Financial constraints and capacity adjustment in the United Kingdom: evidence from a large panel of survey data

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Contents

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 transmission, of financial stability and of economic growth and development. The *CBI Industrial Trends Survey* contains detailed information on the financial constraints faced by a large sample of UK manufacturers. This paper uses the quarterly *CBI Industrial Trends Survey* firm-level data between January 1989 and October 1999. The cleaned sample contains 49,244 quarterly observations on 5,196 firms. The data set is presented and a new method of checking the informational content of the data is developed. The relationship between investment activity and financial constraints is ambivalent because both can affect each other and they are affected by the same kind of economic developments, so it is not clear which is driving the other. But the link between financial constraints faced by the firm and the prevalence and duration of capacity restrictions should be unambiguously positive. Looking at that relationship, two important results emerge. First, 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 do, but financial constraints seem to be of higher relevance to their adjustment.

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

JEL classification: D21, D92, C33, C41.

Summary

Recent research has shown that the causes and effects of financial constraints for firms in the private sector is of key importance for a variety of policy issues relevant to central banks. First, the quantitative and qualitative features of monetary transmission depend on whether or not borrowing and other financial constraints have important effects on the real economy. Second, the real consequences of shocks to the financial system depend on the way in which firms cope with their financial constraints. Due to the interrelationships between firms, financial constraints also may form part of a propagation mechanism creating systemic risk. Third, financial constraints might be especially relevant for investment activities that are difficult to raise finance for but quite important for economic growth, such as research and development, or the introduction of innovative products and processes.

Survey data have a decisive advantage over other micro data sources: firm managers can be directly asked for the main constraints to their activities. Unlike balance sheet information, these data are available in a timely manner. Potentially this makes them a valuable direct tool in policy analysis compared to indirect methods of detecting financial constraints that rely on ambiguous cash-flow sensitivities. However, it is necessary to make sure that managers' statements are compatible with how economists use the concept of financial constraints: their survey responses need to correspond to what theoretically might be expected in a financially constricted environment.

We are able to use the *CBI Industrial Trends Survey (ITS)*, which is an important survey for business cycle analysis in the United Kingdom. For the eleven years between January 1989 and October 1999, the cleaned, unbalanced panel contains 49,244 quarterly observations on 5,196 firms. According to the CBI, the *ITS* represents around 33% of total UK manufacturing employment. The data set covers all size ranges, including small firms for which very little information is available from other micro data sets. More than 63% of the *ITS* observations cover firms with less than 200 employees. On average, around 21% of respondents state that they are constrained by inadequate amounts of finance, and that these constraints have an influence on their investment plans.

First, we describe the financing environment for small firms in the United Kingdom during the 1990s. We then present our data set by means of descriptives statistics. At this stage, the differences between large and small firms appear modest. We proceed to examine the usefulness of our data on financial constraints. Our focus is on capacity adjustment as the *ITS* data on capacity restrictions, planned expansion and rates of capacity utilisation are especially rich. Firms report whether their capacity is insufficient with respect to demand. Those firms which indicate financial constraints should have insufficient capacity often and take longer to get rid of their capacity restriction, either because they are less able to finance their investments or else because the capacity shortfall is larger.

To test this prediction, we first look at the statistical *association* between two types of constraints: capacity restrictions and financial constraints. We test whether those two types of constraints tend to occur jointly. Then we analyse the duration of capacity gaps with respect to

spells of capacity restrictions. To the best of our knowledge, the duration of capacity constraints has never been investigated before on a microeconometric level.

For both size classes, we find a clear contemporaneous association between the two types of constraints. This association stays intact when we look at whether capacity constraints were present in the previous period. With respect to duration, financially constrained firms take longer to end a period of insufficient capacity. On average, the actions taken by a firm to close its capacity gap will leave it with a level of capacity that is about 20% lower if it is financially constrained, compared to a firm that does not report financial constraints. This is entirely consistent with the results we obtain from association analysis.

We conclude that the survey data contain useful information on financial constraints.

Splitting the sample shows that the relationship between financial constraints and the duration of capacity restrictions is weaker for larger firms, indicating that financial constraints might be of less relevance to their activity. On the other hand, small firms appear able to overcome their capacity shortfalls faster than larger firms. This might indicate that small firms, due to flat hierarchies and low co-ordination costs, are more flexible in coping with the demand shocks typical for their size.

1 Introduction

Firms' activities are financially constrained if internal finance is insufficient and external finance is either relatively costly, carrying an external finance premium, or rationed. Understanding the causes and effects of financial constraints 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).(1) Second, financial constraints on real activities form one crucial link that determines the real consequences of financial imbalances of various types, like banking crises or asset price bubbles. Under financial constraints, the net value of firms becomes an important determinant of their growth prospects. If firms form credit chains, their financial constraints become also important for the propagation of financial shocks, potentially creating systemic risk.(2) 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.(3) 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 a major topic on the research agenda. 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 (2003a) 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 Spain – only Italian small firms show an excess sensitivity of investment with respect to cash flow.(4)

It is conceivable that the importance of financial constraints for the real activity of firms also depends on the financial system. Allen and Gale (2002) 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

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(1) Chirinko and von Kalckreuth (2003) compare the interest rate channel and the balance sheet channel for German firms.

(2) See Kiyotaki and Moore (1997), or Stiglitz and Greenwald (2003), Chapter 7.

(3) See, for example, Hall (2002). The point was made as early as 1962 by Kenneth J. 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).

(4) The key results have been collected in Angeloni, Kasyhap and Mojon (2003): see Chatelain, Generale, Hernando, von Kalckreuth and Vermeulen (2003b) for a detailed comparative study.

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 United Kingdom, see von Kalckreuth (2004) for first results on Germany. With respect to the United Kingdom, 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 eleven 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 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 Petersen (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 standing in a situation of asymmetric information.[5] 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, ie 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 United Kingdom (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 United Kingdom was generally regarded as unsatisfactory. Since then, with the upturn in the 1990s, the situation appears to have eased.

The next part, Section 3, is dedicated to the presentation of our data set. Harnessing the panel variation in the micro database of a time-tested survey offers the chance to improve our understanding of funding constraints considerably. The raw percentages do not show small firms as being particularly strongly affected by financial constraints. Although the severest

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

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).

Section 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 restrictions. 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. To the best of our knowledge, the duration of capacity constraints has never been investigated before on a microeconometric level.

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 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 United Kingdom

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.(6) In some sectors, the productivity of SMEs exceeds that of larger firms.(7) SMEs also account for 56% of employment and 52% of turnover.(8) 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 United Kingdom appears to lag behind the United States 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.(9)

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(6) See Bank of England (2003).

(7) See Bank of England (2003).

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

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

The political interest in the topic has spawned academic research. Hughes (1994)[10] 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 United Kingdom during this time. Small companies were more highly geared, more reliant on short-term bank debt and less profitable than larger firms. Traditionally, economists have argued that such financial structures are due to market imperfections which arise mainly as a result of information asymmetries.[11] The owner of a small business generally has much better information than the bank on his firm's 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 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[12] in 1990 asserts that qualitative evidence supports the view that the observed capital structure of some small firms was due to failures relating to the supply of finance. However, most other evidence provides little conclusive support of such market imperfections in the financing of small firms in the United Kingdom in general.[13] 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 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 confirmed by anecdotal evidence of debt aversion among small firms, especially following the recession in the early 1990s.[14] 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 while 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.

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(10) See also Cosh and Hughes (1994) for further details.

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

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

(13) 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.

(14) See Bank of England (1998).

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, although to what extent this is due to changes in demand or constraints on supply is unclear. Recently published research(15) 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-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(16) 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. 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, 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).

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(15) See Cosh and Hughes (2003).
(16) See Chittenden, Michaelas and Poutziouris (1999).

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 data.*

According to the CBI, the *ITS* represents around 33% of the total current employment within UK manufacturing. The survey has an average response rate of 1,000, around 50% of the total number of firms that are on the survey panel. The survey has a core of around 800 companies, the rest being floating participants. The survey sample is constructed from a broad mix of CBI membership, trade association member companies and others, with the aim of ensuring both sector and regional representation.(17) Our investigation focuses on eleven 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.

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.

(17) See Wood (2001), describing the current state of affairs. During our sample period the response rate was slightly higher. Our raw data include 51,381 observations from 44 quarters, ie 1,168 observations on average.

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

Two-digit SIC code	Employment Size: 1-199	200-499	500-4,999	5,000 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.*

3.2 Summary descriptive statistics

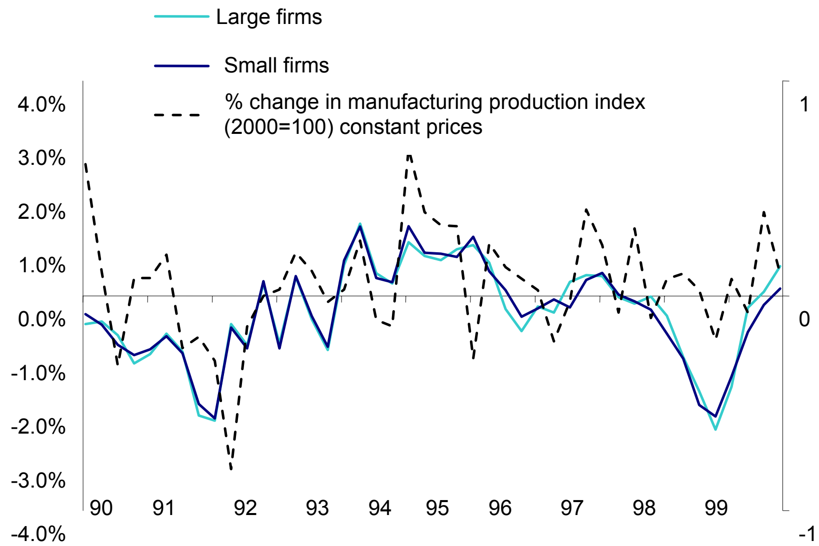
In order to compare the experience and constraints of small and larger firms, we simplify the size categories further, classifying as 'small' those firms with fewer than 199 employees and as 'large' all those with 200 employees and more. This has the effect of smoothing some of the larger firms' experiences. 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. On the whole, the differences in the experiences of large and small firms are surprisingly small.

- *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 A. 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 2000 prices. It can be seen that the optimism data reflect 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).

Chart A: Trend in business optimism



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

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.*
1 = more optimistic, 0 = same and -1 = less optimistic.

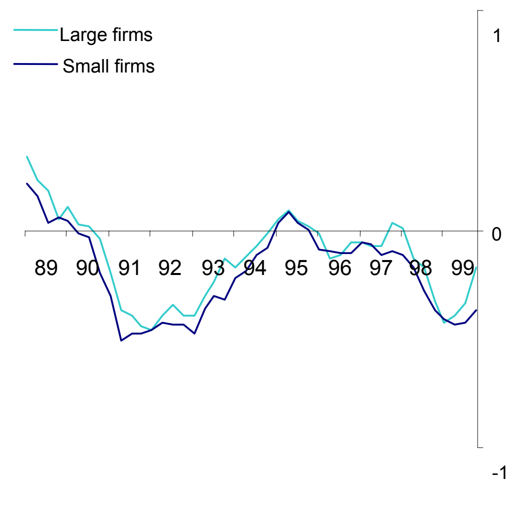
- *Output*

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 B, small firms' trend over time was consistently lower than that of large firms and has remained largely negative.

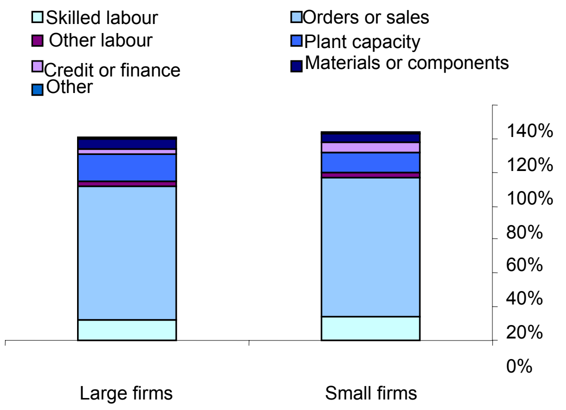
Of the factors named by firms as likely to limit their output over the next four months (Survey Question 14), by far the most important was orders or sales, with over 80% of both small and large firms citing this particular factor (Chart C). Lack of skilled labour was a slightly more significant factor for small firms than for large firms, while 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.

Chart B: Trend in output



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

Chart C: Output constraints

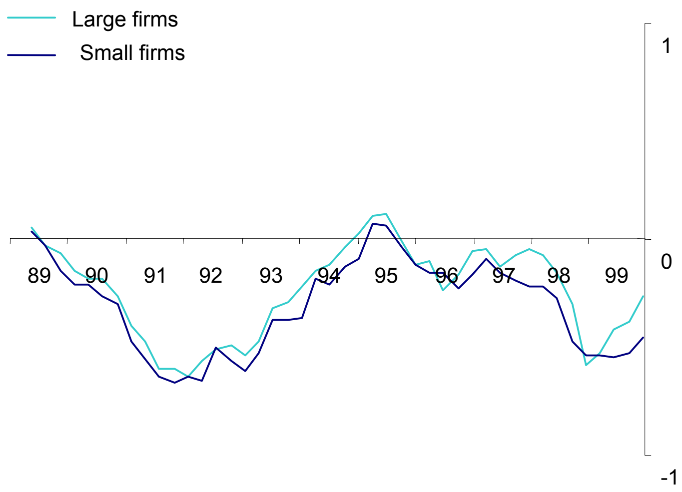


Source: *CBI Industrial Trends Survey*.
Respondents were able to give one or more responses, hence results do not sum to 100%.

- *Total orders*

The *ITS* allows an analysis of whether the order books of small and large firms are above or below normal in volume terms. Chart D 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 their 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 B and D correlate with the trend in business optimism shown in Chart A; all three of these charts track the wider economic business cycle.

Chart D: Trend in total order book



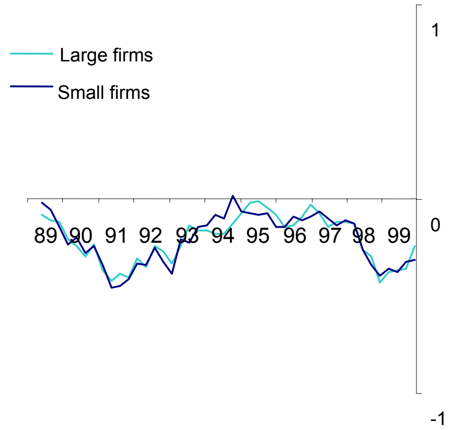
Source: *CBI Industrial Trends Survey*.
1= above normal, 0 = about normal and -1 = below normal

- *Investment intentions*

In Survey Question 3, the *ITS* asks about respondents' intentions for both buildings and plant and machinery investment over the coming twelve months compared with the preceding twelve months. As can be seen in Chart E, 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 F shows firms' intentions regarding investment in plant and machinery is more volatile. Although they also track each closely, large firms appear to be more positive about their investment intentions than are small firms.

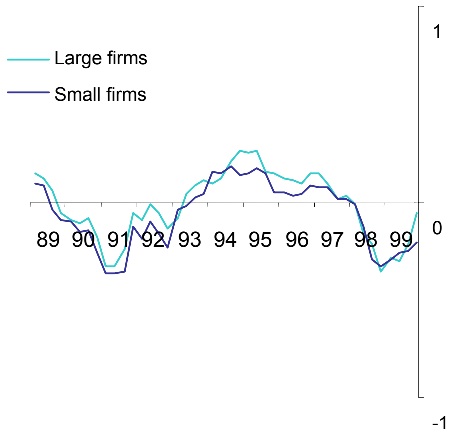
Chart E:

Investment intentions buildings



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

Chart F:
Investment intentions plant and machinery



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

- *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.

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

- *Constraints on capital expenditure*

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

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: 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 allowed to give one or more responses, hence shares do not sum to 100%.

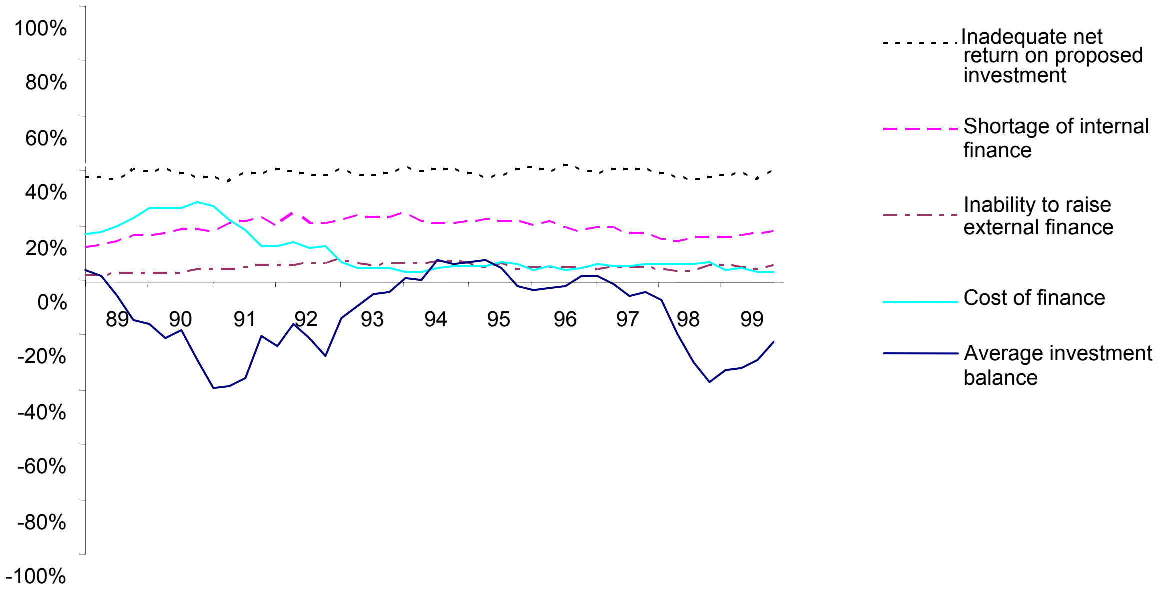
Table 5 shows both the overall frequency with which firms cite a given constraint (any rank) to investment expenditure and the frequency with which this constraint was given the first rank. Firms could name more than one constraint on capital expenditure, but they were asked to rank the importance of 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 microeconometric 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 twelve 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 among small firms, the proportion affected is very low. Overall, it was the constraint least commonly cited by small firms.

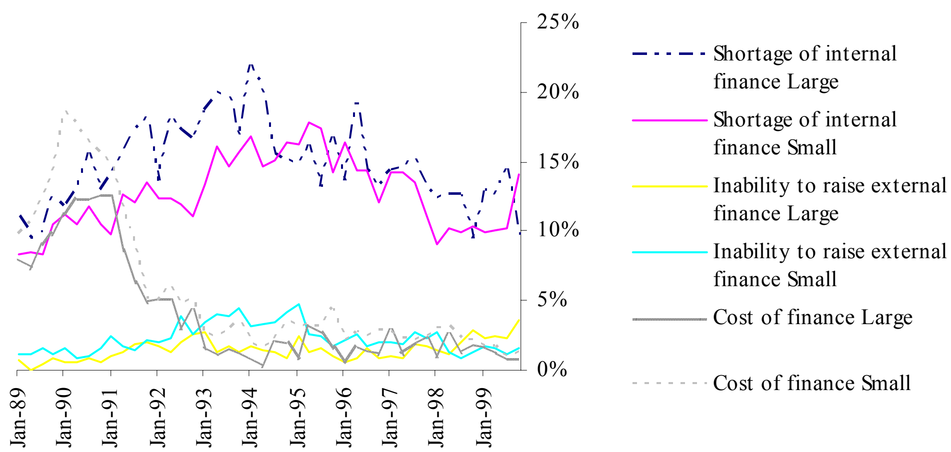
Small firms cite the shortage of internal finance less commonly than do large firms, with only 18.1% of small firms mentioning internal finance as a limiting factor compared with 20.2% of large firms. A finer breakdown (not shown) reveals that almost 30% of the firms in the largest size category, with 5,000 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.

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



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

Chart H: 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.

Chart G plots the proportion of firms that cited the various constraints listed in Question 16c as relevant for their investment demand, together with the average balance of investment intentions. Chart H depicts the evolution in time for the three items that are related to financing, separately for large and small firms. 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 G) – 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.

Table 6: Variability and persistence of financial constraints

	Unconstraint in t-1	**Constraint in t-1**	**Total**
Unconstraint in t-1	19,990 87.61%	2,826 12.39%	22,816 100%
Constraint 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.

For inferential purposes, it is important to know whether there is sizable 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 sizable 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 A 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. 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.

Figure 1: Capital demand and external finance premium

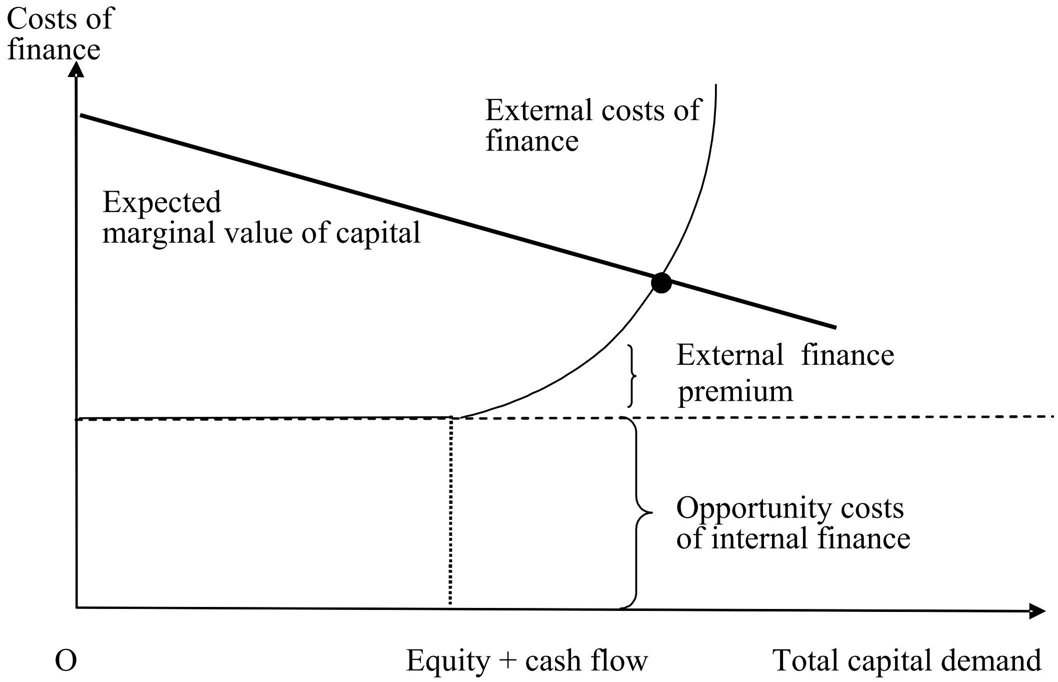


Figure 1, adapted from Bernanke, Gertler and Gilchrist (1999), shows that the costs of external finance depend on the difference between the actual capital demand and what can be financed internally. By means of this graph, we can interpret the responses to the questions on financial constraints in terms 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). In this case, the interest rate cannot be raised beyond a certain value, and 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 Figure 1, the existence of such a regime would make the external costs of finance schedule break off at some maximum interest rate.

Consider an equation describing the capital accumulation decision, such as

$$I_{i,t}/K_{i,t\text{-}1} = z_{i,t}'\beta + \gamma fc_{i,t} + \varepsilon_{i,t} \qquad \textbf{(1)}$$

with $I_{i,t}/K_{i,t\text{-}1}$ as the investment rate, $z_{i,t}$ a vector of variables describing marginal profitability of investment, and $fc_{i,t}$ as a variable describing external finance premia or quantitative constraints. The error term $\varepsilon_{i,t}$ will be correlated with the financial constraints variable via a second equation that explains the financial constraints indicators as a function of the financial structure and capital demand. The external finance premium will depend, among other things, on the inherited ratio of net debt to installed capital, $D_{i,t\text{-}1}/K_{i,t\text{-}1}$ and financing needs $I_{i,t}/K_{i,t\text{-}1}$:

$$fc_{i,t} = f(D_{i,t\text{-}1}/K_{i,t\text{-}1},\ I_{i,t}/K_{i,t\text{-}1},...) + \eta_{i,t} \qquad \textbf{(2)}$$

This simultaneous relationship makes the predicted sign of γ in equation **(1)** indeterminate under the conditions of binding financial constraints.(18)

If we had continuous variables describing the accumulation of capital, this problem could be resolved using instrumental variables techniques or GMM methods. Von Kalckreuth (2004) explores the informational content of German Ifo survey data using GMM estimators. Breitung, Chirinko and von Kalckreuth (2003) investigate the simultaneity of 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. Further, there is no data on the financial structure in the *ITS*. 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 restrictions.

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.(19) 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. Von Kalckreuth (2004) provides a simple theoretical model of financial constraints and the speed of adjustment. The *ITS* survey gives us information on whether or not a firm experiences capacity restrictions by asking the following question:

(18) Let the external finance premium be a function of net debt to installed capital, $D_{i,t}/K_{i,t\text{-}1}$. With *CF* as cash flow and *Div* as dividend payment, the equation of motion for net debt is given by $D_{i,t} = D_{i,t\text{-}1} - CF_{i,t} + I_{i,t} + Div_{i,t}$. After solving for optimal dividend payment in terms of the predetermined variables, the equation for $fc_{i,t}$ assumes the general form (2). On the relationship between investment demand and balance sheet pressure, see Benito and Young (2002).

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

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. If a firm reports capacity restrictions, this is an indicator for a gap between the existing and the desired capital stock. Let us look first at the line of causation that runs from equation **(2)** to equation **(1)**. A high $fc_{i,t}$ in equation **(1)** – induced by high indebtedness or a large financial shock $\eta_{i,t}$ – will make that the investment corresponding to a given $x_{i,t}$ is spread over a longer period of time, inducing and prolonging capacity restrictions. On the other hand, with a given financial structure, a high realisation of $z_{i,t}$ or a large shock $\varepsilon_{i,t}$ in equation **(1)** will not only lead to capacity restrictions and a long adjustment process, but also trigger financial constraints in equation **(2)**. Larger gaps take more time to fill, and this is reinforced when financial constraints are present. We can see that each of the two relationships alone is sufficient to explain a positive relationship between financial constraints and the frequency and duration of capacity restrictions.

In the next paragraphs, we shall compare the occurrence and duration of capacity restrictions for constrained and unconstrained 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 at the micro level.

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 ability to raise external finance (Group 2) and, finally, those that report being rationed on the market for external finance (Group 3). Whereas only 12.74% of the first group claims to be capacity restricted, the corresponding figures are 20.74% of the second group and 20.06% 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.[20] The picture

[20] 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 monograph on non-parametric statistics.

we can gather from comparing small and large firms in this respect (not shown) is essentially similar.

Table 7: Association of capacity restrictions and financial constraints - all firms

		Capacity restrictions		
		Not restricted	Restricted	Total
Financial constraints	Not constrained	33,825 87.26%	4,941 12.74%	38,776 100%
	Internal finance	6,384 79.26%	1,670 20.74%	8,054 100%
	External finance	1,694 79.94%	425 20.06%	2,119 100%
	Total	41,913 85.63%	7,036 14.37%	48,949 100%
		Association tests		
		Pearson's test:	Chi2(2) = 404.24	P < 0.0005
		Likelihood ratio test:	Chi2(2) = 375.38	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 four months (columns).

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, thereby looking at *changes* of state. This examination also anticipates our duration analysis: by definition, a switch from an unrestricted to a restricted state 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. Generally, capacity restrictions are cited much more frequently when there were the same sort of 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.

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 four 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 four 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 four months (columns).

Tables 9 and 10 reveal an interesting difference between large and small firms. Among the firms that did not report capacity restrictions in the previous period, there is no clear size differential for transition rates. But among the restricted firms, a large firm will stay restricted 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 restrictions when there are no financial constraints. Transition probabilities of financially constrained large and small firms are similar. This might indicate that the duration of capacity restrictions is shorter for small firms. We also see that the transition rate is more affected by financial constraints when the firm is small: for large firms, the difference between financially constrained and unconstrained firms is less accentuated, albeit still significant.

4.4 The design of the duration analysis

We now proceed to consider the duration of states of restricted capacity. To the best of our knowledge, the duration of capacity restrictions has never been investigated before on a microeconometric level. This makes our exercise interesting and worthwhile in its own right, as capacity restrictions may play an important role in the propagation of inflationary shocks.(21) 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.(22)

In order to estimate survival curves, we 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, ie 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,(23) taken from 862 firms.

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

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(21) See Álvarez-Lois (2004) and Macklem (1997).

(22) The econometric analysis of duration data began only in the late 1970s, see Heckman and Singer (1984) and Kiefer (1988) for compact 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 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.

(23) This number of observations includes the initial zero and the initial 1 for each string.

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. Our observations are quarterly, and the vast majority of observed periods of capacity restrictions 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-Meier 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

$$F(t) = P(T > t), \qquad 0 < t < \infty \tag{3}$$

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 restrictions, 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[24] (or *product limit*) estimator is a non-parametric maximum likelihood estimator of the survivor function. The estimator is given by

$$\hat{F}_t = \prod_{j \le t} \left(1 - \hat{\lambda}_j\right), \qquad \text{with } \hat{\lambda}_j = \frac{d_j}{n_j} \tag{4}$$

The index j enumerates observed times to completion, ie 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 $\hat{\lambda}_j$ are estimated probabilities for the observational unit to complete at j, given that it has reached j-1, the last observed time to completion. Estimates of these conditional probabilities are obtained by dividing the observed number of completions, 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 $\left(1 - \hat{\lambda}\right)$ 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

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

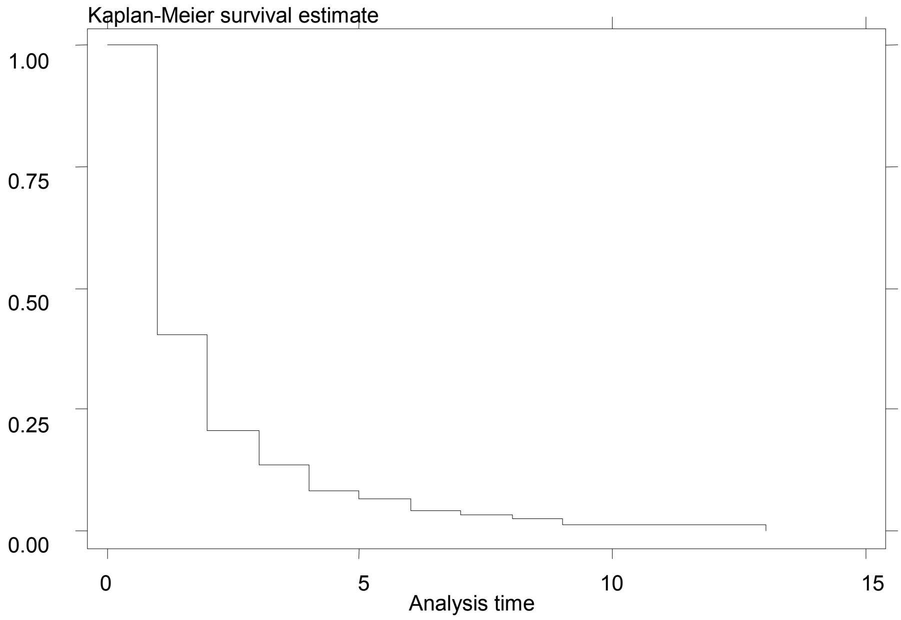
computed as a product of all the contemporaneous and prior conditional survival probabilities. For this estimate to be unbiased, the censoring mechanism needs to be independent, that is, the completion probabilities of non-censored and censored individuals must be identical. This will be assumed throughout below.

Table 11: Survivor function and completion probabilities for the entire sample						
Time	**Beg. total**	**Completed**	**Net lost**	**Completion rates**	**Survivor function**	**Std. Dev.**
1	1,431	856	133	0.5982	0.4018	0.0138
2	442	216	43	0.4887	0.2055	0.0122
3	183	63	16	0.3443	0.1347	0.0106
4	104	40	11	0.3846	0.0829	0.0090
5	53	12	7	0.2264	0.0641	0.0083
6	34	13	4	0.3824	0.0396	0.0074
7	17	3	2	0.1765	0.0326	0.0072
8	12	3	3	0.2500	0.0245	0.0061
9	6	3	0	0.5000	0.0122	

Table 12: Composition of subsamples			
Subsample	**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

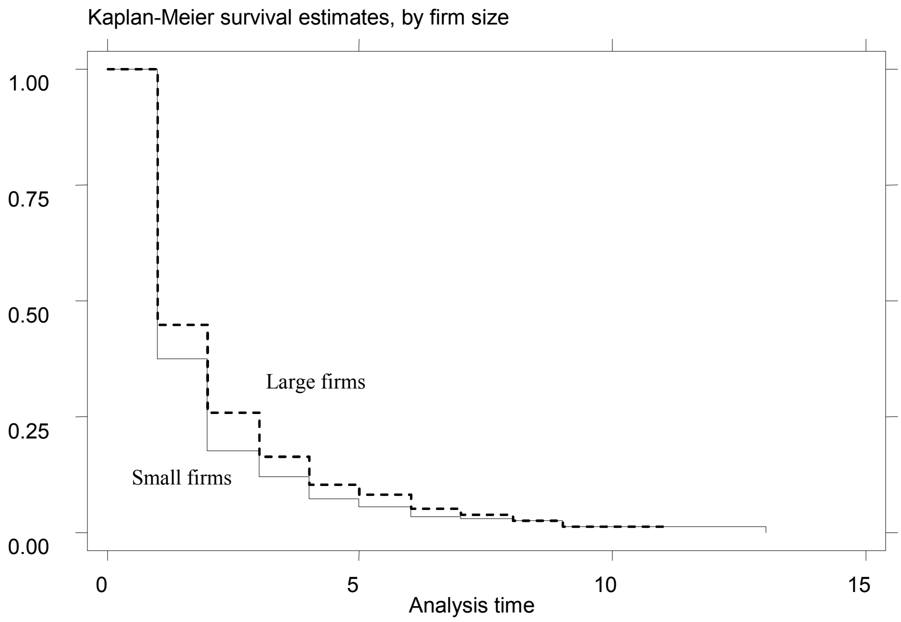
Table 11 not only describes termination and censoring over time, but also gives the numerical values for the survivorship and completion rates in the entire sample. The first column, time, is the number of quarters *after* the original switch from unconstrained to constrained. If, for example, the capacity 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 duration interval. 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 **(4)**. According to this estimate, about 40% of firms that start out with capacity restrictions 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. During the first three quarters, completion probabilities seem to be falling, ie 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. From the fourth quarter on, the relationship ceases to be monotonic. 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 Figure 2.

Figure 2: Kaplan-Meier estimates of the survival function for the entire sample



We want to compare the survivor experiences for various subsamples. The relative sizes of the groups and some global statistics are given in Table 12. Figure 3 compares the duration experiences of small and large firms. Among the total number of capacity restrictions 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 restrictions.

Figure 3: Kaplan-Meier survival curves for small and large firms



It is interesting to speculate about possible reasons. One explanation is that larger firms might be hit by disproportionately larger demand shocks, ie shocks that are larger relative to their size. 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. A third potential reason for the slower response of large firms is external supply constraints in the machinery production industry. If one firm accounts for a large share of total demand for a certain specialised capital good, its rate of increase in capacity will be constrained by the capacity of the capital goods producers – inverting the accelerator principle. Presumably, large firms are in this situation more often.

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 analytically to 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 Figure 1, we prefer the less ambivalent first grouping.

Ultimately, 172 among the 1,431 spells start with the firm citing 'costs of finance' as an impediment to investment. This answer might be considered a function of both the classical user costs of capital and the external finance premium. Among the 172 spells thus characterised, 64 cases are also characterised by lack of internal finance or inability to raise external finance. In the remaining 108 cases, costs of finance are named as an impediment without either lack of internal finance or the inability to obtain external finance being cited. Whereas the former configuration is consistent with a firm that has run out of internal finance and now faces a high external finance premium, the latter group seems to indicate high opportunity costs. Internal funds are available, but there is a higher yield for some alternative use. Chart H shows that 'costs of finance' were cited widely during the period of high interest rates at the beginning of the 1990s whereas they have lost almost all importance since. According to the classical user cost mechanism,[25] opportunity costs are important for determining the 'desired' capital stock and thus whether or not there is net investment demand, given the current capital stock inherited from the previous period. This gap is controlled for by conditioning on firms that state capacity restrictions. What we are interested in, however, is whether financially constrained firms reach their target later. We will therefore not use 'costs of finance' as an indicator for financial constraints in the body of our analysis. Lack of internal finance as a sorting criterion will qualify as constrained the 64 cases that are consistent with an interpretation in terms of an elevated external finance premium, but not the remaining 108 spells. However, see Section 4.6 below for additional estimation results on the basis of a 'cost of finance' classification.

(25) See, among others, Jorgenson (1963), Hall and Jorgenson (1967), and Eisner and Nadiri (1968).

Figure 4: Kaplan-Meier survival curves for financially constrained and unconstrained firms

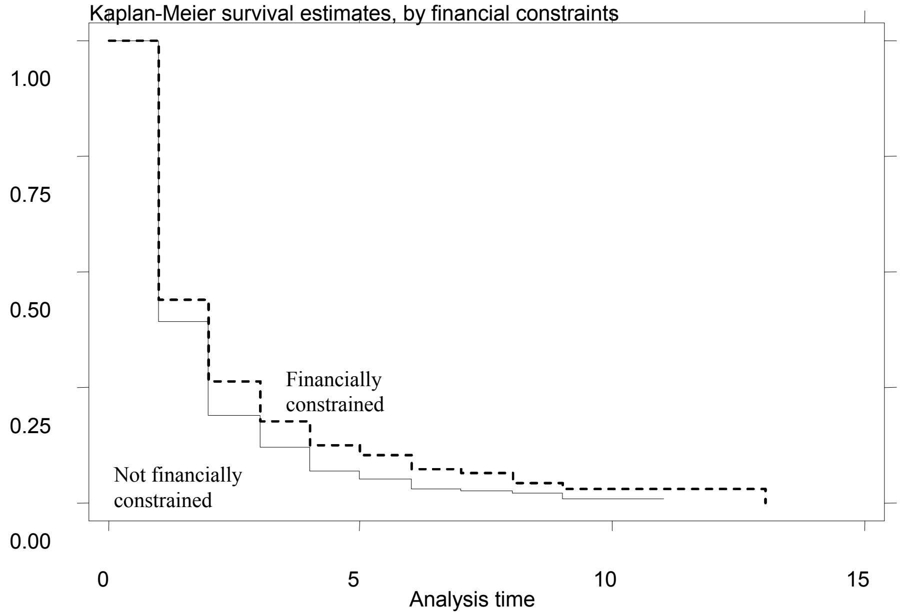


Figure 4 depicts the results for the first criterion (shortage of internal finance) for the whole sample. The survival curve for financially unconstrained firms is everywhere beneath the curve for the financially constrained firms. This means the unconstrained firms are able to complete their spell of 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 larger capacity gap (and accordingly higher financing needs) might be more likely to report financial constraints. Comparing the survival curves is essentially a test on whether at least one of these hypotheses is true.

Figure 5:
Small firms only:
KM survival curves for financially constrained and unconstrained firms

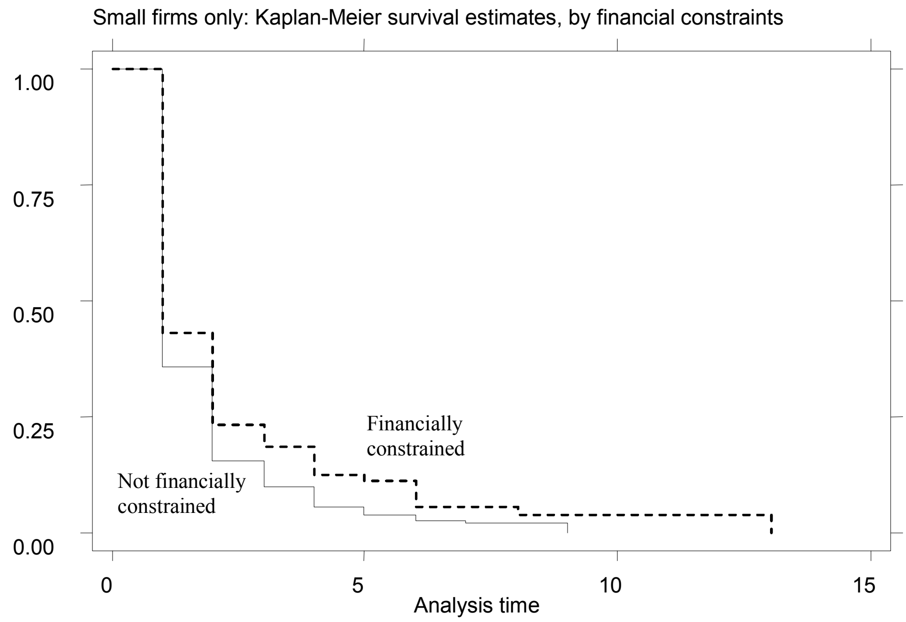
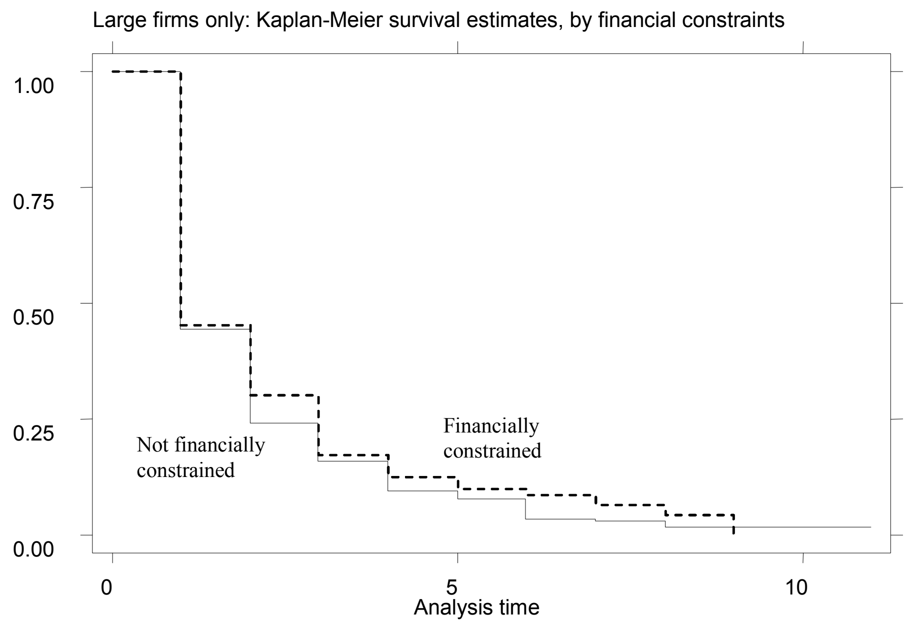


Figure 6:
Large firms only:
KM survival curves for financially constrained and unconstrained firms



It is instructive to look at the effect of financial constraints separately for small and for large firms. Figure 5 shows constrained and unconstrained small firms, and Figure 6 performs the same comparison for large firms. For both subsamples, the curve for constrained firms is situated above the curve for unconstrained firms, as is expected. The figures 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*.(26) Let $\lambda(t, x_i)$ be the *hazard* for a unit with characteristics x_i at time *t*, defined as

$$\lambda(t,x) = \lim_{h \to 0} P\left(t \le T < t+h \middle| T \ge t, x_i\right) \Big/ h \qquad \textbf{(5)}$$

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:

$$\lambda(t,x) = \lambda_0(t) \cdot \exp(x_i{}'\beta) \qquad \textbf{(6)}$$

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 $\exp(x_i{}'\beta)$, which is approximately $1+\beta$ for small β. The hazard ratios between two individuals with characteristics x_1 and x_0 are calculated as $\exp[(x_1 - x_0)\beta]$. Equation **(6)** 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 β 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

(26) 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.

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 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 quarters	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 restrictions, 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. One observation had to be dropped because the longest duration interval (13 quarters) predicts the event perfectly. The first entry gives the estimated coefficients. The term in curly brackets translates this coefficient into a hazard ratio. 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: *** significant at the 1% level, ** significant at the 5% level.

Table 13 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 $\chi^2(1)$-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 firms 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 two-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 seem less strong.

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 quarters	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 restrictions, 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) two-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. The first entry gives the estimated coefficients. The term in curly brackets translates this coefficient into a hazard ratio. 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: *** significant at the 1% level, ** significant at the 5% level.

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 quarters	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 restrictions, 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) two-digit sectors, as 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. The first entry gives the estimated coefficients. The term in curly brackets translates this coefficient into a hazard ratio. 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: *** significant at the 1% level, ** significant at the 5% level.

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 $\chi^2(1)$-statistic yields a value of 0.94, corresponding to a p-value of 0.33.

Additionally, we have run an estimation that classifies a spell as financially constrained not only if a firm reports either lack of internal finance or the inability to obtain external finance, but also if 'cost of finance' are cited as an impediment to more investment. The use of time dummies in the current estimation context allows to neutralise at least partly the strong cyclical dependence of the 'cost of finance' statements. Using this indicator, *fin(3)*, financial constraints are no longer significant on a 5% level. For a model with financial constraints only, analogous to column (5) in Table 15, we obtain a coefficient of –0.12 with a z-value of 1.88 (p=0.060). Taking into account both financial constraints and size, as in column (6) of Table 15, the coefficient is –0.12, with a z-value of –1.92 (p=0.055). Adding an interaction term, as in column (7) of Table 15, we estimate a *fin(3)* coefficient of –0.14, with a z-value of –1.72 (p=0.085). We do not think, however, that *fin(3)* is an adequate indicator for financial constraints. As discussed in Section 4.5 already, the difference between *fin(2)* and *fin(3)* is given by those firms that report costs of finance as impediments for investment without reporting shortage of internal finance or the inability to obtain external finance at the same time. This pattern is consistent with firms that have a more profitable alternative use for their internal resources, such as paying back debt. In this case, the classical user cost mechanism predicts a decrease of the desired capital stock. Thus there is no reason to expect that the spell of restricted capacity, indicating a difference between desired and installed capacity, will be very long for those firms.

The estimates for large and for small firms in Tables 11, 12 and 13 are not independent, as the coefficients on the duration time dummies are restricted to be identical.(27) 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, collected in Table 16, 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

(27) The time dummies are related to the conditional probabilities of completing for the baseline group, see Appendix 2.

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.

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 No. firm quarters	1,431 862 2,290	887 527 1,364	544 349 926	1,431 862 2,290	887 527 1,364	544 349 926

Cox duration model with grouped data for spells of capacity restrictions, 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. One observation had to be dropped because the longest duration interval (13 quarters) predicts the event perfectly. The first entry gives the estimated coefficients. The term in curly brackets translates this coefficient into a hazard ratio. 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: *** significant at the 1% level, ** significant at the 5% level.

The size of the sample for our duration analysis is affected by the fact that we need to observe the start of the spell in order to take proper account of ageing. What if ageing is absent or unimportant, the hazard function memoryless? We could make use of all the strings that contain capacity restrictions and at least one further observation and a look on Table 11 does not seem to make the assumption of a constant completion rate too harsh.

As a matter of fact, this brings us back to the analysis in Section 4.3, Tables 8, 9 and 10. The lower half of these tables look at the frequency of restricted and non-restricted capacity, given that there were capacity restrictions in the previous period, separately for firms that do report financial constraints and those that do not. Under the assumptions made above, these are estimates of the conditional transition probabilities, and the distribution of the duration of spells would simply be geometric. And the way to tell whether those transition probabilities are different is just the three tests we have performed. For both types of firms, financial constraints prove to be significant for the transition to the unconstrained state, but the difference between the estimated conditional probabilities effect was clearly lower for the large firms.

As a whole, our Cox 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 restrictions. 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 4 do not support this interpretation. It is quite possible that our sample size is not big enough to deliver significant results for our subsample 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.

There are various possible interpretations for this 'difference in differences'. First, standard theory suggests that financial constraints might mean less of a restriction for larger firms, especially when those are given by 'lack of internal finance'. It may be easier and cheaper for them to obtain external finance, not only from banks and shareholders, but also from suppliers, in the form of trade credit. However, it is also conceivable that large firms find it easier to absorb a given increase in financing costs by adapting other real activities, eg by decumulating inventories (when they can rely on being supplied with priority), postponing hiring, scaling down training, or turning to renting and leasing capital goods.(28) Finally, the costs of not being able to satisfy demand for an extended time can be considerable for a large monopolist who needs to deter potential competitors from market entry, as compared to small firms for which the perfect competition paradigm will often be better suited.

5 Conclusion and outlook

In our empirical work, we have focused on two questions. First, we ask whether there is informational content in the CBI data on financial constraints, as a precondition to using them for monitoring purposes. This has led us to investigate the interactions between financial constraints, defined as a shortage of internal finance or the inability to raise external finance, and capacity restrictions, signalling a gap between the actual and desired capital stock. Our method of validating survey data has never been used before in the literature. Second, we use the data set to compare the importance of financial constraints for small and large firms. The CBI data set offers a unique opportunity for such comparisons.

Our association and duration analysis shows that indeed there is informational content in the CBI data on financial constraints – as theoretically expected, financially constrained firms are more often capacity restricted and they take longer to close capacity gaps than unconstrained firms. This important result means we can take our survey information seriously. They indicate that financial constraints and real activity are indeed interrelated. Survey information on the

(28) A referee pointed this possibility out to us.

ups and downs of financial constraints indicators can therefore be a potentially valuable policy tool.

Quantitatively, the differences between financially constrained and unconstrained firms are clear, but not large: a financially constrained firm will leave the state of capacity restrictions at a rate that is about 20% lower than for a firm that does not report financial constraints.

Concerning the importance of financial constraints for small and large firms, the descriptive statistics – somewhat surprisingly – do not show any clear distinction. The analysis of association indicates that a small firm with capacity restrictions will leave this state quicker than a large firm, and that financial constraints seem to matter more. This is entirely consistent with our formal duration analysis: small firms are able to close their capacity gaps faster. For small firms, however, financial constraints make a clear difference: shortage of internal finance or the inability to raise external finance significantly prolong their spells of capacity restrictions. For larger firms, the measured effect is positive, too, but insignificant. As the association analysis has shown statistically significant differences between financially constrained and unconstrained large firms, we conclude that the relationship between financial constraints and the speed of adjustment is weaker for larger firms, but not absent.

This interesting pattern – small firms adapting faster in general, but with a speed that is more closely related to financial conditions, might be the basis for further theoretical and empirical work on comparative advantages of firms belonging to different size classes: we should expect to find small firms in sectors where there is a premium for high speed of adjustment. And they can be at a relative disadvantage in areas with large peaks in the demand for finance or discontinuous cash flows, eg because of long gestation lags.

The precise nature of the relationship between the real and the financial spheres remains to be worked out. The measured differences between firms that report financial constraints, and those that do not, will partly be due to the effects that investment has on the firms' balance sheets. Real investment decisions may certainly cause financial constraints, and on the other hand those financial constraints may slow down or prevent expansion plans. Further research aims at identifying the two directions of causation using a structural approach.

Appendix 1: 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), Section 5.8 for a more general exposition).

In equation **(5)**, 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

$$\lambda(t,x) = \frac{f(t,x)}{S(t,x)} = \frac{d}{dt}\log S(t,x) \qquad \textbf{(A.1)}$$

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 β, the constituting assumption is

$$\lambda(t,x) = \lambda_0(t)\cdot \exp(x'\beta) \qquad \textbf{(A.2)}$$

The hazard function for an individual with covariates *x* differs from a baseline hazard λ_0 by a multiple $\exp(x'\beta)$ 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:

$$\frac{\lambda(t,x_1)}{\lambda(t,x_0)} = \exp((x_1 - x_0)\beta) \qquad \textbf{(A.3)}$$

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:

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

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:

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

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

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

The seemingly unwieldy transformation above yields a key insight. Both the censored and the uncensored individuals contribute the amount $S(l_i - 1, x, \beta)$ 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

$$\theta_{i,j} = \frac{S(j - 1, x_i, \beta) - S(j, x_i, \beta)}{S(j - 1, x_i, \beta)} \qquad \text{for } j = l_i \qquad \textbf{(A.7)}$$

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 $l_i - 1$.(29) For the censored cases, we have the information that the spell has not ended in $t = l_i$, the conditional probability of which is

$$\left(1-\theta_{i,j}\right) = \frac{S(j, x_i, \beta)}{S(j-1, x_i, \beta)} \qquad \text{for } j = l_i \tag{A.8}$$

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

$$S(l_i - 1, x, \beta) = \prod_{i=1}^{l_i - 1}\left(1-\theta_{i,j}\right) \tag{A.9}$$

Substituting these expressions into **(A. 6)** yields the likelihood function:

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

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 **(A. 10)** yields an expression that has the form of the likelihood for a generalised binary regression model:

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

For each duration experience *i*, **(A.12)** is the likelihood for l_i independent binary observations with probabilities $\theta_{i,j}$ and outcomes $z_{i,j}$. In order to use this for an estimate of β, we need the link function that relates $\theta_{i,j}$ to the covariates x_i. A link function is a transformation such that the transformed probability $\theta_{i,j}$ 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:

$$S(t, x, \beta) = S_o(t)^{\exp(x'\beta)} \tag{A.13}$$

(29) This conditional probability of completion is conceptually similar, although not identical, to the hazard rate defined above in **(3)** and **(A.1)**. However, whereas $\theta_{i,j}$ 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.

and some more algebra yields the following link function:

$$\ln\left[-\ln\left(1-\theta_{i,j}\right)\right] = x'\beta + \tau_j, \quad \text{where} \qquad \textbf{(A.14)}$$

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

The link function **(A.14)** is the complementary log-log function. After creating artificial values j and $z_{i,j}$ for each interval $t \le l_i$, we define time dummies for each interval j. We can estimate β 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)**.(30)

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 $S_0(0) \equiv 1$. 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 11 were calculated by simulating survival curves with 20,000 replications of τ_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.

(30) For our estimations, we used the cloglog routine in Stata, version 8.

References

Advisory Council on Science and Technology (1990), *The enterprise challenge: overcoming barriers to growth in small firms*, HMSO London.

Aghion, P and Bolton, P (1992), 'An incomplete contracts approach to financial contracting', *Review of Economic Studies*, Vol. 59, pages 473-94.

Allen, F and Gale, D (2002), *Comparing financial systems*, MIT Press.

Álvarez-Lois, P P (2004), 'Capacity constraints, idiosyncratic demand uncertainty and the dynamics of inflation', *Economics Letters*, Vol. 83:1, pages 15-21.

Angeloni, I, Kashyap, A and Mojon, B (2003), *Monetary policy transmission in the euro area*, Cambridge University Press.

Arrow, K (1962), 'Economic welfare and the allocation of resources for invention', in Nelson, R (ed), *The rate and direction of incentive activity*, Princeton University Press for the National Bureau of Economic Research, pages 609-25.

Bank of England (1998), *Finance for small firms – a fifth report.*

Bank of England (2003), *Finance for small firms – a tenth report.*

Benito, A and Young, G (2002), 'Financial pressure and balance sheet adjustment by UK firms', *Bank of England Working Paper no. 168*

Bernanke, B S, Gertler, M and Gilchrist, S (1999), 'The financial accelerator in a quantitative business cycle framework', in Taylor, J B and Woodford, M (eds), *Handbook of macroeconomics*, Vol. 1, pages 1,341-93.

Büning, H and Trenkler, G (1994), *Nichtparametrische statistische Methoden* (Non-parametric statistical methods), 2nd edition, Berlin, New York, Walther de Gruyter.

Breitung, J, Chirinko, R S and von Kalckreuth, U (2003), 'A vectorautoregressive investment model (VIM) and monetary policy transmission: panel evidence from German firms', *Economic Research Centre of the Deutsche Bundesbank Discussion Paper no. 6/03*, January.

Chatelain, J B, Generale, A, Hernando, I, von Kalckreuth, U and Vermeulen, P (2003a), 'New findings on firm investment and monetary transmission in the euro area', *Oxford Review of Economic Policy*, Vol. 19, pages 73-83.

Chatelain, J B, Generale, A, Hernando, I, von Kalckreuth, U and Vermeulen, P (2003b), 'Firm investment and monetary transmission in the euro area', in Angeloni, I, Kashyap, A and Mojon, B (eds), *Monetary policy transmission in the euro area*, Cambridge University Press, pages 133-61.

Chirinko, R S and von Kalckreuth, U (2002), 'Further evidence on the relationship between firm investment and financial status', *Economic Research Centre of the Deutsche Bundesbank Discussion Paper no. 8/02*, November.

Chirinko, R S and von Kalckreuth, U (2003), 'On the German monetary transmission mechanism: interest rate and credit channels for investment spending', *CESifo Working Paper no. 838*, January.

Chittenden, F, Michaelas, N and Poutziouris, P (1999), 'Financial policy and capital structure choice in UK SMEs: evidence from company panel data', *Small Business Economics*, Vol. 12 (2).

Cosh, A and Hughes, A (1994), 'Size, financial structure and profitability: UK companies in the 1980s', in Hughes, A and Storey, D J (eds), *Finance and the small firm*, Routledge.

Cosh, A and Hughes, A (2003), *Enterprise challenged – Policy and performance in the British SME sector 1999-2002*, ESRC Centre for Business Research, University of Cambridge.

Cox, D R (1972), 'Regression models and life tables', *Journal of the Royal Statistical Society, Series B (Methodological)*, Vol. 34, No. 2, pages 187-220.

Demsetz, H (1969), 'Information and efficiency: another viewpoint', *Journal of Law and Economics*, Vol. 12(1), April, pages 1-22.

Eisner, R and Nadiri, M I (1968), 'Investment behavior and neo-classical theory', *The Review of Economics and Statistics*, Vol. 50, August, pages 369-82.

Fazzari, S M, Hubbard, R G and Petersen, B C (1988), 'Financing constraints and corporate investment', *Brookings Papers on Economic Activity*, Vol. 1, pages 141-95.

Hall, B (2002), 'The financing of research and development', *Oxford Review of Economic Policy*, Vol. 1, pages 35-51.

Hall, R E and Jorgenson, D W (1967), 'Tax policy and investment behavior', *American Economic Review*, Vol. 57, June, pages 391-414.

Hay, D A and Morris, D J (1984), *Unquoted companies: their contribution to the United Kingdom economy*, Macmillan, London.

Hayashi, F (1982), 'Tobin's marginal q and average q: a neoclassical interpretation', *Econometrica*, Vol. 50, January, pages 213-24.

Heckman, J J and Singer, B (1984), 'Econometric duration analysis', *Journal of Econometrics*, Vol. 24, pages 63-132.

HM Treasury/Small Business Service (2003), *Bridging the finance gap: a consultation on improving access to growth capital for small businesses*, HMSO.

Hosmer, D W and Lemeshow, S (1999), *Applied survival analysis - Regression modeling of time to event data*, Wiley.

Hughes, A (1994), 'The 'problems' of finance for smaller business', in Dimsdale, N and Prevezer, M (eds), *Capital markets and corporate governance*, Clarendon Press, Oxford.

Jorgenson, D W (1963), 'Capital theory and investment behaviour', *American Economic Review*, Vol. 53, May, pages 247-59.

Kalbfleisch, J D and Prentice, R L (2002), *The statistical analysis of failure time data*. 2nd edition, Wiley.

von Kalckreuth, U (2003a), 'Exploring the role of uncertainty for corporate investment decisions in Germany', *Schweizerische Zeitschrift für Volkswirtschaft und Statistik (Swiss Journal of Economics)*, Vol. 139, June, pages 173-206.

von Kalckreuth, U (2003b), 'Investment and monetary transmission in Germany: a microeconometric investigation', in Angeloni, I, Kashyap, A and Mojon, B (eds), *Monetary policy transmission in the euro area*, Cambridge University Press, pages 173-86.

von Kalckreuth, U (2004), 'Financial constraints for investors and the speed of adaptation: are innovators special?', *Economic Research Centre of the Deutsche Bundesbank Discussion Paper no. 20/04*, August.

Kaplan, S N and Zingales, L (1997), 'Do investment-cash flow sensitivities provide useful measures of finance constraints?', *Quarterly Journal of Economics*, Vol. 112, February, pages 169-215.

Kaplan, S N and Zingales, L (2000), 'Investment-cash flow sensitivities are not valid measures of financing constraints', *Quarterly Journal of Economics*, Vol. 115, May, pages 707-12.

Kiefer, N M (1988), 'Economic duration data and hazard functions', *Journal of Economic Literature*, Vol. 26, pages 646-79.

Kiyotaki, N and Moore, J (1997), 'Credit chains', *mimeo*, January (available at http://econ.lse.ac.uk/staff/kiyotaki/).

Macklem, T (1997), 'Capacity constraints, price adjustment and monetary policy', *Bank of Canada Review*, Spring, pages 39-56.

Maddala, G S (1983), *Limited dependent and qualitative variables in econometrics*, Econometric Society Monographs No. 3, Cambridge, Cambridge University Press.

Mason, C M and Harrison, R T (2001), *Designing an investment readiness programme: some considerations*, Report to the SBS.

Mitchell, J, Smith, R J and Weale, M R (2002a), 'Quantification of qualitative firm-level survey data', *The Economic Journal*, Vol. 112, March, C117-C135.

Mitchell, J, Smith, R J and Weale, M R (2002b), 'Aggregate versus disaggregate survey-based indicators of economic activity', *NIESR Discussion Paper 194*, March.

Norton, E (1990), 'Similarities and differences in small and large corporation beliefs about capital structure policy', *Small Business Economics*, Vol. 2:3, pages 229-46.

Stigler, G J (1967), 'Imperfections in the capital market', *Journal of Political Economy*, Vol. 75:3, June, pages 287-92.

Stiglitz, J E and Greenwald, B (2003), *Towards a new paradigm in monetary economics*, Cambridge, Cambridge University Press.

Stiglitz, J E and Weiss, A (1981), 'Credit rationing in markets with imperfect information', *American Economic Review*, Vol. 71, June, pages 393-410.

Wood, J (2001), *A technical guide to CBI business surveys*, CBI, London.

Wooldridge, J M (2002), *Econometric analysis of cross section and panel data*, MIT Press.