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Channels of Firm Adjustment: Theory and Empirical Evidence

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Abstract

We provide a comprehensive analysis of how firms choose between different expansion and contraction forms, unifying existing approaches from the industrial organization and corporate finance literature. Using novel data covering almost the entire universe of UK firms, we document firms' use of internal adjustment, greenfield investment and mergers and acquisitions (M&As). We describe frequency and aggregate importance of the different channels, and show that their use varies systematically with observable firm characteristics, in particular firm size and the magnitude of adjustment. We also demonstrate that there is positive assortative matching on the UK merger market. Based on these facts, we propose a theoretical framework which accommodates all three adjustment channels in a unified setting, and is able to replicate the adjustment and matching patterns found in the data.

Keywords: Adjustment Channels, Mergers and Acquisitions, Greenfield Investment, Investment

JEL classification: E22, G31, G32, G33, G34, L25

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1 Introduction

Firms constantly adapt to changes in their market environment and technological possibilities. One key mechanism through which this adjustment takes place is through changes in the scale and scope of their operations. Indeed, the importance and magnitude of micro-level adjustments in employment and turnover has been extensively documented in the literature (see Davis et al., 2006, for a recent overview). Building on these empirical facts, a number of theoretical models have been developed over the past decades which have significantly improved our understanding of individual firms' growth processes and their implications for aggregates such as industry-level employment, productivity or firm size distributions (e.g., Jovanovic, 1982; Hopenhayn, 1992; Hopenhayn and Rogerson, 1993; Asplund and Nocke, 2006).

At the same time, however, only little attention has been paid to the actual *channels* through which firm expansions and contractions take place. Changes in firm-level employment and turnover can be achieved in three principal ways. On the one hand, firms can adjust internally, i.e., by changing employment or output at existing production facilities while continuing to use them. On the other hand, firms can expand or contract externally by changing the number of establishments or divisions they operate. This external adjustment, in turn, can happen via greenfield investment, i.e., by shutting down or opening up establishments or divisions; or through the market for corporate control, i.e., by buying or selling parts of a firm's operations through mergers and acquisitions (M&As).

The choice of adjustment channel can have very different economic implications. Firm and plant closures usually lead to substantial social costs in terms of temporary unemployment of workers or lost technological and product-specific know-how (e.g., Jovanovic and Rousseau, 2008). On the other hand, researchers like Jensen (1993) have argued that M&As present a more efficient form of resource transfer between expanding and contracting firms and that over-restrictive regulations prevent firms from using this mechanism.

Despite these considerations, there exists to our knowledge no analysis of the different adjustment channels in one integrated setting. Research in corporate finance has analysed determinants of M&As and asset sales without comparing them to other adjustment mechanisms such as plant contraction or closure (e.g., Maksimovic and Phillips, 2001; Schoar, 2002). Likewise, studies in industrial economics have been predominantly at the *establishment* level (e.g., Disney et al., 2003; Foster et al., 2006) and have thus abstracted from adjustment processes such as greenfield and M&A that are important at the *firm* level. This lack of an integrated analysis of corporate adjustment strategies is an important omission, not only because of the different economic implications described above, but also because the choice of adjustment channel depends on the alternatives available to the individual firm.

In this paper, we aim to fill this gap by analysing all three adjustment channels in a unified framework. We start by presenting a number of novel stylised facts about firms' choice of adjustment forms, using unique business register data for the United Kingdom. In contrast to most of the existing literature, our data allow for an analysis of all three adjustment channels in one integrated setting. They are also not limited to publicly traded firms or to the manufacturing sector, and as such are much more comprehensive than existing sources, representing over 99% of UK turnover and employment between 1997 and 2005.

We show that even though only a small fraction of adjustments take place through the creation or closure of new establishments or the use of M&As, these events trigger changes in turnover which are up to 40 times larger than the average internal adjustment (i.e., changes at existing establishments). As a consequence, external adjustment forms account on average for almost 25% of firm-level changes in turnover, and substantially more in some industrial sectors. We also show that simple firm-level variables such as firm size or the size of a given expansion or contraction strongly correlate with the choice of adjustment channel. In particular, larger firms and those carrying out large expansions or contractions rely more on the two external adjustment forms. Finally, we examine matching patterns in the UK merger market and find that matching is positive assortative (i.e., large firms buy other large firms) rather than negative assortative as predicted by existing theories of adjustment via M&A (e.g., Jovanovic and Rousseau, 2002).

Based on these facts, we propose a theoretical framework in which firms respond to shocks to their marginal costs by expanding or contracting their production capacity through one of the three adjustment forms. Specifically, an individual firm's decision between internal and external adjustment is driven by a span of control problem which gives rise to a trade-off between firm scope and productivity at existing establishments, similar to Nocke and Yeaple (2008). The preferred mode of external adjustment, in turn, is determined on the market for corporate control, where potential acquirers are matched with potential targets, both of which face the outside option of remaining unmatched and relying on greenfield adjustment instead. We show under which assumptions the model generates the correlations found in the data between a firm's choice of adjustment channel and firm and adjustment size, while also replicating the positive assortative pattern of matching we observe on the UK merger market.

Apart from the corporate finance and industrial economics literature discussed above, our paper relates to two important recent contributions by Jovanovic and Rousseau (2002) and Warusawitharana (2008). These authors propose models of firm dynamics which incorporate both internal adjustment and M&As, and present empirical evidence to support them. While thus similar in motivation, there are a number of important differences between these papers and our work. First, neither Jovanovic and Rousseau nor Warusawitharana provide a separate analysis of greenfield investment, implicitly treating it as part of internal adjustments. As we shall see below, this is not merely a minor modification but substantially changes the firm's decision problem. In order to address this issue appropriately, we also rely on a conceptually different modelling framework, which is our second contribution. Rather than invoking the theory of investment under adjustment costs (which is appropriate for the question posed by the above authors), we use insights from the multi-product firm and matching literatures. This is necessary to accommodate all three forms of adjustment in one integrated setting and also brings the model closer to the data by separately modelling firms and individual plants.

Third, our model also differs in one important empirical prediction from Jovanovic and Rousseau (2002) and Warusawitharana (2008). Specifically, it predicts positive assortitative matching on the M&A market, which is consistent with our own evidence for the UK, as well as with recent studies for the United States (Rhodes-Kropf et al., 2005; Robinson and Viswanathan, 2008).

Finally, we are able to use much more comprehensive data than previous studies, covering 99% of employment and turnover in the United Kingdom, rather than focusing exclusively on publicly traded firms. We think that this broader focus is essential, given that our results show that the relative importance of the three adjustment channels varies dramatically with firm size.

The rest of the paper is structured as follows. Section 2 describes our data and presents a number of stylised facts on the choice of adjustment channels by UK firms. Section 3 describes our theoretical framework and discusses the assumptions necessary to replicate the patterns found in the data. Section 4 concludes. Two appendices contain further details on our empirical data and the proofs of our theoretical model's propositions.

2 Stylised Facts on Firm-Level Adjustment Channels

2.1 Description of data

Our primary data source is the Business Structure Database (BSD) which is maintained by the Office for National Statistics (ONS) in the United Kingdom. The BSD is constructed from annual snapshots of the UK's business register, the IDBR. For each year between 1997 and 2005, it contains the universe of British companies which were either registered for Value Added Tax (VAT) purposes or operated a Pay as You Earn (PAYE) income tax scheme. In 2005 the BSD was comprised of 2.2 million live enterprises, representing an estimated 99% of economic activity in terms of employment and turnover (ONS, 2006). The comprehensiveness of the BSD is in contrast to the data sources used in related studies of M&A activity which focus mainly on publicly traded, and thus large, firms (e.g., Jovanovic and Rousseau, 2002;

Warusawitharana, 2008).

The BSD captures the structure of ownership of firms, plants and business sites that make up the British economy using different aggregation categories. In this paper, we focus on the categories 'enterprise groups' and 'enterprises' which for the purpose of our analysis can be thought of as firms and plants, respectively, in the sense of our theoretical model below (see Appendix A for the exact statistical definitions of enterprise groups and enterprises and a discussion of the appropriate choice of aggregation level).

Upon entry into the IDBR, each enterprise and enterprise group is allocated a unique reference number which remains with the unit for as long as it stays on the register. Furthermore, the ONS maintains a list of enterprises for each enterprise group, using information from Dun and Bradstreet and the VAT system (ONS, 2006). Thus, every enterprise also has an enterprise group reference number.

These identifiers allow the analysis of demographic events over time. We have developed an algorithm to identify these events, following a general typology provided by Eurostat (European Commission, 2003). In our methodology, the most basic event is a change in employment or turnover at a continuing enterprise ('internal adjustment'). This is easily observed from the entries of two adjacent years for the same enterprise. If an enterprise identifier disappears from the data, we code this as a plant exit. Likewise, the appearance of a new identifier is coded as a plant entry ('greenfield investment'). Finally, the combination of enterprise and enterprise group references allows for the analysis of ownership changes. For example, if enterprise group A buys enterprise 1 from enterprise group B, the enterprise reference number of enterprise 1 will remain unchanged but its enterprise group identifier will change from B to A. Of course, an enterprise group can carry out several or all of these activities in a given year. For example, it might expand employment and turnover at one of its existing enterprises, create a new enterprise via greenfield investment and buy another one from another enterprise group ('M&A investment').

2.2 Stylised facts

2.2.1 Frequency, aggregate importance and firm-level determinants of adjustment strategies

We begin by providing some basic information about the frequency, size and aggregate importance of the three adjustment channels. Panel A of Table 1 displays the fraction of all adjustments of turnover (i.e., sales revenue) in the UK economy between 1997 and 2005 which take place through each of the three channels.[1] Note that firms can use several channels at the same time so that the percentages do not have to add up to 100%. It is evident from Table 1 that M&As and greenfield investment are rare events. On average, these two channels were used in only about 1% of turnover expansions and contractions in the UK economy, with the vast majority of both expansion and contractions occurring via internal adjustments.

Fact 1. M&As and greenfield investment are rare events. Over 99% of turnover expansions and contractions involve internal adjustments, whereas only about 1% rely at least in part on M&A or greenfield investments/disinvestments.

Panel B shows that, when they take place, M&As and greenfield investments are major events. The average M&A expansion is almost 40 times larger than the average internal expansion in terms of the added turnover, and the average M&A contraction is 30 times larger than internal contractions. Greenfield investments are smaller than M&A expansions but still around 12 times larger than the average internal expansion. Greenfield disinvestments, in contrast, are of comparable size to M&As at over 30 times the size of internal contractions.

Panel B implies that despite their infrequent occurrence, greenfield investment and M&A still account for a large fraction of overall turnover adjustments. Panel C displays the exact numbers. As seen, the two forms together account for 18% of economy-wide turnover expansions and for 26% of contractions. M&As account for a larger share of overall adjustments – around 15% on both the expansion and the contraction side of adjustment. Greenfield transactions, in contrast, are significantly more important in explaining contractions: 11% of aggregate turnover reductions are achieved via firm/establishment closures while the corresponding number on the expansion side is just 2%.

Fact 2. M&As and greenfield expansions and contractions are an order of magnitude larger than internal adjustments. Consequently, and despite their infrequent occurrence, they account for up to a quarter of economy-wide turnover adjustments.

How do firms choose between the three adjustment forms? Tables 2 and 3 provide some initial evidence on how firm size (measured by initial turnover, i.e., before the adjustment in question) and the size of a given turnover expansion or contraction correlate with the choice of adjustment

[1] The BSD contains information on both turnover and employment at the enterprise level. We focus on turnover since this information is updated on a yearly basis, whereas this is not necessarily the case for employment, in particular for some of the smaller enterprises (see Appendix A for details). In practice, however, all of the results presented in the following are qualitatively identical when using employment (results available from the authors upon request).

channel. We use these two basic firm-level determinants because they have been the focus of the existing literature (see Jovanovic and Rousseau, 2002; Warusawitharana, 2008).

Panels A and B of Table 2 show that internal adjustment accounts for close to 100% of the overall expansions and contractions of the bottom 50% of firms in terms of turnover (i.e., those firms with initial turnover equal to or less than £152,000 in 1995 prices). However, the importance of the two external adjustment channels increases steadily with firm size. For the largest 0.1% of enterprise groups (corresponding to a turnover of more than approximately £150 million), M&As and greenfield investment account for 16% and 13% of overall turnover expansions, respectively (17% and 14% for turnover contractions).

A similar pattern arises when we look at the size of a given turnover adjustment (Table 3). The smallest 50% of expansions and contractions (those changing turnover by less than approximately £27,000) are almost exclusively carried out via internal adjustment. As adjustment size increases, however, M&As and greenfield investment become more important. For the largest 0.1% of expansions (those expanding turnover by at least £61.5 million), around 18% of the overall size increase is achieved via M&As, and 4% via greenfield investment. For the largest 0.1% of contractions (those reducing turnover by more than £74 million), M&A accounts for 21% and greenfield disinvestment for 14%.

One shortcoming of the purely descriptive approach in Tables 2 and 3 is that one cannot analyse multivariate correlations in such a setting. In particular, it is the case in our data that large firms carry out large expansions and contractions. Thus, it is unclear whether the correlations displayed in Tables 2 and 3 are driven by firm size, adjustment size, or a combination of both. In addition, these univariate correlations might simply pick up sectoral differences in M&A and greenfield activity caused by other sector-wide determinants, such as differences in market concentration, which are likely to be correlated with average firm and adjustment size.

To address these issues, we employ multivariate fractional regression methods (see Papke and Wooldridge, 1996; Mullahy and Robert, 2008). Denoting the fraction of a gross turnover expansion or contraction carried out by firm i through adjustment form m by y_{im}, we assume that

$$E(y_{im}|x_i) = \frac{\exp(x_i\alpha_m)}{\sum_{j=1}^{M}\exp(x_i\alpha_j)} = \frac{\exp(x_i\alpha_m)}{1+\sum_{j=1}^{M-1}\exp(x_i\alpha_j)}, \tag{1}$$

where matrix x_i contains the independent variables (firm size, expansion size) and α_j the corresponding regression coefficients (note the normalization $\alpha_M = 0$). The advantage of the multinomial logit functional form embodied in (1) is that it imposes two conditions which capture key features of our data. First, $E(y_{im}|x_i)\epsilon\,[0,1]$ for all i and m; and secondly, $\sum_{m=1}^{M} E(y_{im}|x_i) =$

1 for all i.[2]

Table 4 presents the results. In all specifications, we control for year and two-digit industry fixed effects (55 industries) to reduce problems arising from omitted sector characteristics, as discussed above. We have chosen internal adjustment as the excluded category so that coefficient estimates should be interpreted as changes relative to internal expansions or contractions. Looking at expansions first, internal adjustment clearly declines as a fraction of overall adjustment as firm size and the size of the planned expansion increase. Secondly, initial firm size and expansion size have a different impact on M&As and greenfield. While both forms of external adjustment increase in importance with firm and expansion size, the latter variable has a much stronger impact on M&As and the former on greenfield investment. It thus seems that firms undertaking larger expansions will increasingly rely on M&A. A similar pattern seems to hold on the contraction side, although the differences between M&As and greenfield investment are much less pronounced here.[3]

In Table 5, we carry out an additional robustness check by using Tobit and Poisson rather than multivariate fractional logit. These two alternative estimation techniques are both suitable for accomodating the large number of zeros for M&A and greenfield adjustment (compare Table 1) but do not impose any adding-up constraints on predicted values. In this table, we separately regress the fraction of an adjustment carried out through each of the three channels on firm size and the size of an expansion/contraction. Reassuringly, the results are similar to Table 4. Internal adjustment declines in importance with increasing firm and adjustment size, whereas both of the external adjustment forms increase in importance. Comparing the relative coefficient magnitudes between greenfield and M&A adjustment, we again find that firm size has a larger effect on greenfield than on M&A, whereas the opposite holds true for the size of an expansion/contraction (again, results are clearer on the expansion than on the contraction side).

Fact 3. Large expansions and contractions are predominantly undertaken via external adjust-

[2]Estimation of the parameters in (1) is carried out via pseudo-maximum-likelihood methods. A desirable feature of the multivariate fractional logit model is that the parameters α_j will be consistently estimated even when y_{im} takes on values at the extremes of the bounded range they occupy (i.e., $y = 0$ or $y = 1$, as is frequently the case in our data). All that is required is that the conditional mean $E(y_{im}|x_i)$ is correctly specified (see Papke and Wooldridge, 1996, for the univariate case; Mullahy and Robert, 2008, provide an extension to the multivariate case analysed here).

[3]In an additional robust check (see Table A4), we restrict the sample to external expansions/contractions only, in order to compare the relative importance of greenfield investment and M&As more directly. Consistent with the results reported here, firm size had a negative and significant impact on the fraction of expansion carried out through M&As, and expansion size had a significantly positive impact. The same pattern appeared for contractions but the differences between the two external adjustment forms were economically negligible and only statistically significant for firm size.

ment.

Fact 4. Large firms rely more on external adjustment than small firms.

Fact 5. When choosing between the two forms of external expansion, large firms rely more on greenfield than M&As. Firm size does not influence the choice of adjustment channel for external contractions.

Fact 6. When choosing between the two forms of external adjustment, firms rely more on M&As than on greenfield when the desired expansion size is large. The size of the desired adjustment does not influence the choice of adjustment channel for external contractions.

The finding that firms rely more on M&As for large expansions is consistent with previous empirical results in Jovanovic and Rousseau (2002) and Warusawitharana (2008), and lends support to the theoretical mechanisms proposed in these papers. Note, however, that at least on the expansion side, there also seem to be clear-cut empirical regularities on how firms choose between the two external adjustment forms. To the best of our knowledge, no theoretical mechanism has been proposed to date to explain these patterns.

Finally, we note that so far we have focused on economy-wide patterns only, and have paid no attention to potential sectoral differences. In unreported results, we show that there is indeed substantial sectoral variation in the relative importance of the three adjustment channels. For example, we find that the two external adjustment forms account for between 25% and 35% of aggregate turnover expansions in sectors such as manufacturing, utilities and mining, but for less than 3% in agriculture. On the contraction side, these variations are even larger, ranging from around 4% in agriculture to 35% in manufacturing, and to over 50% in mining and utilities. At the same time, however, the correlation patterns between firm and adjustment size and the choice of adjustment channel are surprisingly stable across individual sectors. In all the major sectors which we analysed, reliance on external adjustment forms increases with firm size and with the size of an expansion or contraction (results are available from the authors upon request for 18 separate sectors which together account for 99% of UK turnover). This is why we will try to develop a general, rather than a sector-specific, theory of firm adjustment channels in Section 3 below, which should be applicable to a large number of sectors with suitable parameter adjustments.

2.2.2 Matching patterns on the UK merger market

We are also interested in the pattern of matches formed on the market for corporate control. The prediction of models such as the 'Q-theory of mergers' (Jovanovic and Rousseau, 2002) is that there should be negative assortative matching between acquirers and targets, because gains from trade in these settings increase in the cost differential between the merging firms. However, recent empirical research for the U.S. suggests that merger patterns might instead be positive assortative (see Rhodes-Kropf et al., 2005; Rhodes-Kropf and Robinson, 2008; and Han and Rousseau, 2009). Since the nature of the matching process has important implications for how we model adjustment channels, we briefly examine matching patterns in the UK, again using a substantially larger sample than all previous research.

In Table 6, we consider acquirer-target matches and regress the acquirer's size on the target's size. As seen in column 1, the correlation of target and acquirer size is indeed positive and highly statistically significant. In column 2, we control for industry-pair fixed effects to rule out the possibility that those correlations are driven by cross- or within-industry acquisition patterns. For example, we might find a positive correlation simply because firm size varies substantially across industries and a substantial proportion of acquisitions take place within industries, even if within-industry size correlations are actually negative. The same would be true if cross-industry acquisitions predominantly took place between industries with similar average sizes. By including a fixed effect for each acquirer-target industry combination in our data, column 2 controls for such industry-specific effects. As seen, including industry-pair fixed effects slightly lowers the acquirer-target size correlation, but it remains positive and highly statistically significant.

Finally, columns 3 and 4 include the size of the acquired enterprise as an additional control variable (i.e., in addition to the size of the enterprise group selling this enterprise which we denoted by 'target size' above). In our data, large acquirers tend to undertake large expansions, so that a positive size correlation might simply pick up the fact that acquirers want to save on transaction costs by buying one large target, rather than several smaller ones (and that it is the large enterprise groups that have the largest enterprises and are thus the most natural transaction partners). Including this additional control variable again reduces the firm size correlation slightly, but the relevant coefficient remains positive and statistically significant. We conclude that the evidence is strongly suggestive of a positive assortitative matching pattern on the UK merger market.

Fact 7. Matching on the market for corporate control is positive assortative ('like-buys-like').

Apart from the correlation of target and acquirer size, a full description of matching patterns also requires looking at average acquirer-target size differences. That is, we would not only like to know whether the transaction parties' sizes are positively correlated but also whether the acquirer or the target is larger. In Table 8 we report some simple statistics on average acquirer-target size differences (again in terms of initial enterprise group turnover). First, we calculate the average size difference for each industry in log points of initial turnover, and then average across industries to obtain the differences shown in Table 8 (line 1). As seen, acquirers are on average 1.42 log points larger than targets. Looking sector by sector, acquirers are larger than targets in 92% of industries, with the difference being statistically significant in 85% of cases. In only 8% of sectors are targets larger than acquirers on average, and this difference is only statistically significant in 3% of all industries. We conclude that on average, acquirers are larger than the firms from which they acquire assets.

Fact 8. Firms acquiring assets are larger than the firms from which they acquire these assets (the targets).

3 The Model

We now propose a simple model which is consistent with the above facts. Our starting point is that firms adjust the scale and scope of their production in response to idiosyncratic productivity shocks. In order to rationalize the induced pattern of adjustment, our model combines two basic building blocks.

Firstly, it formalises a trade-off between scope and productivity of monopolistically competitive multi-plant firms, similar to Nocke and Yeaple (2008): the more plants are under control of a given firm, the higher the marginal cost of production at any given establishment. This span of control problem breaks the equivalence between the intensive (changes in the scale of production at a given plant) and the extensive (changes in the number of plants) margin of adjustment. In terms of our data, these margins correspond directly to what we previously called internal and external adjustment, respectively. Accordingly, our goal in this part of the paper (Section 3.2) is to verify if, and under what assumptions, our model will be able to replicate stylised facts 1-4.

Secondly, our model endogenises the choice between the two channels of external adjustment in terms of a matching problem (Section 3.3). Given our interest in replicating stylised facts, the matching approach is a natural choice since the resulting equilibrium on the market for corporate control offers rich empirical predictions. This is because, when considering an acquisition (divestiture), firms take into account (i) the characteristics of the potential target (acquirer), and (ii) their outside option of relying on greenfield activity instead. Hence, we are able to explain outcomes on the market for corporate control – who engages in M&A activity, and with which partner – in terms of observable firm and transaction characteristics. The goal in this second part of the model is thus to check the consistency of its predictions with stylised facts 4-8.

3.1 Demand and technology

We consider an economy where monopolistically competitive firms differ in their organisational capabilities. Accordingly, firms are seen as a bundle of technological and organisational resources, and cross-sectional variation in firm size and scope reflects the underlying heterogeneity of these non-mobile capabilities across firms (Matsusaka, 2001). As in our data, firms can comprise multiple plants, and we assume that a given firm's plants sell products which are differentiated from one another. Key to the firm problem is a trade-off between scope and productivity, similar to a growing number of studies concerned with firm heterogeneity (Nocke and Yeaple, 2008; Eckel and Neary, 2010; Bernard et al., 2009, 2010).

Our model's basic structure in this subsection follows Nocke and Yeaple (2008). There is a mass L of identical consumers with the following linear-quadratic utility function,

$$U = \int x(j)dj - \int [x(j)]^2 \, dj - 2\sigma \left[\int x(j)dj \right]^2 + Z, \tag{2}$$

where $x(j)$ is consumption of product j in the differentiated goods industry, Z is consumption of an outside good, and $\sigma > 0$ is a parameter that measures the degree of product differentiation. Assuming consumer income is sufficiently large, an individual consumer's inverse demand for product j is then given by

$$p(j) = 1 - 2x(j) - 4\sigma \int x(l)dl.$$

The outside good is produced in a perfectly competitive industry which operates under constant returns to scale. In the differentiated goods industry, there is a mass M of atomless firms which differ in their organisational capabilities. A firm's *organisational capability* is given by the pair (c_0, θ), where both c_0 and θ are positive parameters drawn from continuous distribution functions defined over a finite support. The parameter θ is time-invariant, while c_0 is subject to firm-specific shocks. Firms can comprise any number $n \geq 1$ of plants, all of which operate under the common organisational capabilities idiosyncratic to the firm.[4] Hence, there is (technological) heterogeneity across firms, but not across the individual plants belonging to a given firm.

We presume that firms have constant marginal cost at the plant level but that they face decreasing returns to the span of control at the firm level, e.g., as a consequence of scarce managerial resources (Lucas, 1978). For concreteness, we adopt the following specification of the marginal cost common to the plants of a firm with organisational capability (c_0, θ):

$$c(n; c_0, \theta) = c_0 e^{n/\theta}. \tag{3}$$

[4] Notice that, in what follows, we ignore integer constraints for n.

We choose this specification for analytical convenience and also, as will become clear later, because it allows us to isolate θ as a determinant of firm size but not of plant size.[5] The specification in (3) gives marginal cost in multi-plant firms as a nonlinear function defined by an intercept of $c_0 e^{1/\theta}$ for a single-plant firm ($n = 1$) and an elasticity with respect to the number of plants of n/θ. The key properties of this marginal cost function, which will be important in the following, are

$$\frac{\partial c(n; c_0, \theta)}{\partial n} > 0, \qquad \frac{\partial^2 c(n; c_0, \theta)}{\partial \theta \partial n} < 0, \qquad \frac{\partial c(n; c_0, \theta)}{\partial c_0} > 0. \tag{4}$$

The first property formalises the span of control problem: an increase in a firm's number of plants increases its individual plants' marginal cost.[6] The second property, in turn, indicates that the intensity of the span of control problem is decreasing in the scope parameter θ. Finally, we assume that the firm's marginal cost is increasing in the autonomous marginal cost term c_0.

In addition to the marginal cost of production $c(n; c_0, \theta)$, a firm faces a fixed cost of ρ per plant. Each firm's profit maximization problem then consists of the choice of (i) the number of plants n, and (ii) the quantity x_j of output produced at each of its plants $j \in [1, n]$. We examine this problem in three steps. First, for a given number n of plants, we analyze the intensive margin problem, i.e., the firm's plant-level quantity choice. Then, we consider the firm's extensive margin problem, i.e., the determination of firm scope via the optimal choice of the number $n(c_0, \theta)$ of plants. Finally, in Section 3.3, we analyze the firm's extensive margin decision between greenfield expansion/contraction and M&A.

In terms of our empirical analysis, the decision of how to partition a given size adjustment between changes in the number of plants and changes in each existing plant's size corresponds to the choice between internal and external adjustment as described by stylised facts 1-4. The decision whether to rely on M&As or greenfield to achieve a given change in the optimal number of plants, in turn, corresponds to the choice of external adjustment channel as described in facts 5-8.

3.2 Internal vs external adjustment

3.2.1 Plant-level quantity choice

The linear-quadratic specification of consumer preferences gives rise to a linear demand system. Hence, in equilibrium, firms operating in the differentiated goods industry face a linear residual

[5] We discuss the generality of our results with respect to functional form assumptions below.

[6] Schoar (2002) provides empirical evidence indicating that the addition of new product lines has an adverse effect on the productivity of a firm's existing plants.

demand curve for the output produced in each of their individual plants,

$$D(p) = \frac{L}{2}(a - p),$$

where p is the price and a the endogenous demand intercept, which is taken as given by the monopolistically competitive firms. It follows that inverse demand is

$$P(x) = a - \frac{2x}{L},$$

where x is output.

The endogenous demand intercept a is common to all firms and thus to their respective plants. Since marginal costs, as determined by (c_0, θ), are symmetric across a firm's plants, the firm will optimally produce the same quantity at each of its plants. Given a firm's number n of plants, its profit-maximizing level of output per plant is then given by

$$x(c(n; c_0, \theta)) \equiv \arg\max_x \left[P(x) - c(n; c_0, \theta)\right] x = \frac{L}{4}(a - c(n; c_0, \theta)). \tag{5}$$

Accordingly, gross profits at the plant level are

$$\pi(c(n; c_0, \theta)) \equiv \left[P(x(c(n; c_0, \theta))) - c(n; c_0, \theta)\right] x(c(n; c_0, \theta)) = \frac{L}{8}(a - c(n; c_0, \theta))^2. \tag{6}$$

3.2.2 Determination of firm scope

Firm scope, defined as the number n of plants of a given firm, is optimally determined as

$$n(c_0, \theta) \equiv \arg\max_n \left[\pi(c(n; c_0, \theta)) - \rho\right] n,$$

where ρ indicates the fixed cost of adding another plant. From the envelope theorem, $\pi'(c(n(c_0, \theta); c_0, \theta)) = -x(c(n(c_0, \theta); c_0, \theta))$, so that the first-order condition for $n(c_0, \theta)$ can be written as

$$\left[\pi(c(n(c_0, \theta); c_0, \theta)) - \rho\right] - n(c_0, \theta) x(c(n(c_0, \theta); c_0, \theta)) \frac{\partial c(n(c_0, \theta); c_0, \theta)}{\partial n} = 0. \tag{7}$$

From (7), the impact of an additional plant on the firm's profit can be decomposed into two terms: (i) the profit net of the fixed cost of the marginal plant, and (ii) the negative effect via the increased marginal cost of production $c(n(c_0, \theta); c_0, \theta)$ at all plants. Following Nocke and Yeaple (2008), we refer to this second term as the *inframarginal cost effect*.

The specification of marginal cost in (3) implies that $n(\cdot)\partial c(n(\cdot); \cdot)/\partial n = c(n(\cdot); \cdot) \log(\frac{c(n(\cdot); \cdot)}{c_0})$. Hence, the choice of the number of plants enters (7) only through the induced marginal cost

$\tilde{c}(c_0, \theta) \equiv c(n(c_0, \theta); c_0, \theta)$. We adopt the assumption that the fixed cost ρ is not too large, so that the firm earns a stricly positive profit if it only operates a single plant, i.e.,

$$\pi(c_0 e^{1/\theta}) = \left[P(x(c_0 e^{1/\theta})) - c_0 e^{1/\theta}\right] x(c_0 e^{1/\theta}) = \frac{L}{8}\left(a - c_0 e^{1/\theta}\right)^2 > \rho. \tag{8}$$

This allows us to proceed with a description of the relationship between a firm's organisational capability (c_0, θ) and its marginal cost.

Lemma 1 *The optimal determination of firm scope implies that a firm's number of plants $n(c_0, \theta)$ is chosen such that induced marginal cost $\tilde{c}(c_0, \theta) \equiv c(n(c_0, \theta); c_0, \theta)$ is increasing in c_0 and constant in θ. Specifically,*

$$n(c_0, \theta) = \theta \log\left(\frac{\tilde{c}(c_0, \theta)}{c_0}\right)$$

and

$$\frac{dn(c_0, \theta)}{dc_0} < 0, \qquad \frac{dn(c_0, \theta)}{d\theta} > 0, \qquad \frac{d\tilde{c}(c_0, \theta)}{dc_0} > 0, \qquad \frac{d\tilde{c}(c_0, \theta)}{d\theta} = 0.$$

The fundamental determinants of a firm's induced marginal cost $\tilde{c}(c_0, \theta)$ are the autonomous cost term c_0 and the scope parameter θ. As expected, a higher c_0 gives rise to higher induced marginal cost. Intuitively, a variation in c_0 triggers a movement in the optimal number of plants $n(c_0, \theta)$ which mitigates the effect of c_0 on $\tilde{c}(c_0, \theta)$, but does not eliminate it. By contrast, a variation in θ leads to an adjustment in the number of plants which just compensates the direct effect on $\tilde{c}(c_0, \theta)$. In detail, for a given number n of plants, the magnitude of the inframarginal cost effect, $\chi(c(n; c_0, \theta); c_0, \theta) \equiv nx(c(n; c_0, \theta))\partial c(n; c_0, \theta)/\partial n$, exerted by the marginal plant is decreasing in θ. Thus, firms with a higher θ optimally choose a larger number of plants; however, $n(c_0, \theta)$ is increasing at a rate such that induced marginal cost $\tilde{c}(c_0, \theta)$ actually remains constant.

3.2.3 Reformulation in terms of observables

We now link the model's central parameters, i.e., those describing a firm's organisational capability (c_0, θ), to the observable variables used in the empirical section of this paper (firm size as measured by turnover, and the size of a given turnover expansion/contraction). This will later allow us to reinterpret the model's comparative statics with respect to c_0 and θ in terms of these basic firm-level characteristics.

First, optimal turnover (i.e., sales), per plant in the model are given by

$$s(\tilde{c}(c_0, \theta)) \equiv P(x(\tilde{c}(c_0, \theta)))x(\tilde{c}(c_0, \theta)) = \frac{L}{8}\left(a^2 - \tilde{c}(c_0, \theta)^2\right). \tag{9}$$

This is a measure for *plant size*, and its variation in reaction to idiosyncratic shocks captures the importance of internal adjustment. Note that c_0 and θ only influence plant size through their effect on induced marginal cost, and that $ds(c(n; c_0, \theta))/dc(n; c_0, \theta) < 0$; that is, there is a negative relationship between a plant's marginal cost and its size. Together with Lemma 1 this implies that firms with a high c_0 have smaller plants, whereas variation in θ does not have any consequences for plant size.

Second, our model also predicts a relationship between a firm's cost structure and its total size. For comparability with the empirical section, we measure *firm size* by aggregate sales across a firm's plants,

$$S(\tilde{c}(c_0, \theta)) \equiv n(c_0, \theta) s(\tilde{c}(c_0, \theta)) = \theta \log \left(\frac{\tilde{c}(c_0, \theta)}{c_0} \right) \frac{L}{8} \left(a^2 - \tilde{c}(c_0, \theta)^2 \right). \tag{10}$$

The following lemma is concerned with the relation between $S(\tilde{c}(c_0, \theta))$ and a firm's organisational capabilities (c_0, θ).

Lemma 2 *A firm's aggregate sales $S(\tilde{c}(c_0, \theta))$ are decreasing in c_0 and increasing in θ:*

$$\frac{dS(\tilde{c}(c_0, \theta))}{dc_0} < 0, \qquad \frac{dS(\tilde{c}(c_0, \theta))}{d\theta} > 0.$$

Accordingly, firm size is decreasing in autonomous marginal cost c_0, but increasing in the scope parameter θ.

3.2.4 Reaction to idiosyncratic shocks and link to stylised facts 1-4

We are now in a position to analyse firms' response to idiosyncratic technology shocks.

Lemma 3 *Consider the effect of a shock to a firm's autonomous marginal cost c_0.*

(i) A given shock to c_0 has a stronger effect on the firm's optimal number of plants $n(c_0, \theta)$, the larger its organisational capacity θ:

$$\frac{d}{d\theta} \left(\frac{dn(c_0, \theta)}{dc_0} \right) < 0.$$

(ii) A given shock to c_0 has the same effect on the firm's induced marginal cost $\tilde{c}(c_0, \theta)$, irrespective of its organisational capacity θ:

$$\frac{d}{d\theta} \left(\frac{d\tilde{c}(c_0, \theta)}{dc_0} \right) = 0.$$

(iii) A given shock to c_0 has a stronger effect on the firm's aggregate sales $S(\tilde{c}(c_0, \theta))$, the larger its organisational capacity θ:

$$\frac{d}{d\theta}\left(\frac{dS(\tilde{c}(c_0, \theta))}{dc_0}\right) < 0.$$

In response to a shock to their autonomous marginal cost, firms can adjust their scope in order to partially compensate the effects of the shock. In particular, as the magnitude of the underlying shock increases, firms' optimal adjustment strategy increasingly relies on this external margin; as a consequence, the shock's impact on induced marginal cost is mitigated.

Notice that part (iii) of Lemma 3 implies that firms with higher θ will experience a stronger variation in firm size in response to the *same* shock to autonomous marginal cost. Accordingly, the scope parameter θ is related to both firm size (see Lemma 2) and the size of adjustment. With this in mind, we can now translate Lemma 3 in terms of observables.

Proposition 1 *Consider the effect of a shock to a firm's autonomous marginal cost c_0.*

(i) Large firms rely more on external adjustment than small firms. That is, they carry out a larger fraction of overall adjustment via the creation or acquisition of plants (if expanding) or via the closure or sale of plants (if contracting).

(ii) Large expansions and contractions are predominantly undertaken via external adjustment.

Parts (i) and (ii) of Lemma 3 state that larger firms (those with higher θ) adjust the number of plants more strongly in response to a given shock, but that changes in plant size (as determined by $\tilde{c}(c_0, \theta)$) are the same across firms with different θs. It follows that a larger fraction of overall adjustment must be carried out via the extensive margin at larger firms. Noting that θ is also associated with higher overall adjustment (see Lemma 3, part (iii)), it also follows that higher overall adjustment is associated with heavier reliance on external adjustment. Put differently, the same shock to c_0 generates relatively more external adjustment at firms with high θ, and these are also the firms which react with more overall adjustment. In the data, we would thus expect to see positive correlations between the extent of external adjustment, on the one hand, and firm size and the magnitude of the overall adjustment, on the other hand.[7] These are of course our findings stated in stylised facts 3 and 4.

[7] If this is unclear, consider the following hypothetical calibration. We initially set c_0 to the same value across firms but choose different values for θ. We now shock c_0 to the same extent across firms. But because firms differ in terms of θ, the resulting change in firm size will be stronger for high-θ firms. In addition, these are the firms which rely more heavily on external adjustment. Thus, in the data we observe that large firms and firms with high overall adjustment (both characterised by a high θ) will rely more on external adjustment.

Regarding stylised facts 1 and 2, note that, as a matter of convenience, our model formalises n as a continuous variable. Hence, in equilibrium, firm adjustment always relies on both the intensive and the extensive margin and there is no difference in the relative frequency of adjustments along these margins. However, an appropriate reinterpretation for the case of integer n immediately mends this problem. In this scenario, the existence of fixed costs ρ of adding a plant would imply that there must be a minimum adjustment scale to make external adjustment profitable. Accordingly, only adjustments in response to sufficiently large technology shocks would result in external adjustment. Consequently, external adjustments are rare (fact 1) but large on average (fact 2) compared to internal adjustments, as the latter account for all adjustments to small shocks.

We conclude our analysis of the trade-off between internal and external adjustment channels by discussing the robustness of our theoretical predictions. Our key assumption is to invoke a span of control problem which gives rise to a trade-off between firm scope and profitability at the firm's individual plants. Following Nocke and Yeaple (2008), we choose to let this trade-off originate on the supply side. Yet, our particular modelling approach is not without alternatives. Firm-specific shocks could reflect shifts in demand rather than fluctuations in productivity; and externalities across a firm's plants could arise as a consequence of interactions on the demand side instead of technology. However, alternative models along these lines would be largely isomorphic to the framework we consider.

Thus, the linear demand system implied by the assumed quasi-linear preference structure in (2) is not essential, but merely a convenient way of mapping marginal cost into demand and thus plant and firm size. Similarly, the specific functional form of the marginal cost function postulated in (3) does not matter for the gist of our results as long as it satisfies the properties laid out in (4).[8] That $\partial c(n; c_0, \theta)/\partial n > 0$ is the manifestation of the presumed span of control problem, while $\partial c(n; c_0, \theta)/\partial c_0 > 0$ allows for technology shocks to have an effect on marginal cost, thus being the trigger for firms' desire to adjust the scale and scope of their operations. Finally, given $\partial^2 c(n; c_0, \theta)/\partial\theta\partial n < 0$, firms with a strong capacity to coordinate multiple plants (those with a high θ) have low production costs and also a low sensitivity of that cost to variations in firm scope. The first property implies that these firms are large, while the second property implies that their number of plants reacts very elastically to variations in autonomous

[8] Notice the following differences to related specifications employed in the literature. Ordering plants $j \in [1, n]$, Eckel and Neary (2010) assume $c(j; c_0, \theta) = c_0 + \frac{j}{\theta}$, implying that the negative scope effect of adding another plant works only on the marginal plant rather than on the marginal and inframarginal plants. Nocke and Yeaple (2008) assume $c(n; c_0, \theta) = c_0 n^{1/\theta}$, where $1/\theta$ denotes the elasticity of marginal cost with respect to the number of plants n, which is constant rather than variable. Based on this alternative specification, they show that a firm's optimal number of plants can be increasing so fast that induced marginal cost is actually increasing in the firm's organisational capability θ. But again, high-θ firms are large so that our main results apply also for this setup.

marginal cost. In other words, large firms frequently undertake large adjustments and choose to do so via the external channels of adjustment.

3.3 External adjustment channels

A firm's preferred channel of external adjustment, i.e., the decision between the creation or closure of establishments (greenfield investments/divestitures) on the one hand and changes in firm scope brought about by participation in the market for corporate control (M&As) on the other hand, is determined such as to maximise the gains from such adjustment. In order to examine the underlying trade-off, we first need to understand the valuation of plants.

3.3.1 Valuation of plants

Suppose each plant produces under constant returns to scale and has a Cobb-Douglas production function, where $\alpha < \frac{1}{2}$ is the capital share in the production costs. The market value of the plant and its assets is then given by

$$\begin{aligned} \tilde{m}(\tilde{c}(c_0,\theta)) &\equiv P(x(\tilde{c}(c_0,\theta)))x(\tilde{c}(c_0,\theta)) - (1-\alpha)\tilde{c}(c_0,\theta)x(\tilde{c}(c_0,\theta)) \\ &= \frac{1}{2}\left[a-(1-2\alpha)\tilde{c}(c_0,\theta)\right]\frac{L}{4}(a-\tilde{c}(c_0,\theta)), \end{aligned}$$

where the first term is revenue from sales, while the second term corrects for the incurred labor costs. It is also convenient to define the market value of the plant's assets per unit of output $x(\tilde{c}(c_0,\theta))$,

$$m(\tilde{c}(c_0,\theta)) \equiv \frac{\tilde{m}(\tilde{c}(c_0,\theta))}{x(\tilde{c}(c_0,\theta))} = \frac{1}{2}\left[a-(1-2\alpha)\tilde{c}(c_0,\theta)\right].$$

Notice that $m(\tilde{c}(c_0,\theta))$ is decreasing in marginal cost $\tilde{c}(c_0,\theta)$. An individual plants's assets are composed of its physical capital as well as the property rights over the output it sells, which are embodied in the fixed cost ρ of creating a new plant via greenfield investment. Accordingly, the plant's book value is given by

$$b(\tilde{c}(c_0,\theta)) \equiv \alpha\tilde{c}(c_0,\theta)x(\tilde{c}(c_0,\theta)) + \rho = \alpha\tilde{c}(c_0,\theta)\frac{L}{4}(a-\tilde{c}(c_0,\theta)) + \rho,$$

where the first term is the book value of the capital used for production, while the second term represents the fixed cost of greenfield investment. Notice that the book value per unit of output $x(\tilde{c}(c_0,\theta))$ is increasing in marginal cost $\tilde{c}(c_0,\theta)$. This is because we have exogeneously fixed the price of capital to unity, and less productive firms need more capital to produce any given quantity of output.

3.3.2 The market for corporate control

The market for corporate control relocates capital from targets to acquirers, whereby the acquirer incurs the fixed cost ρ from an acquisition as well as additional capital conversion costs to be detailed below. In detail, we define an acquisition as the *relocation of an individual target plant* to an acquirer.[9] Heterogeneity in firms' organisational capabilities gives rise to differences in marginal costs across firms. Depending on the idiosyncratic cost shocks firms receive, they may either want to keep their number of plants constant (no external adjustment) or alternatively adjust their scope by means of external adjustment. The latter firms which seek to adjust externally, in turn, can do so by increasing or decreasing the number of their plants. Accordingly, since a firm can never find it optimal to simultaneously act as a buyer and a seller, the market for corporate control involves two disjoint sets of agents: potential acquirers and potential targets.[10]

Formally, potential acquirers and potential targets interact in a two-sided matching game, deciding whether and with whom to match. Since firms are risk-neutral and monetary transfers in terms of an acquisition price paid by the acquirer to the target's owner are possible and empirically the norm, we assume that the surplus from an acquisition is fully transferable between the transacting parties. An equilibrium in the matching game is described as a *stable assignment*, that is, a profile of matches between acquirers and targets where (i) no matched agent would prefer to remain unmatched, and (ii) there are no two (matched or unmatched) agents who prefer to form a new alternative match. An important property of a stable assignment under *transferable utility* is that it must maximise the total surplus over all possible assigments (Becker, 1973; Shapley and Shubik, 1972).

Potential participants in the takeover market have always the option to stay out. Specifically, firms that want to increase their number of plants can do so via greenfield expansion. When setting up a new plant, they then face costs equal to the plant's book value $b(\tilde{c}(c_0, \theta))$. Similarly, contracting firms have the option of realizing a salvage value from disassembling existing capital via plant closure. We assume that the salvage value is scaled by a factor $\lambda < 1$ relative to the

[9] Maksimovic and Phillips (2001) show that more than half of all M&As in the U.S. involve trade in individual plants and divisions rather than entire corporations. Against this background, our subsequent analysis considers plants (rather than firms) as the relevant units being transacted.

[10] Hence, we conceptualize M&As as 'acquisitions' rather than 'mergers of equals'.

plant's book value net of the fixed cost ρ,[11]

$$\lambda\left[b(\tilde{c}(c_0,\theta))-\rho\right]=\lambda\alpha\tilde{c}(c_0,\theta)x(\tilde{c}(c_0,\theta))=\lambda\alpha\tilde{c}(c_0,\theta)\frac{L}{4}(a-\tilde{c}(c_0,\theta)).$$

By contrast, the payoffs for expanding or contracting firms which decide to participate in the market for corporate control are endogenously determined by the matched acquirer-target pairs. Matching on the market for corporate control is voluntary; that is, we abstract from hostile takeovers by assuming that potential targets can repel unwanted bids.[12]

Let $\tilde{c}^i$ denote the induced marginal cost common to all plants in firm i, and let $\tilde{c}^{ac}$ denote the marginal cost of a generic potential acquirer and $\tilde{c}^{tt}$ denote the marginal cost of a generic potential target. Henceforth, we will simply identify particular plants via their marginal cost. Given that there is a mass M of atomless firms subject to cost shocks, there is a continuum of potential acquirers, whose marginal costs $\tilde{c}^{ac}$ we assume to be continuously distributed on $\left[\tilde{c}^{ac,m},\tilde{c}^{ac,M}\right]$ according to some distribution F^{ac}. Similarly, there is a continuum of potential targets, whose marginal costs $\tilde{c}^{tt}$ are continuously distributed on $\left[\tilde{c}^{tt,m},\tilde{c}^{tt,M}\right]$ according to some distribution F^{tt}. For convenience, we assume that the distribution of idiosyncratic cost shocks is such that the set of potential acquirers and the set of potential targets have equal measure.[13]

3.3.3 Capital conversion and surplus from M&A

Technology, as identified via induced marginal cost $\tilde{c}^i$, is embodied in a firm's capital. Hence, technology is not perfectly mobile across firms. When considering the acquisition of a potential target, a potential acquirer therefore faces capital conversion costs $\Gamma(\tilde{c}^{ac},\tilde{c}^{tt})$ which arise as a consequence of converting type-$\tilde{c}^{tt}$ capital into capital that is in line with its own technology $\tilde{c}^{ac}$.[14] We assume that the larger the technological gap between the acquirer and the target, the higher the cost of converting inferior capital into more productive capital. Formally, the conversion cost $\Gamma(\tilde{c}^{ac},\tilde{c}^{tt})$ is zero if $\tilde{c}^{ac}\geq\tilde{c}^{tt}$, and increasing and strictly convex in the marginal cost differential $(\tilde{c}^{tt}-\tilde{c}^{ac})$ if $\tilde{c}^{ac}<\tilde{c}^{tt}$:

$$\frac{\partial\Gamma(\tilde{c}^{ac},\tilde{c}^{tt})}{\partial\tilde{c}^{ac}}<0,\qquad\frac{\partial\Gamma(\tilde{c}^{ac},\tilde{c}^{tt})}{\partial\tilde{c}^{tt}}>0,\qquad\frac{\partial^2\Gamma(\tilde{c}^{ac},\tilde{c}^{tt})}{\partial\tilde{c}^{ac}\partial\tilde{c}^{tt}}<0.$$

[11]Similar assumptions are also made in Jovanovic and Rousseau (2002) and Warusawitharana (2008). Analyzing equipment-level data from U.S. aerospace plants that closed during the 1990s, Ramey and Shapiro (2001) find that, even after controlling for age-related depreciation, used capital sells at a substantial discount, corresponding to $\lambda = 0.75$. Focusing on continuing plants, Cooper and Haltiwanger (2006) obtain somewhat lower discounts, with λ ranging from 0.8 to 0.98. Warusawitharana (2008) calibrates $\lambda = 0.98$.

[12]In their study of mergers among publicly traded U.S. firms, Andrade et al. (2001) report that between 1973 and 1998 only 8.3% of all takeover bids were hostile and only 4.4% eventually succeeded. We do not explain such mergers.

[13]Our subsequent results generalise to the case of unequal measures (results available from the authors upon request).

[14]For a similar assumption, see Han and Rousseau (2009).

A necessary condition for an M&A transaction relocating capital from a target ($\tilde{c}^{tt}$) to an acquirer ($\tilde{c}^{ac}$) to take place is that there are (absolute) gains from it,

$$H(\tilde{c}^{ac}, \tilde{c}^{tt}) = \left[m(\tilde{c}^{ac}) - m(\tilde{c}^{tt})\right] x(\tilde{c}^{tt}) - \left[\Gamma(\tilde{c}^{ac}, \tilde{c}^{tt}) + \chi(\tilde{c}^{ac}; c_0^{ac}, \theta^{ac}) - \chi(\tilde{c}^{tt}; c_0^{tt}, \theta^{tt})\right] - \rho, \quad (11)$$

where the first term captures the direct gains from relocating production capacity from the target to the acquirer. These gains must be weighed against the fixed cost ρ of the transaction and another term, which captures the conversion costs as well as the within-firm externalities arising from the inframarginal cost effect. Specifically, the acquirer's plants are subject to increased marginal cost, while the plants retained by the target firm benefit from reduced marginal cost.[15]

In what follows, we proceed under the assumption that the inframarginal cost differential is small relative to the fixed cost ρ, implying that $\rho + [\chi(\tilde{c}^{ac}; c_0^{ac}, \theta^{ac}) - \chi(\tilde{c}^{tt}; c_0^{tt}, \theta^{tt})] \geq 0$. It is then evident from (11) that the existence of gains from an M&A transaction necessarily requires that $m(\tilde{c}^{ac}) - m(\tilde{c}^{tt}) \geq 0$, or equivalently,

$$\tilde{c}^{ac} \leq \tilde{c}^{tt}. \quad (12)$$

However, since an acquirer's and a target's plants generally produce different quantities, $x(\tilde{c}^{ac}) \neq x(\tilde{c}^{tt})$, the transacted plant's post-acquisition size must be adjusted via internal investment. Hence, the gross surplus generated from relocating a plant via M&A followed by internal adjustment to bring it to its efficient post-acquisition scale $x(\tilde{c}^{ac})$ is

$$\begin{aligned} G(\tilde{c}^{ac}, \tilde{c}^{tt}) &= \left[m(\tilde{c}^{ac}) - m(\tilde{c}^{tt})\right] x(\tilde{c}^{tt}) - \left[\Gamma(\tilde{c}^{ac}, \tilde{c}^{tt}) + \chi(\tilde{c}^{ac}; c_0^{ac}, \theta^{ac}) - \chi(\tilde{c}^{tt}; c_0^{tt}, \theta^{tt})\right] - \rho \\ &\quad + \left[m(\tilde{c}^{ac}) - \alpha\tilde{c}^{ac}\right] \left[x(\tilde{c}^{ac}) - x(\tilde{c}^{tt})\right]. \end{aligned}$$

Similarly, we define the relevant outside options for the parties in the market for corporate control. For a potential acquirer, the payoff from remaining unmatched on the merger market and expanding by greenfield investment at scale $x(\tilde{c}^{ac})$ is

$$G(\tilde{c}^{ac}, 0) = \left[m(\tilde{c}^{ac}) - \alpha\tilde{c}^{ac}\right] x(\tilde{c}^{ac}) - \chi(\tilde{c}^{ac}; c_0^{ac}, \theta^{ac}) - \rho.$$

For a potential target, the payoff from remaining unmatched on the merger market and contracting via the sale of disembodied used capital is

$$G(0, \tilde{c}^{tt}) = \left[\lambda\alpha\tilde{c}^{tt} - m(\tilde{c}^{tt})\right] x(\tilde{c}^{tt}) + \chi(\tilde{c}^{tt}; c_0^{tt}, \theta^{tt}).$$

[15]Notice that the monetary transaction price paid by the acquirer does not appear in (11) because it simply redistributes resources between the acquirer and the target and thus does not affect their joint gains; this is an implication of our assumption of transferable utility.

We are now ready to define the net surplus – relative to the parties' outside options – created by an acquisition:

$$\Delta(\tilde{c}^{ac}, \tilde{c}^{tt}) \equiv G(\tilde{c}^{ac}, \tilde{c}^{tt}) - G(\tilde{c}^{ac}, 0) - G(0, \tilde{c}^{tt}) = \left[\alpha\tilde{c}^{ac} - \lambda\alpha\tilde{c}^{tt}\right] x(\tilde{c}^{tt}) - \Gamma(\tilde{c}^{ac}, \tilde{c}^{tt}). \tag{13}$$

Accordingly, the net surplus from an acquisition is given by the net benefit per unit multiplied by the transaction size as measured by the production capacity of the transacted plant, net of the incurred cost of capital conversion. The net benefit per unit, in turn, is given by the difference between the acquirer's benefit from economising on the purchase price of new capital via greenfield expansion and the target's opportunity cost due to the foregone salvage value from plant closure.[16] For an acquirer-target match to be viable, it must generate a surplus $\Delta(\tilde{c}^{ac}, \tilde{c}^{tt}) \geq 0$. This is the case if the transaction generates a non-negative net benefit, a necessary condition for which is

$$\tilde{c}^{ac} \geq \lambda\tilde{c}^{tt}. \tag{14}$$

3.3.4 The stable assignment

Taken together, conditions (12) and (14) imply

$$\tilde{c}^{tt} \geq \tilde{c}^{ac} \geq \lambda\tilde{c}^{tt}. \tag{15}$$

In other words, the market for corporate control relocates capital from high cost firms to low cost firms,[17] but the cost differential between the matched firms cannot be too large. It is worth emphasizing that this last property does not hinge on the existence of capital conversion costs; instead, gains from trade on the market for corporate control arise as a consequence of the discount for the sale of disembodied used capital ($\lambda < 1$).

The remainder of this section is concerned with the scenario where $\tilde{c}^{ac,m} < \tilde{c}^{tt,m} \leq \frac{1}{\lambda}\tilde{c}^{ac,M}$ holds. As shown in Appendix B.5, this restriction is a necessary condition for the coexistence of M&A and greenfield investment along the stable assignment on the market for corporate control (in other words, there is scope for gains from adjustment via both external adjustment channels). Given that we do indeed observe such a coexistence in our data, the restriction seems

[16] Notice that inframarginal cost considerations have cancelled out in the derivation of (13) and thus are irrelevant in the context of our analysis of external adjustment: The inframarginal cost effect matters for the determination of firm scope and hence for the selection of firms into external adjustment activity (Section 3.2). However, since inframarginal cost considerations are *equally* relevant for variations of firm scope via both available channels of external adjustment, they do not matter for the selection of firms into greenfield versus M&A activity.

[17] That capital flows from high cost firms to low cost firms is the basic prediction of the 'Q-theory of mergers' (Jovanovic and Rousseau, 2002).

reasonable. We now seek to examine the characteristics of the potential acquirers and targets who are matched on the market for corporate control or instead remain unmatched and engage in greenfield expansions/contractions. To that end, the properties of the surplus function (13) are crucial.

Notice that (13) denotes the joint surplus a potential acquirer and a potential target can realize by undertaking an acquisition, but does not describe the division of the surplus among the two parties. Because a stable assignment under transferable utility must maximise the total surplus over all possible assignments, the first-order derivatives of the surplus function $\Delta(\tilde{c}^{ac}, \tilde{c}^{tt})$ determine which firms are matched or remain unmatched, while the cross derivative determines which acquirer is matched to which target (Roth and Sotomayor, 1990). In the context of our model, the following pattern applies. The partial derivative with respect to the acquirer's marginal cost is

$$\frac{\partial \Delta(\tilde{c}^{ac}, \tilde{c}^{tt})}{\partial \tilde{c}^{ac}} = \alpha x(\tilde{c}^{tt}) - \frac{\partial \Gamma(\tilde{c}^{ac}, \tilde{c}^{tt})}{\partial \tilde{c}^{ac}} > 0.$$

Given $\tilde{c}^{tt}$, an increase in $\tilde{c}^{ac}$ raises the net benefit per unit of production capacity transacted in an acquisition. The reason behind this property are the increased savings from an acquisition relative to the alternative of greenfield expansion for high cost acquirers. In addition, given $\tilde{c}^{tt}$, an increase in $\tilde{c}^{ac}$ reduces the incurred conversion costs $\Gamma(\tilde{c}^{ac}, \tilde{c}^{tt})$.

By contrast, the sign of the partial derivative with respect to the target's marginal cost is

$$\frac{\partial \Delta(\tilde{c}^{ac}, \tilde{c}^{tt})}{\partial \tilde{c}^{tt}} = -\lambda \alpha x(\tilde{c}^{tt}) + \left[\alpha \tilde{c}^{ac} - \lambda \alpha \tilde{c}^{tt}\right] \frac{\partial x(\tilde{c}^{tt})}{\partial \tilde{c}^{tt}} - \frac{\partial \Gamma(\tilde{c}^{ac}, \tilde{c}^{tt})}{\partial \tilde{c}^{tt}} < 0.$$

Thus, given $\tilde{c}^{ac}$, an increase in $\tilde{c}^{tt}$ reduces the net surplus generated from an acquisition. This is because (i) the outside option of greenfield contraction is more attractive for high cost targets, and (ii) acquirers face higher conversion costs when integrating them. Moreover, the induced reduction in the transaction size $x(\tilde{c}^{tt})$ has an additional negative effect.

Finally, the cross derivative of the surplus function (13) is

$$\frac{\partial^2 \Delta(\tilde{c}^{ac}, \tilde{c}^{tt})}{\partial \tilde{c}^{ac} \partial \tilde{c}^{tt}} = \alpha \frac{\partial x(\tilde{c}^{tt})}{\partial \tilde{c}^{tt}} - \frac{\partial^2 \Gamma(\tilde{c}^{ac}, \tilde{c}^{tt})}{\partial \tilde{c}^{ac} \partial \tilde{c}^{tt}}. \tag{16}$$

The sign of the cross derivative depends on the relative magnitude of the two terms in (16) both of which are negative. It is therefore useful to start from the benchmark where conversion costs are absent, i.e., $\Gamma(\tilde{c}^{ac}, \tilde{c}^{tt}) = 0$ globally. In this case (16) degenerates to

$$\frac{\partial^2 \Delta(\tilde{c}^{ac}, \tilde{c}^{tt})}{\partial \tilde{c}^{ac} \partial \tilde{c}^{tt}}|_{\Gamma=0} = \alpha \frac{\partial x(\tilde{c}^{tt})}{\partial \tilde{c}^{tt}} < 0.$$

The negative sign of the cross derivative indicates substitutability between the individual characteristics of an acquirer-target match. This reflects the fact that the increase in the surplus from an acquisition due to an increase in $\tilde{c}^{ac}$ increases in the transaction size as measured by the acquired plant's capacity $x(\tilde{c}^{tt})$, which, in turn, is decreasing in $\tilde{c}^{tt}$. Therefore, absent conversion costs, the surplus maximizing assignment on the market for corporate control should generate a profile of matches such that larger transactions occur for acquirer-target pairs with a higher net benefit $\alpha\tilde{c}^{ac} - \lambda\alpha\tilde{c}^{tt}$ per unit transacted.

However, the presence of conversion costs may twist this result. Intuitively, the fact that $\Gamma(\tilde{c}^{ac}, \tilde{c}^{tt})$ is increasing and convex in the difference $(\tilde{c}^{tt} - \tilde{c}^{ac})$ punishes potential matches between technologically distant partners, i.e., mergers that would otherwise generate the highest gains. Indeed, the conversion costs may increase so fast in the cost differential such as to dominate the advantageous effect discussed above. Specifically, if

$$-\frac{\partial^2\Gamma(\tilde{c}^{ac}, \tilde{c}^{tt})}{\partial\tilde{c}^{ac}\partial\tilde{c}^{tt}} > -\alpha\frac{\partial x(\tilde{c}^{tt})}{\partial\tilde{c}^{tt}} = \alpha\frac{L}{4}, \tag{17}$$

the cross derivative (13) becomes positive. In this case, the surplus maximizing assignment involves a profile of matches where larger transactions occur between technologically similar firms.

Lemma 4 *Under sufficiently convex conversion costs, such that (17) holds, the stable assignment on the market for corporate control is positive assortative. Otherwise, the stable assignment on the market for corporate control is negative assortative.*

Assortative matching is a direct implication of the fact that aggregate surplus must be maximized in a stable assignment. Lemma 4 states that sufficiently convex conversion costs $\Gamma(\tilde{c}^{ac}, \tilde{c}^{tt})$ are necessary to generate a stable assignment with positive assortative matching. The empirical evidence presented in Section 2 shows that the UK merger market displays a pattern of positive assortative acquirer-target matches. Against this background, we therefore proceed to examine the case where the conversion costs satisfy (17). The following lemma examines this scenario in greater detail.

Lemma 5 *Suppose $\tilde{c}^{ac,m} < \tilde{c}^{tt,m} \leq \frac{1}{\lambda}\tilde{c}^{ac,M}$ such that both greenfield adjustment and acquisitions can potentially coexist as part of the stable assignment on the market for corporate control. Suppose further that the capital conversion costs $\Gamma(\tilde{c}^{ac}, \tilde{c}^{tt})$ are sufficiently convex such that (17) holds.*

(i) If acquisitions do not occur as part of the stable assignment, then $\tilde{c}^{ac,M} < \tilde{c}^{tt,m}$ and conversion costs must be sufficiently strong.

(ii) If $\tilde{c}^{tt,m} \leq \tilde{c}^{ac,M}$, acquisitions occur as part of the stable assignment.

(a) *The minimum cost match* $(\underline{c}^{ac}, \underline{c}^{tt})$ *is formed by the potential target with the lowest marginal cost,* $\underline{c}^{tt} = \tilde{c}^{tt,m}$*, and its acquirer with weakly lower marginal cost,* $\underline{c}^{ac} \leq \tilde{c}^{tt,m}$*.*

(b) *If* $\tilde{c}^{ac,M} \leq \tilde{c}^{tt,M}$*, the maximum cost match* $(\bar{c}^{ac}, \bar{c}^{tt})$ *is formed by the potential acquirer with the highest marginal cost,* $\bar{c}^{ac} = \tilde{c}^{ac,M}$*, and its target with weakly higher marginal cost,* $\bar{c}^{tt} \geq \tilde{c}^{ac,M}$*. Otherwise, if* $\tilde{c}^{ac,M} > \tilde{c}^{tt,M}$*, the maximum cost match* $(\bar{c}^{ac}, \bar{c}^{tt})$ *is formed by* $\bar{c}^{ac} = \tilde{c}^{tt,M}$ *and its target with identical marginal cost* $\bar{c}^{tt} = \tilde{c}^{tt,M}$*.*

(c) *Potential targets* $\tilde{c}^{tt} \in [\underline{c}^{tt}, \bar{c}^{tt}]$ *are taken over by potential acquirers* $\tilde{c}^{ac} \in [\underline{c}^{ac}, \bar{c}^{ac}]$*, whereby matching is positive assortative and the market for corporate control clears,*

$$F^{tt}(\bar{c}^{tt}) - F^{tt}(\underline{c}^{tt}) = F^{ac}(\bar{c}^{ac}) - F^{ac}(\underline{c}^{ac}).$$

All other firms adjust via greenfield contraction or expansion.

According to Lemma 5, the market for corporate control matches a subset of the externally adjusting firms into acquirer-target pairs. Specifically, the potential target with the lowest marginal cost, $\tilde{c}^{tt,m}$, is always matched, while potential targets with very high marginal cost (those with $\tilde{c}^{tt} > \bar{c}^{tt}$) adjust via greenfield disinvestment, i.e., plant closures and subsequent sales of disembodied used capital. On the other side of the market, the potential acquirer with the highest marginal cost, $\tilde{c}^{ac,M}$, is matched provided there exists a viable target $\tilde{c}^{tt} \geq \tilde{c}^{ac,M}$; potential acquirers with very low marginal cost (those with $\tilde{c}^{ac} < \underline{c}^{ac}$) adjust via greenfield expansions instead. Throughout, acquisitions relocate capital from targets to acquirers with weakly lower marginal cost, and the pattern of acquirer-target matches is positive assortative, such that high cost targets are absorbed by high cost acquirers ('like-buys-like').

Figure 1 graphically illustrates the properties of the stable assignment on the market for corporate control. Matched targets and acquirers can be identified in terms of their marginal cost. In the empirically relevant case where both M&As and greenfield investment are observed, the stable assignment matches potential acquirers with sufficiently high marginal cost, but rations those with low marginal cost. As explained above, the surplus from matching on the market for corporate control relative the outside option of greenfield investment is increasing in a potential acquirer's marginal cost. The key mechanism behind this result is that less productive firms face higher costs of greenfield expansion because they need to purchase a larger quantity of physical capital. Similarly, potential targets with sufficiently low marginal cost are matched, but rationing happens for high cost firms. This reflects the fact that the outside option of contracting via sales of used capital is less attractive for low cost firms who sell only a relatively small quantity of physical capital.

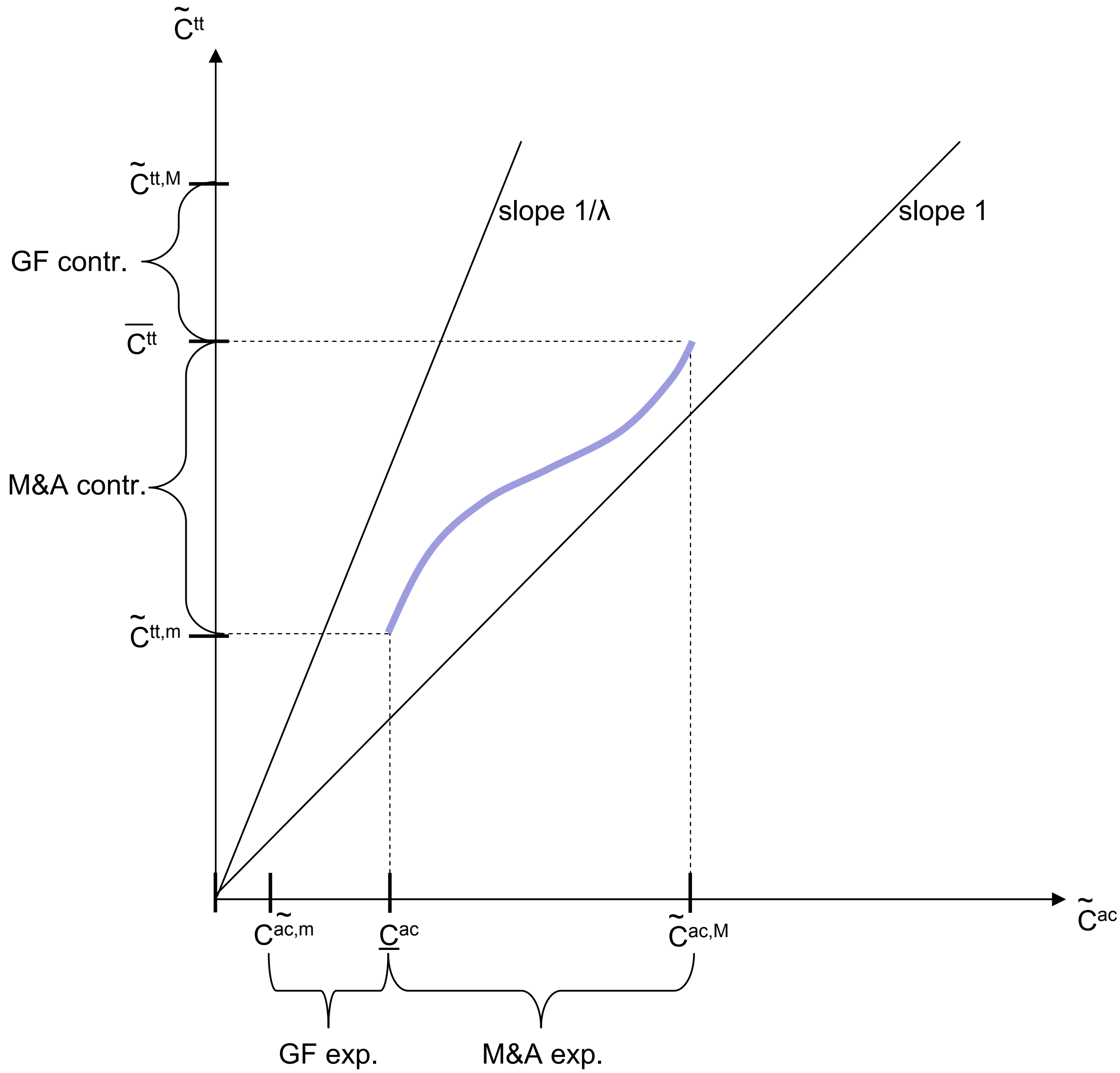

Figure 1: Stable assignment on the market for corporate control

3.3.5 Link to stylised facts 5-8

We conclude this section by restating our results in terms of observables: firm size and the magnitude of adjustment. In contrast to our previous analysis, we now stress cross-sectional heterogeneity in the autonomous cost parameter c_0. We do so for two reasons. First, as explained in Lemma 5, firms' external adjustment behaviour is determined by their marginal cost, and by Lemma 1, $d\tilde{c}(c_0, \theta)/d\theta = 0$; so cross-sectional heterogeneity in marginal cost arises only as a consequence of heterogeneity in c_0. Second, even in a more general environment where $d\tilde{c}(c_0, \theta)/d\theta \neq 0$, the effective heterogeneity in θ is reduced by a selection effect: Since the decision to adjust externally in response to a cost shock selects high-θ firms, while low-θ firms prefer to adjust internally, the remaining variation in θ across firms undertaking external adjustment (the focus of this section) is likely to be lower than the variation in c_0.[18] Since $dS(\tilde{c}(c_0, \theta))/dc_0 < 0$ (Lemma 2), we then conclude that high cost firms are small in terms of their aggregate sales turnover.

Proposition 2 *Consider the set of externally adjusting firms.*

(i) Among the potential acquirers, large firms are more likely to expand by greenfield investment, while small firms are more likely to expand by plant acquisition (M&A).

(ii) Among the potential targets, small firms are more likely to contract via plant closure, while large firms are more likely to contract by plant sale (M&A).

(iii) Acquisitions relocate capital from small firms to weakly larger firms, whereby larger targets sell plants to larger acquirers (positive assortative matching).

(iv) Large transactions are more likely to proceed via M&A rather than greenfield adjustment.

The first three parts of Proposition 2 reformulate results from Lemma 5. Finally, the last part of Proposition 2 provides a prediction concerning the relationship between transaction size and the preferred mode of external adjustment. Inspection of the surplus function (13) indicates that the gains from M&A adjustment relative to greenfield adjustment are determined by, among other things, the transaction size, $x(\tilde{c}^{tt})$. Specifically, a marginal increase in transaction size increases the surplus of a given acquirer-target match by the amount $[\alpha\tilde{c}^{ac} - \lambda\alpha\tilde{c}^{tt}] > 0$. Ceteris paribus, therefore, larger transactions are more likely to proceed via M&A rather than greenfield adjustment.[19] This is consistent with stylised fact 6.

[18] This is true if the initial variation in θ is not substantially larger and/or the correlation between θ and c_0 is not too high.

[19] Formally, this follows from $\frac{\partial\Delta(\tilde{c}^{ac}, \tilde{c}^{tt})}{\partial\tilde{c}^{tt}} < 0$.

Recall that marginal cost determines not only firm size but also factor demand. Specifically, less productive firms require more capital to produce any given quantity of output. Therefore, when trading off the two channels of external adjustment, the motive of economising on the purchase price of new capital is more important for small (i.e., high cost) potential acquirers. As a consequence, these firms are more likely to undertake an acquisition, while large potential acquirers tend to expand via greenfield investment (fact 5).

A similar trade-off is operative on the contraction side, where our model predicts a positive correlation between firm size and the likelihood of the contraction to happen via plant sale (M&A). This is the one prediction where our model is at odds with our earlier evidence – recall that we concluded that there is no link between firm size and the choice of external adjustment channel for contractions (fact 5). One explanation, which is admittedly favourable to our model, is that the variation in (adverse) idiosyncratic cost shocks on the target side is too small to yield detectable differences in contraction behaviour. Another explanation is that additional factors play a role in firms' decision behaviour, which are absent from our model. For example, it could be that antitrust authorities are generally less inclined to permit the acquisition of larger firms because of the resulting increase in market power of the acquirer (this increase would of course be lower for acquisitions of smaller firms).

As pointed out above, gains from trade on the market for corporate control arise as a consequence of the discount for the sale of disembodied used capital ($\lambda < 1$). Our model shares this aspect with other models in the tradition of the Q-theory of mergers. Similar to those models, our theory also predicts that the market for corporate control relocates capital from less to more productive firms. Since more productive firms are larger, this is consistent with stylised fact 8. Different from the basic Q-theory of mergers, though, our model also predicts the pattern of matches on the market for corporate control to be positive assortative. This 'like-buys-like' aspect of M&A transactions corresponds to stylised fact 7. A critical assumption to generate such positive assortative pattern is the existence of capital conversion costs, which put a bound on the technological gap for a viable acquirer-target pair.[20]

[20]Finally note that one implication of our model for empirical analysis is that the decision between the three adjustment forms should be modelled as a two-tier structure. First, firms choose between internal and external adjustment; and second, they choose between greenfield and M&A investment. This is of course the estimation strategy we have pursued in one of our earlier robustness checks (see footnote 3 and Table A4). As seen there, a two-tier approach yields very similar results to the one-tier approach we used earlier.

4 Conclusions

We have presented a comprehensive analysis of how firms choose between different expansion and contraction forms. Using novel data covering almost the entire universe of UK firms between 1997 and 2005, we have documented firms' use of internal adjustment, greenfield investment and mergers and acquisitions (M&As). We have described frequency and aggregate importance of the different channels, and have shown that their use varies systematically with two observable firm characteristics, firm size and the magnitude of adjustment. We have also examined the pattern of matches formed on the market for corporate control, demonstrating that larger firms buy smaller firms and that there is positive assortative matching on the UK merger market. Based on these facts, we have proposed a theoretical framework which accommodates all three adjustment channels in a unified setting, and is able to replicate the adjustment and matching patterns found in the data. The key features of the model are a span of control problem, which gives rise to a trade-off between firm scope and productivity, and the existence of capital conversion costs, which prevent M&As between potential partners that are technologically too distant.

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A Additional Details on Data Construction

In this appendix, we discuss two more technical aspects of the BSD which are relevant for our analysis. The first one concerns the appropriate level of aggregation. As discussed in Section 2.1, the BSD captures the ownership structure of firms, plants and business sites using different aggregation categories. Besides the two categories used in our analysis, the enterprise and the enterprise group, the BSD also contains a third category, the so-called local unit. The ONS defines these three categories as follows (ONS, 2006). An enterprise "is the smallest combination of legal units that is an organisational unit producing goods or services, which benefits from a certain degree of autonomy in decision-making, especially for the allocation of its current resources". An enterprise group is "an association of enterprises bound together by legal and/or financial links". Finally, a local unit is "an enterprise or part thereof (e.g., a workshop, factory, warehouse or office) situated in a geographically identified place".

Similar to enterprises and enterprise groups, each local unit is allocated a unique reference number upon entry into the IDBR, and the ONS maintains a list of local units for each enterprise. Thus, in principle, our methodology for computing demographic events described in Section 2.1 can be implemented at different levels of aggregation. As discussed, in this paper we take the enterprise group as the decision-making unit and analyse how it changes turnover through adjustments at its existing enterprises and the acquisition/sale or creation/closure of new ones. In our view, the enterprise group is a natural choice for the upper level of our analysis, given that many of the expansion and contraction decisions we are interested in here are of first-order importance to a firm and are likely to be made centrally and at the highest level of a firm.[21]

Another reason for working at the enterprise group/enterprise level (rather than at the enterprise group/local unit or enterprise/local unit level) is that there are a number of important data issues related to the local unit level of the BSD. First, the local unit structure of enterprises is updated much less frequently than the links between enterprise groups and enterprises, in particular for smaller enterprises.[22] This makes an implementation of the above methodology problematic, in particular when looking at year-to-year changes in ownership structure, as we

[21] This is particularly true for the two external forms of adjustment, greenfield investment and M&As. While enterprises are defined above as "benefiting from a certain degree of autonomy in decision-making in the allocation of current resources", this definition does not include strategic investment decisions such as the acquisition or the opening up of new plants or operations.

[22] See ONS (2001, 2003) and Jones (2000, p.51). The local unit structure of enterprises is updated through the Annual Register Inquiry (ARI) which samples large enterprises (100 or more employees before 2003, 50 in later years) every year but only one in four of medium-sized enterprises (20-99 and 20-49 employees before and after 2003, respectively). For smaller enterprises, updating takes place on an ad-hoc basis only. In contrast, the ownership information linking the enterprise group and the enterprise level is updated at least once a year (see Dun & Bradstreet, 2001; ONS, 2006).

do in this paper. Second, most enterprises with multiple local units only report information on turnover and employment at the enterprise level, preventing the implementation of our methodology at the local unit level for these enterprises (see Criscuolo et al., 2003). Finally, local unit identifiers are considered by the ONS to be less stable over time than enterprise identifiers (ONS, 2006). That is, local units sometimes change their identifiers even though no corporate event has occurred, creating problems of false exit in our methodology.

A second important issue concerns the choice of variable to measure enterprise group size and size changes in our analysis. At the enterprise level, the BSD contains employment and turnover information (from PAYE and VAT records, respectively). At first glance, employment might seem to be a better indicator of enterprise group size changes as the number of employees is more directly under the control of a firm. Again, however, data quality makes us opt for turnover. This is because employment information for smaller enterprises in the BSD is updated less regularly than turnover information.[23] Using employment data as a size change indicator would thus lead to an underestimate of the importance of internal adjustment relative to external adjustment. We note, however, that this issue does not seem to matter much in practice. As we demonstrate in unreported results (available from the authors upon request), all of the qualitative results in this paper go through when using employment rather than turnover information.

B Theoretical Appendix

B.1 The linear demand system

See Nocke and Yeaple (2008).

B.2 Proof of Lemma 1

Since the choice of the number of plants enters (7) only through the induced marginal cost $\tilde{c}(c_0, \theta) \equiv c(n(c_0, \theta); c_0, \theta)$, the optimal determination of firm scope can equivalently be for-

[23]See Criscuolo et al. (2003) and ONS (2001) for details. While turnover is updated continuously from VAT sources, employment is frozen at the point at which an enterprise arrives on the IDBR. Afterwards, it is only updated through the ARI which mainly covers larger enterprises (see footnote 23). ONS (2001) reports that in the year 2000, enterprises accounting for close to 10% of employment had not had their employment information updated since the Census of Employment in 1993.

malised in terms of choosing $\tilde{c}(c_0,\theta)$ rather than n. Hence, (7) can be rewritten as

$$\begin{aligned}\Psi(\tilde{c}(c_0,\theta)) &= [P(x(\tilde{c}(c_0,\theta))) - \tilde{c}(c_0,\theta)]\, x(\tilde{c}(c_0,\theta)) - \rho - \tilde{c}(c_0,\theta)\log\left(\frac{\tilde{c}(c_0,\theta)}{c_0}\right) x(\tilde{c}(c_0,\theta)) \\ &= \frac{L}{8}(a-\tilde{c}(c_0,\theta))^2 - \rho - \tilde{c}(c_0,\theta)\log\left(\frac{\tilde{c}(c_0,\theta)}{c_0}\right)\frac{L}{4}(a-\tilde{c}(c_0,\theta)) = 0. \qquad \text{(B.1)}\end{aligned}$$

From (8), $\Psi(c_0 e^{1/\theta}) = \frac{L}{8}(a - c_0 e^{1/\theta})^2 - \rho > 0$. Moreover, $\Psi(a) = -\rho < 0$. Since $\Psi(c)$ is continuous, this implies that there exists a $\tilde{c}(c_0,\theta)$ such that $\Psi(\tilde{c}(c_0,\theta)) = 0$. We claim that $\tilde{c}(c_0,\theta)$ is unique. To see this, notice that $\Psi(\tilde{c}(c_0,\theta)) = 0$ and $\rho > 0$ imply $\frac{L}{8}(a-\tilde{c}(c_0,\theta))^2 - \tilde{c}(c_0,\theta)\log\left(\frac{\tilde{c}(c_0,\theta)}{c_0}\right)\frac{L}{4}(a-\tilde{c}(c_0,\theta)) > 0$ and thus

$$(a-\tilde{c}(c_0,\theta)) - 2\tilde{c}(c_0,\theta)\log\left(\frac{\tilde{c}(c_0,\theta)}{c_0}\right) > 0. \qquad \text{(B.2)}$$

Taking the partial derivative of $\Psi(\tilde{c}(c_0,\theta))$ with respect to c yields

$$\Psi_c(\tilde{c}(c_0,\theta)) = -\frac{L}{4}\left[(a-\tilde{c}(c_0,\theta))\left(2+\log\left(\frac{\tilde{c}(c_0,\theta)}{c_0}\right)\right) - \tilde{c}(c_0,\theta)\log\left(\frac{\tilde{c}(c_0,\theta)}{c_0}\right)\right] < 0,$$

where the last inequality follows from (B.2). The uniqueness of $\tilde{c}(c_0,\theta)$ now follows from $\Psi_c(\tilde{c}(c_0,\theta)) < 0$.

We next show that $\frac{d\tilde{c}(c_0,\theta)}{dc_0} > 0$ and $\frac{d\tilde{c}(c_0,\theta)}{d\theta} = 0$. The claimed results follow from total differentiation of (B.1), which implies

$$\frac{d\tilde{c}(c_0,\theta)}{dc_0} = \frac{(a-\tilde{c}(c_0,\theta))\frac{\tilde{c}(c_0,\theta)}{c_0}}{\left[(a-\tilde{c}(c_0,\theta))\left(2+\log\left(\frac{\tilde{c}(c_0,\theta)}{c_0}\right)\right) - \tilde{c}(c_0,\theta)\log\left(\frac{\tilde{c}(c_0,\theta)}{c_0}\right)\right]} > 0, \qquad \text{(B.3)}$$

where the inequality again follows from (B.2), and

$$\frac{d\tilde{c}(c_0,\theta)}{d\theta} = 0. \qquad \text{(B.4)}$$

From the specification of marginal cost in (3), $\tilde{c}(c_0,\theta) = c_0 e^{n/\theta}$, and thus

$$n(c_0,\theta) = \theta\log\left(\frac{\tilde{c}(c_0,\theta)}{c_0}\right). \qquad \text{(B.5)}$$

Notice that $n(c_0,\theta) \geq 1$ implies $\tilde{c}(c_0,\theta) \geq c_0 e^{1/\theta}$. From (B.5),

$$\frac{dn(c_0,\theta)}{dc_0} = \frac{\theta}{c_0}\left(\varepsilon_{\tilde{c}}(c_0) - 1\right) < 0, \qquad \text{(B.6)}$$

where $\varepsilon_{\tilde{c}}(c_0) \equiv \frac{d\tilde{c}(c_0,\theta)}{dc_0}\frac{c_0}{\tilde{c}(c_0,\theta)}$. From (B.3), it follows that $0 < \varepsilon_{\tilde{c}}(c_0) < 1$ and hence $\frac{dn(c_0,\theta)}{dc_0} < 0$. Similarly, from (B.5) and using (B.4),

$$\frac{dn(c_0,\theta)}{d\theta} = \log\left(\frac{\tilde{c}(c_0,\theta)}{c_0}\right) > 0.$$

B.3 Proof of Lemma 2

From (10), a firm's aggregate sales are

$$S(\tilde{c}(c_0,\theta)) \equiv n(c_0,\theta)s(\tilde{c}(c_0,\theta)) = \theta \log\left(\frac{\tilde{c}(c_0,\theta)}{c_0}\right)\frac{L}{8}\left(a^2 - \tilde{c}(c_0,\theta)^2\right). \tag{B.7}$$

We first show that $S(\tilde{c}(c_0,\theta))$ is decreasing in c_0. From (B.7),

$$\frac{dS(\tilde{c}(c_0,\theta))}{dc_0} = \frac{dn(c_0,\theta)}{dc_0}s(\tilde{c}(c_0,\theta)) + n(c_0,\theta)\frac{ds(\tilde{c}(c_0,\theta))}{d\tilde{c}(c_0,\theta)}\frac{d\tilde{c}(c_0,\theta)}{dc_0} < 0, \tag{B.8}$$

where the inequality follows from $dn(c_0,\theta)/dc_0 < 0$, $ds(\tilde{c}(c_0,\theta))/d\tilde{c}(c_0,\theta) < 0$ and $d\tilde{c}(c_0,\theta)/dc_0 > 0$.

Next, we show that $S(\tilde{c}(c_0,\theta))$ is increasing in θ. Again, from (B.7),

$$\frac{dS(\tilde{c}(c_0,\theta))}{d\theta} = \frac{dn(c_0,\theta)}{d\theta}s(\tilde{c}(c_0,\theta)) + n(c_0,\theta)\frac{ds(\tilde{c}(c_0,\theta))}{d\tilde{c}(c_0,\theta)}\frac{d\tilde{c}(c_0,\theta)}{d\theta} > 0, \tag{B.9}$$

where the inequality follows from $dn(c_0,\theta)/d\theta > 0$, $ds(\tilde{c}(c_0,\theta))/d\tilde{c}(c_0,\theta) < 0$ and $d\tilde{c}(c_0,\theta)/d\theta = 0$.

B.4 Proof of Lemma 3

Recall (B.6),

$$\frac{dn(c_0,\theta)}{dc_0} = \frac{\theta}{c_0}\left(\varepsilon_{\tilde{c}}(c_0) - 1\right) < 0.$$

We claim that the absolute value of $dn(c_0,\theta)/dc_0$ is increasing in θ. To see this, notice that

$$\frac{d}{d\theta}\left(\frac{dn(c_0,\theta)}{dc_0}\right) = \frac{1}{c_0}\left(\varepsilon_{\tilde{c}}(c_0) - 1\right) + \frac{\theta}{c_0}\frac{d}{d\theta}\left(\varepsilon_{\tilde{c}}(c_0)\right) < 0. \tag{B.10}$$

The first summand is negative, since $0 < \varepsilon_{\tilde{c}}(c_0) < 1$. The second summand is zero, since $d\tilde{c}(c_0,\theta)/d\theta = 0$.

Next, recall (B.3),

$$\frac{d\tilde{c}(c_0,\theta)}{dc_0} = \frac{(a - \tilde{c}(c_0,\theta))\frac{\tilde{c}(c_0,\theta)}{c_0}}{\left[(a-\tilde{c}(c_0,\theta))\left(2+\log\left(\frac{\tilde{c}(c_0,\theta)}{c_0}\right)\right) - \tilde{c}(c_0,\theta)\log\left(\frac{\tilde{c}(c_0,\theta)}{c_0}\right)\right]} > 0.$$

We claim that $d\tilde{c}(c_0,\theta)/dc_0$ is constant in θ. To see this, notice that

$$\frac{d}{d\theta}\left(\frac{d\tilde{c}(c_0,\theta)}{dc_0}\right) = 0, \tag{B.11}$$

which follows immediately from the fact that $d\tilde{c}(c_0,\theta)/d\theta = 0$ established in (B.4).

Finally, recall (B.8),

$$\frac{dS(\tilde{c}(c_0,\theta))}{dc_0} = \frac{dn(c_0,\theta)}{dc_0} s(\tilde{c}(c_0,\theta)) + n(c_0,\theta)\frac{ds(\tilde{c}(c_0,\theta))}{d\tilde{c}(c_0,\theta)}\frac{d\tilde{c}(c_0,\theta)}{dc_0} < 0.$$

Hence,

$$\begin{aligned}\frac{d}{d\theta}\left(\frac{dS(\tilde{c}(c_0,\theta))}{dc_0}\right) &= \frac{d}{d\theta}\left(\frac{dn(c_0,\theta)}{dc_0}\right) s(\tilde{c}(c_0,\theta)) + \frac{dn(c_0,\theta)}{dc_0}\frac{ds(\tilde{c}(c_0,\theta))}{d\tilde{c}(c_0,\theta)}\frac{d\tilde{c}(c_0,\theta)}{d\theta} \\ &\quad + \frac{dn(c_0,\theta)}{d\theta}\frac{ds(\tilde{c}(c_0,\theta))}{d\tilde{c}(c_0,\theta)}\frac{d\tilde{c}(c_0,\theta)}{dc_0} + n(c_0,\theta)\frac{ds(\tilde{c}(c_0,\theta))}{d\tilde{c}(c_0,\theta)}\frac{d}{d\theta}\left(\frac{d\tilde{c}(c_0,\theta)}{dc_0}\right).\end{aligned}$$

By Lemma 1, $\frac{d\tilde{c}(c_0,\theta)}{dc_0} > 0$, $\frac{dn(c_0,\theta)}{dc_0} < 0$, $\frac{d\tilde{c}(c_0,\theta)}{d\theta} = 0$, $\frac{dn(c_0,\theta)}{d\theta} > 0$; by (B.10) and (B.11), $\frac{d}{d\theta}\left(\frac{dn(c_0,\theta)}{dc_0}\right) < 0$ and $\frac{d}{d\theta}\left(\frac{d\tilde{c}(c_0,\theta)}{dc_0}\right) = 0$; finally, $\frac{ds(\tilde{c}(c_0,\theta))}{d\tilde{c}(c_0,\theta)} < 0$. Together, these results establish that

$$\frac{d}{d\theta}\left(\frac{dS(\tilde{c}(c_0,\theta))}{dc_0}\right) < 0.$$

B.5 Coexistence of greenfield adjustment and M&A along the stable assignment

It is convenient to formalise the description of the stable assignment on the market for corporate control in terms of the *matching function* Φ mating a given acquirer $\tilde{c}^{ac}$ to its target $\Phi(\tilde{c}^{ac})$, where $\Phi(\tilde{c}^{ac}) = 0$ means that the acquirer expands via greenfield investment; whenever $\Phi(\tilde{c}^{ac}) \neq 0$, we say that $\tilde{c}^{ac}$ is matched to a target and thus expands via M&A.

As a consequence of condition (15), viable matches must satisfy $\Phi(\tilde{c}^{ac}) \in \left[\tilde{c}^{ac}, \frac{1}{\lambda}\tilde{c}^{ac}\right]$. This observation leads to the following lemma, which infers necessary and sufficient conditions for the occurrence of M&A along the stable assignment on the market for corporate control.

Lemma 6 *The stable assignment on the market for corporate control can only involve acquisitions if*

$$\tilde{c}^{tt,m} \leq \frac{1}{\lambda}\tilde{c}^{ac,M} \qquad \text{and} \qquad \tilde{c}^{ac,m} \leq \tilde{c}^{tt,M}. \tag{B.12}$$

The stable assignment on the market for corporate control must involve acquisitions if

$$\tilde{c}^{tt,m} \leq \tilde{c}^{ac,M} \qquad \text{and} \qquad \tilde{c}^{ac,m} \leq \tilde{c}^{tt,M}. \tag{B.13}$$

Lemma 6 places a restriction on the support of the cost distributions F^{ac} and F^{tt}. If condition (B.12) does not hold, then firms will rely exclusively on greenfield activity to realise their desired external adjustment. There is no potential for gains from trade via M&A, and regardless of their characteristics or exposure to cost shocks, firms will choose greenfield investment and plant closures as their preferred mode of external adjustment. On the other hand, if (B.12) holds such that F^{tt} has positive mass in $\left[\tilde{c}^{ac,m}, \frac{1}{\lambda}\tilde{c}^{ac,M}\right]$, then gains from trade emerge and the nature of the capital conversion costs $\Gamma(\tilde{c}^{ac}, \tilde{c}^{tt})$ determines whether some firms will achieve their desired external adjustment by means of M&A. Finally, if F^{tt} has positive mass in $\left[\tilde{c}^{ac,m}, \tilde{c}^{ac,M}\right]$ as stipulated by condition (B.13), then there is scope for M&A transactions that do not incur any capital conversion costs: namely via matches where $\Phi(\tilde{c}^{ac}) = \tilde{c}^{ac}$ such that $\Delta(\tilde{c}^{ac}, \Phi(\tilde{c}^{ac})) > 0$. This immediately implies that acquisitions must be part of the surplus maximising stable assignment.

Indeed, given the existence of conversion costs, there is a tendency for matches to form along the 45° line, i.e., $\Phi(\tilde{c}^{ac}) = \tilde{c}^{ac}$. Since matches of this type are not subject to conversion costs, the surplus function (13) is unambigously positive: $\Delta(\tilde{c}^{ac}, \Phi(\tilde{c}^{ac})) > 0$ for all $\tilde{c}^{ac} = \Phi(\tilde{c}^{ac}) \in (0, a)$. Hence, the stable assignment on the market for corporate control can only involve greenfield adjustment if market conditions prevent matches of the type $\Phi(\tilde{c}^{ac}) = \tilde{c}^{ac}$ to form globally.

This observation leads to another lemma, which infers necessary and sufficient conditions for the occurrence of greenfield expansions along the stable assignment on the market for corporate control.

Lemma 7 *The stable assignment on the market for corporate control can only involve greenfield investment if*

$$\tilde{c}^{ac,m} < \tilde{c}^{tt,m} \qquad or \qquad \tilde{c}^{tt,M} < \tilde{c}^{ac,M}. \tag{B.14}$$

The stable assignment on the market for corporate control must involve greenfield investment if

$$\tilde{c}^{ac,m} < \lambda\tilde{c}^{tt,m} \qquad or \qquad \tilde{c}^{tt,M} < \tilde{c}^{ac,M}, \tag{B.15}$$

or if (B.14) holds and capital conversion costs $\Gamma(\tilde{c}^{ac}, \tilde{c}^{tt})$ *are sufficiently strong.*

Recall that cost shocks give rise to the need for external adjustment. Moreover, the set of potential acquirers is given by those firms that received an advantageous cost shock which reduces their induced marginal cost. Conversely, the set of potential targets was exposed to adverse cost shocks which increase their induced marginal cost. In view of these considerations, the first condition in (B.14) is likely to be satisfied, while the second condition is less likely to hold.

Therefore, focusing on the first condition in (B.14), Lemmas 6 and 7 together imply that a necessary condition for the coexistence of M&A and greenfield investment is

$$\tilde{c}^{ac,m} < \tilde{c}^{tt,m} \leq \frac{1}{\lambda}\tilde{c}^{ac,M}.$$

Finally notice that, given this condition, the scope for greenfield activity increases in the strength of the capital conversion costs $\Gamma(\tilde{c}^{ac}, \tilde{c}^{tt})$.

B.6 Proof of Lemma 4

Assortative matching follows directly from the fact that aggregate surplus must be maximised in a stable assignment, and the sign of (16) determines whether matching is positive or negative assortative.

B.7 Proof of Lemma 5

(i) If $\tilde{c}^{ac,m} < \tilde{c}^{tt,m} \leq \tilde{c}^{ac,M}$, then there is a potential acquirer with marginal cost $\tilde{c}^{ac} = \tilde{c}^{tt,m}$ who can match with $\tilde{c}^{tt,m}$ without incurring conversion costs, implying $\Delta(\tilde{c}^{ac}, \tilde{c}^{tt,m}) > 0$. So the stable assignment must involve acquisitions.

If $\tilde{c}^{ac,M} < \tilde{c}^{tt,m} \leq \frac{1}{\lambda}\tilde{c}^{ac,M}$, then there is no potential acquirer who can match with $\tilde{c}^{tt,m}$ without incurring conversion costs, but there are potential acquirers with marginal cost $\tilde{c}^{ac}$ such that $\tilde{c}^{tt,m} \in \left[\tilde{c}^{ac}, \frac{1}{\lambda}\tilde{c}^{ac}\right]$. To prevent such matches, conversion costs must be sufficiently strong.

(ii) (a) Since $\tilde{c}^{tt,m} \leq \tilde{c}^{ac,M}$, the stable assignment involves acquisitions. Let $\underline{c}^{tt}$ be the potential target with the lowest marginal cost among all matched targets. Since $\tilde{c}^{ac,m} < \tilde{c}^{tt,m}$ and $\partial\Delta(\tilde{c}^{ac}, \tilde{c}^{tt})/\partial\tilde{c}^{tt} < 0$, it follows that $\underline{c}^{tt} = \tilde{c}^{tt,m}$ (since any alternative lowest match could be broken). Finally, from condition (15), it follows that $\underline{c}^{tt} = \tilde{c}^{tt,m}$ is matched to an acquirer with weakly lower marginal cost $\underline{c}^{ac} \in [\max\left\{\tilde{c}^{ac,m}, \lambda\tilde{c}^{tt,m}\right\}, \tilde{c}^{tt,m}]$.

(b) Since $\tilde{c}^{tt,m} \leq \tilde{c}^{ac,M}$, the stable assignment involves acquisitions. Let $\bar{c}^{tt}$ be the potential target with the highest marginal cost among all matched targets.

Suppose first $\tilde{c}^{ac,M} \leq \tilde{c}^{tt,M}$. Then, since $\partial\Delta(\tilde{c}^{ac}, \tilde{c}^{tt})/\partial\tilde{c}^{ac} > 0$, it follows that the potential acquirer with marginal cost $\tilde{c}^{ac} = \min\left\{\bar{c}^{tt}, \tilde{c}^{ac,M}\right\}$ must be matched (since any alternative highest match could be broken). But from condition (15), it follows that $\bar{c}^{tt}$ must be matched to an acquirer with weakly lower marginal cost, which implies $\tilde{c}^{ac,M} \leq \bar{c}^{tt}$. Hence, $\bar{c}^{ac} = \tilde{c}^{ac,M}$ is matched and takes over a target with weakly higher marginal cost $\bar{c}^{tt} \in \left[\tilde{c}^{ac,M}, \min\left\{\frac{1}{\lambda}\tilde{c}^{ac,M}, \tilde{c}^{tt,M}\right\}\right]$.

Suppose next $\tilde{c}^{ac,M} > \tilde{c}^{tt,M}$. Then, since $\bar{c}^{tt} \leq \tilde{c}^{tt,M} < \tilde{c}^{ac,M}$ and $\partial\Delta(\tilde{c}^{ac}, \tilde{c}^{tt})/\partial\tilde{c}^{ac} > 0$, it follows that the potential acquirer with marginal cost $\tilde{c}^{ac} = \bar{c}^{tt}$ must be matched (since any alternative highest match could be broken). Hence, the highest match must lie on the 45° line and does not incur any conversion costs, implying $\Delta(\bar{c}^{ac}, \bar{c}^{tt}) >$

0. But then $\bar{c}^{tt} = \tilde{c}^{tt,M} < \tilde{c}^{ac,M}$, for otherwise there could form other viable matches along the 45° line with $\tilde{c}^{ac} = \tilde{c}^{tt} > \bar{c}^{tt}$, which contradicts the fact that $\bar{c}^{tt}$ is the potential target with the highest marginal cost among all matched targets. Hence, $\bar{c}^{ac} = \tilde{c}^{tt,M}$ is matched and takes over a target with identical marginal cost $\bar{c}^{tt} = \tilde{c}^{tt,M}$.

(c) Follows directly from (a) and (b) and Lemma 4.

Table 1 – Descriptive Statistics, Adjustment Strategies (1997-2005)

	Internal adjustment	M&A	Greenfield	All adjustments
Panel A: Usage Frequency of Adjustment Channels (%, total count in last column)				
Gross expansions	99.84%	0.50%	0.20%	5,044,793
Gross contractions	99.56%	0.66%	0.44%	3,600,784
Panel B: Average Size of Adjustment by Cannel Channels (£000s)				
Gross expansions	882.4	34831.7	11108.2	1070.6
Gross contractions	1143.4	34164.1	37325.0	1520.1
Panel C: Aggregate Importance of Adjustment Channels (% of total adjustment)				
Gross expansions	81.77%	16.10%	2.01%	£776 bill.
Gross contractions	74.41%	14.83%	10.80%	£787 bill.

Source: ONS and authors' calculations.

Notes: Panel A shows the fraction of all turnover adjustments involving internal adjustment, M&As and greenfield investment or disinvestment. Panel B shows the average transaction size of each of these channels, and Panel C their contribution to overall adjustment. All figures are averages over 1997-2005. Turnover is measured in '000s GBP in constant 1995 prices, using 2-digit sectoral output price deflators from the EUKLEMS project.

Table 2 – Gross Expansion and Contraction in Turnover by Size of Firm (1997-2005)

		A) Expansions in Turnover			B) Contractions in Turnover		
Size Category of Firm	Size (£'000s)	Internal Adjustment (%)	M&A (%)	Greenfield (%)	Internal Adjustment (%)	M&A (%)	Greenfield (%)
Bottom 50%	0-152	99.94	0.05	0.01	99.95	0.03	0.02
51% to 75%	153-342	99.90	0.08	0.02	99.87	0.08	0.05
76% to 95%	343-1,782	99.61	0.30	0.09	99.33	0.41	0.26
96% to 99%	1,783-9,976	97.56	1.80	0.64	95.31	2.97	1.72
99% to 99.9%	9,977-147,384	90.86	6.64	2.50	83.94	9.69	6.37
Top 0.1%	>147,384	70.96	15.72	13.32	69.06	17.40	13.54
Total	**All**	**99.64**	**0.26**	**0.10**	**99.32**	**0.42**	**0.26**

Notes: Table shows the choice of adjustment channel by the size class of firms in terms of turnover (see Columns 1 and 2). Panel A focuses on gross expansions while panel B focuses on gross contractions. The three columns of each panel give the percentage of total turnover expansions or contractions that is accounted for by each channel (figures are unweighted averages over all adjustments belonging to a given size class).

Table 3 – Gross Expansion/Contraction in Turnover by Transaction Size (1997-2005)

	A) Expansions in Turnover				B) Contractions in Turnover			
Size Category of Expansion/ Contraction	Exp. Size (£'000s)	Internal Adjustm. (%)	M&A (%)	Greenfield (%)	Contr. Size (£'000s)	Internal Adjustm. (%)	M&A (%)	Greenfield (%)
Bottom 50%	1-27	99.99	0.01	0.01	1-24	99.96	0.02	0.02
51% to 75%	28-89	99.91	0.05	0.04	25-75	99.85	0.09	0.06
76% to 95%	90-582	99.52	0.32	0.16	76-514	99.09	0.58	0.33
96% to 99%	583-3,625	97.15	2.15	0.70	515-3,764	94.33	3.49	2.18
99% to 99.9%	3,625-61,593	88.92	8.77	2.31	3,765-74,311	80.46	11.60	7.93
Top 0.1%	>61,593	77.59	18.16	4.25	>74,311	64.17	21.44	14.40
Total	**All**	**99.64**	**0.26**	**0.10**	**All**	**99.32**	**0.42**	**0.26**

Notes: Table shows the choice of adjustment channel by the size of turnover expansions/contractions (see columns 1,2 and 6). Panel A focuses on gross expansions while panel B focuses on gross contractions. The last three columns of each panel give the percentage of total turnover expansions or contractions that is accounted for by each channel (figures are unweighted averages over all adjustments in a given adjustment size class). The first column in each panel lists the range of turnover changes associated with the percentile ranges listed in the first column of the table.

Table 4 – Firm Size, Expansion/Contraction Size and Choice of Adjustment Form (multivariate fractional logit)

	Expansion – M&A vs. Internal	Expansion – Greenfield vs. Internal	Contraction – M&A vs. Internal	Contraction – Greenfield vs. Internal
Firm size (logs)	0.116***	0.477***	0.419***	0.454***
	(5.02)	(12.76)	(11.49)	(12.44)
Expansion/contraction size (logs)	0.712***	0.353***	0.439***	0.413***
	(25.39)	(9.10)	(14.20)	(15.48)
Excluded channel	Internal		Internal	
Observations	4,938,769		3,600,679	
Industry FE	2 digit		2 digit	

Source: ONS and authors' calculations.

Notes: Table shows results for multinomial fractional logit regressions. Figures in brackets are t-stats clustered at the 2-digit industry-level (55 industries). The dependent variables are the fractions of M&As, greenfield and internal adjustment in total employment or turnover adjustment. Internal adjustment is the excluded category. The regressors are initial firm size and the size of the overall expansion or contraction. Firm size and expansion/contraction size are measured as the log of turnover in '000s of British pounds in constant 1995 prices, using 2-digit sectoral output price deflators from the EUKLEMS project. All regressions include year and 2-digit industry fixed effects. *, **, and *** indicate statistical significance at the 10%, 5%, and 1%-level, respectively.

Table 5 – Firm Size, Expansion/Contraction Size and Choice of Adjustment Form (Tobit and Poisson)

	Tobit			Poisson		
	M&A	Greenfield	Internal	M&A	Greenfield	Internal
Expansions						
Log(firm size)	0.121 (47.31)***	0.246 (52.26)***	-0.003 (309.96)***	0.079 (4.39)***	0.446 (12.63)***	-0.004 (8.54)***
Log(exp. size)	0.405 (121.04)***	0.260 (54.91)***	-0.003 (321.52)***	0.612 (24.66)***	0.264 (6.78)***	-0.004 (7.89)***
Observations	4,938,769	4,938,769	4,938,769	4,938,769	4,938,769	4,938,769
Industry FE	2-digit	2-digit	2-digit	2-digit	2-digit	2-digit
Contractions						
Log(firm size)	0.291 (67.93)**	0.288 (55.98)**	-0.016 (103.52)***	0.310 (9.51)**	0.341 (10.20)**	-0.009 (9.11)***
Log(contr. size)	0.293 (72.98)**	0.283 (58.91)**	-0.032 (149.01)***	0.350 (12.32)**	0.317 (11.60)**	-0.005 (7.87)***
Observa-tions	3,600,679	3,600,679	3,600,679	3,600,679	3,600,679	3,600,679
Industry FE	2-digit	2-digit	2-digit	2-digit	2-digit	2-digit

Source: ONS and authors' calculations.

Notes: Table shows results for Tobit and Poisson regressions. Figures in brackets are t-stats based on standard errors clustered at the 2-digit industry-level (55 industries). The dependent variable is the fraction of M&As, greenfield and internal adjustment in total turnover adjustment. The regressors are initial firm size and the size of the overall expansion and contraction. Firm size and expansion/contraction size are measured as the log of turnover in '000s of British pounds in constant 1995 prices, using 2-digit sectoral output price deflators from the EUKLEMS project. All regressions include year and 2-digit industry fixed effects. *, **, and *** indicate statistical significance at the 10%, 5%, and 1%-level, respectively.

Table 6 – Correlation of Target and Acquirer Size

	(1) Acquirer size (log sales)	(2) Acquirer size (log sales)	(3) Acquirer size (log sales)	(4) Acquirer size (log sales)
Target size (log sales)	0.374***	0.300***	0.316***	0.243***
	(0.020)	(0.030)	(0.037)	(0.047)
Size of the acquired asset (enterprise log sales)			0.113***	0.100***
			(0.038)	(0.033)
Observations	45,128	45,128	44,589	44,589
FE	Year only	Year & 3-digit-Industry-Pair	Year only	Year & 3-digit-Industry-Pair

Source: ONS and authors' calculations.

Notes: Table shows results for OLS regressions. Figures in brackets are t-stats clustered at the enterprise group level (columns 1 and 3) or at the 3-digit industry-pair level (columns 2 and 4). The dependent variable is the size of the acquiring enterprise group, the independent variable the size of the enterprise group selling an enterprise. Columns 3 and 4 also include the size of the sold-off enterprise. Size is measured as the log of turnover in '000s of British pounds in constant 1995 prices, using 2-digit sectoral output price deflators from the EUKLEMS project. *, **, and *** indicate statistical significance at the 10%, 5%, and 1%-level, respectively.

Table 7 – Average Within-Industry Acquirer-Target Size Differences

Average of Within-Industry Acquirer-Target Size Differences (log points of initial turnover)	1.42
Acquirer-target size difference positive and significant, fraction of all industries	85%
Acquirer-target size difference positive but insignificant, fraction of all industries	7%
Acquirer-target size difference negative but insignificant, fraction of all industries	5%
Acquirer-target size difference negative and significant, fraction of all industries	3%
Observations	45,128

Source: ONS and authors' calculations.

Notes: Table shows the average across industries of within-industry acquirer-target size differences (line 1), and the fraction of industries in which acquirer-target size differences are positive and significant, positive but insignificant, negative but insignificant, and negative and significant, respectively (lines 2-5). Size differences are measured as the log difference of initial turnover between the acquiring and the selling enterprise group. Turnover is measured in '000s of British pounds in constant 1995 prices, using 2-digit sectoral output price deflators from the EUKLEMS project.

Table A4 – Firm Size, Expansion/Contraction Size and Choice of Adjustment Form (multivariate fractional logit – two-tier structure)

	(1) Expansion – External vs. Internal	(2) Expansion – Greenfield vs. M&A	(3) Contraction – External vs. Internal	(4) Contraction – Greenfield vs. M&A
Firm size (logs)	0.199***	0.154***	0.433***	0.023**
	(8.11)	(13.43)	(12.15)	(2.64)
Expansion/contraction size (logs)	0.629***	-0.159***	0.429***	-0.011
	(22.76)	(-12.67)	(15.18)	(-1.56)
Excluded channel	Internal	M&A	Internal	M&A
Observations	4,938,769	30,763	3,600,679	36,456
Industry FE	2 digit	2 digit	2 digit	2 digit

Source: ONS and authors' calculations.

Notes: Table shows results for multinomial fractional logit regressions. Figures in brackets are t-stats clustered at the 2-digit industry-level (55 industries). The dependent variables are the fractions of M&As, greenfield and internal adjustment in total employment or turnover adjustment. Internal adjustment is the excluded category. The regressors are initial firm size and the size of the overall expansion or contraction. Firm size and expansion/contraction size are measured as the log of turnover in '000s of British pounds in constant 1995 prices, using 2-digit sectoral output price deflators from the EUKLEMS project. All regressions include year and 2-digit industry fixed effects. *, **, and *** indicate statistical significance at the 10%, 5%, and 1%-level, respectively.