedious exercise; as a result, we focus on comparing estimates of elasticity of output with respect to intermediate inputs, labour and capital. This would be useful in illustrating the poor performance of the other estimators against the system GMM and to highlight their theoretical shortcomings (as explained in detail in section 5.3). Tables 5.1 and 5.2 report the returns-to-scale coefficients obtained for manufacturing and service sectors respectively. In the manufacturing sector, we generally find that our estimates are statistically significant at the 90% level across different estimators. Our preferred system GMM estimator produces a sum of output elasticities that are close to one (i.e., 0.99 in high-tech and medium high-tech manufacturing; 0.93 in medium low-tech manufacturing and; 1.05 in low-tech manufacturing), with an average of 0.99. This suggests that firms in the manufacturing sector produce the same quantity of output from a given proportion of input utilized. In contrast, the average sum of elasticities estimates from OLS and fixed effects are 0.57 and 0.74 respectively, indicating a decreasing returns-to-scale. These estimators produce particularly, low capital coefficients, suggesting that, as expected, there is a downward bias on capital introduced by the different endogeneity issues explained in section 5.3. Levinsohn-Petrin approach also produces very low coefficients on capital, especially in the high-tech manufacturing sector. As shown in section 5.3.2, a major shortcoming of the Levinsohn-Petrin approach is that it does not allow for unobserved time-invariant effects in the error term that is correlated with factor inputs. As these fixed-effects are likely to be important due to the existence of unobservable variables such as managerial ability that determine output levels, this a major drawback with the Levinsohn-Petrin (2003) approach.

Table 5-2: Returns-to-scale from system GMM, OLS, Fixed-effects and Levinsohn-Petrin estimators, Services

			System GMM					
Variables	**High-tech KI**	**z-value**	**KI**	**z-value**	**Low-tech KI**	**z-value**	**Other Low-tech KI**	**z-value**
ln Intermediate inputs	0.563	5.51	0.527	5.92	0.62	6.38	0.75	8.06
ln Employment	0.402	2.52	0.463	3.71	0.219	1.83	0.223	1.65
ln Capital	0.149	1.94	0.03	2.11	0.188	2.78	0.004	0.41
Returns-to-scale	**1.114**		**1.02**		**1.027**		**0.977**	
			OLS					
Variables	**High-tech KI**	**t-value**	**KI**	**t-value**	**Low-tech KI**	**t-value**	**Other Low-tech KI**	**t-value**
ln Intermediate inputs	0.085	6.52	0.081	6.52	0.082	10.56	0.111	6.71
ln Employment	0.193	11.19	0.192	11.3	0.269	14.87	0.211	9.11
ln Capital	0.003	0.92	0.003	0.95	-0.001	-0.54	-0.001	-0.49
Returns-to-scale	**0.281**		**0.276**		**0.35**		**0.321**	
			Fixed-effects					
Variables	**High-tech KI**	**t-value**	**KI**	**t-value**	**Low-tech KI**	**t-value**	**Other Low-tech KI**	**t-value**
ln Intermediate inputs	0.277	5.78	0.211	5.66	0.289	11.42	0.426	7.4
ln Employment	0.238	7.06	0.25	9.46	0.385	20.2	0.234	5.28
ln Capital	0.001	0.25	0.012	2.8	0.003	0.67	0.002	0.59
Returns-to-scale	**0.516**		**0.473**		**0.677**		**0.662**	

Levinsohn-Petrin								
Variables	**High-tech KI**	**t-value**	**KI**	**t-value**	**Low-tech KI**	**t-value**	**Other Low-tech KI**	**t-value**
ln Intermediate inputs	0.831	5.06	1.079	5.79	0.656	31.51	0.779	15.6
ln Employment	0.281	7.15	0.262	9.5	0.253	33.89	0.304	6.25
ln Capital	0.028	1.14	0.096	1.86	0.035	4.00	0.039	1.84
Returns-to-scale	**1.140**		**1.437**		**0.944**		**1.122**	

A similar pattern appears in the service sector, as shown in table 5.2. The system GMM approach produces reasonable coefficients on intermediate inputs, labour and capital, while OLS and fixed-effect yield very low coefficients on these variables. Levinsohn-Petrin approach, again, produces a low capital coefficient. This indicates that the endogeneity issues associated with OLS, fixed-effect and Levinsohn-Petrin are not limited to the manufacturing sector. Since the system GMM produces reasonable coefficients on the elasticity of output with respect to intermediate inputs, labour and capital, the rest of this section interprets results from our system GMM estimation.

Tables 5.7 and 5.8 in appendix 5.6 present the entire results from our system GMM estimation across 8 industrial sectors[49]. The tables also report the results of the specification test associated with each estimated equation: the Hansen test of over-identifying restriction and two Arellano and Bond (1991) tests for first-order and second-order serial correlation in differenced residuals. The results of the Hansen tests reveal J-statistics with p-values between 0.20 and 0.99 which indicates that we cannot reject the null hypothesis that our instruments are valid at the 10% level. With regards to the two Arellano and Bond (1991) tests, the AR(1) tests in Tables A5.1 and A5.2 produce p-values of 0.00, while the AR(2) tests yield p-values between 0.13 and 0.70 which means that we cannot reject the null hypothesis of no second-order serial correlation (at the 10% level) for all the 8 industrial sectors. These results provide the basis for treating our model as adequate. In what follows, we discuss the parameter estimates associated with J_{it} and X_{it} by grouping them into: expansion, contraction and Other TFP effects.

As a robustness check, we recode each of the expansion and contraction category and re-estimate using the system GMM approach. Specifically, internal expansion was recoded from internal expansion 'only' + internal expansion 'dominant' to internal expansion 'only'. The same recoding was done for greenfield investment, mergers and acquisition, internal contraction, plant closure and plant sale. Our recoding led to 2 further categories of firms using a combination of several paths of adjustment. In particular, we merged three category of expanding firms namely; internal expansion

[49] Appendix A5 also produces the entire results from our OLS, fixed-effects and Levinsohn-Petrin estimation.

‘dominant’, greenfield investment ‘dominant’ and mergers and acquisition ‘dominant’ and referred to them as expansion dominant. We also merge the three contraction ‘dominant’ categories and referred to those as contraction dominant. These new categories were re-estimated using the system GMM approach. The results presented in tables 5.15 and 5.16 (in appendix 5.7) are qualitatively similar to those presented in tables 5.3 and 5.4 (i.e., no statistically significant long-run adjustment effects and few statistical significant short-run adjustment effects).

5.4.1 Expansion Effects on TFP

Table 5-3: System GMM estimation of expansion effects on TFP, 1997-2012, Great Britain[a]

			Manufacturing					
Variables	**High-tech**	**z-value**	**Med. high-tech**	**z-value**	**Medium low-tech**	**z-value**	**Low-tech**	**z-value**
Internal expansion *(t-1)*	0.024	0.26	0.089	1.51	0.020	0.70	0.103	2.31
Greenfield investment (*t-1*)	-0.334	-2.13	0.135	0.63	-0.065	-0.29	-0.079	-0.51
Mergers and acquisition (*t-1*)	-0.137	-0.27	-0.210	-1.04	0.235	1.54	0.098	0.32
Internal expansion (*Long-run*)	-0.080	-0.49	-0.032	-0.68	-0.048	-1.26	-0.277	-1.09
Greenfield investment (*Long-run)*	0.048	0.40	0.009	0.18	-0.057	-1.01	-0.099	-1.22
Mergers and acquisition (*Long-run*)	0.163	1.25	-0.007	-0.17	0.043	0.55	0.118	1.14
			Services					
Variables	**High-tech KI**	**z-value**	**KI**	**z-value**	**Low-tech KI**	**z-value**	**Other Low - tech KI**	**z-value**
Internal expansion *(t-1)*	0.296	2.70	-0.046	-0.37	-0.004	-0.03	0.020	0.31
Greenfield investment (*t-1*)	0.010	0.05	0.322	1.70	0.234	1.50	-0.084	-0.34
Mergers and acquisition (*t-1*)	-0.109	-0.36	-0.480	-0.73	0.092	0.18	-0.373	-0.52
Internal expansion (*Long-run*)	0.111	0.41	0.292	1.05	0.181	1.15	-0.054	-0.24
Greenfield investment (*Long-run)*	0.060	0.22	-0.021	-0.09	-0.185	-1.29	0.003	0.01
Mergers and acquisition (*Long-run*)	0.046	0.22	-0.104	-0.64	-0.022	-0.20	-0.157	-0.47

[a] Parameter values for dummy variables are converted using exp(β) - 1

The result obtained for the expansion-paths variables in equation (5.28) are reported in table 5.3. We start by comparing the ex-ante TFP performance of expanding and non-adjusting firms. This tells us whether future expanding firms were more productive than their non-adjusting counterparts even before expansion. It therefore differs from the firm-level variables used to study the determinants of firms’ choice of adjustment in chapter four. Table 5.3 shows that firms that decide to expand internally generally enjoy better ex-ante TFP than non-adjusting firms, except for KI and low-KI service sectors. However, these coefficients are statistically insignificant in most industrial sectors apart from low-tech manufacturing and high-tech KI service; in these sectors, we find that firms that use internal expansion had on average 11% and 34%[50] higher ex-ante TFP than firms that did not adjust.

With regards to greenfield investment, we find mixed results – the coefficients on the greenfield dummy is positive in medium high-tech manufacturing, high-tech KI service, KI service and low-tech KI service sectors and, it is negative in the other 4 industrial sectors. Most of these coefficients are however, statistically insignificant apart from those in the high-tech manufacturing and KI service sectors. When compared to non-adjusting firms, firms in high-tech manufacturing had on average 28% lower ex-ante TFP, while firms in the KI service sector had on average 38% higher ex-ante TFP. There are similar mixed results for firms that use mergers and acquisition. However, none of the coefficients associated with the mergers and acquisition dummy is statistically significant. In sum, we find some evidence that internal expansion tends to occur in response to improvement in TFP, one period before the expansion. By contrast, firms that use external expansion, particularly mergers and acquisition display no improvement in productivity, prior to using this form of expansion. There are few studies against which to make any comparison, however, this result is partly at odds with our first hypothesis (in chapter two) that high-productivity firms are more likely to use external forms of expansion than low-productivity firms.

Turning now to the ex-post productivity effect of alternative forms of expansion, table 5.3 reveals that internal expansion has a negative long-run effect on TFP in all the manufacturing sectors, while the same form of expansion has a positive long-run effect on TFP in all the service sectors (except for the other low-tech KI service sector). However, the coefficients associated with this dummy variable are statistically insignificant across all the 8 industrial sectors. Our result also indicates that none of the external forms of expansion – greenfield investment and mergers and acquisition - has an economically meaningful effect on TFP in the long-run. This suggests that all the 3 channels of expansion have no long-run effect on TFP, which is partly at odds with our third hypothesis (in chapter two) that states that external forms of expansion should lead to higher level of productivity than internal expansion. However, the theoretical ideas used to build our third hypothesis fail to consider long-run productivity effects of firm's expansion and, instead focus mainly on the short-run effects.

In comparison with previous empirical studies, most researchers have focused on a particular path of expansion (e.g., mergers and acquisition) without comparing this impact to the effect of other forms of adjustment (e.g., internal expansion and/or greenfield investment). Prior studies have also

[50] Parameter estimates for our dummy variables are converted using [*exp*(β)-1] *100

provided mixed evidence concerning the productivity impact of each channel of adjustment. For instance, Schoar (2002) observe that mergers and acquisition has both positive and negative effects on acquirer's 'purchased' and 'existing' plants respectively. It is therefore difficult to compare our empirical evidence to prior studies. However, we view our finding of no long-run expansion effect as novel given our choice of appropriate control groups and the fact that we use the system GMM approach to alleviate endogeneity concerns regarding the relationship between firm expansion and their productivity levels.

5.4.2 Contraction Effects on TFP

Table 5-4: System GMM estimation of contraction effects on TFP, 1997-2012, Great Britain[a]

	Manufacturing							
Variables	**High-tech**	**z-value**	**Med. high-tech**	**z-value**	**Med. low-tech**	**z-value**	**Low-tech**	**z-value**
Internal contraction (*t-1*)	-0.015	-0.19	-0.023	-0.50	0.054	1.58	-0.019	-0.39
Plant closure (*t-1*)	-0.001	-0.03	0.124	1.11	0.118	1.55	0.166	1.06
Plant sale (*t-1*)	-0.449	-0.94	0.114	0.26	0.489	1.48	-0.257	-0.51
Internal contraction (*Long-run*)	0.029	0.21	-0.048	-1.38	-0.056	-1.38	0.081	0.80
Plant closure (*Long-run*)	0.014	0.12	0.021	0.45	0.016	0.44	0.005	0.05
Plant sale (*Long-run*)	0.114	0.67	0.045	0.93	0.031	0.61	-0.090	-0.75
	Services							
Variables	**High-tech KI**	**z-value**	**KI**	**z-value**	**Low-tech KI**	**z-value**	**Other Low-tech KI**	**z-value**
Internal contraction (*t-1*)	-0.023	-0.22	-0.017	-0.16	-0.038	-0.22	-0.078	-0.80
Plant closure (*t-1*)	-0.364	-1.69	-0.173	-0.78	0.090	0.48	-0.080	-0.21
Plant sale (*t-1*)	-0.323	-0.58	1.058	0.69	0.193	0.20	0.122	0.18
Internal contraction (*Long-run*)	-0.129	-0.59	-0.134	-1.06	0.085	0.84	0.077	0.74
Plant closure (*Long-run*)	-0.436	-2.92	-0.075	-0.54	0.123	1.44	-0.460	-1.47
Plant sale (*Long-run*)	-0.218	-0.59	0.177	0.63	0.152	1.40	0.340	1.31

[a] Parameter values for dummy variables are converted using exp(β) - 1

In this section, we interpret results for contracting-path variables in equation (5.28). Similar to previous section, we start by comparing the ex-ante TFP performance of contracting and non-adjusting firms to see whether future contracting firms were less productive than their non-adjusting counterparts even before contraction. It is evident from table 5.4 that there no clear ex-ante TFP disadvantage of future contracting firms as the coefficients associated with the contraction dummies are generally poorly determined. Most of the contraction-paths coefficients (except for plant closure in the high-tech KI service sector) are statistically insignificant; indicating that future contracting firms do not appear to be less productive, the year before contraction. This result partly contrasts with our second hypothesis which states that high-productivity firms are more likely to use external forms of contraction than low-productivity firms. In terms of related empirical studies, our finding is similar to that of Hillier et al. (2006) and Yu and Park (2006) who report no significant relationship between firms' operating efficiency (i.e., labour productivity) and their decision to lay off employees. This suggests that firms' contraction decisions may be influenced by other factors such as their financial health and over-diversification, instead of being driven by their immediate efficiency level.

With respect to the ex-post productivity effect of alternative forms of contraction, table 5.4 also shows that there are no economically meaningful effects of contraction paths on long-run TFP. This is evident from the statistical insignificant coefficients on all the contraction dummies (except for plant closure in the high-tech KI service sector). This result is also partly at odds with our fourth hypothesis which states that external contraction should result in higher level of productivity than internal contraction. However, the theoretical ideas used to formulate this hypothesis fail to consider long-run productivity effects of firm's contraction. In relation to previous empirical studies, it is difficult to compare our empirical evidence because prior researchers have focused their attention on the productivity impact of a particular path of contraction (e.g., plant closure) without comparing this impact to the effect of other forms of contraction (e.g., internal contraction and/or plant sale). Previous empirical studies have also provided mixed evidence regarding the productivity impact of different channels of contraction. For instance, while Chen et al. (2001) reported that employee layoffs has a positive effect on ex-post firm-level productivity, Mishra and Mishra (1994) reported an opposite effect. However, given our choice of appropriate control groups and the fact that we use the system GMM approach to ease endogeneity concerns regarding the relationship between firm contraction and their productivity levels, our finding of no long-run contraction effect is also viewed as novel.

5.4.3 Other Effects on TFP

The results for the parameter estimates associated with X_{it} in equation (5.28) will be discussed in this section. Tables 5.5 and 5.6 present these results for manufacturing and service sector respectively. The result obtained for the first of our X_{it} variables shows that the TFP impact of having a non-zero R&D spending is generally positive, except for firms with the lowest R&D expenditure (i.e., R&D band 1) where it is negative in 5 out of 8 industries. However, the coefficients associated with these dummies are poorly determined across sectors, suggesting no clear ex-post TFP improvements from undertaking R&D. Only 3 coefficients in the manufacturing sector are statistically significant and 2 out of the 3 indicate that R&D has a positive ex-post effect on TFP.

Table 5-5: System GMM estimation of other effects on TFP, 1997-2012, Manufacturing

Variables	High-tech	z-value	Med High-tech	z-value	Med Low-tech	z-value	Low-tech	z-value
R&D band 2	0.104	0.15	-0.503	-1.20	-0.107	-1.15	0.115	0.60
R&D band 3	-0.165	-0.22	0.267	1.23	-0.146	-3.15	0.275	1.55
R&D band 4	0.067	0.51	-0.097	-1.23	0.064	1.34	0.212	1.89
R&D band 5	0.177	1.55	0.012	0.18	0.128	2.21	0.121	0.92
ln Age	-0.140	-1.79	-0.116	-1.73	-0.081	-1.85	-0.307	-2.62
Single-plant firm	0.080	2.01	0.015	0.82	0.037	1.77	0.045	0.83
Multi-region firm	0.057	1.12	0.008	0.34	0.045	1.81	0.031	0.72
ln Herfindahl	0.007	0.30	0.001	0.13	-0.025	-2.68	-0.010	-0.69
UK-Owned (with FDI)	-0.027	-0.50	0.045	1.88	0.020	0.77	0.033	0.60
SE Asia-Owned	-0.061	-0.35	-0.025	-0.40	0.005	0.06	-0.107	-0.82
EU-Owned	-0.015	-0.18	0.050	1.23	-0.022	-0.56	0.048	0.57
USA-Owned	-0.015	-0.17	0.037	1.00	0.052	1.22	0.094	1.13
AUSCANSA-Owned	-0.005	-0.06	0.085	1.62	0.000	0.00	0.051	0.50
Other Foreign-Owned	-0.079	-0.93	-0.015	-0.26	-0.038	-0.79	-0.156	-1.17
North-East	-0.112	-0.72	-0.117	-1.84	-0.032	-0.62	-0.053	-0.66
Yorkshire-Humberside	0.060	0.72	-0.042	-1.33	-0.053	-1.20	-0.038	-1.02
North-West	-0.013	-0.21	-0.083	-2.26	-0.066	-1.78	-0.123	-2.57
West Midlands	0.065	0.49	-0.050	-1.43	-0.058	-1.62	-0.054	-0.86
East Midlands	-0.092	-1.76	-0.062	-1.94	-0.023	-0.59	-0.080	-1.65
South-West	-0.053	-0.88	-0.054	-1.71	-0.013	-0.31	-0.033	-0.75
Eastern	-0.047	-0.86	-0.047	-1.74	-0.020	-0.57	-0.052	-1.36
London	0.125	1.45	-0.057	-1.60	-0.067	-0.89	0.194	2.17
Scotland	-0.043	-0.61	-0.041	-1.17	0.058	1.34	-0.099	-1.99
Wales	-0.084	-1.00	-0.069	-2.16	-0.053	-1.40	-0.048	-0.84
Tyneside	0.094	0.59	0.111	1.46	0.002	0.02	-0.022	-0.18
Northern Ireland	-0.149	-0.90	-0.114	-1.43	-0.038	-0.60	-0.042	-0.48
Manchester	-0.017	-0.13	0.211	2.28	0.044	0.46	0.054	0.45
Liverpool	-0.001	0.00	-0.057	-1.05	0.076	0.28	0.140	1.44
Birmingham	-0.194	-1.24	0.032	0.75	0.003	0.06	0.068	0.66
Coventry	-0.068	-0.41	-0.068	-0.92	-0.005	-0.10	-0.024	-0.20
Leicester	-0.012	-0.11	-0.042	-0.50	-0.098	-1.14	0.185	1.21
Nottingham	0.273	1.38	-0.004	-0.06	0.130	1.04	0.055	0.31
Bristol	0.284	1.61	0.105	1.36	-0.185	-3.02	0.017	0.21
Glasgow	-0.038	-0.33	0.147	1.52	-0.010	-0.08	0.070	1.11
Edinburgh	-0.049	-0.38	-0.164	-1.78	0.165	1.35	0.179	1.90
Cardiff	-0.043	-0.21	0.073	0.60	0.037	0.63	-0.166	-1.10
Time trend	0.028	2.83	0.015	2.24	0.022	4.63	0.019	1.83
Dummy 2008-12	-0.015	-0.34	0.010	0.39	-0.030	-1.26	0.001	0.04

Table 5-6: System GMM estimation of other effects on TFP, 1997-2012, Services

Variables	High-tech KI	z-value	KI	z-value	Low-tech KI	z-value	Other low-tech KI	z-value
R&D band 2	0.150	0.21	-0.093	-0.09	-0.118	-0.23	-1.318	-0.88
R&D band 3	-0.257	-0.94	0.036	0.06	0.103	0.43	0.406	0.84
R&D band 4	0.047	0.33	0.005	0.03	0.029	0.12	0.260	0.85
R&D band 5	-0.039	-0.20	-0.059	-0.39	0.155	0.63	0.070	0.26
ln Age	-0.252	-1.63	-0.064	-0.99	-0.393	-2.76	-0.047	-0.81
Single-plant firm	0.119	1.59	0.021	0.32	-0.010	-0.32	0.086	1.17
Multi-region firm	0.001	0.01	0.073	1.18	0.046	0.96	0.180	1.99
ln Herfindahl	-0.004	-0.17	0.017	1.00	0.012	0.85	0.010	0.56
UK-Owned (with FDI)	-0.080	-0.75	0.188	1.16	0.186	1.62	0.269	1.00
SE Asia-Owned	0.168	0.79	1.569	1.82	0.361	2.29	-0.038	-0.15
EU-Owned	0.024	0.21	0.185	0.94	0.164	1.91	0.152	0.67
USA-Owned	0.066	0.56	0.282	1.50	0.172	2.01	-0.041	-0.08
AUSCANSA-Owned	0.009	0.02	0.259	0.88	0.119	0.80	-0.077	-0.27
Other Foreign-Owned	-0.148	-0.32	0.336	1.59	0.118	0.90	-0.237	-1.08
North-East	-0.268	-1.22	0.049	0.53	-0.166	-3.22	0.109	0.95
Yorkshire-Humberside	-0.021	-0.17	-0.004	-0.05	-0.041	-0.91	-0.014	-0.15
North-West	-0.129	-0.67	-0.057	-0.94	-0.087	-2.54	-0.137	-1.50
West Midlands	-0.350	-2.70	-0.078	-0.83	-0.094	-2.29	0.054	0.47
East Midlands	0.018	0.12	-0.094	-1.02	-0.107	-2.35	-0.128	-1.46
South-West	-0.221	-1.33	-0.095	-1.22	-0.065	-1.90	0.048	0.49
Eastern	-0.008	-0.07	0.060	0.92	-0.035	-1.04	0.125	1.42
London	0.030	0.36	0.242	4.13	0.140	2.59	0.098	1.09
Scotland	-0.180	-1.04	0.023	0.30	-0.081	-2.65	-0.033	-0.44
Wales	-0.379	-2.32	-0.097	-1.08	-0.081	-1.73	-0.076	-0.78
Tyneside	-0.103	-0.20	-0.134	-0.97	0.129	1.42	-0.156	-0.90
Northern Ireland	0.193	0.66	0.049	0.15	0.742	2.46	-0.052	-0.22
Manchester	0.124	0.45	0.153	0.97	0.041	0.58	-0.430	-0.64
Liverpool	-0.242	-0.76	-0.029	-0.23	0.009	0.08	0.072	0.12
Birmingham	0.560	2.22	-0.030	-0.23	-0.100	-1.34	-0.182	-1.54
Coventry	-0.060	-0.22	-0.025	-0.12	0.001	0.01	-0.154	-1.13
Leicester	-0.336	-0.93	0.215	1.33	0.112	0.80	-0.192	-0.50
Nottingham	-0.208	-1.03	-0.514	-1.02	-0.065	-0.46	-0.040	-0.15
Bristol	0.272	1.39	0.268	1.93	0.153	1.66	0.207	0.56
Glasgow	0.188	0.66	-0.112	-1.15	0.041	0.62	0.072	0.53
Edinburgh	0.032	0.15	-0.081	-0.99	0.078	1.60	0.154	1.20
Cardiff	-0.200	-0.71	0.069	0.83	-0.003	-0.05	-0.046	-0.31
Time trend	0.031	2.40	0.010	1.36	0.015	1.43	0.001	0.09
Dummy 2008-12	-0.093	-1.07	-0.034	-0.52	-0.096	-2.00	0.033	0.48

The result obtained for the second of our X_{it} variable shows that higher firm age is significantly related to lower TFP, especially in all the manufacturing and low-tech KI service sectors; in other service sectors, there is no significant relationship between age and TFP. A negative coefficient is precisely what would be expected if older firms are less likely to employ the latest technology. The coefficient obtained for the third variable in X_{it} shows that single-plant dummy is positive and statistically significant for the high-tech manufacturing and medium low-tech manufacturing sectors, but not significant for the other 6 industries. This offers some evidence to suggest that single-plant enterprises derive greater efficiency benefits from "their leaner organizational structure that allows them to take strategic actions to exploit emerging market opportunities and to create a market niche position for themselves" (Dhawan, 2001:271).

In terms of the fourth variable included in X_{it}, tables 5.5 and 5.6 show that we obtain the expected positive relationship between multi-region dummy and TFP. The coefficient on the multi-region dummy is statistically significant for the medium low-tech manufacturing and other low-tech KI service sectors, suggesting that there are positive productivity effects associated with locating firms near markets and suppliers in these sectors (e.g., Fujita et al., 1999). The coefficient obtained on the fifth X_{it} variable - Herfindahl index - is only statistically significant in medium low-tech manufacturing where it is negative. This suggests that greater level of competition in the medium low-tech manufacturing industry requires that firms operate more efficiently. This result is in line with the view of Nickell (1996), who suggests that by facing an increasing number of competitors in their industries, firms might be more inclined to undertake measures aimed at improving their TFP.

With regards to the sixth variable included in X_{it}, tables 5.5 and 5.6 show that most of the coefficients on our foreign-ownership dummies are generally positive except for high-tech manufacturing and other low-tech KI service sectors. However, most of these coefficients are poorly determined across sectors, apart from the low-tech KI service sector; thus, only in the latter sector is there any evidence that multinational enterprises operate with better management and/or marketing capabilities that make them more efficient than domestic firms. Turning to the regional dummies, our result shows that the impact on TFP of being in a government office region is generally negative (with South-East as the benchmark region). The coefficients associated with the regional dummies are economically significant in at least one industrial sector, except for firms located in the Tyneside region. Overall, and based on taking average ranking across the 8 industrial sectors in tables 5.5 and 5.6, firms located in Wales experienced the largest negative impact on TFP (e.g., around 5% and 32% lower in low -tech manufacturing and high-tech KI service sectors respectively).

In contrast, the parameter estimates on city dummies are generally positive, however these estimates are poorly determined.

Lastly, tables 5.5 and 5.6 shows that UK firms experienced significant TFP boost from positive (exogeneous) technical improvements. This is indicated by the statistically significant and positive coefficients for the time trend variable in all the manufacturing and high-tech KI service sectors. The exogenous technical change was highest in high-tech KI service sector (at around a 3.1% per annum increase in TFP), while the manufacturing sectors also experienced significant boosts from the use of new technology (around 1.5% to 2.8% per annum). These results are broadly in line with those found in Harris and Moffat (2011). However, we find no evidence of a slowdown in TFP improvement since 2007 – i.e., the UK productivity puzzle in Harris and Moffat (2016a). This is indicated by the statistically insignificant coefficients on the 2008-12 dummy variable in all sectors except for low-tech KI service sector.

5.5 Summary and Conclusion

This chapter has sought to establish the existence of a causal impact of firm adjustment on TFP. In contrast to our hypotheses (hypotheses 3 and 4 in chapter two), no statistically significant long-run effect of adjustment paths on TFP was identified for any of the industries considered (except for plant closure in the high-tech KI service sector). However, the theoretical ideas that were used to construct hypotheses 3 and 4 fail to consider long-run productivity effects of firm's expansion and contraction, focusing instead on short-run effects.

In order to highlight the potential problem from ignoring the dynamic relation between firm adjustment and productivity (and ignoring fixed-effects, selection bias due to firm entry and exit and, endogeneity of factor inputs in a production function), we use the following estimators: OLS, fixed-effects, and Levinsohn-Petrin. The unreasonably low estimates of capital coefficients (and low factor elasticities produced by OLS and fixed-effects) suggests that there are methodological issues (explained in section 5.3) that arises from using these estimators. In light of the poor performance of these estimators, it would seem that the system GMM estimator is to be preferred because of its theoretical advantage. Under the assumption that 'internal' instruments are valid, the system GMM estimator should produce unbiased and consistent estimates. Indeed, the system GMM results indicate that the estimates obtained are economically sensible since they pass our specification tests – the Hansen J test of over-identifying restrictions and the AR(2) second-order serial correlation tests – pointing therefore, to the validity of instrument set adopted. The reasonable estimates of factor elasticities produced by system GMM is also indicative of its improvement on OLS, fixed-effects, and Levinsohn-Petrin.

Although the system GMM estimator is unlikely to solve all endogeneity problems, it remains the “gold standard” for consistently identifying the impact of an independent variable on a dependent variable, in the absence of natural experiments or ‘external’ instruments. Therefore, providing economic justification for the use of system GMM in corporate finance and industrial economic research is one of our major contribution to literature. Another novelty in this chapter is that we use appropriate control groups to study the impact of firm adjustment on productivity. Thus, we view our finding of no long-run adjustment effect as novel, given our choice of appropriate control groups and the fact that we use the system GMM approach to alleviate endogeneity concerns that may arise from studying the impact of firm adjustment on productivity.

5.6 Appendix

Table 5-7: System GMM production function estimation 1997-2012, Manufacturing

Variables	High-tech	z-value	Med High-tech	z-value	Med Low-tech	z-value	Low-tech	z-value
ln Intermediate inputs	0.654	5.52	0.677	9.30	0.758	13.11	0.526	3.92
ln Employment	0.243	1.91	0.206	1.95	0.114	1.27	0.298	2.74
ln Capital	0.093	1.70	0.105	1.67	0.060	1.83	0.223	2.47
Time trend	0.028	2.83	0.015	2.24	0.022	4.63	0.019	1.83
R&D band 2	0.104	0.15	-0.503	-1.20	-0.107	-1.15	0.115	0.60
R&D band 3	-0.165	-0.22	0.267	1.23	-0.146	-3.15	0.275	1.55
R&D band 4	0.067	0.51	-0.097	-1.23	0.064	1.34	0.212	1.89
R&D band 5	0.177	1.55	0.012	0.18	0.128	2.21	0.121	0.92
ln Age	-0.140	-1.79	-0.116	-1.73	-0.081	-1.85	-0.307	-2.62
Single-plant firm	0.080	2.01	0.015	0.82	0.037	1.77	0.045	0.83
Multi-region firm	0.057	1.12	0.008	0.34	0.045	1.81	0.031	0.72
UK-Owned	-0.027	-0.50	0.045	1.88	0.020	0.77	0.033	0.60
SE Asia-Owned	-0.061	-0.35	-0.025	-0.40	0.005	0.06	-0.107	-0.82
EU-Owned	-0.015	-0.18	0.050	1.23	-0.022	-0.56	0.048	0.57
USA-Owned	-0.015	-0.17	0.037	1.00	0.052	1.22	0.094	1.13
AUSCANSA-Owned	-0.005	-0.06	0.085	1.62	0.000	0.00	0.051	0.50
Other Foreign-Owned	-0.079	-0.93	-0.015	-0.26	-0.038	-0.79	-0.156	-1.17
ln Herfindahl	0.007	0.30	0.001	0.13	-0.025	-2.68	-0.010	-0.69
Manchester Dum	-0.017	-0.13	0.211	2.28	0.044	0.46	0.054	0.45
Birmingham Dum	-0.194	-1.24	0.032	0.75	0.003	0.06	0.068	0.66
Glasgow Dum	-0.038	-0.33	0.147	1.52	-0.010	-0.08	0.070	1.11
Tyneside Dum	0.094	0.59	0.111	1.46	0.002	0.02	-0.022	-0.18
Edinburgh Dum	-0.049	-0.38	-0.164	-1.78	0.165	1.35	0.179	1.90
Bristol Dum	0.284	1.61	0.105	1.36	-0.185	-3.02	0.017	0.21
Cardiff Dum	-0.043	-0.21	0.073	0.60	0.037	0.63	-0.166	-1.10
Liverpool Dum	-0.001	0.00	-0.057	-1.05	0.076	0.28	0.140	1.44
Nottingham Dum	0.273	1.38	-0.004	-0.06	0.130	1.04	0.055	0.31
Leicester Dum	-0.012	-0.11	-0.042	-0.50	-0.098	-1.14	0.185	1.21
Coventry Dum	-0.068	-0.41	-0.068	-0.92	-0.005	-0.10	-0.024	-0.20
North East	-0.112	-0.72	-0.117	-1.84	-0.032	-0.62	-0.053	-0.66

Variables	High-tech	z-value	Med High-tech	z-value	Med Low-tech	z-value	Low-tech	z-value
Yorks-Humberside	0.060	0.72	-0.042	-1.33	-0.053	-1.20	-0.038	-1.02
North West	-0.013	-0.21	-0.083	-2.26	-0.066	-1.78	-0.123	-2.57
West Midlands	0.065	0.49	-0.050	-1.43	-0.058	-1.62	-0.054	-0.86
East Midlands	-0.092	-1.76	-0.062	-1.94	-0.023	-0.59	-0.080	-1.65
South West	-0.053	-0.88	-0.054	-1.71	-0.013	-0.31	-0.033	-0.75
Eastern	-0.047	-0.86	-0.047	-1.74	-0.020	-0.57	-0.052	-1.36
London	0.125	1.45	-0.057	-1.60	-0.067	-0.89	0.194	2.17
Scotland	-0.043	-0.61	-0.041	-1.17	0.058	1.34	-0.099	-1.99
Wales	-0.084	-1.00	-0.069	-2.16	-0.053	-1.40	-0.048	-0.84
Northern Ireland	-0.149	-0.90	-0.114	-1.43	-0.038	-0.60	-0.042	-0.48
Internal expansion$_{LR}$	-0.080	-0.49	-0.032	-0.68	-0.048	-1.26	-0.277	-1.09
Greenfield investment$_{LR}$	0.048	0.40	0.009	0.18	-0.057	-1.01	-0.099	-1.22
Mergers and acquisition$_{LR}$	0.163	1.25	-0.007	-0.17	0.043	0.55	0.118	1.14
Internal contraction$_{LR}$	0.029	0.21	-0.048	-1.38	-0.056	-1.38	0.081	0.80
Plant closure$_{LR}$	0.014	0.12	0.021	0.45	0.016	0.44	0.005	0.05
Plant sale$_{LR}$	0.114	0.67	0.045	0.93	0.031	0.61	-0.090	-0.75
Internal expansion$_{t-1}$	0.024	0.26	0.089	1.51	0.020	0.70	0.103	2.31
Greenfield investment$_{t-1}$	-0.334	-2.13	0.135	0.63	-0.065	-0.29	-0.079	-0.51
Mergers and acquisition$_{t-1}$	-0.137	-0.27	-0.210	-1.04	0.235	1.54	0.098	0.32
Internal contraction$_{t-1}$	-0.015	-0.19	-0.023	-0.50	0.054	1.58	-0.019	-0.39
Plant closure$_{t-1}$	-0.001	-0.03	0.124	1.11	0.118	1.55	0.166	1.06
Plant sale$_{t-1}$	-0.449	-0.94	0.114	0.26	0.489	1.48	-0.257	-0.51
Dummy 2008-12	-0.015	-0.34	0.010	0.39	-0.030	-1.26	0.001	0.04
Intercept	2.421	3.40	2.518	4.53	2.151	5.12	3.796	3.67
Industry 2-digit SIC92 dummies	Yes		Yes		Yes		Yes	
AR(1) z-statistic	-3.68		-4.24		-4.96		-4.21	
AR(1) z-statistic p-value	0.00		0.00		0.00		0.00	
AR(2) z-statistic	0.75		-1.43		-0.57		0.61	
AR(2) z-statistic p-value	0.45		0.15		0.57		0.55	
Hansen test	108.70		85.22		214.70		94.00	
Hansen test p-value	0.20		0.32		0.80		0.65	
Number of observations	5,885		16,033		16,113		24,071	
Number of firms	2,111		5,614		6,751		9,024	

Table 5-8: System GMM production function estimation 1997-2012, Services

Variables	High-tech KI	z-value	KI	z-value	Low-tech KI	z-value	Other low-tech KI	z-value
Intermediate inputs	0.563	5.51	0.527	5.92	0.620	6.38	0.750	8.06
Employment	0.402	2.52	0.463	3.71	0.219	1.83	0.223	1.65
Capital	0.149	1.94	0.030	2.11	0.188	2.78	0.004	0.41
Time trend	0.031	2.40	0.010	1.36	0.015	1.43	0.001	0.09
randd2	0.150	0.21	-0.093	-0.09	-0.118	-0.23	-1.318	-0.88
randd3	-0.257	-0.94	0.036	0.06	0.103	0.43	0.406	0.84
randd4	0.047	0.33	0.005	0.03	0.029	0.12	0.260	0.85
randd5	-0.039	-0.20	-0.059	-0.39	0.155	0.63	0.070	0.26
Age	-0.252	-1.63	-0.064	-0.99	-0.393	-2.76	-0.047	-0.81
Single plant	0.119	1.59	0.021	0.32	-0.010	-0.32	0.086	1.17
Multi-region firm	0.001	0.01	0.073	1.18	0.046	0.96	0.180	1.99
UK-Owned	-0.080	-0.75	0.188	1.16	0.186	1.62	0.269	1.00
SE Asia-Owned	0.168	0.79	1.569	1.82	0.361	2.29	-0.038	-0.15
EU-Owned	0.024	0.21	0.185	0.94	0.164	1.91	0.152	0.67
USA-Owned	0.066	0.56	0.282	1.50	0.172	2.01	-0.041	-0.08
AUSCANSA-Owned	0.009	0.02	0.259	0.88	0.119	0.80	-0.077	-0.27
Other FO-Owned	-0.148	-0.32	0.336	1.59	0.118	0.90	-0.237	-1.08
Herfindahl	-0.004	-0.17	0.017	1.00	0.012	0.85	0.010	0.56
Manchester Dum	0.124	0.45	0.153	0.97	0.041	0.58	-0.430	-0.64
Birmingham Dum	0.560	2.22	-0.030	-0.23	-0.100	-1.34	-0.182	-1.54
Glasgow Dum	0.188	0.66	-0.112	-1.15	0.041	0.62	0.072	0.53
Tyneside Dum	-0.103	-0.20	-0.134	-0.97	0.129	1.42	-0.156	-0.90
Edinburgh Dum	0.032	0.15	-0.081	-0.99	0.078	1.60	0.154	1.20
Bristol Dum	0.272	1.39	0.268	1.93	0.153	1.66	0.207	0.56
Cardiff Dum	-0.200	-0.71	0.069	0.83	-0.003	-0.05	-0.046	-0.31
Liverpool Dum	-0.242	-0.76	-0.029	-0.23	0.009	0.08	0.072	0.12
Nottingham Dum	-0.208	-1.03	-0.514	-1.02	-0.065	-0.46	-0.040	-0.15
Leicester Dum	-0.336	-0.93	0.215	1.33	0.112	0.80	-0.192	-0.50
Coventry Dum	-0.060	-0.22	-0.025	-0.12	0.001	0.01	-0.154	-1.13
North East	-0.268	-1.22	0.049	0.53	-0.166	-3.22	0.109	0.95
Yorks-Humberside	-0.021	-0.17	-0.004	-0.05	-0.041	-0.91	-0.014	-0.15
North West	-0.129	-0.67	-0.057	-0.94	-0.087	-2.54	-0.137	-1.50

Variables	High-tech KI	z-value	KI	z-value	Low-tech KI	z-value	Other low-tech KI	z-value
West Midlands	-0.350	-2.70	-0.078	-0.83	-0.094	-2.29	0.054	0.47
East Midlands	0.018	0.12	-0.094	-1.02	-0.107	-2.35	-0.128	-1.46
South West	-0.221	-1.33	-0.095	-1.22	-0.065	-1.90	0.048	0.49
Eastern	-0.008	-0.07	0.060	0.92	-0.035	-1.04	0.125	1.42
London	0.030	0.36	0.242	4.13	0.140	2.59	0.098	1.09
Scotland	-0.180	-1.04	0.023	0.30	-0.081	-2.65	-0.033	-0.44
Wales	-0.379	-2.32	-0.097	-1.08	-0.081	-1.73	-0.076	-0.78
Northern Ireland	0.193	0.66	0.049	0.15	0.742	2.46	-0.052	-0.22
Internal expansion$_{LR}$	0.111	0.41	0.292	1.05	0.181	1.15	-0.054	-0.24
Greenfield investment$_{LR}$	0.060	0.22	-0.021	-0.09	-0.185	-1.29	0.003	0.01
Mergers and acquisition$_{LR}$	0.046	0.22	-0.104	-0.64	-0.022	-0.20	-0.157	-0.47
Internal contraction$_{LR}$	-0.129	-0.59	-0.134	-1.06	0.085	0.84	0.077	0.74
Plant closure$_{LR}$	-0.436	-2.92	-0.075	-0.54	0.123	1.44	-0.460	-1.47
Plant sale$_{LR}$	-0.218	-0.59	0.177	0.63	0.152	1.40	0.340	1.31
Internal expansion$_{t-1}$	0.296	2.70	-0.046	-0.37	-0.004	-0.03	0.020	0.31
Greenfield investment$_{t-1}$	0.010	0.05	0.322	1.70	0.234	1.50	-0.084	-0.34
Mergers and acquisition$_{t-1}$	-0.109	-0.36	-0.480	-0.73	0.092	0.18	-0.373	-0.52
Internal contraction$_{t-1}$	-0.023	-0.22	-0.017	-0.16	-0.038	-0.22	-0.078	-0.80
Plant closure$_{t-1}$	-0.364	-1.69	-0.173	-0.78	0.090	0.48	-0.080	-0.21
Plant sale$_{t-1}$	-0.323	-0.58	1.058	0.69	0.193	0.20	0.122	0.18
Dummy 2008-12	-0.093	-1.07	-0.034	-0.52	-0.096	-2.00	0.033	0.48
Intercept	2.979	3.54	2.650	5.45	3.284	5.51	1.808	4.55
Industry 2-digit SIC92 dummies	Yes		Yes		Yes		Yes	
AR(1) z-statistic	-3.59		-3.66		-3.41		-3.54	
AR(1) z-statistic p-value	0.00		0.00		0.00		0.00	
AR(2) z-statistic	1.50		0.65		0.63		-0.38	
AR(2) z-statistic p-value	0.13		0.52		0.53		0.70	
Hansen test	137.40		66.76		159.50		199.00	
Hansen test p-value	0.99		0.84		0.78		0.92	
Number of observations	6,584		12,219		74,293		8,121	
Number of firms	3,012		6,499		35,489		3,942	

Table 5-9: OLS production function estimation 1997-2012, Manufacturing

Variables	High-tech	t-value	Med. high-tech	t-value	Med. low-tech	t-value	Low-tech	t-value
ln Intermediate inputs	0.210	8.32	0.182	11.65	0.201	10.37	0.190	9.27
ln Employment	0.408	13.33	0.386	17.71	0.333	13.82	0.322	11.74
ln Capital	0.004	1.08	0.011	2.95	0.006	2.36	0.011	4.09
Time trend	-0.022	-0.31	0.020	0.58	0.031	0.77	0.033	1.79
R&D band 2	-0.046	-0.34	0.006	0.30	-0.014	-0.62	0.053	2.43
R&D band 3	0.030	1.22	-0.010	-0.63	-0.009	-0.54	0.034	2.11
R&D band 4	0.067	3.75	-0.002	-0.16	0.028	1.49	0.029	2.17
R&D band 5	0.018	5.01	0.013	5.83	0.014	6.98	0.008	4.10
ln Age	-0.001	-0.10	-0.027	-3.19	-0.028	-4.14	-0.027	-3.87
Single-plant firm	-0.034	-1.58	0.032	2.50	0.006	0.33	0.030	1.73
Multi-region firm	-0.008	-0.24	0.008	0.42	0.043	1.12	0.006	0.27
UK-Owned	-0.058	-1.47	0.037	2.92	0.041	2.08	0.031	1.61
SE Asia-Owned	0.021	0.84	0.028	2.27	0.066	2.62	0.042	1.99
EU-Owned	-0.075	-1.63	0.046	2.00	0.071	1.27	0.076	1.62
USA-Owned	-0.041	-0.94	-0.002	-0.04	0.056	2.28	-0.086	-1.35
AUSCANSA-Owned	0.055	2.54	0.019	1.76	0.012	1.04	0.038	3.27
Other Foreign-Owned	0.062	2.49	0.005	0.27	0.026	2.01	0.034	2.67
ln Herfindahl	0.012	0.82	0.003	0.64	-0.016	-3.04	-0.005	-0.96
Manchester Dum	-0.051	-0.63	0.126	2.03	0.027	0.78	0.002	0.05
Birmingham Dum	-0.071	-1.58	0.018	0.75	-0.018	-0.69	0.056	1.45
Glasgow Dum	0.036	0.82	0.073	2.09	0.030	0.76	0.031	0.72
Tyneside Dum	0.151	2.09	0.067	1.25	0.041	1.27	-0.083	-1.70
Edinburgh Dum	-0.014	-0.23	-0.102	-1.60	0.094	1.69	0.113	2.45
Bristol Dum	0.168	1.38	0.062	1.70	-0.083	-1.98	0.042	1.99
Cardiff Dum	0.098	1.02	0.034	0.56	0.021	0.62	-0.049	-0.65
Liverpool Dum	-0.053	-0.63	-0.031	-0.88	0.085	0.84	0.021	0.59
Nottingham Dum	0.449	1.53	0.004	0.11	0.058	0.82	-0.021	-0.62
Leicester Dum	0.051	0.55	-0.050	-1.07	-0.163	-1.48	0.066	1.70
Coventry Dum	0.072	1.61	-0.012	-0.23	0.009	0.38	0.003	0.08
North East	-0.153	-3.74	-0.082	-1.69	-0.035	-1.50	-0.029	-1.25

Variables	High-tech	t-value	Med. high-tech	t-value	Med. low-tech	t-value	Low-tech	t-value
Yorks-Humberside	-0.022	-0.52	-0.040	-2.12	-0.033	-1.31	-0.023	-1.30
North West	0.010	0.32	-0.076	-3.10	-0.040	-1.90	-0.058	-1.73
West Midlands	-0.038	-1.30	-0.066	-3.48	-0.041	-2.30	-0.058	-2.56
East Midlands	-0.070	-2.42	-0.058	-3.23	-0.013	-0.60	-0.058	-2.39
South West	-0.033	-1.09	-0.058	-3.29	-0.025	-1.24	-0.034	-1.80
Eastern	-0.019	-0.72	-0.034	-1.90	-0.016	-0.84	-0.045	-2.12
London	0.058	1.76	-0.061	-2.75	-0.084	-1.48	0.013	0.58
Scotland	-0.037	-1.37	-0.037	-2.05	0.015	0.69	-0.068	-3.92
Wales	-0.066	-2.06	-0.048	-2.97	-0.035	-1.91	-0.055	-3.07
Northern Ireland	-0.014	-0.20	-0.050	-1.29	-0.020	-0.63	-0.023	-0.83
Internal expansion$_{LR}$	0.010	0.56	-0.012	-1.13	0.002	0.24	0.011	1.08
Greenfield investment$_{LR}$	0.036	1.72	0.017	1.10	0.003	0.23	-0.009	-0.45
Mergers and acquisition$_{LR}$	-0.014	-0.61	0.012	1.08	-0.002	-0.10	0.027	2.42
Internal contraction$_{LR}$	-0.053	-3.49	-0.031	-2.79	-0.034	-3.47	-0.016	-1.53
Plant closure$_{LR}$	-0.070	-2.06	-0.040	-3.32	-0.041	-3.02	-0.044	-2.38
Plant sale$_{LR}$	0.021	0.85	-0.045	-1.55	-0.166	-1.75	-0.069	-2.66
Internal expansion$_{t-1}$	0.067	3.96	0.072	8.48	0.061	6.63	0.054	5.12
Greenfield investment$_{t-1}$	-0.092	-1.09	0.023	0.87	-0.047	-0.65	-0.186	-2.12
Mergers and acquisition$_{t-1}$	0.057	1.27	0.020	1.11	0.068	2.62	0.048	1.28
Internal contraction$_{t-1}$	-0.030	-1.46	-0.023	-2.77	-0.037	-4.07	-0.066	-2.69
Plant closure$_{t-1}$	-0.038	-1.54	-0.001	-0.05	-0.039	-1.38	-0.061	-1.74
Plant sale$_{t-1}$	-0.011	-0.23	-0.013	-0.31	-0.063	-1.52	-0.063	-1.90
Dummy 2008-12	-0.002	-0.08	-0.020	-1.02	-0.050	-2.50	0.001	0.07
Intercept	1.016	9.51	1.052	14.02	1.106	9.98	0.956	9.43
Industry 2-digit SIC92 dummies	Yes		Yes		Yes		Yes	
R-squared	0.968		0.963		0.947		0.949	
Number of observations	5,885		16,033		16,113		24,071	
Number of firms	2,111		5,614		6,751		9,024	

Table 5-10: OLS production function estimation 1997-2012, Services

Variables	High-tech KI	t-value	KI	t-value	Low-tech KI	t-value	Other low-tech KI	t-value
ln Intermediate inputs	0.085	6.52	0.081	6.52	0.082	10.56	0.111	6.71
ln Employment	0.193	11.19	0.192	11.30	0.269	14.87	0.211	9.11
ln Capital	0.003	0.92	0.003	0.95	-0.001	-0.54	-0.001	-0.49
Time trend	-0.011	-0.11	-0.013	-0.43	0.051	2.01	0.283	0.74
R&D band 2	-0.021	-0.30	0.026	0.81	0.022	0.98	0.147	1.22
R&D band 3	0.009	0.23	0.034	0.84	-0.016	-0.63	0.132	2.26
R&D band 4	0.038	1.66	-0.039	-1.02	0.071	2.52	0.069	0.58
R&D band 5	0.008	2.00	0.006	2.01	-0.001	-1.14	-0.007	-1.72
ln Age	-0.015	-1.14	-0.009	-0.89	-0.015	-3.95	-0.026	-2.35
Single-plant firm	-0.077	-2.00	0.041	1.30	0.004	0.23	0.057	0.76
Multi-region firm	0.106	0.97	0.508	1.86	0.049	2.14	-0.008	-0.17
UK-Owned	0.036	0.75	-0.026	-0.35	0.019	1.69	0.108	1.62
SE Asia-Owned	-0.007	-0.17	-0.021	-0.44	0.040	2.36	0.378	0.77
EU-Owned	-0.138	-0.99	0.165	1.70	0.049	1.20	0.176	1.13
USA-Owned	-0.358	-1.57	0.090	1.18	-0.050	-0.87	-0.092	-2.09
AUSCANSA-Owned	0.065	2.14	0.031	2.49	0.022	3.62	0.044	2.00
Other Foreign-Owned	0.032	0.97	0.025	1.19	0.002	0.30	0.040	1.28
ln Herfindahl	0.005	0.58	0.010	1.58	0.000	-0.16	0.018	2.28
Manchester Dum	0.074	0.85	0.078	0.89	0.021	1.02	-0.256	-0.97
Birmingham Dum	0.187	2.55	-0.069	-0.94	-0.056	-1.90	0.001	0.03
Glasgow Dum	0.119	0.97	-0.078	-2.20	-0.021	-1.03	0.073	1.47
Tyneside Dum	0.092	0.35	-0.094	-1.76	0.081	2.26	-0.056	-1.02
Edinburgh Dum	-0.018	-0.30	-0.044	-1.19	0.010	0.42	0.091	1.90
Bristol Dum	0.116	1.84	0.068	1.78	0.045	1.47	-0.043	-0.33
Cardiff Dum	-0.071	-0.89	0.039	1.26	0.000	0.00	-0.004	-0.06
Liverpool Dum	-0.021	-0.12	-0.014	-0.20	0.027	0.72	-0.168	-0.39
Nottingham Dum	-0.015	-0.17	-0.332	-1.14	-0.037	-0.73	-0.018	-0.23
Leicester Dum	0.027	0.19	0.026	0.33	0.086	1.12	-0.152	-0.54
Coventry Dum	0.050	0.36	-0.081	-0.83	-0.030	-0.65	-0.033	-0.36
North East	-0.118	-0.55	0.057	1.63	-0.074	-3.88	0.080	1.93
Yorks-Humberside	-0.027	-0.64	-0.003	-0.16	-0.027	-2.16	0.037	1.17
North West	-0.021	-0.54	-0.018	-0.78	-0.027	-2.34	0.017	0.48

Variables	High-tech KI	t-value	KI	t-value	Low-tech KI	t-value	Other low-tech KI	t-value
West Midlands	-0.152	-2.64	-0.020	-0.50	-0.042	-2.96	0.026	0.72
East Midlands	-0.027	-0.84	-0.017	-0.48	-0.058	-4.14	-0.026	-0.70
South West	-0.068	-1.51	-0.018	-0.68	-0.015	-1.33	0.052	1.47
Eastern	-0.032	-0.96	0.027	1.03	-0.018	-1.80	0.081	2.47
London	-0.028	-0.93	0.075	3.32	0.025	2.32	0.077	2.51
Scotland	-0.067	-1.43	0.034	1.50	-0.026	-2.54	0.022	0.58
Wales	-0.121	-3.00	0.005	0.21	-0.031	-2.98	-0.012	-0.34
Northern Ireland	0.092	0.82	0.020	0.20	-0.007	-0.23	0.019	0.32
Internal expansion$_{LR}$	0.008	0.36	0.006	0.47	0.004	0.64	-0.013	-0.71
Greenfield investment$_{LR}$	-0.003	-0.10	0.029	1.42	0.010	1.16	-0.002	-0.08
Mergers and acquisition$_{LR}$	-0.002	-0.06	0.011	0.25	0.026	1.77	0.035	0.48
Internal contraction$_{LR}$	-0.038	-1.93	-0.024	-2.04	-0.025	-4.92	-0.002	-0.10
Plant closure$_{LR}$	-0.116	-3.48	-0.076	-3.13	-0.034	-3.41	-0.071	-2.22
Plant sale$_{LR}$	0.100	0.72	-0.059	-0.54	-0.091	-2.99	0.090	0.88
Internal expansion$_{t-1}$	0.104	3.77	0.063	2.59	0.055	7.43	0.046	1.68
Greenfield investment$_{t-1}$	0.020	0.22	0.062	2.09	0.048	2.15	-0.015	-0.21
Mergers and acquisition$_{t-1}$	0.270	2.44	-0.146	-1.59	0.080	1.72	-0.024	-0.29
Internal contraction$_{t-1}$	-0.094	-2.77	-0.019	-1.03	0.001	0.05	-0.012	-0.56
Plant closure$_{t-1}$	-0.022	-0.39	-0.098	-2.02	-0.005	-0.29	-0.153	-1.40
Plant sale$_{t-1}$	-0.005	-0.04	-0.672	-1.12	0.025	0.28	0.041	0.48
Dummy 2008-12	-0.015	-0.43	-0.035	-1.41	0.007	0.70	0.041	1.18
Intercept	0.433	4.22	0.547	5.96	0.429	9.63	0.546	4.77
Industry 2-digit SIC92 dummies	Yes		Yes		Yes		Yes	
R-squared	0.937		0.933		0.957		0.906	
Number of observations	6,584		12,219		74,293		8,121	
Number of firms	3,012		6,499		35,489		3,942	

Table 5-11: Fixed-effects production function estimation 1997-2012, Manufacturing

Variables	High-tech	t-value	Med. high-tech	t-value	Med. low-tech	t-value	Low-tech	t-value
ln Intermediate inputs	0.204	4.35	0.333	11.34	0.422	8.31	0.319	20.96
ln Employment	0.438	8.93	0.416	11.93	0.403	10.83	0.355	30.31
ln Capital	0.031	2.41	0.010	1.70	0.008	1.55	0.004	2.16
Time trend	0.098	1.17	0.101	2.34	-0.005	-0.17	0.029	1.32
R&D band 2	0.038	0.91	0.069	2.28	0.015	0.71	0.023	1.62
R&D band 3	-0.027	-0.68	0.033	2.16	0.013	0.71	0.016	1.60
R&D band 4	0.008	0.34	0.025	2.13	0.037	2.33	0.033	3.53
R&D band 5	0.029	4.98	0.013	5.09	0.008	1.98	0.002	1.32
ln Age	-0.050	-1.76	-0.024	-1.61	-0.059	-3.23	0.023	3.05
Single-plant firm	0.000	0.00	-0.016	-1.36	0.001	0.10	0.000	-0.03
Multi-region firm	-0.126	-2.32	-0.031	-1.09	0.038	0.86	0.004	0.15
UK-Owned	0.015	0.33	0.027	1.49	-0.009	-0.48	0.007	0.56
SE Asia-Owned	-0.039	-0.89	0.012	0.70	0.025	1.19	-0.010	-0.67
EU-Owned	-0.066	-0.80	-0.041	-0.79	0.018	0.50	-0.010	-0.34
USA-Owned	0.011	0.13	0.040	0.64	0.008	0.26	0.004	0.17
AUSCANSA-Owned	0.040	1.18	-0.002	-0.12	0.028	1.96	0.056	7.05
Other Foreign-Owned	0.022	0.72	-0.002	-0.13	0.015	1.00	0.014	1.85
ln Herfindahl	0.061	2.99	0.007	0.78	0.026	1.98	0.007	1.64
Manchester Dum	-0.621	-2.05	-0.344	-1.22	2.722	1.11	-0.079	-0.86
Birmingham Dum	-0.223	-0.57	0.371	1.37	-0.067	-0.62	-0.040	-0.50
Glasgow Dum	0.129	0.48	-0.228	-0.87	0.061	0.55	0.060	0.55
Tyneside Dum	0.582	0.69	0.015	0.08	-0.295	-0.97	-0.053	-0.53
Edinburgh Dum	0.003	0.02	-0.393	-2.01	0.889	2.85	-0.008	-0.05
Bristol Dum	0.060	0.61	0.686	2.55	-0.012	-0.06	-0.021	-0.37
Cardiff Dum	-0.154	-0.71	-0.002	-0.01	0.195	0.91	-0.039	-0.28
Liverpool Dum	-0.028	-0.08	0.171	0.90	-0.175	-1.97	0.059	0.55
Nottingham Dum	-0.053	-0.16	-0.138	-0.95	0.497	0.84	0.053	0.48
Leicester Dum	0.376	0.69	0.059	0.28	0.309	2.36	-0.005	-0.04
Coventry Dum	0.581	1.06	0.084	1.43	-0.039	-0.13	-0.132	-1.25
North East	-0.289	-1.51	-0.158	-1.24	0.042	0.46	0.034	0.64
Yorks-Humberside	-0.004	-0.02	-0.132	-1.14	0.188	1.20	0.071	1.32
North West	-0.106	-0.69	-0.176	-1.60	-0.265	-1.50	0.009	0.17

Variables	High-tech	t-value	Med. high-tech	t-value	Med. low-tech	t-value	Low-tech	t-value
West Midlands	-0.245	-1.40	-0.267	-2.27	0.053	1.12	-0.035	-0.73
East Midlands	-0.296	-1.57	-0.164	-1.53	0.064	0.73	0.060	1.16
South West	-0.122	-1.00	-0.164	-1.66	0.040	0.41	0.032	0.70
Eastern	-0.052	-0.58	-0.101	-1.03	0.060	0.68	0.048	1.02
London	0.043	0.13	-0.021	-0.21	0.168	1.30	0.050	0.83
Scotland	0.071	0.50	-0.040	-0.23	0.075	0.71	-0.048	-0.60
Wales	-0.078	-0.55	-0.071	-0.68	-0.033	-0.39	-0.033	-0.50
Northern Ireland	0.127	0.39	-0.450	-1.72	-0.370	-0.71	-0.091	-0.63
Internal expansion$_{LR}$	-0.019	-0.66	-0.029	-2.39	0.009	0.48	-0.028	-4.11
Greenfield investment$_{LR}$	-0.012	-0.36	-0.002	-0.06	0.019	0.84	0.010	0.87
Mergers and acquisition$_{LR}$	0.053	1.22	0.024	1.12	0.040	1.33	0.050	4.01
Internal contraction$_{LR}$	-0.030	-1.66	-0.020	-1.77	0.024	1.12	-0.008	-1.09
Plant closure$_{LR}$	-0.118	-2.80	0.008	0.53	0.016	0.63	-0.002	-0.18
Plant sale$_{LR}$	0.024	0.43	-0.072	-1.84	-0.112	-1.06	-0.043	-1.90
Internal expansion$_{t-1}$	0.041	2.70	0.063	7.09	0.069	6.49	0.062	13.95
Greenfield investment$_{t-1}$	-0.079	-1.88	0.033	1.82	0.037	1.81	0.048	4.97
Mergers and acquisition$_{t-1}$	0.004	0.10	0.001	0.04	0.029	1.23	0.058	3.93
Internal contraction$_{t-1}$	-0.015	-0.93	-0.020	-2.31	-0.012	-1.01	-0.027	-4.94
Plant closure$_{t-1}$	-0.057	-2.30	0.007	0.43	-0.010	-0.65	-0.016	-1.74
Plant sale$_{t-1}$	-0.006	-0.13	0.026	0.67	-0.029	-0.58	-0.081	-2.25
Dummy 2008-12	-0.056	-1.99	-0.011	-0.81	-0.040	-2.54	-0.022	-3.16
Intercept	2.503	7.43	2.526	10.80	2.799	11.15	2.338	17.51
Industry 2-digit SIC92 dummies	Yes		Yes		Yes		Yes	
R-squared	0.645		0.638		0.559		0.486	
Number of observations	5,885		16,033		16,113		24,071	
Number of firms	2,111		5,614		6,751		9,024	

Table 5-12: Fixed-effects production function estimation 1997-2012, Services

Variables	High-tech KI	t-value	KI	t-value	Low-tech KI	t-value	Other low-tech KI	t-value
ln Intermediate inputs	0.277	5.78	0.211	5.66	0.289	11.42	0.426	7.40
ln Employment	0.238	7.06	0.250	9.46	0.385	20.20	0.234	5.28
ln Capital	0.001	0.25	0.012	2.80	0.003	0.67	0.002	0.59
Time trend	0.127	0.71	0.048	0.71	0.055	1.90	-0.495	-2.01
R&D band 2	-0.192	-2.84	0.051	0.57	0.001	0.04	0.111	1.11
R&D band 3	-0.076	-0.91	0.017	0.40	0.020	0.77	-0.057	-0.93
R&D band 4	0.005	0.13	0.026	0.58	0.020	0.91	-0.067	-1.32
R&D band 5	-0.002	-0.23	0.009	1.85	-0.005	-2.65	0.001	0.19
ln Age	0.056	1.67	0.035	1.11	0.028	2.16	0.046	1.43
Single-plant firm	-0.027	-0.70	0.054	1.94	-0.014	-0.66	0.255	1.68
Multi-region firm	0.140	1.45	0.095	1.74	-0.017	-0.37	0.003	0.03
UK-Owned	-0.079	-1.92	0.011	0.16	0.014	0.68	0.070	1.19
SE Asia-Owned	-0.188	-2.11	-0.087	-1.63	0.009	0.28	-0.009	-0.16
EU-Owned	0.078	0.81	-0.147	-1.58	0.028	1.20	0.234	0.87
USA-Owned	-0.031	-0.37	-0.022	-0.25	-0.011	-0.28	-0.073	-0.79
AUSCANSA-Owned	0.000	0.01	0.071	2.24	0.051	3.98	0.134	2.87
Other Foreign-Owned	-0.016	-0.43	-0.016	-0.59	0.009	0.73	-0.066	-1.66
ln Herfindahl	0.014	1.16	-0.010	-0.68	0.009	1.42	0.002	0.19
Manchester Dum	-0.585	-0.97	0.145	0.96	-0.269	-1.65	-0.417	-1.68
Birmingham Dum	0.269	1.57	0.125	1.22	-0.132	-0.81	0.032	0.26
Glasgow Dum	0.079	0.36	-0.309	-0.74	0.143	1.02	0.618	2.23
Tyneside Dum	-0.452	-1.41	-0.345	-1.43	0.105	0.69	-0.982	-1.98
Edinburgh Dum	0.689	2.07	1.337	2.27	-0.214	-0.69	-0.015	-0.10
Bristol Dum	0.112	0.31	0.281	0.73	-0.063	-0.71	-0.081	-3.41
Cardiff Dum	1.491	2.88	-0.235	-1.10	-0.183	-1.77	2.204	9.55
Liverpool Dum	-1.453	-1.59	-0.035	-0.17	0.051	0.35	0.499	1.92
Nottingham Dum	0.501	1.73	0.077	0.36	0.059	0.38	-0.121	-0.18
Leicester Dum	-2.694	-1.35	0.488	1.27	0.358	1.80	0.689	0.97
Coventry Dum	0.382	0.78	-0.315	-0.65	-0.189	-1.11	1.342	1.00
North East	-0.050	-0.18	-0.240	-1.30	0.149	1.51	-0.527	-1.75

Variables	High-tech KI	t-value	KI	t-value	Low-tech KI	t-value	Other low-tech KI	t-value
Yorks-Humberside	0.209	0.89	-0.063	-0.25	0.034	0.57	-0.338	-1.26
North West	-0.040	-0.21	-0.118	-0.65	0.051	0.66	0.056	0.28
West Midlands	0.005	0.03	-0.334	-1.67	-0.071	-1.06	-0.346	-1.94
East Midlands	-0.131	-0.49	-0.502	-1.77	0.142	2.32	-0.360	-0.89
South West	-0.365	-1.49	-0.015	-0.08	-0.008	-0.14	-0.004	-0.02
Eastern	-0.003	-0.02	-0.125	-0.61	0.009	0.16	0.018	0.10
London	0.014	0.12	-0.311	-2.08	0.026	0.54	0.064	0.37
Scotland	-0.237	-1.12	-0.573	-2.04	0.069	0.56	-0.162	-0.61
Wales	-0.825	-3.21	0.003	0.02	-0.044	-0.36	-0.621	-1.42
Northern Ireland	8.405	0.92	-0.267	-0.51	-0.137	-0.62	-0.976	-0.35
Internal expansion$_{LR}$	0.066	1.43	-0.049	-2.12	-0.037	-3.36	-0.105	-3.07
Greenfield investment$_{LR}$	0.121	1.83	0.026	0.87	-0.009	-0.55	0.033	0.65
Mergers and acquisition$_{LR}$	0.073	1.23	0.047	1.11	0.066	3.26	0.056	0.89
Internal contraction$_{LR}$	-0.009	-0.23	-0.011	-0.49	-0.004	-0.40	-0.022	-0.80
Plant closure$_{LR}$	-0.012	-0.20	-0.022	-0.53	0.008	0.58	0.082	1.42
Plant sale$_{LR}$	0.268	1.20	0.118	1.19	-0.057	-1.51	-0.076	-0.63
Internal expansion$_{t-1}$	0.085	3.40	0.036	2.38	0.055	7.58	0.077	3.16
Greenfield investment$_{t-1}$	0.052	1.10	0.022	0.85	0.050	3.70	0.115	2.19
Mergers and acquisition$_{t-1}$	0.058	1.47	0.030	0.65	0.068	2.49	0.043	0.61
Internal contraction$_{t-1}$	-0.030	-0.87	-0.023	-1.29	-0.023	-2.45	-0.054	-2.17
Plant closure$_{t-1}$	-0.103	-1.18	-0.042	-1.24	-0.011	-0.75	-0.004	-0.08
Plant sale$_{t-1}$	0.013	0.14	0.029	0.26	-0.187	-2.05	-0.178	-1.16
Dummy 2008-12	0.035	0.83	-0.077	-2.83	-0.011	-1.00	-0.043	-1.23
Intercept	3.244	9.23	2.728	9.03	2.321	16.39	2.084	6.36
Industry 2-digit SIC92 dummies	Yes		Yes		Yes		Yes	
R-squared	0.449		0.556		0.549		0.415	
Number of observations	6,584		12,219		74,293		8,121	
Number of firms	3,012		6,499		35,489		3,942	

Table 5-13: Levinsohn-Petrin production function estimation 1997-2012, Manufacturing

Variables	High-tech	t-value	Med. high-tech	t-value	Med. low-tech	t-value	Low-tech	t-value
ln Intermediate inputs	1.140	5.79	0.699	3.28	0.717	6.06	1.078	7.14
ln Employment	0.311	15.86	0.229	19.41	0.259	27.44	0.228	31.53
ln Capital	0.000	0.00	0.073	1.87	0.047	2.93	0.029	1.28
Time trend	0.030	7.65	0.018	13.78	0.015	9.91	0.011	6.67
R&D band 2	-0.082	-1.20	-0.003	-0.07	0.013	0.35	0.041	1.88
R&D band 3	-0.079	-0.63	-0.025	-1.01	-0.013	-0.54	0.036	2.36
R&D band 4	0.033	1.19	0.006	0.43	0.005	0.39	0.014	1.46
R&D band 5	0.075	5.83	0.015	1.87	0.008	0.61	-0.007	-0.61
ln Age	-0.030	-2.19	-0.050	-6.34	-0.055	-7.67	-0.059	-9.08
Single-plant firm	0.042	1.76	0.008	0.77	0.024	2.41	0.038	3.17
Multi-region firm	0.041	1.72	0.008	0.68	0.017	1.50	0.013	1.27
UK-Owned	-0.011	-0.58	0.037	2.96	0.011	0.76	0.022	1.55
SE Asia-Owned	-0.067	-1.63	-0.055	-2.91	-0.047	-0.95	-0.073	-2.07
EU-Owned	-0.051	-2.26	0.001	0.10	-0.002	-0.21	0.027	2.03
USA-Owned	0.014	0.60	0.034	3.30	0.026	1.63	0.063	3.06
AUSCANSA-Owned	-0.043	-0.47	0.016	0.43	0.030	0.88	0.002	0.04
Other Foreign-Owned	-0.021	-0.40	-0.067	-1.80	0.018	0.47	-0.067	-1.53
ln Herfindahl	0.033	2.21	-0.010	-1.65	-0.007	-1.39	0.009	1.90
Manchester Dum	0.108	0.94	0.056	0.67	0.047	0.93	-0.036	-0.60
Birmingham Dum	-0.100	-1.50	-0.015	-0.74	-0.006	-0.23	0.101	2.53
Glasgow Dum	0.038	0.51	0.070	1.32	0.045	0.91	0.065	1.86
Tyneside Dum	0.160	1.24	0.002	0.04	0.087	2.47	-0.062	-1.07
Edinburgh Dum	0.003	0.04	-0.166	-1.70	0.054	0.93	0.130	1.99
Bristol Dum	0.151	1.59	0.082	1.14	-0.077	-2.17	0.076	1.38
Cardiff Dum	0.085	0.80	-0.055	-1.02	0.031	0.63	-0.089	-1.01
Liverpool Dum	0.176	0.94	-0.074	-1.56	0.064	0.57	0.038	0.79
Nottingham Dum	0.524	1.57	0.035	0.40	0.043	0.54	0.001	0.03
Leicester Dum	0.077	0.48	-0.068	-1.31	-0.187	-1.04	0.013	0.38
Coventry Dum	0.042	0.39	-0.038	-0.39	0.007	0.15	0.070	1.10
North East	-0.182	-4.19	-0.057	-2.08	-0.087	-4.17	-0.053	-2.14
Yorks-Humberside	-0.042	-1.14	-0.077	-3.87	-0.054	-3.07	-0.045	-2.49
North West	-0.051	-1.50	-0.062	-3.21	-0.066	-3.30	-0.066	-3.43

Variables	High-tech	t-value	Med. high-tech	t-value	Med. low-tech	t-value	Low-tech	t-value
West Midlands	-0.051	-1.72	-0.081	-5.34	-0.082	-4.63	-0.090	-4.06
East Midlands	-0.113	-2.94	-0.054	-3.18	-0.042	-2.25	-0.069	-3.46
South West	-0.064	-2.33	-0.054	-2.79	-0.046	-2.64	-0.040	-2.02
Eastern	-0.026	-0.99	-0.017	-1.04	-0.023	-1.17	-0.048	-2.57
London	0.125	2.55	-0.014	-0.60	-0.092	-2.45	0.023	0.78
Scotland	-0.052	-1.80	-0.042	-2.00	-0.010	-0.48	-0.069	-3.35
Wales	-0.064	-1.95	-0.067	-3.62	-0.057	-2.79	-0.083	-4.14
Northern Ireland	-0.033	-0.45	-0.059	-1.49	-0.051	-1.39	-0.009	-0.24
Internal expansion$_{LR}$	0.021	1.15	0.017	1.97	0.017	1.64	0.040	4.18
Greenfield investment$_{LR}$	0.029	1.62	0.014	1.21	0.005	0.43	-0.004	-0.33
Mergers and acquisition$_{LR}$	-0.039	-1.65	0.006	0.49	-0.029	-1.82	-0.006	-0.43
Internal contraction$_{LR}$	-0.076	-4.83	-0.041	-3.98	-0.032	-4.36	-0.030	-3.46
Plant closure$_{LR}$	-0.039	-1.86	-0.034	-2.97	-0.021	-1.88	-0.030	-3.43
Plant sale$_{LR}$	0.032	0.71	-0.073	-2.33	-0.084	-1.77	-0.113	-4.28
Internal expansion$_{t-1}$	0.099	5.57	0.113	12.25	0.081	8.36	0.087	9.34
Greenfield investment$_{t-1}$	-0.010	-0.16	0.066	4.10	0.009	0.34	0.006	0.26
Mergers and acquisition$_{t-1}$	0.099	1.46	0.036	1.57	0.031	1.24	0.041	1.58
Internal contraction$_{t-1}$	-0.056	-3.89	0.000	-0.06	-0.026	-3.30	-0.040	-5.83
Plant closure$_{t-1}$	-0.079	-2.47	0.014	0.76	-0.022	-1.38	-0.014	-0.80
Plant sale$_{t-1}$	-0.055	-0.88	-0.013	-0.26	-0.136	-2.65	-0.064	-1.75
Dummy 2008-12	-0.049	-1.74	-0.023	-1.91	-0.034	-2.50	0.012	0.86
Industry 2-digit SIC92 dummies	Yes		Yes		Yes		Yes	
CRS Wald test chi-squared	3.93		6.06		0.9		0.72	
CRS Wald test P-value	0.048		0.014		0.343		0.397	
Number of observations	5,885		16,033		16,113		24,071	
Number of firms	2,111		5,614		6,751		9,024	

Table 5-14: Levinsohn-Petrin production function estimation 1997-2012, Services

Variables	High-tech KI	t-value	KI	t-value	Low-tech KI	t-value	Other low-tech KI	t-value
ln Intermediate inputs	0.831	5.06	1.079	5.79	0.656	31.51	0.779	15.60
ln Employment	0.281	7.15	0.262	9.50	0.253	33.89	0.304	6.25
ln Capital	0.028	1.14	0.096	1.86	0.035	4.00	0.039	1.84
Time trend	0.023	2.93	0.029	5.47	0.004	3.32	-0.008	-0.70
R&D band 2	0.122	0.67	-0.024	-0.18	0.106	3.03	0.679	1.05
R&D band 3	0.023	0.16	-0.025	-0.33	0.034	1.17	0.619	1.53
R&D band 4	0.003	0.04	-0.019	-0.34	0.030	1.24	0.328	2.64
R&D band 5	0.164	3.30	-0.016	-0.40	0.071	2.78	0.010	0.08
ln Age	-0.101	-2.55	-0.086	-3.57	-0.053	-8.25	-0.037	-1.01
Single-plant firm	0.060	0.76	0.052	1.82	0.065	6.05	0.182	2.22
Multi-region firm	0.115	1.56	0.015	0.54	0.010	0.86	0.138	1.73
UK-Owned	-0.066	-0.77	-0.031	-0.72	0.021	1.04	-0.223	-1.30
SE Asia-Owned	0.136	1.09	0.167	0.47	0.025	1.05	0.030	0.30
EU-Owned	0.082	0.99	-0.101	-1.03	0.020	1.27	-0.043	-0.33
USA-Owned	0.158	2.05	-0.149	-2.53	0.045	1.97	-0.051	-0.22
AUSCANSA-Owned	-0.135	-0.88	0.100	0.67	0.013	0.25	0.009	0.03
Other Foreign-Owned	-0.030	-0.14	-0.150	-1.42	-0.057	-1.26	-0.473	-2.04
ln Herfindahl	0.011	0.45	-0.043	-3.39	0.005	1.43	-0.041	-1.48
Manchester Dum	-0.024	-0.11	0.241	2.00	0.060	1.78	-0.131	-0.32
Birmingham Dum	0.248	1.48	-0.035	-0.29	-0.077	-0.80	-0.144	-0.79
Glasgow Dum	0.278	1.37	-0.048	-0.41	-0.095	-1.86	0.408	1.97
Tyneside Dum	-0.214	-0.51	-0.070	-0.49	0.099	1.93	-0.136	-0.63
Edinburgh Dum	0.273	1.21	-0.157	-1.39	-0.011	-0.23	0.387	2.74
Bristol Dum	0.190	1.30	0.300	3.39	0.100	1.45	-0.089	-0.59
Cardiff Dum	-0.262	-1.11	0.056	0.67	0.044	1.22	0.372	1.45
Liverpool Dum	-0.684	-1.02	0.106	0.83	0.059	1.15	0.075	0.13
Nottingham Dum	0.278	1.65	-0.027	-0.13	-0.002	-0.04	0.015	0.06
Leicester Dum	0.324	1.71	0.185	1.36	0.060	0.92	-0.007	-0.02
Coventry Dum	-0.330	-0.55	-0.016	-0.04	0.018	0.30	-0.087	-0.35
North East	0.087	0.23	-0.011	-0.12	-0.085	-3.43	0.177	1.23
Yorks-Humberside	0.086	0.86	-0.080	-1.38	-0.078	-5.38	-0.029	-0.29
North West	0.048	0.51	-0.064	-0.88	-0.063	-4.43	0.092	0.89

Variables	**High-tech KI**	**t-value**	**KI**	**t-value**	**Low-tech KI**	**t-value**	**Other low-tech KI**	**t-value**
West Midlands	-0.148	-1.01	-0.102	-1.41	-0.062	-2.94	0.040	0.35
East Midlands	-0.077	-0.86	-0.164	-2.06	-0.078	-4.55	0.011	0.10
South West	-0.108	-1.23	-0.095	-1.82	-0.049	-2.72	0.136	1.15
Eastern	-0.100	-0.90	0.098	2.01	-0.028	-1.65	-0.006	-0.07
London	0.105	1.42	0.196	3.94	0.082	3.77	0.205	2.23
Scotland	-0.340	-2.05	0.021	0.37	-0.044	-2.41	-0.066	-0.72
Wales	-0.301	-1.43	-0.056	-1.05	-0.098	-6.92	-0.344	-1.62
Northern Ireland	0.336	1.34	0.192	0.82	0.072	1.32	-0.050	-0.11
Internal expansion$_{LR}$	0.007	0.16	0.050	1.69	0.043	5.14	-0.026	-0.59
Greenfield investment$_{LR}$	0.039	0.64	0.011	0.37	0.018	2.07	0.005	0.06
Mergers and acquisition$_{LR}$	0.208	2.60	-0.026	-0.70	0.045	3.18	0.113	1.30
Internal contraction$_{LR}$	-0.189	-4.89	-0.075	-3.25	-0.071	-8.29	-0.091	-1.67
Plant closure$_{LR}$	-0.298	-3.40	-0.129	-3.54	-0.077	-5.65	-0.208	-3.02
Plant sale$_{LR}$	0.061	0.28	-0.095	-1.00	-0.084	-2.54	-0.012	-0.06
Internal expansion$_{t-1}$	0.299	5.15	0.209	6.18	0.128	13.17	0.145	2.41
Greenfield investment$_{t-1}$	0.144	1.46	0.049	0.78	0.108	5.93	0.071	0.53
Mergers and acquisition$_{t-1}$	0.503	3.30	0.012	0.11	0.113	3.08	0.053	0.16
Internal contraction$_{t-1}$	-0.042	-0.83	-0.047	-1.51	-0.046	-4.14	-0.157	-2.14
Plant closure$_{t-1}$	0.014	0.09	0.092	1.11	-0.033	-1.54	-0.141	-1.07
Plant sale$_{t-1}$	-0.138	-0.77	-0.349	-0.57	-0.179	-1.99	0.316	1.01
Dummy 2008-12	-0.021	-0.35	-0.172	-3.82	-0.046	-3.07	0.018	0.20
Industry 2-digit SIC92 dummies	Yes		Yes		Yes		Yes	
CRS Wald test chi-squared	0.06		0.04		93.48		0.86	
CRS Wald test P-value	0.814		0.844		0.000		0.354	
Number of observations	6,584		12,219		74,293		8,121	
Number of firms	3,012		6,499		35,489		3,942	

5.7 Robustness Check

Table 5-15: System GMM estimation of expansion effects on TFP, 1997-2012, Great Britain

	Manufacturing							
Variables	**High-tech**	**z-value**	**Med. high-tech**	**z-value**	**Medium low-tech**	**z-value**	**Low-tech**	**z-value**
Internal expansion *(t-1)*	0.085	1.53	0.110	2.27	0.027	0.69	0.091	1.19
Greenfield investment (*t-1*)	-0.216	-1.19	0.021	0.11	-0.055	-0.41	-0.320	-1.21
Mergers and acquisition (*t-1*)	0.126	0.28	-0.272	-1.05	0.084	0.41	0.202	0.53
Expansion dominant (*t-1*)	0.149	0.49	-0.261	-1.16	-0.018	-0.08	0.019	0.05
Internal expansion (*Long-run*)	-0.003	-0.02	-0.033	-0.80	-0.067	-1.33	-0.190	-0.81
Greenfield investment (*Long-run)*	0.026	0.28	0.029	0.61	-0.035	-0.63	-0.093	-1.31
Mergers and acquisition (*Long-run*)	0.099	1.19	0.002	0.05	0.034	0.45	0.071	0.60
Expansion dominant (*Long-run*)	0.031	0.33	0.006	0.11	0.006	0.07	0.013	0.14
	Services							
Variables	**High-tech KI**	**z-value**	**KI**	**z-value**	**Low-tech KI**	**z-value**	**Other Low - tech KI**	**z-value**
Internal expansion *(t-1)*	0.242	1.96	0.038	0.30	-0.032	-0.47	-0.007	-0.08
Greenfield investment (*t-1*)	0.188	0.74	0.495	1.16	0.266	1.05	0.120	0.37
Mergers and acquisition (*t-1*)	0.064	0.35	-0.359	-0.95	-0.118	-0.29	-0.820	-1.01
Expansion dominant (*t-1*)	-0.135	-0.45	0.117	0.40	0.038	0.18	0.272	0.93
Internal expansion (*Long-run*)	0.068	0.19	0.219	0.78	0.163	1.22	0.043	0.23
Greenfield investment (*Long-run)*	0.014	0.04	0.099	0.43	-0.011	-0.10	0.004	0.02
Mergers and acquisition (*Long-run*)	-0.021	-0.10	-0.070	-0.42	-0.090	-0.99	-0.367	-1.43
Expansion dominant (*Long-run*)	0.024	0.12	-0.037	-0.30	-0.024	-0.25	0.401	1.17

Table 5-16: System GMM estimation of Contraction effects on TFP, 1997-2012, Great Britain

	Manufacturing							
Variables	**High-tech**	**z-value**	**Med. high-tech**	**z-value**	**Med. low-tech**	**z-value**	**Low-tech**	**z-value**
Internal contraction (*t-1*)	0.048	0.65	0.018	0.40	0.034	0.75	-0.103	-2.07
Plant closure (*t-1*)	0.000	0.00	-0.003	-0.04	-0.025	-0.27	0.074	0.67
Plant sale (*t-1*)	-0.079	-0.22	-0.231	-1.01	-0.210	-1.08	-1.016	-2.05
Contraction dominant (*t-1*)	0.132	0.69	-0.007	-0.04	0.095	0.84	0.054	0.19
Internal contraction (*Long-run*)	0.051	0.48	-0.026	-0.70	-0.064	-1.65	0.051	0.44
Plant closure (*Long-run*)	0.080	0.95	-0.003	-0.06	-0.006	-0.14	0.009	0.11
Plant sale (*Long-run*)	0.049	0.31	0.033	0.57	0.039	0.59	-0.151	-1.22
Contraction dominant (*Long-run*)	0.205	1.61	-0.004	-0.11	-0.056	-1.10	-0.072	-0.63
	Services							
Variables	**High-tech KI**	**z-value**	**KI**	**z-value**	**Low-tech KI**	**z-value**	**Other Low-tech KI**	**z-value**
Internal contraction (*t-1*)	-0.045	-0.33	-0.019	-0.21	0.036	0.30	-0.051	-0.58
Plant closure (*t-1*)	-0.102	-0.54	0.228	1.51	0.090	0.53	0.219	1.21
Plant sale (*t-1*)	-0.393	-0.91	-0.395	-0.60	0.015	0.03	-1.339	-1.34
Contraction dominant (*t-1*)	0.716	1.55	-0.338	-0.91	-0.314	-0.60	-0.302	-0.82
Internal contraction (*Long-run*)	0.052	0.27	-0.044	-0.48	0.075	0.73	0.152	1.49
Plant closure (*Long-run*)	-0.363	-1.46	-0.152	-1.21	0.069	0.68	-0.547	-1.64
Plant sale (*Long-run*)	-0.398	-0.90	0.175	0.91	0.175	1.38	0.386	1.00
Contraction dominant (*Long-run*)	-0.046	-0.30	0.012	0.09	0.171	1.21	0.220	1.20

6 Conclusion

6.1 Introduction

This thesis has examined the determinants of firms' choice of adjustment and its effect on TFP. It has done so using a dataset that was created by merging Business Enterprise Research and Development (BERD) and Annual Inquiry into Foreign Direct Investment (AFDI) into Annual Respondents Database/Annual Business Survey (ARD/ABS). The first empirical chapter examined the major determinants of firms' choice of adjustment in Great Britain. The second empirical chapter focused on analysing the impact of alternative forms of adjustment on TFP.

The next section will describe the contribution made by this thesis to the literature. The third section will set out our main findings from the empirical analyses of chapters four and five. Section four provides some policy recommendations on the basis of these findings. Section five offers some suggestions for future research. The final section concludes.

6.2 Contribution to the Literature

The contribution of this thesis to the literature has been twofold. Firstly, the chapter that investigated the determinants of firms' choice of expansion and contraction path used a comprehensive set of determinants to provide a better and broader understanding of the potential determinants of firms' adjustment choice. Such determinants are included in the estimation of firms' adjustment choice because their omission would lead to omitted variable(s) problem thus, producing biased estimates. The choice of determinants is also motivated by the theoretical and empirical literature and information available in the BERD, AFDI and ARD/ABS dataset. Thus, although previous studies have provided insights, this thesis has extended the set of adjustment determinants to include: firm size, adjustment size, firm-level variables (R&D, age, multi-plant and foreign ownership), industrial and geographical structure and, persistence and financial crisis.

The second major contribution of this thesis is methodological. The chapter that examines the impact of alternative forms of adjustment on TFP used the appropriate method for dealing with both the simultaneity of adjustment paths-productivity relation and the endogeneity of factor inputs (and self-selection of firms in and out of an industry) in the production function. Most prior studies of the productivity effect of adjustment path have estimated models of the form: output = *f*(capital, labour, intermediate inputs), where TFP is obtained as the residual and, as part of a two-stage approach, TFP is then regressed on a particular path of adjustment (e.g., mergers and acquisition). Clearly, this two-stage approach would lead to biased estimates of adjustment paths (and elasticities of factor inputs) because of an omitted variables problem (e.g., Harris et al., 2005). Thus, we estimated a more appropriate empirical model of the form: output = *f*(capital, labour, intermediate inputs, adjustment paths, other productivity effects, fixed effects), Because of the potential simultaneity and endogeneity concerns with our empirical model, we apply the system GMM estimator. In addition to using the system GMM approach to alleviate endogeneity concerns, we also use the appropriate control groups to study the impact of impact of firm adjustment on productivity. This is the first time the productivity impact of firm adjustment has been analysed using the appropriate control groups and a method that deals the consequences of a dynamic relationship between firm adjustment and productivity.

6.3 Main Findings

There are 2 main empirical findings in this thesis. The first is related to the determinants of firms' choice adjustment in Great Britain (chapter four). This showed that when compared to small firms, large firms tend to rely more on external forms of adjustment, particularly on greenfield investment for expanding firms. Firms also rely more on external forms of expansion when the desired size of expansion is large, however, contracting firms rely less on external contraction as the size of a contraction increases. With regards to the firm-level variables considered, we found that older, multi-plant and foreign-owned firms are more likely to use external forms of expansion, whereas R&D expenditure is negatively related to the external forms of expansion. For contracting firms, we found that the probability of using external forms of contraction reduces with firm's age and single-plant ownership. Lastly, we found that foreign-owned firms are more likely to close plants.

Our second empirical finding is that alternative forms of adjustment have no statistically significant impact on long-run TFP in all the industries considered. Although, the theoretical literature postulates that external forms of adjustment should result in higher level of productivity, our finding of no statistically significant long-run impact suggests that theories do not account for possible long-run productivity effects of adjustment. Previous empirical studies also fail to provide guidance as to what may be expected when comparing the productivity impact of different forms of adjustment. However, our finding of no long-run adjustment effect is viewed as novel, given our choice of appropriate control groups and the fact that we use the system GMM approach to alleviate endogeneity problems that arises from estimating the impact of firm adjustment on productivity.

6.4 Policy Recommendation

In terms of the long-running debate of whether the government should aim its policies at creating favourable environments for businesses to grow, our results in chapter four provide evidence to support such approach. The positive impact of firm size on external forms of adjustment suggest support for corporate tax credits for large firms. Our finding that firms use greenfield investment and mergers and acquisition to carry out large employment expansion suggest that anti-competitive laws that prevents firms from expanding externally may hamper expansion in employment. Also, the finding that firms use mergers and acquisition to outsource corporate R&D and strengthen firm innovation suggests that government should promote policies that can make innovation driven mergers and acquisition a success. In chapter five, we found little evidence for firm-level productivity effects from greenfield investment nor from other cited adjustment activities such as mergers and acquisition, plant closure and plant sale. This result is inconsistent with prior research and policy recommendations of many commentators. However, we illustrate why previous empirical papers that find a relationship between firm adjustment and productivity may be biased.

6.5 Suggestions for Future Research

Although this research attempts to provide comprehensive work regarding the determinants and effects of firms' choice of adjustment on TFP, more work can still be done on this topic. The grouping process of firm adjustment in chapter three of this thesis (i.e., section 3.3) opens a wide variety of topics for future research. The 6 major paths of adjustment – internal expansion, greenfield investment, mergers and acquisition, internal contraction, plant closure and plant sale - are found to be the most frequently used by firms in the UK. However, there are 106 adjustment combinations that are rarely adopted by firms, but account for a third of the economy-wide employment expansion in the UK. This thesis collapsed the 106 adjustment combinations into the 6 major channels of adjustment to avoid complications when empirically modelling firms' choice of adjustment.

Future research might benefit from expanding on the ideas in this thesis to create further adjustment categories e.g., collapsing the 106 adjustment classification into 2 different combinations that reflects whether a firm is expanding or contracting, overall. In other words, future studies could address the determinants of 8 channels of adjustment, instead of the 6 considered in this thesis. Furthermore, while this thesis addresses the determinants and effects of firm adjustment, it does not consider how firms redraw their boundaries after an adjustment. It would be interesting for future researchers to test if there are extensive restructuring following a major adjustment such as mergers and acquisition and if such further restructuring are determined by the same factors considered in this thesis and/or have any effect on firm-level productivity.

Although it is clear that productivity determines firms' choice of adjustment (i.e., more productive firms are more likely to use external forms of adjustment), the empirical strategy taken in this thesis is a reduced-form approach. We used firm-level variable ((R&D, age, multi-plant and foreign ownership) to study the impact of productivity on firms' choice of adjustment. Researchers could carry out a similar study by using a two-stage approach where productivity (or TFP) is estimated in the first stage which is in turn, regressed on firms' choice of adjustment.

6.6 Conclusion

This chapter concludes the thesis. It started by setting out the contribution made to the literature by this thesis. This was firstly in the use of a wider set of determinants to those which have been previously used to understand how firms choose between different channels of adjustment. The second contribution made by this thesis is the use of a superior econometric technique (and appropriate control groups) to deal with issues of simultaneity and endogeneity that arises when estimating the impact of firm's adjustment on productivity.

This chapter then describes the main findings from our empirical chapters. The determinants of firms' choice of adjustment showed that large, older, multi-plant, foreign-owned firms and firms that wish to carry out large expansion are more likely to use external forms of expansion – greenfield investment and mergers and acquisition. For contracting firms, we found that the likelihood of using external forms of contraction falls with firm's age and single-plant ownership. Chapter five showed that different forms of adjustment have no statistically significant impact on TFP. On the basis of these findings, some policy recommendations were made. Finally, the chapter offered some suggestion for future research.

7 References

Abowd, J., Kramarz, F. and Margolis, D. (1999), 'High wage workers and high wage firms', Econometrica, 67, 2, 251-333.

Ackerberg, D., Caves, K. and Frazer, G. (2006), ‘Structural identification of production functions’, Unpublished manuscript.

Ackerberg, D., Benkard, C., Berry, S. and Pakes, A. (2007), ‘Econometric tools for analysing market outcomes. In J. Heckman and E. Leamer (eds), Handbook of Econometrics, 6, 1, 4171–4276, Amsterdam, North-Holland.

Andersson, T. and Svensson, R. (1994), ‘Entry Modes for Direct Investment Determined by the Composition of Firm-Specific Skills’, Scandinavian Journal of Economics, 96, 4, 551-560.

Andolfatto, D. and MacDonald, G. (1994) 'Endogenous Technological Change, Growth, and Aggregate Fluctuations', working paper, University of Waterloo and University of Rochester.

Aghion, P., Harris, C., Howitt, P. and Vickers, J. (2001), ‘Competition, imitation and growth with step-by-step innovation’, Review of Economic Studies, 68, 3, 467–492

Arellano, M. and Bond, S. (1991), 'Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations', Review of Economics Studies, 58, 2, 277-298.

Arellano, M. and Bover, O. (1995), 'Another look at the instrumental variable estimation of error-component models', Journal of Econometrics, 68, 29–51.

Arikan, A. and Stulz, R. (2016), 'Corporate acquisitions, diversification, and the firm's life cycle', Journal of Finance, 71, 1, 139-194.

Armstrong-Stassen, M. (1993), ‘Production workers reactions to a plant closing: The role of transfer, stress and support. Anxiety, Stress and Coping’, An International Journal, 6, 201–214.

Arrow, K. (1962), ‘The Economic Implications of Learning by Doing’, The Review of Economic Studies, 29, 3, 155-173.

Bacolod, M., Blum, B. and Strange, W. (2009), 'Skills in the City', Journal of Urban Economics, 65, 2, 136-153.

Baden-Fuller, C. (1989), 'Exit from declining industries and the case of steel castings' The Economic Journal, 99, 398, 949-961.

Bartelsman, E. and Dhrymes, P. (1998), ‘Productivity dynamics: US manufacturing plants, 1972–1986. Journal of productivity analysis’, 9, 1, 5-34.

Battese, G. and Coelli, T. (1995), 'A model for technical inefficiency effects in a stochastic frontier production function for panel data', Empirical Economics, 20, 2, 325-332.

Battu, H., Belfield, C. and Sloane, P. (2003), 'Human capital spillovers within the workplace: evidence for Great Britain', Oxford Bulletin of Economics and Statistics, 65, 5, 575-594.

Baumol, W. (1959), 'Business Behavior, Value and Growth', Macmillan, New York.

Baumol, W. (1962), 'On the Theory of Expansion of the Firm', American Economic Review, 52, 5, 1078-1087.

Baumol, W., Blinder, A. and Wolff, E. (2003), 'Downsizing in America: Reality, causes, and consequences', Russell Sage Foundation, New York

Beck, T., Levine, R. and Loayza, N. (2000), 'Finance and the Sources of Growth', Journal of financial economics, 58, 1-2, 261-300.

Bena, J. and Li, K. (2014), 'Corporate innovations and mergers and acquisitions', The Journal of Finance, 69, 5, 1923-1960.

Berchtold, D., Loderer, C. and Waelchli, U. (2014), 'Core abilities, divestitures, and the corporate lifecycle', Working paper, University of Bern.

Bergh, D. (1995), 'Size and relatedness of units sold: An agency theory and resource-based perspective', Strategic Management Journal, 16, 3, 221-239.

Bergman, P. and Wigblad, R. (1999), 'Workers' last performance: Why some factories show their best results during countdown', Economic and Industrial Democracy, 20, 3, 343-368.

Bernard, A. and Jensen, J. (2004), 'Why some firms export', Review of economics and Statistics 86, 2, 561-569.

Bernard, A. and Jensen, J. B. (2007). 'Firm structure, multinationals, and manufacturing plant deaths' The Review of Economics and Statistics, 89, 2, 193-204.

Biggs, T., Shah, M. and Srivastava, P. (1996), 'Technological Capabilities and Learning in African Enterprises, Regional Program of Enterprise Development', (RPED) Case Study Series, World Bank, Washington, DC.

Bluestone, B. and Harrison, B. (1982), 'The deindustrialisation of America', Basic Books, New York.

Blundell, R. and Bond, S. (1998), 'Initial Conditions and Moment Restrictions in Dynamic Panel Data Models', Journal of Econometrics, 87, 1, 115-143

Borowiecki, K. (2013), 'Geographic Clustering and Productivity: An Instrumental Variable Approach for Classical Composers', Journal of Urban Economics, 73, 1, 94-110.

Breinlich, H. and Solomon, E. (2010), ‘A Portrait of Firm Expansion and Contraction Channels’, Essex Discussion Paper Series 693.

Breinlich, H., and Niemann, S. (2011a), 'Channels of Firm Adjustment: Theory and Empirical Evidence’, University of Essex, Working paper No. 697.

Breinlich, H., Niemann, S. and Solomon, E. (2011b), 'Channels of size adjustment and firm performance', Discussion paper no. 703, University of Essex.

Breinlich, H., Niemann, S. and Solomon, E. (2012), 'Channels of size adjustment and firm performance', Economics Letters, 116, 2, 202-206.

Brockner, J., Grover, S., Reed, T. and Dewitt, R. (1992), 'Layoffs, job insecurity, and survivors' work effort: Evidence of an inverted-U relationship', Academy of Management Journal, 35, 2, 413-425.

Brockner, J. (1992), 'Managing the effects of layoffs on survivors', California Management Review, 34 2, 9-28.

Brouthers, K. and Brouthers, L. (2000), 'Acquisition or greenfield start-up? Institutional, cultural and transaction cost influences', Strategic Management Journal, 21, 1, 89-97.

Bustos, P. (2011), 'Trade liberalization, exports, and technology upgrading: Evidence on the impact of MERCOSUR on Argentinian firms', American economic review, 101, 1, 304-340.

Cabral, L. (2000), 'Introduction to industrial organization', MIT Press.

Cameron, K. (1994), 'Strategies for successful organizational downsizing', Human Resource Management, 33, 2, 189-211.

Cameron, K., Freeman, S. and Mishra, A. (1993), 'Downsizing and redesigning organizations, in G. Huber and W. Glick (Eds.), Organisational Change and Redesign', 19-63, Oxford University Press, New York.

Campbell, J. (1998), 'Entry, exit, embodied technology, and business cycles', Review of Economic Dynamics, 1, 2, 371-408.

Cascio, W. and Young, C. (1996) 'Corporate Downsizing: A Look at the Last 15 Years', Working paper, Denver: Graduate School of Business, University of Colorado.

Cascio, W., Young, C. and Morris, J. (1997), 'Financial consequences of employment-change decisions in major US corporations', The Academy of Management Journal, 40, 5, 1175-89.

Caves, R. and Caves, R. (1996). Multinational enterprise and economic analysis. Cambridge university press.

Caves, R. and Mehra, S. (1986), 'Entry of foreign multinationals into US manufacturing industries', Competition in global industries, 449-481.

Celikyurt, U., Sevilir, M. and Shivdasani, A. (2010), 'Going public to acquire? The acquisition motive in IPOs', Journal of Financial Economics, 96, 3, 345-363.

Chalos, P. and Chen, C. (2002), 'Employee downsizing strategies: Market reaction and post announcement financial performance', Journal of Business Finance and Accounting, 29, 847-870.

Chen, P., Mehrotra, V., Sivakumar, R. and Wayne, W. (2001), 'Layoffs, shareholders' wealth, and corporate performance', Journal of Empirical Finance, 8, 2, 171-199.

Chesbrough, H. (2006), 'Open innovation: The new imperative for creating and profiting from technology', Harvard Business Press, Boston

Chesbrough, H. (2007) 'Why Business Models Need To Open Up', In: Open Business Models: How to Thrive in the New Innovation Landscape, Harvard Business Press, 1-20.

Cho, K. and Padmanabhan, P. (1995), 'Acquisition versus new venture: The choice of foreign establishment mode by Japanese firms', Journal of International Management, 1, 3, 255-285.

Clark, G. and Wrigley, N. (1997), 'Exit, the firm and sunk costs: reconceptualizing the corporate geography of disinvestment and plant closure', Progress in Human Geography, 21, 3, 338-358.

Coad, A. and Broekel, T. (2012), 'Firm growth and productivity growth: evidence from a panel VAR', Applied Economics, 44, 10, 1251-1269.

Cobb, C. and Douglas, P. (1928), 'A Theory of Production', The American Economic Review, 18, 1, Supplement, Papers and Proceedings of the Fortieth Annual Meeting of the American Economic Association, 139-165.

Cohen, W. and Levinthal, D. (1989), 'Innovation and learning: the two faces of R & D', The economic journal, 99, 397, 569-596.

Colombo, M. and Delmastro, M. (2000), 'A note on the relation between size, ownership status and plant's closure: sunk costs vs. strategic size liability', Economics Letters, 69, 3, 421-427.

Competition and Markets Authority (2014), 'A Quick Guide to UK Merger Assessment', Available in: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/288677/CMA18_A_quick_guide_to_UK_merger_assessment.pdf

Cooley, T., Greenwood, J. and Yorukoglu, M. (1997), 'The replacement problem', Journal of Monetary Economics, 40, 3, 457-499.

Cooper, R. and Haltiwanger, J. (2006), 'On the nature of capital adjustment costs', The Review of Economic Studies, 73, 3, 611-633.

Coucke, K., Pennings, E. and Sleuwaegen, L. (2007), 'Employee layoff under different modes of restructuring: exit, downsizing or relocation', Industrial and Corporate Change, 16, 2, 161-182.

De Loecker, J. (2007), 'Product Differentiation, Multi-product Firms and Estimating the Impact of Trade Liberalization on Productivity', National Bureau of Economic Research Working Paper Series, No. 13155.

Deily, M. (1988), 'Investment activity and the exit decision', The Review of Economics and Statistics, 595-602.

Del Gatto, M., Di Liberto, A. and Petraglia, C. (2011), 'Measuring Productivity', Journal of Economic Surveys, 25, 5, 952-1008.

Denis, D., Denis, D. and Sarin, A. (1997), 'Agency problems, equity ownership, and corporate diversification', Journal of Finance, 52, 1, 135-160.

DePamphilis, D. (2014). 'Mergers, Acquisitions and Other Restructuring Activities', 7th Edition, AP.

Dhawan, R. (2001), ‘Firm Size and Productivity Differential: Theory and Evidence from a Panel of US Firms’, Journal of Economic Behaviour and Organization, 44, 269-293.

Dixit, A. (1989), 'Entry and exit decisions under uncertainty', Journal of Political Economy, 97, 620–638.

Disney, R., Haskel, J. and Heden, Y. (2003), Entry, Exit and Establishment Survival in UK Manufacturing’, Journal of Industrial Economics, 51, 1, 91-112.

Doms, M. and Jensen, J. (1998), ‘Comparing Wages, Skills, and Productivity between Domestically and Foreign Owned Manufacturing Establishments in the United States’, In: Baldwin, R. E., Lipsey, R. & Richardson, J. D. (eds.) Geography and Ownership as Bases for Economic Accounting. Chicago: Chicago Press.

Dunne, T., Roberts, M. and Samuelson, L. (1989), 'The growth and failure of US manufacturing plants', Quarterly Journal of Economics, 104, 4, 671-698.

Dunning, J. (1988), ‘Multinationals, technology and competitiveness’, London: Unwin Hyman.

Duranton, G. and Puga, D. (2000), 'Diversity and specialisation in cities: why, where and when does it matter?', Urban studies, 37, 3, 533-555.

Eckel, C. and Neary, J. (2010), 'Multi-Product Firms and Flexible Manufacturing in the Global Economy', Review of Economic Studies, 77, 1, 188-217.

Elvery, J. (2010), 'City Size and Skill Intensity', Regional Science and Urban Economics, 40, 6, 367-379.

Espahbodi, R., John, T. and Vasudevan, G. (2000), 'The effects of downsizing on operating performance', Review of Quantitative Finance and Accounting, 15, 2, 107-126.

Farinas, J. and Ruano, S. (2005), 'Firm productivity, heterogeneity, sunk costs and market selection', International Journal of Industrial Organization, 23, 505–534.

Foster, L., Haltiwanger, J. and Krizan, C. (2001), ‘Aggregate Productivity Growth: Lessons from Microeconomic Evidence.’ In: Hulten, C.R., Dean, E.R. and Harper, M.J. (eds.) New Developments in Productivity Analysis, Chicago: University of Chicago Press

Foster, L., Haltiwanger J. and Krizan C. (2006), 'Market Selection, Reallocation, and Restructuring in the U.S. Retail Trade Sector in the 1990s', Review of Economics and Statistics, 88, 4, 748-758.

Fox, J. and Smeets, V. (2011), 'Does input quality drive measured differences in firm productivity?', International Economic Review, 52, 4, 961-989.

Freeman, S. and Cameron, K. (1993), 'Organizational downsizing: a convergence and reorientation framework', Organization Science, 4, 1, 10-29.

Fujita, M., Krugman, P. and Venables, A. (1999), 'The Spatial Economy; Cities, Regions and International trade', MIT Press, Cambridge Mass London.

Gibson, J. and Harris, R. (1996), 'Trade liberalisation and plant exit in New Zealand manufacturing', Review of Economics and Statistics, 78, 3, 521-529.

Gombola, M. and Tsetsekos, G. (1992), 'The information content of plant closing announcements: evidence from financial profiles and the stock price reaction', Financial Management, 21, 31-40.

Gomes, J. and Livdan, D. (2004), 'Optimal diversification: Reconciling theory and evidence', Journal of Finance, 59, 2, 507-535.

Grazzi, M., Jacoby, N. and Treibich T. (2013), 'Dynamics of investment and firm performance: Comparative evidence from manufacturing industries'. LEM Working Paper No. 2013/06.

Greene, W. (2003) 'Econometric Analysis', 4th Edition, Upper, Saddle River, New Jersey: Prentice Hall.

Griliches, Z. and Hausman, J. (1986), 'Errors in variables in panel data', Journal of econometrics, 31, 1, 93-118.

Griliches, Z. and Mairesse, J. (1995), 'Production functions: the search for identification', National Bureau of Economic Research, Working Paper Series 5067.

Grunberg, L., Moore, S., and Greenberg, E. (1998), 'Work stress and problem alcohol behavior: A test of the spillover model', Journal of Organizational Behavior, 19, 487–502.

Gugler, K., Mueller, D., Yurtoglu, B. and Zulehner, C. (2003), 'The effects of mergers: an international comparison', International journal of industrial organization, 21, 5, 625-653.

Hall, B. (1988), 'The effect of takeover activity on corporate research and development', In Corporate takeovers: Causes and consequences, 69-100, University of Chicago Press.

Hallock, K. (1998), 'Layoffs, top executive pay, and firm performance', American Economic Review, 88, 711-723.

Haltiwanger, J., Lane, J. and Spletzer, J. (1999), 'Productivity differences across employers: The roles of employer size, age, and human capital', American Economic Review, 89, 2, 94-98.

Han, L. and Rousseau, P. (2009), 'Technology Shocks, Q, and the Propensity to Merge', Working Paper 09-W14, Vanderbilt University.

Hansson, M. (2008), 'On Closedowns: Towards a Pattern of Explanations to the Closedown effect', Doctoral Thesis, Örebro University.

Hansson, M. (2011), 'At the End of the Road: The Process of a Plant Closure, In: Hayton, J. Biron, M., Castro Christiansen, L and Kuvaas, B. (Eds.), Global Human Resource Management Casebook, Routhledge.

Hansson, M. and Wigblad, R. (2006), 'Pyrrhic victories–anticipating the Closedown effect', The International Journal of Human Resource Management, 17, 5, 938-958.

Harris, R. (1989), 'The growth and structure of the UK regional economy 1963-85', Aldershot: Avebury.

Harris, R. (2002), 'Foreign Ownership and Productivity in the United Kingdom—Some Issues When Using the ARD Establishment Level Data', Scottish Journal of Political Economy, 49, 3, 318-335.

Harris, R. and Robinson, C. (2002), 'The Effect of Foreign Acquisitions on Total Factor Productivity: Plant-Level Evidence from U.K. Manufacturing, 1987-1992', The Review of Economics and Statistics, 84, 3, 562-568.

Harris, R. and Robinson, C. (2003), 'Foreign Ownership and Productivity in the United Kingdom Estimates for U.K. Manufacturing Using the ARD', Review of Industrial Organization, 22, 207-223.

Harris, R. and Robinson, C. (2004), 'Industrial policy in Great Britain and its effect on total factor productivity in manufacturing plants, 1990–1998', Scottish Journal of Political Economy, 51, 4, 528-543.

Harris, R. (2005), 'Deriving Measures of Plant-level Capital Stock in UK Manufacturing, 1973-2001', Report to DTI, Available at: http://www.gla.ac.uk/media/media_64430_en.pdf (Accessed: 04.02.2016).

Harris, R. and Li, C. (2007), 'Firm Level Empirical Study of the Contribution of Exporting to Productivity Growth', Report to UK Trade and Investment.

Harris, R. and Moffat, J. (2011), 'Plant-level Determinants of Total Factor Productivity in Great Britain, 1997–2006', SERC Discussion Paper, Spatial Economics Research Centre (SERC), London School of Economics and Political Science (LSE), London.

Harris, R. and Moffat, J. (2012), 'Is Productivity Higher In British Cities?', Journal of Regional Science, 52, 5, 762-786.

Harris, R. and Moffat, J. (2013a), 'Direct Contribution of FDI to Productivity Growth in Britain, 1997–2008',The World Economy, 36, 6, 713-736.

Harris, R. and Moffat, J. (2013b), 'Total Factor Productivity Growth in Local Enterprise Partnership Regions in Britain, 1997–2008', Regional Studies, (ahead-of-print), 1-23.

Harris, R. and Moffat, J. (2016a), 'The UK productivity puzzle, 2008–2012: evidence using plant-level estimates of total factor productivity', Oxford Economic Papers.

Harris, R. and Moffat, J. (2016b), 'Plant closure in Britain since the Great Recession', Economics Letters, 140, 27-30.

Harzing, Anne-Wil, (2002), 'Acquisitions versus greenfield investments: international strategy and management of entry modes', Strategic Management Journal, 23, 3, 211-227.

Häsänen, L., Hellgren, J. and Hansson, M. (2011), 'Goal setting and plant closure: When bad things turn good', Economic and Industrial Democracy, 32, 1, 135-156.

Haskel, J., Hawkes, D. and Pereira, S. (2005). 'Skills, human capital and the plant productivity gap: UK evidence from matched plant, worker and workforce data', CEPR Discussion Paper no. 5334, Centre for Economic Policy Research, London

Hayashi F. (1982), 'Tobin's Marginal q and Average q: A Neoclassical Interpretation', Econometrica, 50, 213-224.

Haynes, M., Thompson, S. and Wright, M. (2003), ‘The determinants of corporate divestment: Evidence from a panel of UK firms’, Journal of Economic Behaviour and Organization, 52, 1, 147–166.

Hellerstein, J., Neumark, D. and Troske, K. (1999), 'Wages, productivity, and worker characteristics: Evidence from plant-level production functions and wage equations' Journal of labour economics', 17, 3, 409-446.

Hennart, J. and Park, Y. (1993), 'Greenfield vs. acquisition: The strategy of Japanese investors in the United States', Management science, 39, 9, 1054-1070.

Hennart, J. and Reddy, S. (1997), 'The choice between mergers/acquisitions and joint ventures: The case of Japanese investors in the United States', Strategic management journal, 18, 1, 1-12.

Herfindahl, O. (1950), ‘Concentration in the US Steel Industry’, PhD Thesis, Columbia University, New York.

Hill, H. and Kalirajan, K. (1993), 'Small enterprise and firm-level technical efficiency in the Indonesian garment industry', Applied Economics, 25, 9, 1137-1144.

Hillier, D., Marshall, A., McColgan, P. and Werema, S. (2007), 'Employee layoffs, shareholder wealth and firm performance: Evidence from the UK', Journal of Business Finance & Accounting, 34, 3-4, 467-494.

Hillier, D., McColgan, P. and Werema, S. (2009), ‘Asset sales and firm strategy: an analysis of divestitures by UK companies’, European Journal of Finance, 15, 1, 71-87.

Hite, G., Owers, J. and Rogers, R. (1987), 'The market for interfirm asset sales: Partial sell-offs and total liquidations. Journal of Financial Economics', 18, 2, 229-252.

Hitt, M., Keats, B., Harback, H. and Nixon, R. (1994), 'Rightsizing: Building and maintaining strategic leadership and long-term competitiveness', Organizational Dynamics, 23, 2, 18-32.

Hoch, I. (1962), 'Estimation of production function parameters combining time series and cross-section data', Econometrica 30, 34–53.

Holland, D., Liadze, I., Rienzo, C. and Wilkinson, D. (2013), 'The relationship between graduates and economic growth across countries', BIS research paper, 110.

Holmes, T. and Schmitz Jr, J. (1990), ‘A theory of entrepreneurship and its application to the study of business transfers’, Journal of political Economy, 98, 2, 265-294.

Holtz-Eakin, D., Newey, W. and Rosen, H. (1988), 'Estimating vector autoregressions with panel data', Econometrica, 56, 1371–1395.

Hopenhayn, H. (1992), ‘Entry, Exit and Firm Dynamics in Long-Run Equilibrium’, Econometrica, 60, 5, 1127-1150.

Hovakimian, A. and Hutton, I. (2010), 'Merger-Motivated IPOs', Financial Management, 39, 4, 1547-1573.

Huggett, M. and Ospina, S. (2001), 'Does productivity growth fall after the adoption of new technology?', Journal of Monetary Economics, 48, 1, 173–195.

Hymer, S. (1976) ‘The international operations of national firms: a study of direct foreign investment. Cambridge’, M.I.T. Press, Mass, London.

Ilmakunnas, P., Maliranta, M. and Vainiomäki, J. (2004), 'The roles of employer and employee characteristics for plant productivity', Journal of productivity analysis, 21, 3, 249-276.

Iranzo, S., Schivardi, F. and Tosetti, E. (2008), 'Skill dispersion and firm productivity: An analysis with employer-employee matched data', Journal of Labour Economics, 26, 2, 247-285.

Jain, P. (1985), 'The effect of voluntary sell-off announcements on shareholder wealth', The Journal of Finance, 40, 1, 209-224.

Jarmin, R. (1999), 'Government Technical Assistance Programs and Plant Survival: The Role of Plant Ownership Type', Working Papers 2, Centre for Economic Studies, U.S. Census Bureau Working Papers, Washington.

Jensen, M. (1986), 'Agency costs of free cash flow, corporate finance, and takeovers’, American Economic Review, 76, 2, 323–329.

Jensen, M. (1993), 'The Modern Industrial Revolution, Exit, and Control Systems', Journal of Finance, 48, 831–880.

Jensen, M. and Meckling, W. (1976), 'Theory of the firm: Managerial behaviour, agency costs, and ownership structure', Journal of Financial Economics, 3, 305–360.

Jensen, J., McGuckin, R. and Stiroh, K. (2001), 'The impact of vintage and survival on productivity: Evidence from cohorts of U.S. manufacturing plants', The Review of Economics and Statistics 83, 2, 323–332.

John, K. and Ofek, E. (1996), ‘Asset sales and increase in focus’, Journal of Financial Economics, 37, 105-126.

Jorgenson, D., Gollop, F. and Fraumeni, B. (1987), 'Productivity and US Economic Growth', Harvard University Press, Cambridge, MA.

Jovanovic, B. (1979), ‘Job matching and the theory of turnover’, Journal of political economy, 87, 5, 972-990.

Jovanovic, B. (1982), ‘Selection and the Evolution of Industry’, Econometrica, 50, 3, 649-670.

Jovanovic, B. and MacDonald, G. (1994), 'Competitive diffusion', Journal of Political Economy, 102, 1, 24-52.

Jovanovic, B. and Nyarko, Y. (1996), 'Learning by Doing and the Choice of Technology', Econometrica, 64, 6, 1299-1310.

Jovanovic, B. and Rousseau, P. (2002), ‘The Q-Theory of Mergers’, American Economic Review, 92, 198–204.

Kang, J. and Shivdasani, A. (1997), 'Corporate restructuring during performance declines in Japan', Journal of Financial Economics, 46, 1, 29-65.

Kaplan, S. and Weisbach, M. (1992), ‘The Success of acquisitions: evidence from Divestitures’, Journal of Finance, 47, 107-138.

Kelley, M. and Harrison, B. (1990), ‘The subcontracting behaviour of single vs. multiplant enterprises in US manufacturing: Implications for economic development’, World Development, 18, 1273-1294.

Koeva, P. (2000), 'The facts about time-to-build', IMF Working Paper WP/00/138.

Kogut, B. and Singh, H. (1988), 'The effect of national culture on the choice of entry mode', Journal of international business studies, 19, 3, 411-432.

Kydland, F. and Prescott, E. (1982), 'Time to build and aggregate fluctuations', Econometrica, 50, 1345-1370.

Lang, L., Poulsen, A. and Stulz, R. (1995), 'Asset sales, firm performance, and the agency costs of managerial discretion', Journal of Financial Economics, 37, 1, 3-37.

Leibenstein, H. (1966), ‘Allocative efficiency vs." X-efficiency"’, American Economic Review, 56, 3, 392-415.

Levinsohn, J. and Petrin, A. (2003), ‘Estimating Production Functions Using Inputs to Control for Unobservables’, The Review of Economic Studies, 70, 317-341.

Li, X. (2013), 'Productivity, restructuring, and the gains from takeovers', Journal of Financial Economics, 109, 1, 250-271.

Licandro, O., Maroto, R. and Puch, L. (2004), ‘Innovation, investment and productivity: evidence from spanish firms’, Research paper in Economics ECO2004/07, European University Institute.

Lichtenberg, F., Siegel, D., Jorgenson, D. and Mansfield, E. (1987), ‘Productivity and changes in ownership of manufacturing plants’, Brookings Papers on Economic Activity, 1987:3, 643-683.

Lichtenberg, F. and Siegel, D. (1990), 'The effects of leveraged buyouts on productivity and related aspects of firm behaviour', Journal of Financial Economics, 27, 1, 165-194.

Littler, C. and Innes, P. (2003a), ‘Downsizing and Deknowledging the Firm’, Work, Employment and Society, 17, 1, 73-100.

Littler, C., Wisner, R. and Dunford, R. (2003b), ‘The Dynamics of Delayering: Changing Management Structures in three Countries’, Journal of Management Studies, 40, 2, 225-256.

Littler, C. and Innes, P. (2004), ‘The Paradox of Managerial Downsizing’, Organizational Studies, 25, 7, 1159-1184.

Loderer, C. and Waelchli, U. (2015). Corporate aging and takeover risk. Review of Finance, 19, 6, 2277-2315.

Loderer, C., Stulz, R. and Waelchli, U. (2016), 'Firm rigidities and the decline in growth opportunities', Management Science, 63, 9, 3000-3020.

Lucas, R. (1978), 'On the Size Distribution of Business Firms', Bell Journal of Economics, 9, 508-523.

Madhok, A. (1997), 'Cost, value and foreign market entry mode: The transaction and the firm', Strategic management journal, 18, 1, 39-61.

Maksimovic, V. and Phillips, G. (2001), 'The market for corporate assets: Who engages in mergers and asset sales and are there efficiency gains?', Journal of Finance, 56, 6, 2019-2065.

Maksimovic, V. and Phillips, G. (2002), 'Do conglomerate firms allocate resources inefficiently across industries? Theory and evidence', Journal of Finance, 57, 2, 721-767.

Maksimovic, V., Phillips, G. and Prabhala, N. (2011), 'Post-merger restructuring and the boundaries of the firm', Journal of Financial Economics, 102, 2, 317-343.

Markides, C. (1992), 'Consequences of corporate refocusing: Ex ante evidence', Academy of Management journal, 35, 2, 398-412.

Marschak, J. and Andrews, W. (1944), 'Random simultaneous equations and the theory of production', Econometrica, 12, 143–205.

Mason, G., O'Leary, B. and Vecchi, M. (2012), 'Certified and uncertified skills and productivity growth performance: Cross-country evidence at industry level', Labour economics, 19, 3, 351-360.

Mayer, T., Melitz, M. and Ottaviano, G. (2011), 'Market Size, Competition, and the Product Mix of Exporters', American Economic Review 104, 2, 495-536.

McFarlane Shore, L., and Tetrick, L. (1991), ‘A construct validity study of the survey of perceived organizational support’, Journal of Applied Psychology, 76, 637–643.

McGuckin, R. and Nguyen, S. (1995), 'On productivity and plant ownership change: New evidence from the longitudinal research database', The RAND Journal of Economics, 257-276.

Meyer, M. and Vickers, J. (1997) 'Performance Comparisons and Dynamic Incentives', Journal of Political Economy, 105, 3, 547-581.

Mishra, A. and Mishra, K. (1994), 'The role of mutual trust in effective downsizing strategies', Human Resource Management, 33, 2, 261-279.

Mitchell, M. and Lehn, K. (1990), 'Do bad bidders become good targets?', Journal of Political Economy, 98, 372-398.

Moffat, J. (2010), 'Regional Selective Assistance in Scotland: does it make a difference to plant performance?' PhD thesis, University of Glasgow.

Montgomery, C. and Thomas, A. (1988), 'Divestment: Motives and gains', Strategic Management Journal, 9, 1, 93-97.

Morris, J., Cascio, W. and Young, C. E. (1999), 'Downsizing after all these years: Questions and answers about who did it, how many did it, and who benefited from it', Organizational Dynamics, 27, 3, 78-87.

Mueller, D. (1972), 'A life cycle theory of the firm', Journal of Industrial Economics, 20, 199-219.

Mundlak, Y. (1961), 'Empirical production function free of management bias', Journal of Farm Economics 43, 1, 44–56.

Nelson, R. (2009). An evolutionary theory of economic change. Harvard University Press.

Nocke, V. and Yeaple, S. (2007), 'Cross-border mergers and acquisitions vs. greenfield foreign direct investment: The role of firm heterogeneity', Journal of International Economics, 72, 2, 336-365.

Nocke, V. and Yeaple, S. (2008), 'Globalization and the size distribution of multiproduct firms', CEPR Discussion paper DP6948

Nocke, V. and Yeaple, S. (2014), 'Globalization and multiproduct firms', International Economic Review, 55, 4, 993-1018.

Office for National Statistics, *Annual Respondents Database, 1973-2008: Secure Data Service Access* [computer file]. *2nd Edition.* Colchester, Essex: UK Data Archive [distributor], June 2012. SN: 6644 , http://dx.doi.org/10.5255/UKDA-SN-6644-2

Office for National Statistics. (2017). *Annual Business Survey, 2008-2015: Secure Access*. [data collection]. *8th Edition.* UK Data Service. SN: 7451, http://doi.org/10.5255/UKDA-SN-7451-8

Office for National Statistics. (2018). *Annual Inquiry into Foreign Direct Investment, 1996-2016: Secure Access*. [data collection]. *6th Edition.* UK Data Service. SN: 6664, http://doi.org/10.5255/UKDA-SN-6664-6

Office for National Statistics. (2018). *Business Expenditure on Research and Development, 1994-2016: Secure Access*. [data collection]. *7th Edition.* UK Data Service. SN: 6690, http://doi.org/10.5255/UKDA-SN-6690-7

Office for National Statistics. (2017). *Business Structure Database, 1997-2017: Secure Access*. [data collection]. *9th Edition.* UK Data Service. SN: 6697, http://doi.org/10.5255/UKDA-SN-6697-9

Olley, G. and Pakes, A. (1996), 'The Dynamics of Productivity in the Telecommunications Equipment Industry', Econometrica, 64, 1263-1297.

Ollinger, M., Nguyen, S., Blayney, D., Chambers, B. and Nelson, K. (2006), 'Food industry mergers and acquisitions lead to higher labor productivity', United States Department of Agriculture, Economic Research Report 27.

O'MAHONY, M. (2012), ‘Human capital formation and continuous training: Evidence for EU countries’, Review of income and wealth, 58, 3, 531-549.

Oulton, N. (2000), 'A Tale of Two Cycles: Closure, Downsizing and Productivity Growth in Uk Manufacturing, I973-89', National Institute Economic Review, 173, 1, 66-79.

Penrose, E. (1959), 'The Theory of the Growth of the Firm', Oxford University Press: New York.

Perry, T. and Shivdasani, A. (2005), 'Do boards affect performance? Evidence from corporate restructuring', The Journal of Business, 78, 4, 1403-1432.

Pfaffermayr, M. (1999). Ownership advantages, foreign production and productivity: evidence from Austrian manufacturing firms. Review of Industrial Organization, 15(4), 379-396.

Phillips, G. and Zhdanov, A. (2013), ‘R&D and the Incentives from Merger and Acquisition Activity’, The Review of Financial Studies, 26, 1, 34-78.

Porter, M. (1987), 'From competitive advantage to corporate strategy', Harvard Business Review, 43-59.

Power, L. (1998), 'The missing link: Technology, investment, and productivity', The Review of Economics and Statistics, 80, 2, 300–313.

Ravenscraft, D. and Scherer, F. (1987), 'Mergers, sell-offs, and economic efficiency', Brookings Institution Press, Washington, DC.

Ravenscraft, D. and Scherer, F. (1989), 'The profitability of mergers', International journal of industrial organization, 7, 1, 101-116.

Rhodes–Kropf, M., Robinson, D. and Viswanathan, S. (2005), 'Valuation waves and merger activity: The empirical evidence', Journal of Financial Economics, 77, 3, 561-603.

Rhodes-Kropf, M. and Robinson, D. (2008), 'The market for mergers and the boundaries of the firm', The Journal of Finance, 63, 3, 1169-1211.

Rincon-Aznar, A., Forth, J., Mason, G., O'Mahony, M. and Bernini, M. (2015), 'UK Skills and Productivity in an International Context', Research Paper No. 262, London: Department of Business, Innovation and Skills (BIS).

Roberts, M. and Tybout, J. (1997), 'The decision to export in Colombia: an empirical model of entry with sunk costs', The American Economic Review, 545-564.

Rosenblatt, Z. and Ruvio, A. (1996), ‘A test of a multidimensional model of job insecurity: The case of Israeli teachers’, Journal of Organizational Behaviour, 17, 587–605.

Rosenfeld, J. (1984), 'Additional evidence on the relation between divestiture announcements and shareholder wealth', The Journal of Finance, 39, 5, 1437-1448.

Saïd, T., Le Louarn, J. and Tremblay, M. (2007), 'The performance effects of major workforce reductions: Longitudinal evidence from North America', The International Journal of Human Resource Management, 18, 12, 2075-2094.

Sakellaris, P., and Wilson, D. (2004), 'Quantifying embodied technological change', Review of Economic Dynamics, 7, 1, 1-26.

Schoar, A. (2002), 'Effects of Corporate Diversification on Productivity', Journal of Finance, 57, 6, 2379-2403.

Sevilir, M. and Tian, X. (2012), ‘Acquiring innovation’, Working paper, Indiana University.

Shima, K. (2010), 'Lumpy capital adjustment and technical efficiency', Economics Bulletin 30, 4, 2817–2824.

Shleifer, A. and Summers, L. (1988), 'Breach of trust in hostile takeovers. In Corporate takeovers: Causes and consequences', 33-68, University of Chicago Press.

Spearot, A. (2012), 'Firm heterogeneity, new investment and acquisitions', The Journal of Industrial Economics, 60, 1, 1-45.

Stafford, H. and Watts, H. (1990), 'Abandoned products, abandoned places: Plant closures by multi-product, multi-locational firms in urban areas', Tijdschrift voor Economische en Sociale Geografie, 81, 3, 162-169.

Sverke, M. Hellgren, J. and Näswall, K. (2002), ‘No security: A meta-analysis and review of job insecurity and its consequences’, Journal of Occupational Health Psychology, 7, 242–264

Sweeting, A. (2010), ‘The Effects of Mergers on Product Positioning: Evidence from the Music Radio Industry', Rand Journal of Economics, 41, 2, 372–397.

Syverson, C. (2010), 'What determines productivity?', National Bureau of Economic Research, Working paper no. 15712.

Van Biesebroeck, J. (2003), 'Productivity dynamics with technology choice: An application to automobile assembly', The Review of Economic Studies, 70, 1, 167-198.

Van Biesebroeck, J. (2005), 'Exporting raises productivity in sub-Saharan African manufacturing firms', Journal of International Economics, 67, 2, 373-391.

Van Reenen, J. (2013), 'Productivity under the 1997–2010 Labour government', Oxford Review of Economic Policy, 29, 1, 113-141.

Wagar, T. (1997), 'Factors affecting permanent workforce reduction: Evidence from large Canadian organizations', Canadian Journal of Administrative Sciences, 14, 303-314.

Warusawitharana, M. (2008), 'Corporate Asset Purchases and Sales: Theory and Evidence', Journal of Financial Economics, 87, 471-497.

Watts, H. and Stafford, H. (1986), 'Plant closure and the multiplant firm: some conceptual issues', Progress in Human Geography, 10, 2, 206-227.

Whinston, M. (1988), 'Exit with multiplant firms', RAND Journal of Economics, 19, 4, 568-588.

Wigblad, R., Hansson, M., Townsend, K. and Lewer, J. (2012), 'Shifting frontiers of control during closedown processes', Personnel Review, 41, 2, 160-179.

Wooldridge, J. (2009), 'On Estimating Firm-level Production Functions Using Proxy Variables to Control for Unobservables', Economic Letters, 104, 3, 112-114

Yang, L. (2008), 'The real determinants of asset sales', The Journal of Finance, 63, 5, 2231-2262.

Yu, G. and Park, J. (2006), 'The effect of downsizing on the financial performance and employee productivity of Korean firms', International Journal of Manpower, 27, 3, 230-250.

Zahra, S. and George, G. (2002), 'Absorptive capacity: A review, reconceptualization, and extension', Academy of management review, 27, 2, 185-203.

Zatzick, C. and Iverson, R. (2006), 'High-involvement management and workforce reduction: competitive advantage or disadvantage?', Academy of management Journal, 49, 5, 999-1015.

Zhao, X. (2009), 'Technological innovation and acquisitions', Management Science, 55, 7, 1170-1183