Financial Constraints and Capacity Adjustment in the United Kingdom: Are Small Firms Really Different? Evidence from a Large Panel of Survey Data

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Abstract

The interrelationship between financial constraints and firm activity is a hotly debated issue. The way firms cope with financial constraints is fundamental to the analysis of monetary transmissions, of financial stability and of growth and development. The CBI Industrial Trends Survey contains detailed information on the financial constraints faced by a large sample of UK manufacturers. We use the quarterly CBI Industrial Trends Survey firm level data between the January 1989 and October 1999. Our cleaned sample contains 49,244 quarterly observations on 5,196 firms. As more than 63% of the observations refer to firms with less than 200 employees, the data set is especially well suited for comparing large and small companies. After presenting the data-set, we develop a new method of checking the informational content of the data. We have to confront the fact that the relationship between investment activity and financial constraints is ambivalent due to simultaneity. However, the link between financial constraints on the one hand and the prevalence and duration of capacity gaps on the other should be unambiguously positive. We obtain two important results. First, we show that there is informational content in the data on financial constraints. Specifically, financially constrained firms take longer to close capacity gaps. This indicates that financial constraints do indeed play a part in the investment process. Second, small firms close their capacity gaps faster than large firms.

Key Words:

Financial constraints, investment, capacity adjustment, small firm finance, duration analysis.

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Financial Constraints and Capacity Adjustment in the United Kingdom: Are Small Firms Really Different? Evidence from a Large Panel of Survey Data

1. Introduction and summary

2. The financing environment for small firms in the UK

3. The data-set

    3.1 The CBI Industrial Trends Survey

    3.2. Summary descriptive statistics

4. Is there informational content in the financial constraints data?

    4.1. The endogeneity problem

    4.2. Occurrence and duration of capacity restrictions

    4.3. Association analysis for capacity restrictions and financial constraints

    4.4. The design of the duration analysis

    4.5. Kaplan-Maier survival curves

    4.6. A proportional hazard (Cox) model of duration

5. Conclusion

Appendix: A maximum likelihood estimator for the proportional hazard model with censored grouped panel data

References

Tables

Charts and graphs

Financial Constraints and Capacity Adjustment in the United Kingdom: Are Small Firms Really Different? Evidence from a Large Panel of Survey Data[1]

1. Introduction and summary

Understanding the causes and effects of financial constraints for firms is of key importance for a variety of policy issues. In monetary transmission theory, the credit channel is supposed to condition and amplify the 'neo-classical' relative price effects of interest rate changes on firm activity. Monetary policy may affect the ability of banks to finance firms (bank lending channel), or else influence firms' ability to attract external finance by affecting the value of their equity (balance sheet channel). Second, financial constraints on real activities form one crucial link that determines the real consequences of financial imbalances of various types: banking crises, asset price bubbles, or government debt. Ultimately, financial constraints due to asymmetric information are especially important for those future oriented activities that deal with generating new knowledge: research, development, and the introduction of innovative products and processes.[2] These activities are fundamental to the long-run performance of any economic system.

For all these reasons, the study of firm financial constraints on a micro level is major topic on the agenda of central bank research. A recent co-ordinated research effort by the European System of Central Banks (ESCB) utilised large national balance sheet databases to show that financial constraints do seem to matter for firm investment and the monetary transmission process (see Chatelain, Generale, Hernando, von Kalckreuth and Vermeulen (2003) for an overview). However, unlike much of the literature on US firms, size does not seem to be a good indicator of informational asymmetries and the assorted financial constraints in European countries. Among some of the larger euro area countries – France, Germany, Italy and

1 This paper was written while the first-named author was seconded at the Bank of England. He is grateful for the warm hospitality he received, the stimulating intellectual environment in London, and for generous support given by the Deutsche Bundesbank. Encouragement and support by Charles Bean, Peter Brierley, Heinz Herrmann, and Garry Young were pivotal in making the project possible. The CBI gave us access to their rich micro data base, and we would like to thank, in particular, Ian McCafferty, Jonathan Wood and Jamie Morrison for their crucial help. Ongoing discussions with many people were productive. Thanks are therefore due to Nick Bloom, Steve Bond, Harald Stahl, Christian Upper, Geoffrey Wood, Garry Young and Mike Young. We are also grateful for important comments on presentations at the Bank of England in London, at the BIS in Basel, at the Deutsche Bundesbank in Frankfurt and at the CESifo institute in Munich.

2 See, for example, Hall (2002). The argument was made as early as 1963 by Kenneth Arrow, already using explicitly a moral hazard argument. Demsetz' (1969) critique makes plain that informational inefficiencies by themselves do not create a case for government intervention – the market fails with respect to a *nirvana* situation of perfect informational symmetry. See also Stigler (1967).

Spain – only Italian small firms show an excess sensitivity of investment with respect to cash flow.[3]

It is conceivable that the importance of financial constraints for the real activity of firms also depends on the financial system. Allen and Gale (2001) argue that intermediaries and markets may have different comparative advantages. A market-based system deals better with situations where innovations occur and where there is a fundamental diversity of opinion, whereas intermediaries are able to save transaction costs when a large amount of experience has been gained and things are no longer changing. The empirical patterns of financial constraints and their importance for monetary policy, financial stability and innovation and growth may therefore depend on economic institutions.

This paper is part of a larger research effort based on large panels of survey data, which aims to compare the significance of financial constraints for firm behaviour in bank-based Germany and the capital market based UK. With respect to the UK, we are able to explore the data base for the CBI Industrial Trends Survey (ITS), which is an important survey for business cycle analysis in the United Kingdom. For the 11 years between January 1989 and October 1999, our cleaned unbalanced panel contains 49,244 quarterly observations on 5,196 firms. According to the CBI, the ITS represents around 33% of the total current employment within UK manufacturing.

Apart from its size and coverage, the data-set has two important characteristics. First, it contains *many small firms,* on which very little information is available from micro data-sets based on quoted companies. More than 63% of the ITS observations refer to firms with less than 200 employees. Second, the data-set contains detailed information on the *financial constraints* that firms face in their investment decisions. Notably, a number of firms (around 20.8% of respondents) explicitly state two things: that they are constrained by the lack of either internal or external financial resources, and that these constraints have an influence on their investment behaviour.

This is exactly what the bulk of the empirical literature on financial constraints, following the seminal article by Fazzari, Hubbard and Peterson (1988), tries to prove. The standard procedure in this literature is to split the sample by some criterion that *a priori* identifies firms as being financially constrained or unconstrained, such as size, dividend behaviour or the risk of default, and then to test whether the observed differences in investment behaviour between the two types of firm are consistent with what is to be expected by a better or worse financial

[3] The key results have been collected in Angeloni, Kasyhap and Mojon (eds., 2003): see Chatelain and Tiomo (2003) on France, von Kalckreuth (2003b) on Germany, Gaiotti and Generale (2003) on Italy, as well as Chatelain, Generale, Hernando, von Kalckreuth and Vermeulen (2003b) for a comparative study of the euro area. On Germany, see also the studies by Chirinko and von Kalckreuth (2003) and Breitung, Chirinko and von Kalckreuth (2003).

standing in a situation of asymmetric information.[4] Armed with the CBI data, this complicated and very indirect procedure, heavily criticised on theoretical grounds by Kaplan and Zingales (1997, 2000), seems to be unnecessary: a subset of respondents explicitly claim to be constrained. However, it needs to be examined whether they have told the truth, i.e. whether or not there is informational content in their assertions. If this is the case, we have the chance to take a closer look at the interrelationship between financial constraints and investment demand.

We start out by describing the financing environment for small firms in the UK (Section 2). Small firms are deemed to be especially vulnerable to financing constraints. During the 1980s and early 1990s, the availability of credit for small firms in the UK was generally regarded as unsatisfactory, a state of affairs that led to considerable political repercussions. Since then, with the upturn in the 1990s, the situation appears to have eased. A thorough analysis, however, still has to confront a dearth of reliable micro data, which is one of the things this study aims to help overcome.

The next part, Section 3, is dedicated to the presentation of our data-set. The raw percentages do not show small firms as being particularly strongly affected by financial constraints. Although the severest form of financial constraints – inability to raise external finance – is more prevalent among small firms (5.1% compared with 3.0% for the other size groups), the share of small firms reporting inadequate internal finance is actually slightly smaller (18.2% as against 20.4% for all other size groups).

Part 4 of our paper examines the informational content of our data on financial constraints. Our focus is on capacity adjustment, as the ITS data on capacity gaps, planned expansion and rates of capacity utilisation are especially rich. First, we look at the association between two types of constraints: capacity restrictions and financial constraints, and then we undertake a *duration analysis* with respect to spells of capacity constraints. Firms report whether their capacity is insufficient with respect to demand. Those firms which indicate financial constraints should take longer to close a capacity gap if there is informational content in their answers – either because they are less able to finance their investments or else because they have bigger gaps to fill.

For both size classes, we find a clear contemporaneous association between the two types of constraints. With respect to duration, financially constrained firms do take longer to end a period of insufficient capacity. However, splitting the sample shows that the latter relationship is statistically significant only for small firms. For larger firms, the measured difference in duration is less marked and not significant at conventional levels. It is quite interesting to see that

4 See, for example, Chirinko and von Kalckreuth (2002).

small firms appear to be able to overcome their capacity shortfalls faster than larger firms - both in general and conditional on their financial status. The paper ends with a conclusion in Section 5.

2. The financing environment for small firms in the UK

Small and medium sized enterprises (SMEs) form an important part of the British economy. They account for almost 54% of gross value added in the economy, excluding the public sector, and almost 40% of net capital expenditure.[5] In some sectors, the productivity of SMEs exceeds that of larger firms.[6] SMEs also account for 56% of employment and 52% of turnover.[7] Historically, however, they have faced particular problems in accessing finance. Every UK government in recent times has laid special emphasis on developing the SME sector as an engine of both growth and productivity. Despite the rapid growth of the British SME sector since the 1970s, rates of entrepreneurial activity remain only moderate in international terms. In particular, the UK appears to lag behind the US in terms of high growth start-ups. Access to finance, especially risk capital, is felt to be one of the key barriers and it is deemed important to ensure that there is an effective supply of finance for this sector.[8]

The political interest in the topic has spawned academic research. Hughes (1994)[9] considers the comparative financial structures and profitability of large and small companies between 1987 and 1989. He recognises a number of important differences in the financial structure between larger and smaller firms in the UK during this time. Small companies were more highly geared, more reliant on short-term bank debt and less profitable than larger firms. Hughes believes these features represented either a chronic market failure constraining small firms to a sub-optimal position, or a financial structure reflecting optimal choice, or some combination of the two. Traditionally, economists have argued that such financial structures are due to market imperfections which arise mainly as a result of information asymmetries.[10] The owner of a small business generally has much better information than the bank on his firms' performance, and has more control of the outcome. These asymmetries may lead to: (i) adverse selection where banks find it difficult to use the price mechanism to distinguish between firms; and (ii) moral hazard where, in the absence of collateral, use of higher interest rates by banks to offset risk would give firms an incentive to alter their behaviour to adopt more risky projects. In the light of the model set up by Stiglitz and Weiss (1981), it has been

5 See Bank of England (2003).

6 See Bank of England (2003)

7 See Small Business Service (2003), www.sbs.gov.uk/statistics SME statistics for the UK (2002), Table 3, All industries.

8 See HM Treasury/Small Business Service (2003).

9 See Hughes (1994) or Cosh and Hughes (1994) for further details.

10 Imperfections are also said to arise from agency costs, bankruptcy costs, appraisal and monitoring problems and an illiquid equity market.

argued that such problems lead to credit rationing for small firms – that is, finance is not made available to all firms with viable projects whose net present value is positive. Owing to the asymmetry of information between banks and small firms, markets are not cleared through the price mechanism, and banks have an incentive to respond to an increased demand in loans by rationing credit rather than by raising interest rates.

Empirical evidence of such failures remains mixed. A report by ACOST[11] in 1990 asserts that qualitative evidence supports the view that the observed capital structure of some small firms was due to supply side failures. However, most other evidence provides little conclusive support of such market imperfections in the financing of small firms in the United Kingdom in general.[12] The financial structure of small firms is seen by many as due predominantly to the optimal choice of owner/managers. Norton (1990) believes that managerial beliefs and desires play a key role in determining a small firm's capital structure and that management perception of a target debt ratio and perceptions of the trade-offs involved in external financing will determine the actual mix of debt and equity used. Smaller companies have lower fixed investment and avoid external finance owing to differences in growth strategies and so, in effect, stay small by choice. This is reinforced by anecdotal evidence of debt aversion among small firms, especially following the recession in the early 1990s.[13] Mason and Harrison (2001) recently investigated the investment readiness of small firms and their results show an aversion to ceding control via the dilution of equity. Hay and Morris (1984) maintain that the lower fixed asset proportion reflects a choice of flexible production methods whilst the structure of long and short-term liabilities may reflect a desire to maintain maximum freedom from external interference. Aghion and Bolton (1992) argue that the wealth-constrained owners place an intrinsic value on ownership, so standard debt financing may therefore be the best way to implement control arrangements.

Throughout the 1990s, trends in small firms financing suggest that there was a steady improvement in how finance providers service the market and there were fairly major changes in small firms financing patterns. One change has been that small firms have, in the aggregate, become markedly less dependent on external finance. Recently published research[14] shows that only 39% of small firms sought external finance of any kind between 2000 and 2002, compared with 65% between 1987 and 1990 and that access to finance is rarely mentioned by small firms as a major barrier to growth. For those small firms that do access external finance, the proportion accounted for by bank finance has declined. This partly reflects a shift towards factoring and asset-based finance. However, it also reflects an absolute decline in the net in-

11 See Advisory Council on Science and Technology (1990).

12 However, supply side problems are seen as more relevant to particular types of SME such as innovative, technology based firms or those with a substantial product development timescale.

13 See Bank of England (1998).

14 See Cosh and Hughes (2003).

debtedness of the sector. Furthermore, total small business deposits at banks have been greater than total lending to the sector since 1997. These findings have been corroborated by work from the Manchester Business School[15] showing that the average gearing levels of small, privately held firms fell between 1992 and 1996. This development may well represent a return to normality.

In our work, we want to focus on an aspect of the problem that has been neglected hitherto. It may well be that the financial structures of small and large firms differ considerably, but do these differences really reflect binding constraints? Do financial constraints matter for firm behaviour? Our database contains self-assessments on the financial limits to investment, and we can combine this information with rich data on the firms' real activity.

3. The data-set

3.1. The CBI Industrial Trends Survey

The *CBI Industrial Trends Survey* (ITS) is a qualitative survey that looks at short and medium-term trends in the UK manufacturing and processing industries. By excluding all seasonal variations, its questions focus on recent and imminent trends in order to allow for direct measures of business perceptions and expectations. The survey is a postal questionnaire aimed at a senior level within firms and is usually completed by either the Chairman or the Chief Executive. The CBI produces both a monthly and quarterly survey, the latter providing more in-depth analysis. It covers a wide range of subject areas including optimism regarding the general and export business situation, investment, capacity, order books, numbers employed, output, deliveries, stocks, prices, constraints to output, export orders and on investment, competitiveness regarding domestic, EU and non-EU market, innovation and training. The quarterly survey is the empirical basis for our analysis. Mitchell, Smith and Weale (2002a and b) have used the ITS micro data to show that disaggregate survey based indicators they developed can outperform traditional aggregate indicators. The full text of the questionnaire can be found in Wood (2001).

According to the CBI, the ITS represents around 33% of the total current employment within UK manufacturing. Our investigation focuses on 11 years of data between January 1989 and October 1999. The cleaned, unbalanced panel contains 49,244 quarterly observations on 5,169 firms. We exclude any divisions of a company, as their information might not be truly relevant to questions relating to size or financial constraints. Furthermore, we exclude all anonymous responses because these companies cannot be tracked over time. For these reasons, our descriptive statistics are not identical to the results published by the CBI.

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15 See Chittenden, Michaelas and Poutziouris (1999).

Apart from its size and coverage, the data-set has a number of important characteristics. First, the survey consists of four employment size groups, the largest of which looks at small firms with less than 199 employees. As can be seen in Table 1, 63% of the ITS observations refer to these small firms. This is extremely valuable, as very little information is available from other micro data-sets, which are generally based on larger, quoted companies. The CBI uses these data to produce a report entitled the *Quarterly SME Trends Survey*, one of the most comprehensive specialist surveys in the SME field. Second, the ITS has a wide-ranging base of firms from the UK manufacturing and processing industries and Table 2 shows the breakdown of two-digit SIC codes by observation.

3.2 Summary descriptive statistics

In order to compare the experience and constraints of small and larger firms, we simplify the size categories further, classifying as 'small' those firms with fewer than 199 employees and as 'large' all those with 200 employees and more. This has the effect of smoothing some of the larger firms' experiences. This is particularly true of the data from those firms with 5,000 and more employees. However, although the data from this size category is the most volatile, it is also based on the fewest observations. All figures within the respective size categories are simple, unweighted averages.

Optimism

One of the most widely reported questions in the ITS looks at the optimism firms' feel about the general business situation in their respective industry: *Are you more, or less, optimistic than you were four months ago about the general business situation in your industry?* The results are shown in Chart 1. In addition to the difference between the share of firms with a positive and a negative outlook, the graph shows the percentage change in the manufacturing production index, at constant prices of 2000. It can be seen that the optimism data reflects the general business cycle for the manufacturing sector fairly well. Eyeballing suggests that manufacturing output and optimism are roughly coincident. It is perhaps surprising that the data from the business optimism question of the survey show so few differences between small and large firms. Essentially, the two time series seem to measure the same process. Since January 1995 the data have diverged to a marginally greater extent, with small firms entering the last business cycle downturn slightly earlier than large firms and exiting it slightly later. With a mean optimism rating of –0.075 for small firms compared with –0.085 for larger firms, the overall levels are almost identical (see Table 3).

Output

Question 4 of the survey reads: *Is your present level of output below capacity (ie are you working below a satisfactory full rate of operation)?* Small firms in the survey were more likely to state that their present level of output was currently below capacity than were large firms. Over the entire data-set, 59% of small firms believed their output was currently below full capacity, compared with 56% of large firms. As can be seen in Chart 2, small firms' trend over time was consistently lower than that of large firms and has remained largely negative.

Of the factors named by firms as likely to limit their output over the next four months (Survey Question 14), by far the most important was orders or sales, with over 80% of both small and large firms citing this particular factor (Chart 3). Lack of skilled labour was a slightly more significant factor for small firms than for large firms, whilst plant capacity was marginally more important to large firms. Credit and finance was mentioned rarely by both sets of firms, although small firms did show a higher propensity to cite this factor with a figure of 6% of small firms compared with 3% of large firms.

Total orders

The ITS allows to analyse whether the order books of small and large firms are above or below normal in volume terms. Chart 4 plots the answers to Survey Question 5a. Both sets of firms generally seem to feel that their present order book is below normal in volume terms. This raises the question of what firms consider normal. Possibly, the respondents' norm is related to capacity. Small firms consistently feel more negative about their order books than do large firms. This is reflected in small firms having a lower overall mean value of –0.306, compared to large firms with a value of –0.251. It is interesting to see how closely Charts 2 and 4 correlate with the trend in business optimism shown in Chart 1; all three of these charts track the wider economic business cycle.

Investment intentions

In Survey Question 3, the ITS asks about respondents' intentions for both buildings and plant and machinery investment over the coming 12 months compared with the preceding 12 months. As can be seen in Chart 5, intentions regarding buildings investment remains largely negative for both small and large firms throughout the period, and both sets of data behave in a broadly similar manner. However, Chart 6 shows firms' intentions regarding investment in plant and machinery is more volatile and small firms do show differences from larger firms. Although they also track each closely, large firms appear to be more positive about their investment intentions than are small firms.

Motivation for capital expenditure

Table 4 lists the main purposes that firms cite for their investment expenditures, as an answer to question 16b. As can be seen from the table, small firms cite the intention to increase efficiency considerably less than do larger firms, with only 46% ranking it as the most important reason for capital expenditure compared with 59% of larger firms.

Instead, small firms cite replacement as a more important factor for capital expenditure than larger firms. It is noticeable that a sizeably higher proportion of smaller firms mention ‘not applicable’ than is the case for large firms. This could reflect indivisibilities, especially for large-scale capital expenditure, where small firms will invest sporadically and will have many periods where they do not invest at all.

Constraints on capital expenditure

The question on constraints on investment is of key importance for our study. We therefore quote the exact wording here for the sake of convenience:

Question 16c: What factors are likely to limit (wholly or partly) your capital expenditure authorisation over the next twelve months?
(If you tick more than one factor, please rank in order of importance)

? inadequate net return on proposed investment
? shortage of internal finance
? inability to raise external finance
? cost of finance
? uncertainty about demand
? shortage of labour, including managerial and technical staff
? other
? n/a

Table 5 shows both the overall frequency with which firms cite a given constraint (any rank) to investment expenditure and the frequency with which this constraint was given the first rank. Firms had the opportunity to name more than one constraint on capital expenditure, but they were asked to rank the importance of their constraints. We interpret the answers to this question as information on marginal investment. For the entire sample, uncertainty about demand is the most common impediment mentioned by all firms. It is cited as the most significant constraint by 55% of all firms over the time period we studied. An interpretation of these figures in the light of theory, however, has to take into account the possibility that many firms focus only on ‘downside risks’, such as an unanticipated decrease in demand, rather than on uncertainty in the sense of imprecise expectations. For a recent review on the micro-econometric literature on investment and uncertainty see von Kalckreuth (2003a). The second most important constraint is inadequate net return, ranked by 39% of firms as their number one constraint. Other constraints seem to have been less important. Costs of finance was cited frequently in the early 1990s, but have been mentioned significantly less often since then.

Table 5 also breaks down the complete data-set into small and large firms. These size classes show a number of differences in the importance given to the surveyed factors that could limit a firm’s capital expenditure. Demand uncertainty seems to be a more important issue for smaller firms than it is for larger firms. This is not implausible: a firm which combines many imperfectly correlated activities will find its overall demand less volatile than does a firm with a smaller number of activities. Furthermore, it is conceivable that small firms are used to meet peak demands in larger firms' order books and are cut out when orders fall. We also see that inadequate net return seems to bother large firms more than small firms.

Turning to financial issues, we see that 5.1% of small firms cite the inability to raise external finance as a factor likely to limit their capital expenditure over the next 12 months. However, it is also interesting to note that only 2.3% mentioned this particular factor as their foremost constraint. This compares with figures of 3.0% and 1.4% respectively in the case of large firms. Therefore, although this severest form of financial constraint is more prevalent amongst small firms, the proportion affected is very low. Overall, it was the restraint least commonly cited by small firms.

Small firms cite the shortage of internal finance less commonly than do large firms, with only 18.1% of small firms mentioning internal finance as a limiting factor compared with 20.2% of large firms. A finer breakdown (not shown) reveals that almost 30% of the firms in the largest size category, with 5000 employees and over, claim to be constrained by the shortage of internal finance. This is somewhat surprising, but it is not impossible that the pressure for high and regular dividends is felt especially strongly by the larger quoted companies. On the other hand, some small firms might find it easier to draw on the private wealth of their owners in the event of liquidity shortages. The cost of finance is a concern for both small and large firms, with a slightly higher proportion of small firms citing it as their main limiting factor.

Although all the financial constraints on investment in the survey rank lower in importance for both small and large firms than do uncertainty about demand and an inadequate net return on proposed investment, it is interesting to look at the trend of such variables over time. As mentioned above, concerns about the cost of finance decreased dramatically for both categories of firms after the last recession in the early 1990s. This is especially noticeable for small firms, as 19% of small firms cited cost of finance as their main constraint on investment in January 1990 compared to only 3% in January 1993. By contrast, a shortage of internal finance appeared to peak as a concern for small firms in the mid-1990s and has become relatively less important for larger firms in recent years when compared with the early quarters in the data-set. This result should be interpreted in the light of the higher investment demand seen during the mid-1990s (see Chart 8) – if investment demand is large, constraints imposed by internal finance are more likely to be binding. Concern about the inability to raise external finance has remained largely constant for both large and small firms, generally being mentioned by 2% to 3% of small firms throughout the 43 quarters covered by our data-set.

For inferential purposes, it is important to know whether there is sizeable individual variation in the financing constraints data. Table 6 conditions on whether in the preceding period a firm reported either shortage of internal finance or inability to raise external finance, and it shows the transition to the next period. It is easy to see that the reports on financial constraints are strongly autocorrelated. Among the firms that do not report financial constraints in a given period, a share of 87.6% will continue to do so in the next period, and 12.4% switch to reporting constraints. But only 33.3% of the firms that report financial constraints in one period will state that they are unconstrained next time, the remaining two-thirds will claim to be still constrained. However, the state of financial constraints is far from being determined by the state in the preceding period – there is lot of individual movement in both directions.

4. Is there informational content in the financial constraints data?

As highlighted in Section 3, a sizeable proportion of firms in the CBI Industrial Trends Survey state that their investment is constrained either by insufficient internal funds or by the inability to raise external finance. These statements are interesting and potentially very rich: as we shall see below, they permit the identification of the financial regime of a firm. Weighted averages of survey questions are often used for forecasting and evaluation purposes on a sectoral or macro level and in many cases turn out to be surprisingly accurate (see, for example, Chart 1 for the question on general optimism). Mitchell, Smith and Weale (2002a, b) show that survey responses contain information that is useful in generating indicators of manufacturing output ahead of the publication of survey data. Furthermore, they show that disaggregate indicators for output growth can outperform traditional aggregate measures with respect to their predictive content. However, it is not clear a priori how well the survey responses reflect the individual financial situation of the answering firm. Therefore, it is necessary to check the informational content of the statements on financial constraints at a micro level. In other words, we want to see whether the statements on financial constraints relate to other information in the data-set in a way that is consistent with theory.

4.1. The endogeneity problem

This, however, is no easy task. Capital accumulation and financial constraints are determined simultaneously: financial constraints depend not only on the financial situation of the firm, but also on the size of the planned investment.

With complete markets and a type of uncertainty common to all agents, the net present value of a firm does not depend on the way it is financed. The Modigliani-Miller separation theorem holds that a firm's real capital allocation decision can be analysed independently of the financing decision – the structure of the asset side of the balance sheet is independent of the liability side. With asymmetric information, however, there will be a premium on external financing over and above a fair default premium which simply compensates for the fact that the debtor will not have to pay in certain states of nature. The creditor is less able than the debtor to evaluate the situation of the firm and the prospects of the investment project to be financed. The finance premium covers expected dead-weight losses caused by monitoring, costs of litigation, adverse selection and moral hazard. The important thing is that its *size depends on the financial structure of the firm*. Investment and the cost of external finance therefore are *jointly endogenous*.

Graph 1, adapted from Bernanke, Gertler and Gilchrist (1999), shows that the costs of external finance depend on the difference between the actual capital demand and what can be financed internally. By means of this graph, we can interpret the responses to the questions on financial constraints in terms of three regimes which are ordered in a natural way: a state of no financial constraints, a state of limited internal finance (the firm needing external finance) and a state of unavailability of external finance. If a firm states that its capital expenditure authorisations are limited by a shortage of internal finance, it is saying that it has to pay an external finance premium because the internal resources are insufficient. And if it reports that no further external finance can be raised, the firm may find itself in the regime described by Stiglitz and Weiss (1981): at a certain credit volume, the credit supply function becomes completely inelastic with respect to the interest rate. Then the firm is credit-rationed. Under certain circumstances, this is the equilibrium outcome of a situation where the severity of the agency problems is a function of the interest rate itself. In the graph, the possible existence of such a regime is accounted for by the vertical portion of the supply curve.

We see that shocks to the financial structure will affect real decisions and vice versa. In any equation describing the capital accumulation decision, the error term will be correlated with the financial constraints variable. If we had continuous variables describing the accumulation of capital, this problem could be resolved using instrumental variables techniques, such as the GMM method developed by Arellano and Bond (1991). Breitung, Chirinko and von Kalckreuth (2003) explore the simultaneity between investment decision and financial conditions by estimating a VAR on a large panel of German manufacturing firms. However, Instrumental Variable analysis is made difficult by the fact that the ITS data on investment and expansion are qualitative: we know whether or not the firm expands or steps up investment, but not by how much.

We therefore want to test the informational content of the data on financial constraints by looking at a relationship where both lines of causality point in the same direction. To this end, we investigate the occurrence and the duration of spells of capacity constraints.

4.2. Occurrence and duration of capacity restrictions

If there are adaptation costs such as delivery lags or time to build constraints, the move to a higher desired capital stock will be spread over several periods. In order to achieve tractability, it is often assumed that marginal adaptation costs increase linearly with the size of investment.[16] Second, the external finance premium might also be an increasing function of the investment intensity. Creditors might want to give finance in instalments, cutting the project into several phases, in order to monitor feasibility and the willingness of the management to comply with the terms of the credit contract. This may induce a sequential and 'evolutionary' development of a project from a smaller to a larger size even in cases where in a world without information asymmetry a massive parallel investment effort might have been optimal. In the extreme case, when a firm has no access to external finance, the amount of investment per period is quite simply limited by the firm's cash flow.

The ITS survey gives us information on whether or not a firm experiences capacity constraints in a given period by asking the following question:

Question 14: What factors are likely to limit your output over the next four months?
(please leave completely blank if you have no limits to output)

? orders or sales	? skilled labour	? other labour	***?*** plant capacity
? credit or finance	? materials or components		? other

Both directions of causation between financial constraints and the expansion decision lead us to predict that a state of capacity restrictions is more probable and will be of longer duration if the respondent also reports financial constraints to investment. With a given marginal valuation of capital, a large external finance premium will induce the firm to spread investment over a longer time horizon, inducing and prolonging capacity constraints. On the other hand, with a given financial structure, a shock in the marginal valuation function will not only trigger financial constraints, but also lead to a longer adaptation process. Larger gaps simply take more time to fill. Below, we shall compare the occurrence and duration of capacity constraints for restricted and unrestricted financing, with a particular emphasis on the distinction between small and large firms. Our analysis shows that the financial constraints data actually do have informational content on the micro level.

The econometric analysis of duration data began only in the late 1970s' (see Heckman and Singer (1984), Kiefer (1988), and Lancaster (1990) for overviews). Not only the statistical models, but also a good part of the terminology, have been borrowed from biostatistics. The classical focus of 'survival analysis' is the evaluation of survival times of human patients or

[16] See Hayashi's (1982) neoclassical micro-foundation of the Q model.

animals after the contraction of a specific disease, with the aim of testing the effects of medical treatments and other factors that might potentially be of relevance. Among the economic applications have been the analysis of the duration of unemployment, for example, by Steiner (1990), or of fiscal behaviour, as in the study by von Hagen, Hughes-Hallet and Strauch (2001). To the best of our knowledge, the duration of capacity constraints has never been investigated before on a micro-econometric level. This makes our exercise interesting and worthwhile in its own right, as capacity constraints may play an important role in the propagation of inflationary shocks.[17]

4.3 Association analysis for capacity restrictions and financial constraints

Table 7 compares the frequency of capacity restrictions for three groups of firms: those that do not seem to be limited by the lack of either internal or external finance (Group 1), those that complain about shortages of internal finance but not about the inability to raise external finance (Group 2) and, finally, those that report being rationed on the market for external finance (Group 3). Whereas only 12.99% of the first group claims to be capacity restricted, the corresponding figures are 22.52% of the second group and 19.17% of the third group. The two latter groups are clearly different from the first group. We perform three statistical tests of association: the well known Pearson test, a likelihood ratio test and Fisher's exact test, and all reject the null hypothesis of independence with a p-value of less than 0.0005.[18] The picture we can gather from comparing small and large firm in this respect (not shown) is essentially similar.

It is also interesting to look at *changes* of states, as the association between the levels of the financial constraints and capacity restrictions might be the result of a special sensitivity to constraints in general on part of the individual respondents. To put it differently: some individuals might have a special propensity to complain. Therefore we want to condition on the state of capacity restrictions in the preceding period. This examination also prepares our duration analysis: by definition, a switch from the state of not restricted to restricted initiates a spell of restricted capacity. If the restricted state is maintained, the spell goes on, and a reverse switch will end it.

Table 8 performs the three above-mentioned non-parametric association tests separately for firms that reported capacity restrictions in the preceding period and those that did not. Gener-

[17] See, for example, Macklem (1997).

[18] Given two discrete (multinomial) variables, all three tests focus on how strongly the realised shares for one variable, conditional on the values that the other variable may take, deviates from the overall shares. Pearson's test and the likelihood ratio test are easily calculated and rely on asymptotic properties of the test statistic: for large numbers their distribution converges against the Chi(2) with (r-1)(s-1) degrees of freedom, r being the number of rows and s being the number of columns in the contingency tables. Fisher's test exploits the exact distribution of the test statistic, but computation can take a very long time for larger tables. See, for example, Büning and Trenkler (1994) or any other book on non-parametric statistics.

ally, capacity restrictions are cited much more frequently when there were restrictions in the previous quarter: Whereas only 7.2% of the unrestricted firms switch to the restricted state, 53.3% of the restricted firms remain restricted. However, under both conditions the probability of capacity restrictions clearly becomes higher when financial constraints are present. Again, the three association tests mentioned above reject the null hypothesis of independence with a p-value of less than 0.0005.

Tables 9 and 10 reveal an interesting difference between large and small firms. Among the firms that were unconstrained in the previous period, there is no clear size differential. But among the constrained firms, a large firm will stay constrained with a probability of 57.8%,(Table 10, lower half), whereas it is only 49.9% for small firms (Table 9, lower half). A closer inspection of the two tables shows that most of that difference is due to different conditional probabilities of capacity constraints when there are no financial restrictions. This might indicate that the duration of capacity constraints is shorter for small firms. A formal duration analysis can tell whether this is true.

4.4. The design of the duration analysis

We now proceed to consider the duration of states of restricted capacity. For a firm in this state, the probability of switching to the unrestricted state may depend on the duration that is already achieved. Such a conditioning on time is called 'ageing', and the word itself makes the idea plain. Mortality among human beings is relatively high during the first months of life, and then drops sharply after a couple of years. In advanced age, mortality rises again and reaches extreme levels at the right end of the scale.

In order to estimate survival curves, we therefore need to have information on the time when the period of constrained capacity began. We limit ourselves to contiguous strings of observations that start with a switch of the capacity restrictions variable from zero (no capacity restrictions reported) to one (output is likely to be limited by plant capacity during the next four months). The string is interrupted if either the state is left, i.e. the 'spell' ends, or else if there is no further information on the firm. One missing survey is enough to cut the string off. For inferential reasons, we can use only those observations which are not censored immediately after entry. That is, after the initial switch from zero to one, we need at least one more consecutive observation on the firm if the string is to contain any information on duration other than that it was non-negative. The cleaned CBI survey data for the period between January 1989 and November 1999 contain 49,244 observations on 5,169 firms. In this data-set, we observe 1,431 of such strings, with a total of 5,153 observations,[19] taken from 862 firms.

[19] This number of observations includes the initial zero and the initial 1 for each string.

We need to pay special attention to three important features of our data-set. First, our duration data are censored considerably. From our 1,431 cases, we observe the end of the spell 1,210 times, but in the remaining 221 spells the string is cut off by missing observations. In these cases, we know that the spell has lasted *at least* until the end of the string, and this information has to be used appropriately. Second, we have *grouped data*. We do not observe the end of the spell in continuous time, but only know that it falls in an interval between two discrete points of time. Our observations are quarterly, and the vast majority of observed periods of capacity constraints are less than four quarters. This means that the granularity of our observations is rather high, and we believe that it would not be correct to use standard models and estimation procedures which assume observed duration times to be continuously distributed in time. Third, as already stated, we are working with a *panel* of survival time data. For many firms, we observe more than one spell. These cannot be assumed to be stochastically independent, and special care has to be taken with testing procedures.

4.5. Kaplan-Maier survival curves

We start by looking at the estimated *survivor functions*. A survivor function is defined both for discrete and continuous distributions by the probability that the duration T exceeds a value t in its range, that is

$$F(t) = P(T > t), \qquad 0 < t < \infty \ . \tag{1}$$

For each hypothetical duration t, the survivor function gives the share of individuals with duration of t or more. In our context, the survivor function depicts the process of firms liberating themselves from capacity constraints, once they have entered into this state. The survivor function gives the mass on the *right tail* of the distribution of duration times. This is convenient, because the right tail is the important component for the incorporation of right censoring.

The Kaplan-Meier[20] (or *product limit*) estimator is a non-parametric maximum likelihood estimator of the survivor function. The estimator is given by

$$\hat{F}_t = \prod_{j \le t} \left(1 - \hat{l}_j\right), \qquad \text{with} \quad \hat{l}_j = \frac{d_j}{n_j} \ . \tag{2}$$

The index j enumerates observed times to completion, i.e. time spans passed since the observational unit entered into the risk pool. We only observe firms at discrete intervals, therefore the j can be thought of as quarters. The $\hat{l}_j$ are estimated probabilities for the observational unit to complete at j, given that it has reached j-1, the last observed time to completion. The estimate of this conditional probabilities is obtained by dividing the observed number of com-

[20] For the derivation of the Kaplan-Meier estimator as a maximum likelihood estimator, see Kalbfleisch and Prentice (2002) and the Appendix to this paper.

pletions, d_j, by the number of observational units that have neither completed nor been censored before j.

As can be seen, the survivor function is estimated recursively. The expression $\left(1-\hat{l}\right)$ is an estimation of the conditional probability that an individual 'survives' in the state, given that it has lasted until j–1. The unconditional probability that the duration is at least j is then computed as a product of all the contemporaneous and prior conditional survival probabilities. For this estimate to be unbiased, the censoring mechanism needs to be independent, that is, the completion probabilities of non-censored and censored individuals must be identical. This will be assumed throughout below.

Table 11 not only describes termination and censoring over time, but also gives the numerical values for the survivorship and completion rates in the entire sample. The first column, time, is the number of quarters *after* the original switch from unconstrained to constrained. If, for example, the capacity state of a firm switches from unrestricted to restricted in the third quarter 1991, then for this firm the fourth quarter 1991 assumes the value of 1. The second column gives the number of firms 'at risk', for which we have information in this quarter. The third column gives the number of completions, the fourth column the number of firms censored in this quarter, on which there is no further information thereafter. The sixth column is the estimated Kaplan-Meier survivor function, based on the estimated hazard rates in the fifth column according to Equation (2). According to this estimate, about 40% of firms that start out with capacity constraints remain in this state for more than one quarter, 20% for more than two quarters, etc. After the fifth quarter, the survivor function has dropped to 6.4%. The longest observed duration is completed after 13 quarters. Completion probabilities seem to be falling, i.e. there is negative age dependence. The more time a firm has spent in a state of constrained capacity, the less likely it is to leave in the next quarter. The size of the sample, on which duration information is based, decreases rapidly with time. After the fifth quarter, not more than 3.7% of the original set of firms is left in the sample. It therefore seems inappropriate to draw any conclusions from survival times larger than that. The last column gives the standard deviation of the survivor function, taking into account the stochastic dependence of the duration experiences for a given firm. The standard deviations are simulated on the basis of a maximum likelihood estimation of the parameters – see the Appendix to this paper – using 20,000 replications. Numerically, they differ only very slightly from what is obtained assuming all duration experiences to be independent. The curve of the survival function given in Table 11 is plotted as Graph 2

We want to compare the survivor experiences for various sub-samples. The relative sizes of the groups and some global statistics are given in Table 12. Graph 3 compares the duration experiences of small and large firms. Among the total number of capacity constraints experiences, 887 were by small firms (with less than 200 employees) and 544 by large firms (200 employees and more). The survival curve of small firms is always beneath that of the larger firms. That is, large firms take longer than small firms to complete their spells of capacity constraints.

It is interesting to speculate about possible reasons. One explanation is that larger firms might be hit by (disproportionately) larger demand shocks. This does not seem immediately plausible; the law of large numbers should help to even out demand volatility for firms with larger and more diversified markets. However, it is conceivable that small firms cope with the volatility of market demand by tying themselves to larger firms and groups, in exchange for an explicit or implicit insurance, thus smoothing their order book situation. Analogous strategies have been modelled to explain relationship banking in the context of firm finance, or implicit contracts in labour markets. Then, of course, it may also be the case that with their flat hierarchies and low co-ordination costs, small firms are more nimble and flexible in coping with demand shocks of a given size than are the more bureaucratic large firms. There is a less flattering third possibility: small firms more than large firms might tend to 'solve' their capacity problems simply by frustrating customers. If all firms are profit maximisers, it is hard to think of any economic reason for such a differential behaviour. The profit motive, however, might be less prevalent among some of the smaller firms.

Next we wish to look at survival experiences by financially constrained and unconstrained firms. The state is measured at the *start of the spell*. As before, there are two natural ways to analytically distinguish financially constrained and unconstrained firms. First, we can group a firm as financially constrained if it reports that it has to scale down investment because of insufficient internal funds. Second, we can classify it as financially constrained if it cites either shortages of internal finance or the inability to obtain external finance. The difference between the two groupings is in those 44 spells where firms cite the inability to obtain external finance as a limitation to investment, without indicating shortages of internal finance at the same time. As such a pattern is incompatible with the standard pecking order view of corporate finance under financial constraints or the natural ordering that results from costly monitoring models as shown in Graph 1, we prefer the less ambivalent first grouping. Ultimately, the answer 'costs of finance' as a limit to capital expenditure might indicate the working of the classical user cost mechanism. Therefore we do not use it as a sorting criterion.

We see that the prevalence of financial limitations is clearly higher among those firms that cite capacity restrictions. Whereas 25.3% of all capacity restrictions experiences are categorised as 'financially constrained' according to the first criterion, and 28.4% according to the second criterion, the corresponding figures for the entire CBI data-set are 19.0% and 20.8%, respectively.

Graph 4 depicts the results for the first criterion (shortage of internal finance) for the whole sample. The survival curve for financially unconstrained firms is everywhere beneath the curve for the financially constrained firms. This means the unconstrained firms are able to complete their spell of restricted capacity faster than the constrained firms. It is convenient to point out again that there are two competing causal explanations for this difference. For a given size of the capacity gap, financial constrained firms might take longer to fill it. On the other hand, firms with a huge capacity gap (and accordingly higher financing needs) might be more likely to report financial constraints. Comparing the survival curves essentially tests those two hypotheses jointly.

It is instructive to look at the effect of financial constraints separately for small and for large firms. Graph 5 shows constrained and unconstrained small firms, and Graph 6 performs the same comparison for large firms. For both sub-samples, the curve for constrained firms is situated above the curve for unconstrained firms, as is expected. The graphs for the second criterion look essentially similar. Eyeballing suggests that the difference is more marked for small firms. It will be necessary to examine this and other differences statistically.

4.6. A proportional hazard (Cox) model of duration

In order to test the effect of size and financial constraints on the duration of capacity restrictions, we need to impose some structure. Let $x = (x_1, x_2)$ be a two dimensional vector of indicator variables for size and financial constraints. Specifically, $x_1 = 1$ indicates large size, and $x_2 = 1$ a state of financial constraints at the beginning of the spell. As we have little *a priori* information about the underlying process, we do not want to restrict the form of the baseline survival function that corresponds to $x = (0,0)$, the case of a small firm without financial constraints. In what follows, we explicitly recognise (1) that duration is distributed continuously over time, and (2) the measurement of the capacity restrictions for a given unit is taken at discrete interval (quarters), j = 1, 2, ... k.[21] Let $l(t, x_i)$ be the *hazard* for a unit with characteristics x_i at time t, defined as

$$l(t,x) = \lim_{h \to 0} P\left(t \le T < t + h \middle| T \ge t, x_i\right) \Big/ h \qquad (3)$$

The hazard is the instantaneous rate at which spells are completed by units that have lasted until time t, defined in the same way as a mortality rate in demographics or a failure rate in the statistical theory of capital stock dynamics (see Appendix 2 for the details). We want to assume that the characteristics x relate to the hazard rate in a proportional fashion:

$$l(t,x) = l_0(t) \cdot \exp(x_i' b) \ , \qquad (4)$$

21 The assumption of absolutely continuous time is made only for expositional convenience. A discrete time concept would not invalidate any of our results, after we have redefined the hazard rate in t as the conditional probability that the spell is completed in t+1, conditional on it having lasted until t. It is possible to conduct duration analysis with distributions of T that have both discrete and continuous portions. See Kalbfleisch and Prentice (2002) for a systematic approach.

with β being a vector of coefficients that needs to be estimated. The hazard ratio between an individual with characteristics x_i and the baseline case is given by $\exp(x_i'b)$, which is approximately $1+\beta$ for small β. The hazard ratios between two individuals with characteristics x_1 and x_0 are calculated as $\exp[(x_1-x_0)b]$. Equation (4) constitutes the model of proportional hazard, developed by Cox (1972). In this set-up, the baseline hazard remains completely unspecified, which is why the proportional hazard model figures among the semi-parametric approaches.

We assume that the spells of different firms are independent events and that the censoring mechanism is independent of the state of the firm. We can write the probability for the completion of a spell to be registered after *j* surveys as a product of conditional probabilities. This allows us to derive a likelihood function that contains ß as well as further (incidental) parameters describing, for the baseline case, the conditional probability of completing in the time interval between $j-1$ and j, given that $j-1$ has been reached. The Appendix contains the full details and a derivation. The likelihood function can be shown to be identical to the likelihood function for a Bernoulli-experiment with probabilities that depend on time as well as on x_i by means of a standard link function. The parameter estimates are asymptotically normally distributed. The panel nature of the data is taken into account by computing robust standard errors, with clusters defined by the firm identity.

Table 11 contains the Maximum Likelihood estimations for a Cox model with two covariates: size and an indicator variable for the presence of financial constraints. As explained above, we use two alternative definitions of financial constraints. The dummy variable *fin(1)* takes a value of 1 to indicate that the firm cites insufficient internal finance at the outset of the spell. The dummy variable *fin(2)* will be 1 if the firm cites either insufficient internal finance or the inability to raise external finance The respective classification is maintained during the entire spell.

In each cell, the first figure gives the estimated coefficients. Below, in curly brackets, this value is translated into a hazard ratio. Column (1), for example, compares the hazard rates for small and large firms. The hazard rate of a large firm is exp(–0.183) times the hazard ratio of a small firm, meaning that large firms are leaving the state of restricted capacity at a rate which is only about 83.3% that of a small firm. The third figure, in round brackets, indicates the robust standard deviations, taking into account stochastic dependence between spells generated by the same firm. The last entry, in square brackets, gives the *z* statistic for statistical significance: under the null hypothesis of no differences, the estimated coefficient divided by its standard error is asymptotically a standard normal variate. Investigating the table, we see that the lack of internal finance lowers the hazard rate to approximately the same extent as large size: the hazard rate for a constrained firm is only 82.6% of an unconstrained firm, meaning a longer duration of the restriction experience. This remains true if we consider both characteristics at the same time. In Column (4), we introduce an interaction term, thereby allowing the sensitivity of large firms with respect to financial constraints to be different from that of small firms. In this regression, we can compare constrained small firms with unconstrained small firms using the *fin(1)* coefficient. Its value is 0.260, which is equivalent to a hazard ratio of 0.771%. The hazard ratio of a large constrained firm (as opposed to a large unconstrained firm) is given by the sum of the *fin(1)* coefficient and the coefficient of the interaction term. We see that this coefficient is smaller, the estimated hazard ratio for large firms is only exp(–0.260+0.170) = 0.915. Furthermore, this value is not significantly different from zero. Performing a Wald-test on whether the sum of the coefficients on *fin(1)* and the interaction term is zero, we obtain a value of the $c^2(1)$-statistic of 0.58, which is equivalent to a p-value of just 0.45. However, the difference in the sensitivity between small and large firms, given by the coefficient of the interaction term, is itself not significant. The last three columns of Table 13 give us the corresponding estimates with respect to our second indicator of financial constraints, *fin(2)*. The picture is essentially similar, although the measured difference in the sensitivity between small and large firms is somewhat smaller.

It may be argued that the detected differences between small and large firm may be sector specific. As firm size (and possibly financial constraints) may be sector specific too, we want to control for sectoral differences in order to avoid a missing variable bias. Table 14 repeats the estimates explained above, adding 20 dummies for 2 digit SIC sectors. This leads to a slight reduction in size effect: the hazard rate goes down from 0.833 to 0.855. In the estimation featuring a size dummy, the fin(1) dummy and the interaction term, large size will lower the hazard rate by about 19%, lack of internal finance will depress it by almost 25%, but the interaction term, although still insignificant by itself, will neutralise almost the entire effect of financial constraints for large firms. Again, the estimates using the second criterion for financial constraints are very similar, although the measured effects seems less strong.

A third set of estimates, collected in Table 15, controls for the position in the business cycle, by including dummies for the time of the start of the spell. This is done in order to account for a possible dependence of duration on the general state of the economy. In a time of depression, investors might be less inclined to close capacity gaps. At the same time, internal financial resources might be scarcer and external finance might be more difficult to obtain. In our estimates, adding the controls for the business cycle situation makes the size effects come out more clearly, whereas the measured effects of financial constraints are somewhat smaller, as predicted. In our preferred estimate, which includes an interaction term, both characteristics lower the hazard rate by about 22 % with respect to the baseline case. These two values are highly significant. For large firms, the interaction term lowers the financial constraints sensitivity by about one half. The hazard rate of a constrained large firm versus an unconstrained firm is measured at 91.6. Statistically, this is not significant –the $c^2(1)$-statistic yields a value of 0.94, corresponding to a p-value of 0.33.

The estimates for large and for small firms in Table 11, 12 and 13 are not independent, as the coefficients on the duration time dummies are restricted to be identical.[22] We want to repeat the comparison by estimating a proportional hazards model separately for large and for small firms. This is equivalent to including interaction terms for time dummies in the previous regressions. As we want to economise on degrees of freedom, we perform this regression only for the basic model without additional dummies indicating sector or date of spell origin. The results do not differ perceptibly from what has been seen before: with small firms, the presence of financial constraints leads us to predict a smaller hazard and a longer duration of the capacity restrictions experience. For large firms, the estimated difference points in the same direction, but it is smaller and not significantly different from zero.

As a whole, our regressions give us two statistically significant results and a consistent overall pattern. Holding everything else constant, size clearly has an effect on the duration of capacity constraints. Hazard rates for large firms are about 20%-25% lower compared to small firms. Second, for small firms at least, financial constraints according to either of our two definitions make a difference. For a constrained small firm, the hazard is between 24% and 29% smaller than for an unconstrained small firm. For large firms, on the other hand, we do not find a statistically significant difference between constrained and unconstrained firms. We do not think that it is justified to conclude that financial constraints are unimportant or uninformative for larger firms. The results from the association analysis in Section 3 do not support this interpretation. It is quite possible that our sample size is not big enough to deliver significant results for our sub-sample of larger firms. The sensitivity difference between the two groups is everywhere insignificant. However, the overall pattern of a lower, but still positive dependence of duration on financial constraints is suggestive.

5. Conclusion

Our association and duration analysis have shown that the CBI financial constraints data are not without informational content – as theoretically expected, financially constrained firms are more often capacity constrained and they take longer to close capacity gaps than unconstrained firms. This means we can take our survey information seriously. They indicate that financial constraints and real activity are indeed interrelated. Survey information on the ups and downs of financial constraints indicators can therefore be a potentially valuable policy tool.

The descriptive analysis does not show any clear distinction between large and small firms with respect to the importance of financial constraints. The analysis of association between financial constraints and capacity restrictions does not yield sizeable differences, either.

[22] The time dummies are related to the conditional probabilities of completing for the baseline group, see Appendix 2

Looking at the duration of capacity restrictions, we see that small firms are able to close their capacity gaps faster. Financial constraints make a clear difference for small firms: they significantly prolong their spells of capacity restrictions. For larger firms, the measured effect is positive, too, but insignificant. We do not think, however, that it is justified to conclude that financial constraints do not matter for large firms.

The precise nature of the relationship between the real and the financial spheres remains to be worked out. Real investment decisions may certainly cause financial constraints, and on the other hand those financial constraints may slow down or prevent expansion plans. By means of a more structural approach, we may have a chance to tell the two directions of causation apart.

Appendix: A maximum likelihood estimator for the proportional hazard model with censored grouped panel data

As has already been discussed, a very important feature of our data-set is that the observations are *grouped*. The observational units are surveyed in certain intervals and if there is a status change, we get to know only the left and the right boundary for the date when the change took place. And as the typical duration experience (spell) only lasts a few quarters, we have to take this limitation very seriously.

This makes it impossible to use many of the standard procedures that assume a continuous flow of information. In a certain sense, however, the restriction also makes life easier. As we do not see what happens in between two surveys, all survivor functions that yield the same pattern of probability masses on the intervals are observationally equivalent. It is only this pattern that counts for inferential purposes. And as there are not too many quarters, the pattern can be parameterised relatively easily.

Below, we think of the duration as distributed in continuous time. Information, however, arrives at discrete points and is supposed to cover the interval between two observations. Our derivation of a maximum likelihood estimator for the case of grouped data relies heavily on Hosmer and Lemeshow (1999), Sect. 7.4 (but also see Kalbfleisch and Prentice (2002), Sect. 5.8 for a more general exposition).

In Equation (3), the hazard function has been defined as the instantaneous rate at which spells are completed by units that have lasted until time t, just like a mortality rate in demographic analysis. Let $f(t,x)$ be the (continuous) density of duration t and $S(t,x)$ the survivor function, indicating the probability of duration of at least t, being the probability mass on the right tail of the distribution. Then the hazard function may be written as

$$l(t,x) = \frac{f(t,x)}{S(t,x)} = \frac{d}{dt}\log S(t,x) \quad . \tag{A.1}$$

The hazard function completely determines the distribution. In survival analysis, the most widely used model to analyse the influence of covariates x is the proportional hazard model introduced into the literature by Cox (1972). Given a set of covariates and a vector of parameters ß, the constituting assumption is

$$l(t,x) = l_0(t)\cdot\exp(x'\text{ß}) \ . \qquad \text{(A.2)}$$

The hazard function for an individual with covariates x differs from a baseline hazard l_0 by a multiple $\exp(x'\text{ß})$ that may or may not be constant. Most importantly for estimation purposes, the baseline hazard remains completely unspecified. Therefore, the Cox model is classified as a semi-parametric approach. The substantive content of the Cox assumption rests in the *hazard ratio* for two units with covariates x_0 and x_1:

$$\frac{?(t,x_1)}{?(t,x_0)} = \exp((x_1 - x_0)\text{ß}) \ . \qquad \text{(A.3)}$$

We want to develop a maximum likelihood procedure for the estimation of a proportional hazard model with censored grouped panel data. In our set-up, measurement is taken at certain intervals: $j = \{1,2,\ldots,k\}$. For all individual spells *i*, we define a censoring variable c_i that takes the value $c_i = 1$ if the end of the duration is observed, and $c_i = 0$ if not. Let $t = l_i$ be the time when the spell i is last observed. Calculating the probability of a given duration experience, we have to distinguish two cases. If $c_i = 1$ (not censored), we know that the duration was completed by $t = l_i$, and the completion event must have occurred somewhere in the interval between $l_i - 1$ and l_i. That means:

$$P_i = S(l_i - 1, x_i, b) - S(l_i, x_i, b) \qquad \text{for} \quad c_i = 1 \ . \qquad \text{(A.4)}$$

If $c_i = 0$, right censoring occurs in $t = l_i$. Up to the last observation, the event has not occurred, and the probability for this outcome is:

$$P_i = S(l_i, x_i, b) \ . \qquad \text{(A.5)}$$

This fundamental distinction is typical for estimation with censored data; see, for example, Maddala (1983), Chapter 6, or Wooldridge (2002), Chapters 16 and 20. Assuming for a moment that the spells are independent, we may write the likelihood function as

$$\begin{aligned} L &= \prod_{i=1}^{n}\left\{S(l_i,x,b)^{1-c_i}\cdot\left[S(l_i-1,x_i,b)-S(l_i,x_i,b)\right]\right\} \\ &= \prod_{i=1}^{n} S(l_i-1,x,b)\left\{\left(\frac{S(l_i,x_i,b)}{S(l_i-1,x_i,b)}\right)^{1-c_i}\cdot\left(\frac{S(l_i-1,x_i,b)-S(l_i,x_i,b)}{S(l_i-1,x_i,b)}\right)^{c_i}\right\} \end{aligned} \qquad \text{(A.6)}$$

The seemingly unwieldy transformation above yields a key insight. Both the censored and the uncensored individuals contribute the amount $S(l_i - 1, x, b)$ to the likelihood, the information that the duration of the experience had not ended by $l_i - 1$. *Conditional on this information*, the contributions differ only for period $t = l_i$. For the non-censored durations with $c_i = 1$, the spell has ended by $t = l_i$. This event has the conditional probability

$$q_{i,j} = \frac{S(j-1, x_i, b) - S(j, x_i, b)}{S(j-1, x_i, b)} \qquad \text{for } j = l_i. \tag{A.7}$$

The above expression is the probability that completion takes place between $l_i - 1$ and l_i, given the fact that it has already lasted until $l_i - 1$.[23] For the censored cases, we have the information that the spell has not ended in $t = l_i$, the conditional probability of which is

$$(1 - q_{i,j}) = \frac{S(j, x_i, b)}{S(j-1, x_i, b)} \qquad \text{for } j = l_i. \tag{A.8}$$

Lastly, we may rewrite the survivor function in $t = l_i - 1$ as the product of conditional survival probabilities for all periods up to $l_i - 1$:

$$S(l_i - 1, x, b) = \prod_{i=1}^{l_i - 1} (1 - q_{i,j}) \ . \tag{A.9}$$

Substituting these expressions into (A6) yields the likelihood function:

$$L = \prod_{i=1}^{n} \prod_{j=1}^{l_i - 1} (1 - q_{i,j}) \cdot \left(q_{i,l_i}{}^{c_i} + (1 - q_{i,l_i})^{1-c_i} \right) . \tag{A.10}$$

We can rewrite this expression in a way that permits the maximum likelihood estimation using standard software. For each spell *i*, and for all $t \le l_i$, we define the artificial outcome

$$z_{i,t} = \begin{cases} 1 \text{ if } c_i = 1 \text{and } t = l_i \\ 0 \text{ else} \end{cases} \ . \tag{A.11}$$

Using this variable in (A10) yields an expression that has the form of the likelihood for a generalised binary regression model:

$$L = \prod_{i=1}^{n} \prod_{j=1}^{l_i} (1 - q_{i,j})^{1 - z_{i,j}} \cdot q_{i,j}{}^{z_{i,j}} \ . \tag{A.12}$$

[23] This conditional probability of completion is conceptually similar, although not identical, to the hazard rate defined above in (3) and (A.1). However, whereas *?i,j* is a true probability that is defined over an interval, the latter is an instantaneous rate that refers to a single point in the distribution and is allowed to have values greater than one. This is analogous to the relationship between a density of a continuous random variable and the probability that a value in a certain interval is assumed.

For each duration experience *i*, (A.12) is the likelihood for l_i independent binary observations with probabilities $q_{i,j}$ and outcomes $z_{i,j}$. In order to use this for an estimate of b, we need the link function that relates $q_{i,j}$ to the covariates x_i. A link function is a transformation such that the transformed probability $q_{i,j}$ is a linear function of x_i. With some algebra, we can show that under the Cox assumption (A.2), the following relationship holds for the survivor function:

$$S(t, x, b) = S_o(t)^{\exp(x'b)}, \qquad \text{(A.13)}$$

and some more algebra yields the following link function:

$$\ln[-\ln(1-q_{i,j})] = x'b + t_j, \quad \text{where} \qquad \text{(A.14))}$$

$$t_j = \ln\left[-\ln\left(\frac{S_0(j)}{S_0(j-1)}\right)\right]. \qquad \text{(A.15)}$$

The link function (A.14) is the complementary log-log function. After creating artificial values *j* and $z_{i,j}$ for each interval $t \leq l_i$, we define time dummies for each interval *j*. We can estimate b and the τ_j as the coefficients of the covariates and the time dummies, respectively, using a binary regression package with the link function (A.14).[24]

Several firms contribute more than one duration experience. We take account of the panel nature of our data-set calculating robust standard deviations clustered with respect to the firm, rather than those standard deviations that assume independence. This allows for an arbitrary correlation pattern for the observations of any given firm. The assumption of independence between firms, however, is retained.

By means of (A.15), we can recover the maximum likelihood estimates of the baseline conditional survival probabilities, $S_0(t)/S_0(t-1)$, taking into account the fact that that $S_0(0) \equiv 1$. Calculating their products yields the estimate of the baseline survivor function. In a model without covariates, the survivorship function estimated in this way is identical to the Kaplan-Meier estimator discussed earlier. The standard deviations in Table A1 were calculated by simulating survival curves with 20,000 replications of $\tau_j, j = 1,...,8$, on the basis of the maximum likelihood estimation of the parameter and the variance-covariance matrix. In the presence of covariates x_j, the baseline survivorship function refers to a hypothetical unit with covariates $x_j = 0$. This is easy to interpret if the covariate is an indicator variable for a sample split. In more complex cases, however, the baseline survivor function does not necessarily make sense by itself.

[24] For our estimations, we have used the cloglog routine in Stata, version 8.

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Tables

Table 1: Breakdown of data-set by employment size

	Employment Size				
	1-199	200-499	500-4,999	5,000 and over	Total
No. of firms	3,394	1,060	647	68	5,169
No. of observations	31,089	10,222	6,994	939	49,244

Source: CBI Industrial Trends Survey

Table 2: Number of observations split by employment size and 2 digit SIC code

2 Digit SIC code	**Employment Size**				
	1-199	**200-499**	**500-4999**	**5000 and over**	**Total**
Coke ovens	17	6	17	0	40
Mineral oil processing	73	35	38	11	157
Nuclear fuel production	0	0	0	2	2
Extraction & preparation of metalliferous ores	35	0	0	0	35
Metal manufacturing	1,429	460	292	62	2,243
Extraction of minerals not elsewhere specified	493	60	103	9	665
Manufacturing of non-metallic mineral products	1,286	436	443	85	2,250
Chemical industries	1,191	722	641	79	2,633
Production of man-made fibres	142	8	32	1	183
Manufacturing of metal goods not elsewhere specified	3,048	651	308	6	4,013
Mechanical engineering	7,116	1,718	1,028	23	9,885
Manufacturing of office machinery & data processing	103	26	90	7	226
Electrical & electronic engineering	2,991	1,420	808	54	5,273
Manufacturing of motor vehicles & parts thereof	691	409	409	187	1,696
Manufacturing of other transport equipment	315	132	136	111	694
Instrument engineering	838	230	69	0	1,137
Food, drink & tobacco manufacturing industries part 1	473	250	420	43	1,186
Food, drink & tobacco manufacturing industries part 2	689	399	454	151	1,693
Textile industries	2,427	1,098	594	7	4,126
Manufacturing of leather & leather goods	295	63	2	0	360
Footwear & clothing industries	1,439	478	262	39	2,218
Timber & wooden furniture industries	1,258	313	154	1	1,726
Manufacturing of paper & paper products	2,854	668	489	38	4,049
Processing of rubber & plastics	1,698	563	169	22	2,452
Other manufacturing industries	188	77	36	1	302
Total	**31,089**	**10,222**	**6,994**	**939**	**49,244**

Source: CBI Industrial Trends Survey

Table 3: Business optimism statistics

	Mean	Std. Dev.	Freq.
Small Firms	-0.075	0.703	31089
Large Firms	-0.085	0.679	18155
Total	-0.079	0.694	49244

Source: CBI Industrial Trends Survey

Table 4: Main reasons given for any expected capital expenditure on buildings, plant or machinery over the coming 12 months

	Small Firms	Large Firms	All Firms
To expand capacity	17.1	19.5	18.0
To increase efficiency	45.5	58.7	50.4
For replacement	27.3	23.7	25.9
Other	3.4	5.7	4.3
N/A	13.2	2.9	9.4

Source: CBI Industrial Trends Survey
Percentage of those firms reporting each reason as their most important

Table 5: Small and large firms investment constraints

		Inadequate net return	Shortage of internal finance	Inability to raise external finance	Cost of finance	Uncertainty about demand	Shortage of labour	Other	N/A
Large Firms	Any rank	47.59%	20.23%	2.99%	9.44%	49.11%	4.92%	2.07%	7.38%
	Rank 1	37.01%	14.94%	1.37%	4.59%	36.81%	2.54%	1.81%	8.03%
Small Firms	Any rank	33.52%	18.12%	5.07%	11.34%	58.25%	6.20%	1.58%	9.77%
	Rank 1	22.95%	12.78%	2.30%	5.63%	49.01%	2.89%	1.44%	10.34%
Total data set	Any rank	38.71%	18.89%	4.30%	10.64%	54.88%	5.73%	1.76%	8.89%
	Rank 1	28.14%	13.58%	1.96%	5.25%	44.51%	2.76%	1.58%	9.49%

Source: CBI Industrial Trends Survey
Firms ranking the constraint as a limit on the capital expenditure authorisations, as a percentage of all firms, including those who did not answer the question at all. Respondents were able to give one or more responses, hence results do not sum to 100%.

Table 6: Variability and Persistence of Financial Constraints

	Unconstr. in t	Constr. in t	Total
Unconstr. in t-1	19,990 87.61%	2,826 12.39%	22,816 100%
Constr. in t-1	2,377 36,68%	4,103 63,32%	6,480 100%
Total	25,162 79,45%	6,510 20,55%	31,672 100%

Source: CBI Industrial Trends Survey. Number and share of responding firms reporting either shortage of internal finance or inability to raise external finance as a factor likely to limit capital expenditure over the next twelve months.

Table 7: Association of Capacity Restrictions and Financial Constraints - All Firms

		Capacity restrictions		
		Not restricted	Restricted	Total
Financial constraints	Not constrained	36,121 87.01%	5,394 12.99%	41,515 100%
	Intemal finance	5,012 77.488%	1,457 22.52%	6,469 100%
	External finance	780 80.83%	185 19,17%	965 100%
	Total	41,913 85.63%	7,036 14.37%	48,949 100%
		Association Tests		
		Pearson's test:	Chi2(2) = 431.39	P < 0.0005
		Likelihood ratio test:	Chi2(2) = 389.00	P < 0.0005
		Fisher's exact test		P < 0.0005

Source: CBI Industrial Trends Survey. Number and share of responding firms reporting shortage of internal finance or inability to raise external finance as a factor likely to limit capital expenditure over the next twelve months (rows) and number and share of firms reporting plant capacity as likely to limit output over the next 4 months (columns) .

Table 8: All Firms - Association of Capacity Restrictions and Financial Constraints Conditional on state of capacity restrictions in the previous period

Case 1: No capacity restrictions in previous period		Capacity restrictions		
		Not restricted	Restricted	Total
Financial constraints	Not constrained	20,656 93.69%	1,392 6.31%	22,048 100%
	Internal finance	3,718 89,20%	450 10.80%	4,168 100%
	External finance	1,005 88,55%	130 11.45%	1,135 100%
	Total	25,379 92.79%	1,972 7.21%	27,351 100%
		Association Tests		
		Pearson's test:	Chi2(2) = 137.18	P < 0.0005
		Likelihood ratio test:	Chi2(2) = 124.07	P < 0.0005
		Fisher's exact test		P < 0.0005

Case 2: Capacity restrictions in previous period		Capacity restrictions		
		Not restricted	Restricted	Total
Financial constraints	Not constrained	1,616 49.60%	1,642 50,40%	3,258 100%
	Internal finance	385 39,29%	595 60,71%	980 100%
	External finance	97 38,49%	155 61,51%	252 100%
	Total	2,098 46,73%	2,392 53.27%	4,490 100%
		Association Tests		
		Pearson's test:	Chi2(2) = 39,47	P < 0.0005
		Likelihood ratio test:	Chi2(2) = 39.76	P < 0.0005
		Fisher's exact test		P < 0.0005

Source: CBI Industrial Trends Survey. Number and share of responding firms reporting shortage of internal finance or inability to raise external finance as a factor likely to limit capital expenditure over the next twelve months (rows) and number and share of firms reporting plant capacity as likely to limit output over the next 4 months (columns) .

Table 9: Small Firms - Association of Capacity Restrictions and Financial Constraints Conditional on state of capacity restrictions in the previous period

Case 1: No capacity restrictions in previous period		**Capacity restrictions**		
		Not restricted	Restricted	Total
Financial constraints	Not constrained	13,346 94.04%	846 5.96%	14,192 100%
	Internal finance	2,171 89.45%	256 10.55%	2,427 100%
	External finance	772 89.15%	94 10.85%	866 100%
	Total	16,289 93.16%	1,196 6.84%	17,485 100%
		Association Tests		
		Pearson's test:	Chi2(2) = 91.47	P < 0.0005
		Likelihood ratio test:	Chi2(2) = 82.16	P < 0.0005
		Fisher's exact test:		P < 0.0005
Case 2: Capacity restrictions in previous period		**Capacity restrictions**		
		Not restricted	Restricted	Total
Financial constraints	Not constrained	1,002 53.84%	859 46.16%	1,861 100%
	Internal finance	212 40.38%	313 59.62%	525 100%
	External finance	65 39.39%	100 60,61%	165 100%
	Total	1,279 50.14%	1,272 49.86%	2,551 100%
		Association Tests		
		Pearson's test:	Chi2(2) = 37,82	P < 0.0005
		Likelihood ratio test:	Chi2(2) = 38.01	P < 0.0005
		Fisher's exact test:		P < 0.0005

Source: CBI Industrial Trends Survey. Number and share of responding firms reporting shortage of internal finance or inability to raise external finance as a factor likely to limit capital expenditure over the next twelve months (rows) and number and share of firms reporting plant capacity as likely to limit output over the next 4 months (columns) .

Table 10: Large Firms - Association of Capacity Restrictions and Financial Constraints Conditional on state of capacity restrictions in the previous period

Case 1: No capacity restrictions in previous period		Capacity restrictions		
		Not restricted	Restricted	Total
Financial constraints	Not constrained	7,310 93.05%	546 6.95%	7,859 100%
	Internal finance	1,547 88,86%	194 11.14%	1,741 100%
	External finance	233 86,62%	36 13.38%	269 100%
	Total	9,090 92.13%	776 7.87%	9,866 100%
		Association Tests		
		Pearson's test:	Chi2(2) = 137.18	P < 0.0005
		Likelihood ratio test:	Chi2(2) = 124.07	P < 0.0005
		Fisher's exact test:		P < 0.0005

Case 2: Capacity restrictions in previous period		Capacity restrictions		
		Not restricted	Restricted	Total
Financial constraints	Not constrained	614 43.95%	783 56,05%	1,397 100%
	Internal finance	173 38,02%	282 61,98%	455 100%
	External finance	32 36.78%	55 63.22%	87 100%
	Total	819 42.24%	1,120 57.76%	1,939 100%
		Association Tests		
		Pearson's test:	Chi2(2) = 6.06	P = 0.048
		Likelihood ratio test:	Chi2(2) = 6.10	P = 0.047
		Fisher's exact test:		P = 0.049

Source: CBI Industrial Trends Survey. Number and share of responding firms reporting shortage of internal finance or inability to raise external finance as a factor likely to limit capital expenditure over the next twelve months (rows) and number and share of firms reporting plant capacity as likely to limit output over the next 4 months (columns) .

Table 11: Survivor Function and Completion Probabilities for the Entire Sample						
Time	**Beg. Total**	**Completed**	**Net Lost**	**Completion Rates**	**Survivor Function**	**Std. Dev.**
1	1431	856	133	0.5982	0.4018	00138
2	442	216	43	0.4887	0.2055	00123
3	183	63	16	0.3443	0.1347	00107
4	104	40	11	0.3846	0.0829	00090
5	53	12	7	0.2264	0.0641	00082
6	34	13	4	0.3824	0.0396	00074
7	17	3	2	0.1765	0.0326	00072
8	12	3	3	0.2500	0.0245	00069
9	6	3	0	0.5000	0.0122	.

Table 12: Composition of Sub-Samples			
Sub-Sample	**No. of experiences**	**Times at risk**	**Incidence rates**
All Firms	1,431	2,291	0.528
Small Firms	887	1,365	0.559
Large Firms	544	926	0.482
Shortage of int. finance	363	625	0.467
No shortage of int. finance	1,068	1,666	0.551
Shortage of int. or ext. finance	407	703	0.472
No shortage of int. or ext. finance	1,024	1,588	0.553

Table 13: ML Estimation of a Proportional Hazard Model with Grouped Panel Data							
Coefficient	(1)	(2)	(3)	(4)	(5)	(6)	(7)
large (empl. ≥ 200)	-0.183 {0.833} (0.063) [-2.90]***		-0.187 {0.829} (0.063) [-2.96]***	-0.229 {0.796} (0.074) [-3.09]***		-0.185 {0.831} (0.063) [-2.94]***	-0.209 {0.811} (0.075) [-2.79]***
fin(1) (Shortage internal finance)		-0.192 {0.826} (0.072) [-2.65]***	-0.196 {0.822} (0.072) [-2.72]***	-0.260 {0.771} (0.090) [-2.89]***			
*large*fin(1)* (Interaction term)				0.171 {1.186} (0.147) [1.17]			
fin(2) (Shortage internal or external finance)					-0.181 {0.834} (0.068) [-2.68]***	-0.184 {0.832} (0.068) [-2.71]***	-0.216 {0.806} (0.087) [-2.48]**
*large*fin(2)* (Interaction term)							0.086 {1.090} (0.138) [0.62]
Duration time dummies	9	9	9	9	9	9	9
Sector dummies	no	no	no	no	no	no	no
Dummies for time origin of spells	no	no	no	no	no	no	no
No. of spells No. of firms No. firm years	1,431 862 2,290	1,431 862 2,290	1,431 862 2,290	1,431 862 2,290	1,431 862 2,290	1,431 862 2,290	1,431 862 2,290

Cox duration model with grouped data for spells of capacity constraints, estimated as a binary regression model using the complementary log-log function as link function, see the Appendix for details. A spell is classified as pertaining to a financially constrained firm if, at the time when the spell starts, the firm reports financial constraints. The dummy variable fin(1) takes a value of 1 if a firm reports shortage of intemal finance in the answer to question 16c, else it is zero. The dummy variable fin(2) takes a value of 1 if the firm reports either shortage of internal finance or inability to raise external finance, else it is zero. Likewise, a spell is classified as belonging to a large firm if the firm has 200 employees or more at the beginning of the spell. One observation had to be dropped because the longest duration interval (13 quarters) predicts the event perfectly

Table 14: ML Estimation of a Proportional Hazard Model with Grouped Panel Data Controlling for Sector Heterogeneity							
Coefficient	(1)	(2)	(3)	(4)	(5)	(6)	(7)
large (empl. ≥ 200)	-0.156 {0.855} (0.067) [-2.35]**		-0.162 {0.851} (0.066) [-2.44]**	-0.209 {0.811} (0.077) [-2.73]***		-0.160 {0.852} (0.066) [-2.41]**	-0.197 {0.821} (0.078) [-2.51]**
fin(1) (Shortage internal finance)		-0.206 {0.814} (0.071) [-2.90]***	-0.210 {0.810} (0.071) [-2.96]***	-0.287 {0.751} (0.089) [-3.21]***			
*large*fin(1)* (Interaction term)				0.203 {1.225} (0.145) [1.40]			
fin(2) (Shortage internal or external finance)					-0.187 {0.830} (0.068) [-2.76]***	-0.189 {0.827} (0.068) [-2.80]***	-0.242 {0.785} (0.087) [-2.78]***
*large*fin(2)* (Interaction term)							0.139 {1.149} (0.139) [1.00]
Duration time dummies	9	9	9	9	9	9	9
Sector dummies	20	20	20	20	20	20	20
Dummies for time origin of spells	no	no	no	no	no	no	no
No. of spells No. of firms No. firm years	1,429 861 2,288	1,429 861 2,288	1,429 861 2,288	1,429 861 2,288	1,429 861 2,288	1,429 861 2,288	1,429 861 2,288

Cox duration model with grouped data for spells of capacity constraints, estimated as a binary regression model using the complementary log-log function as link function, see the Appendix for details. A spell is classified as pertaining to a financially constrained firm if, at the time when the spell starts, the firm reports financial constraints. The dummy variable fin(1) takes a value of 1 if a firm reports shortage of internal finance in the answer to question 16c, else it is zero. The dummy variable fin(2) takes a value of 1 if the firm reports either shortage of internal finance or inability to raise external finance, else it is zero. Likewise, a spell is classified as belonging to a large firm if the firm has 200 employees or more at the beginning of the spell. Additionally, the regressions summarised in this table use 20 dummies representing SIC (1980) 2 digit sectors. One observation had to be dropped because the longest duration interval (13 quarters) predicts the event perfectly. Two more observations and one sector (manufacturing of office machinery and data processing) were dropped because the sector dummy predicts the event perfectly

Table 15: ML Estimation of a Proportional Hazard Model with Grouped Panel Data Controlling for Sector Heterogeneity and Business Cycle Effects							
Coefficient	(1)	(2)	(3)	(4)	(5)	(6)	(7)
large (empl. ≥ 200)	-0.216 {0.806} (0.068) [-3.16]**		-0.215 {0.806} (0.068) [-3.14]***	-0.245 {0.782} (0.080) [-3.07]***		0.213 {0.807} (0.068) [-3.12]***	-0.229 {0.795} (0.081) [-2.83]***
fin(1) (Shortage internal finance)		-0.199 {0.820} (0.073) [-2.72]***	-0.197 {0.821} (0.073) [-2.71]***	-0.245 {0.783} (0.090) [-2.73]***			
*large*fin(1)* (Interaction term)				0.126 {1.135} (0.152) [0.83]			
fin(2) (Shortage internal or external finance)					-0.172 {0.841} (0.068) [-2.54]**	-0.169 {0.844} (0.068) [-2.49]**-	-0.193 {0.825} (0.086) [-2.25]**
*large*fin(2)* (Interaction term)							-0.061 {1.063} (0.143) [-0.43]
Duration time dummies	9	9	9	9	9	9	9
Sector dummies	20	20	20	20	20	20	20
Dummies for time origin of spells	41	41	41	41	41	41	41
No. of spells No. of firms No. firm years	1,429 861 2,288	1,429 861 2,288	1,429 861 2,288	1,429 861 2,288	1,429 861 2,288	1,429 861 2,288	1,429 861 2,288

Cox duration model with grouped data for spells of capacity constraints, estimated as a binary regression model using the complementary log-log function as link function, see the Appendix for details. A spell is classified as pertaining to a financially constrained firm if, at the time when the spell starts, the firm reports financial constraints. The dummy variable fin(1) takes a value of 1 if a firm reports shortage of internal finance in the answer to question 16c, else it is zero. The dummy variable fin(2) takes a value of 1 if the firm reports either shortage of internal finance or inability to raise external finance, else it is zero. Likewise, a spell is classified as belonging to a large firm if the firm has 200 employees or more at the beginning of the spell. Additionally, the regressions summarised in this table use 20 dummies representing SIC (1980) 2 digit sectors, s well as 41 dummies indicating the time origin of the spell. One observation had to be dropped because the longest duration interval (13 quarters) predicts the event perfectly. Two more observations and one sector (manufacturing of office machinery and data processing) were dropped because the sector dummy predicts the event perfectly.

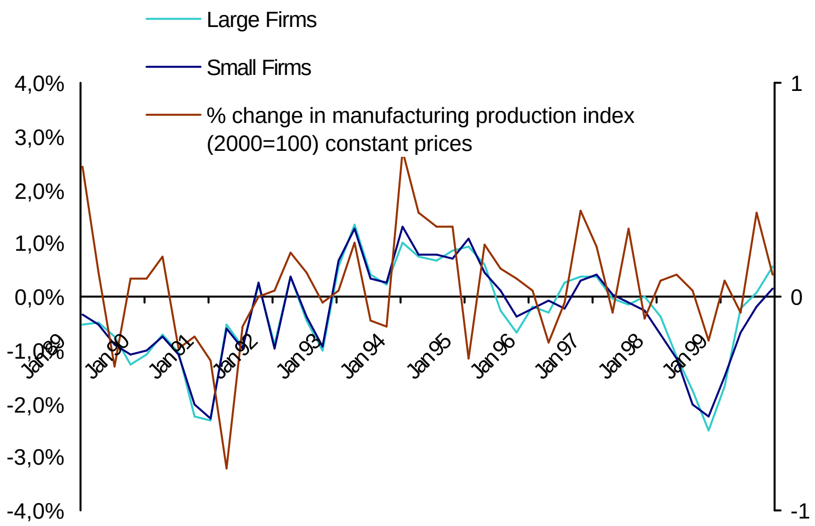
Table 16: Maximum Likelihood Estimation of a Proportional Hazard Model with Grouped Panel Data – Separate Estimates for Large and for Small firms

Coefficient	(1) all firms	(2) small firms only	(3) large firms only	(4) all firms	(5) small firms only	(6) large firms only
fin(1)	-0.192 {0.826} (0.072) [-2.65]***	-0.257 {0.774} (0.089) [-2.89]***	-0.096 {-0.909} (0.118) [-0.81]			
fin(2)				0.181 {0.834} (0.068) [-2.68]***	-0.212 {0.809} (0.086) [-2.46]**	-0.136 {0.873} (0.107) [-1.27]
Duration time dummies	9	9	9	9	9	9
No. of spells No. of firms (firm years)	1,431 862 2,290	887 527 (1364)	544 349 (926)	1,431 862 2,290)	887 527 (1364)	544 349 (926)

Cox duration model with grouped data for spells of capacity constraints, estimated as a binary regression model using the complementary log-log function as link function, see the Appendix for details. A spell is classified as pertaining to a financially constrained firm if, at the time when the spell starts, the firm reports shortage of internal finance or inability to raise external finance as a factor likely to limit capital expenditure over the next twelve months. Likewise, a spell is classified as belonging to a large firm if the firm has 200 employees or more at the beginning of the spell. One observation had to be dropped because the longest duration interval (13 quarters) predicts the event perfectly.

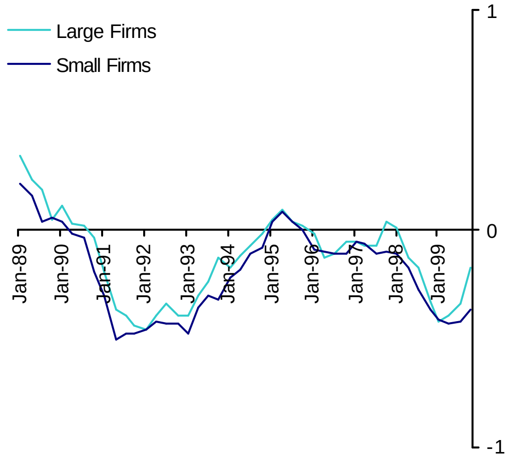
Charts

Chart 1: Trend in business optimism



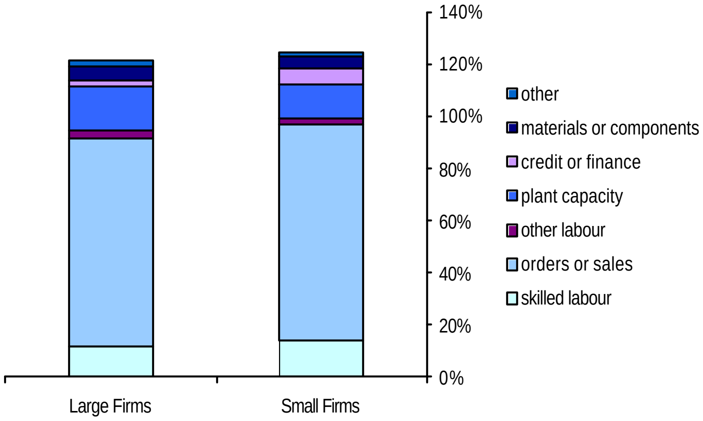
Source: CBI Industrial Trends Survey
1 = more optimistic, 0 = same and -1 = less optimistic

Chart 2: Trend in output



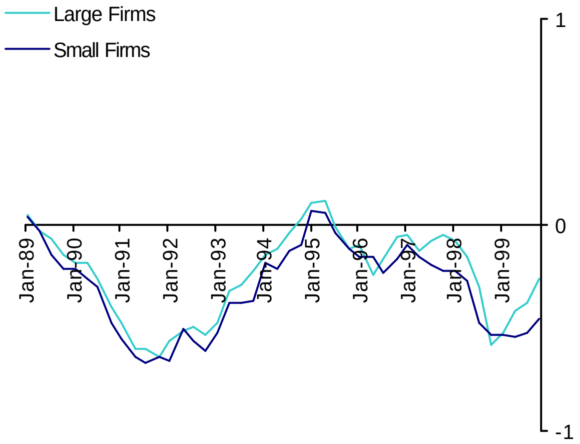
Source: CBI Industrial Trends Survey
1 = not below capacity, -1 = below capacity

Chart 3: Output constraints



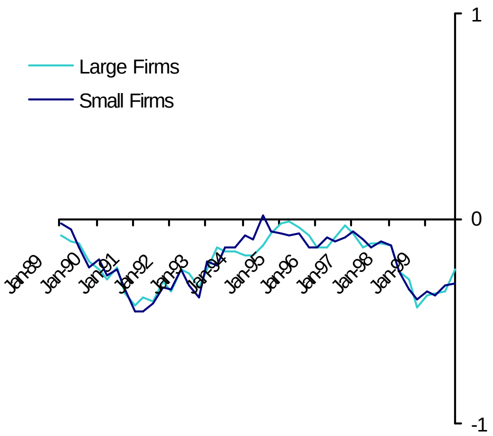
Source: CBI Industrial Trends Survey
Respondents were able to give one or more responses, hence results do not sum to 100%.

Chart 4: Trend in total order book



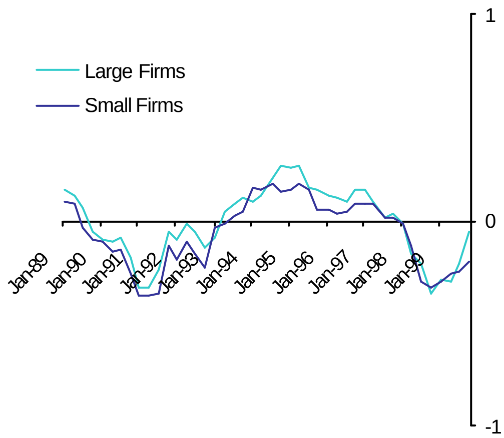
Source: CBI Industrial Trends Survey
1= above normal, 0 = about normal and -1 = below normal

Chart 5:
Investment intentions buildings



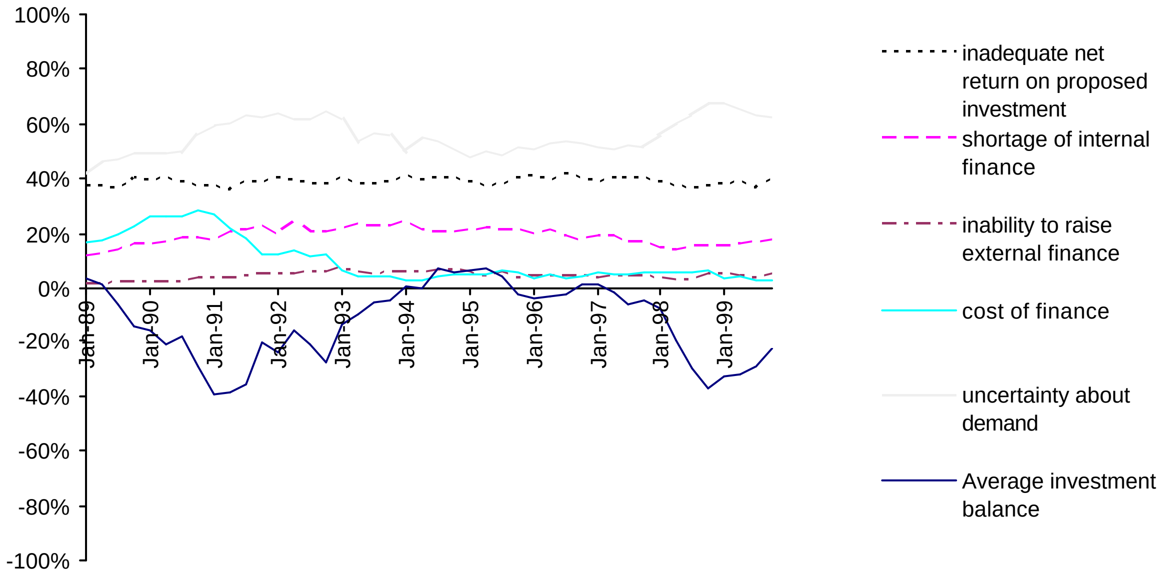
Source: CBI Industrial Trends Survey
1 = more authorisations, 0 = same and -1 = less authorisations

Chart 6:
Investment intentions plant and machinery



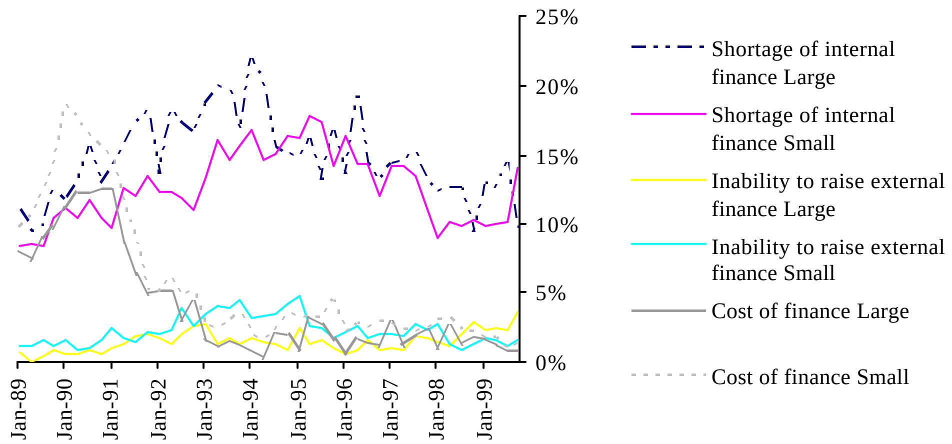
Source: CBI Industrial Trends Survey
1 = more authorisations, 0 = same and -1 = less authorisations

Chart 7: Trend in investment constraints and an average investment balance over the whole data-set



Source: CBI Industrial Trends Survey
% of firms ranking each constraint as the most important limit on the capital expenditure authorisations

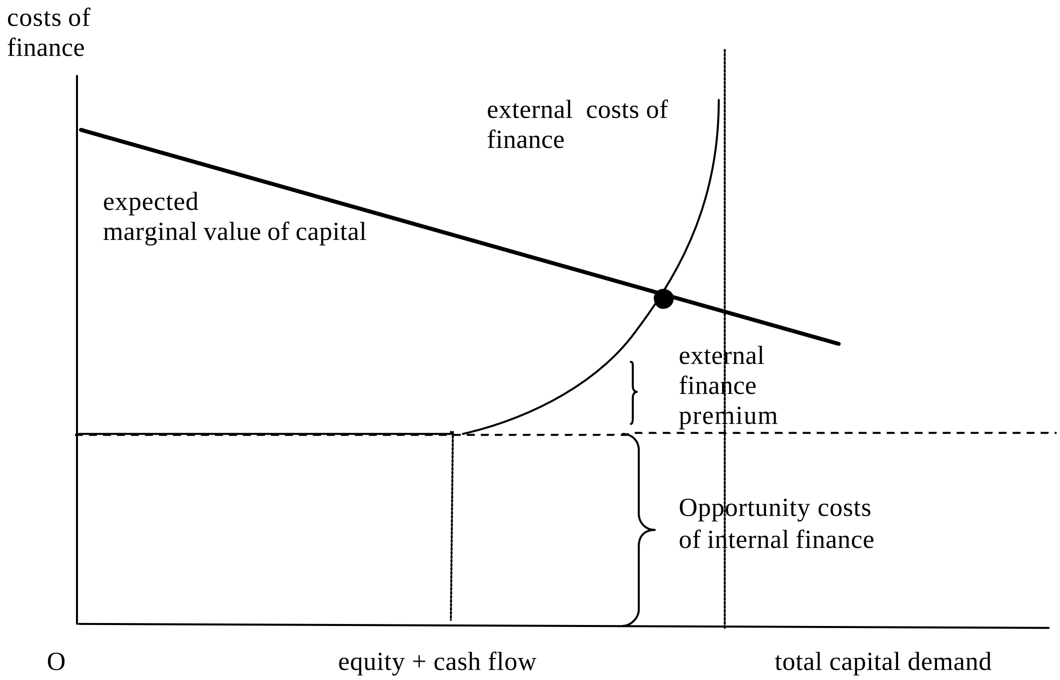
Chart 8: Trend in financial constraints on investment



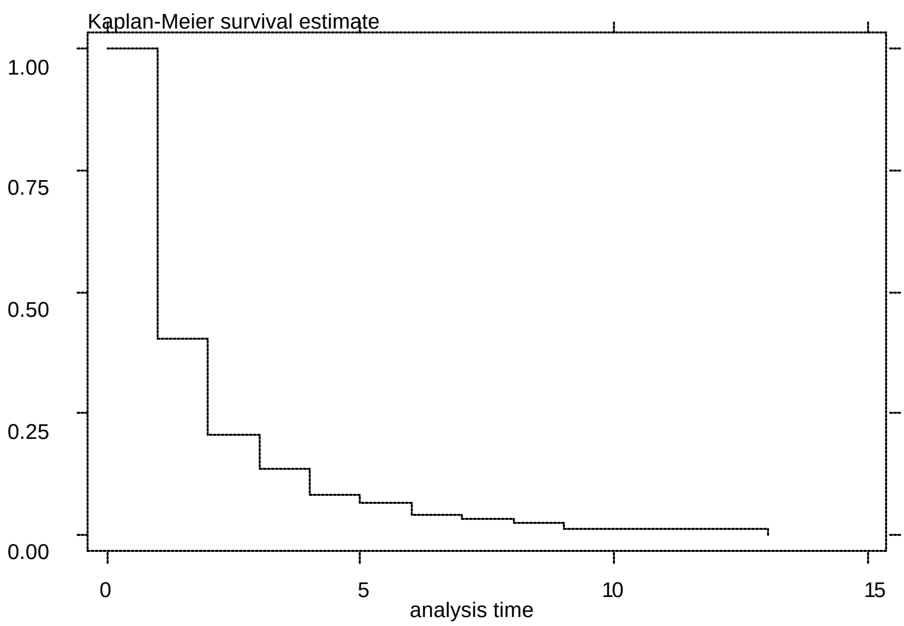
Source: CBI Industrial Trends Survey
Percentage of firms ranking each constraint as the most important limit on the capital expenditure authorisations

Graphs

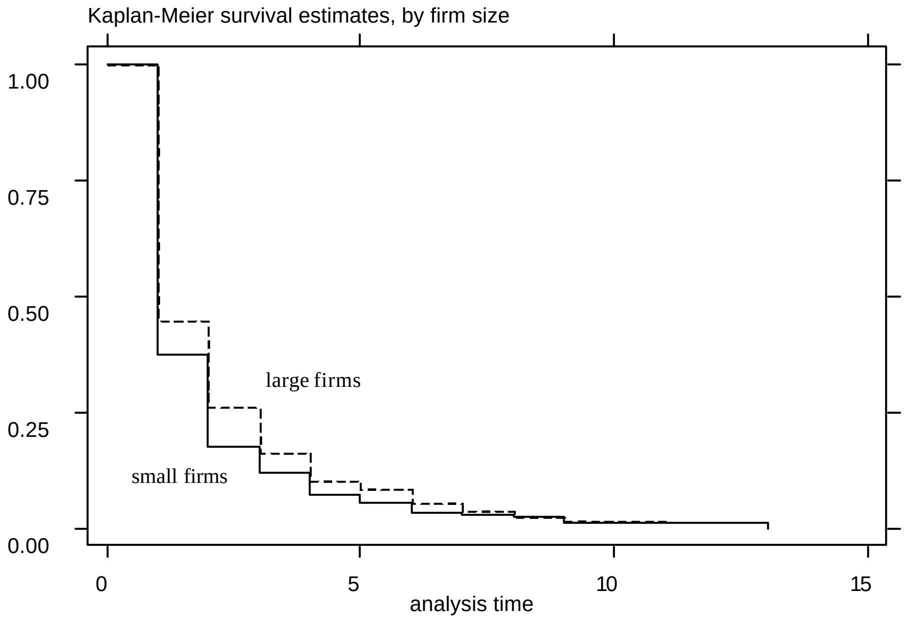
Graph 1: Capital demand and external finance premium



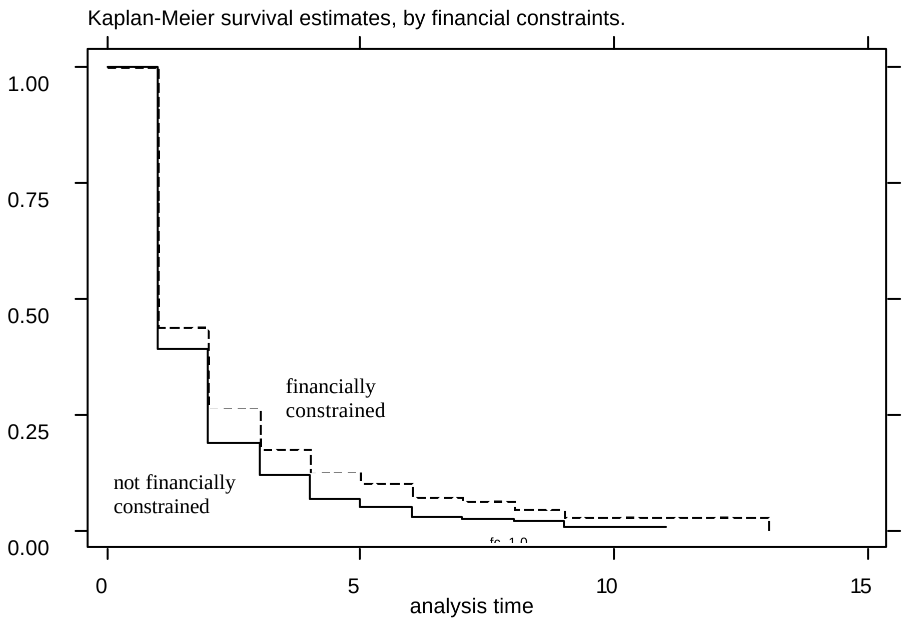
Graph 2: Kaplan-Maier estimates of the survival function for the entire sample



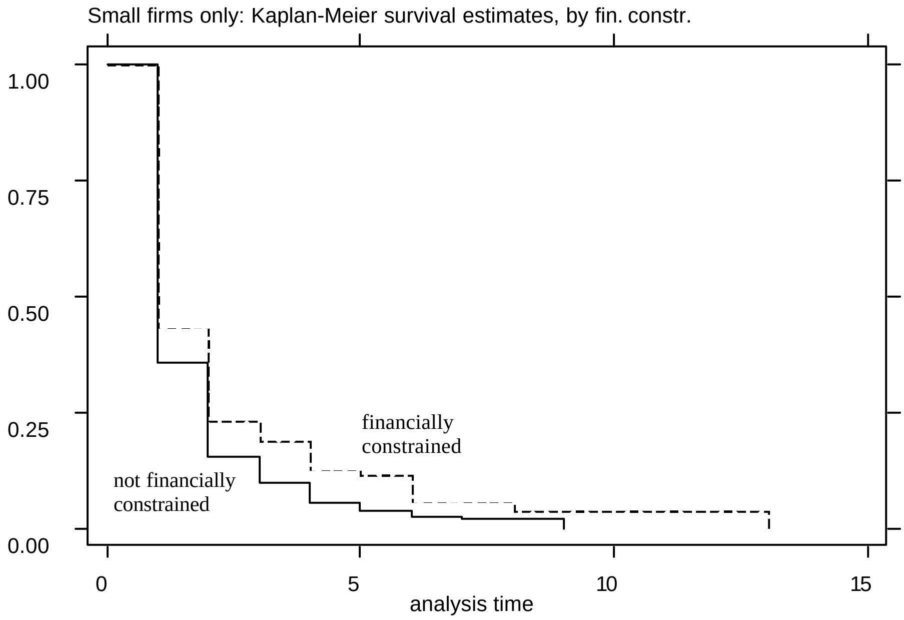
Graph 3: Kaplan-Maier survival curves for small and for large firms



Graph 4: Kaplan-Maier survival curves for fin. constrained and unconstrained firms



Graph 5:
Small Firms Only:
KM survival curves for financially constrained and unconstrained firms



Graph 6:
Large Firms Only:
KM survival curves for financially constrained and unconstrained firms