

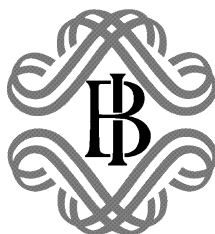
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Firm investment and monetary transmission in the euro area

by J. B. Chatelain, A. Generale, I. Hernando,
U. von Kalckreuth and P. Vermeulen



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FIRM INVESTMENT AND MONETARY TRANSMISSION IN THE EURO AREA

by J.B. Chatelain*, A. Generale**, I. Hernando***, U. von Kalckreuth**** and P.
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Abstract

We present a comparable set of results on the monetary transmission channels on firm investment for the four largest countries of the euro area (Germany, France, Italy and Spain). With particularly rich micro datasets for each country containing over 215,000 observations from 1985 to 1999, we explore what can be learned on the interest channel and broad credit channel. For each of those countries we estimate neo-classical investment relationships, explaining investment by its user cost, sales and cash flow. We find investment to be sensitive to user cost changes in all those four countries. This implies an operative interest channel in these euro area countries. We also find investment in all those countries to be quite sensitive to cash flow movements. However we find that only in Italy smaller firms react more to cash flow movements, implying that a broad credit channel might not be as pervasive in all countries.

JEL classification numbers: E22, E50.

Keywords: investment, monetary transmission channels, user cost of capital.

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1. Introduction¹

Monetary policy is generally thought to be able to affect business investment through multiple channels. First, a traditional interest rate channel is identified, whereby changes in market interest rates imply changes in the cost of capital, which in turn affect investment. It is however well known that on aggregate data it is difficult to find clear evidence of this channel. Second, changes in market interest rates have an effect on the net cash flow (i.e. cash flow after interest payments) available to a firm. In the presence of imperfect capital markets, the availability of net cash flow will have an effect on investment. This is generally referred to as the broad credit channel.

This paper provides an investigation of those two channels, based on results from a unique comparative study on the four largest euro area countries.² Using rich firm databases for each country, standardised regressions were run to make comparison across countries feasible. Although, for confidentiality reasons, individual data could not be pooled – so that no formal statistical testing is possible – the standardisation of the analysis should still allow to detect possible asymmetries in the working of the above channels. In particular, reliance on firm data should make it possible to identify whether there are differences in the behaviour of firms with otherwise similar characteristics. This is a distinct advantage, relative to the inference based on aggregate data in which “true” differences in behaviour are potentially confounded by differences due to composition of the firms in the aggregate.

The rest of the paper is structured as follows. In section 2 we motivate the research and spell out the relevant questions that could be answered by comparing the results across countries. In section 3 we describe the theoretical framework. In section 4 we present the

¹ This paper represents the authors’ personal opinions and does not necessarily reflect the views of the institutions they are affiliated to. We would like to thank the members of the Eurosystem’s Monetary Transmission Network and the participants of the monetary economics workshop at the NBER Summer Institute 2001 for helpful discussions and feedback, and especially Daniele Terlizzese for his very helpful comments.

² Mojon, Smets and Vermeulen (2001) investigate the elasticity of investment w.r.t its user cost using industry data on the same four countries. The MTN project has led to a number of complementary companion papers on investment and monetary policy: Butzen, Fuss and Vermeulen (2001), Gaiotti and Generale (2001), Chatelain and Tiomo (2001), von Kalckreuth (2001), Valderrama (2001) and Lünnehan and Mathä (2001).

data we use. In section 5 we present the regression results. In section 6 we test whether a broad credit channel is operative in the euro area. In section 7 we investigate the link between monetary policy, user cost and cash flow.

2. Motivation of the analysis

Since the beginning of monetary unification in Europe, a large body of empirical analysis has been devoted to the transmission mechanism of monetary policy. These analyses are usually justified by the observation that a common monetary policy affects economies characterized by a high degree of heterogeneity.

This paper is a contribution on the issue of monetary policy transmission in the euro area; it focuses on the four major euro area countries by using data collected at the national level. Our perspective is at the same time wider and narrower to the one motivating previous research. It is narrower since we limit our attention to a specific channel of monetary policy, that on firms' investment spending. It is wider since, by using micro data, we try to take into account the relevance of firms' balance sheet conditions in the transmission of monetary policy. The contribution of the paper consists mainly in an assessment of the main determinants of investment spending in each of the countries.

The interest in the transmission mechanism is motivated by a variety of reasons that also can have policy implications. First, to assess carefully the monetary stance in the area it is important to know if the pure interest channel is the only channel at work. If agents' financial conditions are shown to be important, then knowing these same conditions proves to be important for the policy maker; at the same time this knowledge helps to better forecast the likely effects of a monetary decision.

As it is well known, the main channels of monetary policy transmission have been thoroughly examined mainly using macro information (see the survey in Guiso, Kashyap, Panetta and Terlizzese, 1999). These kind of analyses on the one hand permitted to uncover regularities and differences across the countries of the euro area; on the other hand showed to be limited in many respects. First of all, it is known that aggregation can blur the differences in the transmission of monetary policy and impede the identification of important parts of the transmission mechanism. Hence the recourse to micro data is often motivated in

the literature by the recognition of the limits of aggregate studies. As an example for the US, Chirinko, Fazzari and Meyer (1999) motivate the use of micro data, in their analysis on the relationship between investment spending and user cost of capital, exactly because studies at the aggregate level often failed to find an economically significant relation between these two variables. As the authors note, this failure could have been due “*to biased estimates due to problems of simultaneity, capital markets frictions, or firm heterogeneity that may be better addressed with micro data*”.

Moreover micro data are needed also because of the “*extensive variation [in micro data that] will likely provide better instruments [for instrumental variable estimation] than can be obtained at the aggregate level.*” The motivation for employing micro data can be generally ascribed to the advantages of panel data estimation versus time series estimation, often reckoned in the econometric literature. “*By utilizing information on both the intertemporal dynamics and the individuality of entities being investigated, one is better able to control in a more natural way for the effects of missing or unobserved variables*” (Hsiao, 1995). Moreover, in our analysis on the determinants of investment, the use of micro data permits to have firm level measures of the user cost, sales and cash flow, thus taking into account that the transmission of monetary impulses occurs at the firm-level.

In fact, as it is well known and indeed very well explained by Chirinko, Fazzari and Meyer (1999) one of the difficulties found in the empirical analysis on the relation between investment and the user cost is that these estimates turned out to be too low. As they report, this is maybe due to simultaneity bias. As they argue “*investment comprises a volatile component of aggregate demand, positively correlated with the business cycle, and business cycle movements correlate with interest rates. Positive investment shocks, for example, can cause positive movements in output and the demand for credit that affect the required rates of return on debt and equity. Conventional wisdom suggests that simultaneity between investment shocks and interest rates biases the user cost elasticity towards zero.*” In this respect, the cross-sectional variation coming from the tax component in the user cost variable that we use in estimation can be regarded as an exogenous source of variation, thus allowing to identify the effects of the cost of capital on investment. Moreover, simultaneity problems are reduced by IV or GMM estimation.

Hence the combination of instrumental variable estimation and the exogenous source of variability ensured by tax variations should permit to better identify user cost effects properly.³

As a last point, that is relevant for preferring micro data, it is worth mentioning Hsiao (1995) again: “*longitudinal data allow a researcher to analyze a number of important economic questions that cannot be addressed using cross-sectional or time-series data sets.*” This is the case if one wants to precisely identify the existence of a broad credit channel, that is the second channel of monetary transmission.

The literature on the broad credit channel of monetary policy has emphasised the relevance of information asymmetries in the transmission of monetary policy. In particular, the difficulty faced by lenders in monitoring the projects of “opaque” firms implies that firms’ financial conditions are important for the availability and cost of external finance. The result that in the presence of information asymmetries the Modigliani Miller theorem does not hold implies also that firms that are likely to be more exposed to problems of asymmetric information should react more to a monetary tightening, which has the effect of reducing their net worth (Gilchrist and Zakrajsek, 1995). The analysis of the reaction to a common shock of groups of firms characterised by weaker balance sheets and the comparison with other firms that are in a better financial position solves the identification problems encountered with the use of macro-data. In particular, whereas aggregate data are able to identify the relevance of the interest rate channel, it is only by analysing the different behaviour of different groups of agent that we are able to robustly identify the presence of a broad credit channel.

There are also drawbacks in using micro data. They mainly consist in the difficulty of recovering aggregate effects from micro estimations, the main reasons being that usually shorter time periods are available in panels, thus implying that variation in the monetary policy stance can be more limited than with time series data, and that samples are often biased towards specific types of firms. We are aware of these difficulties: as documented in

³ It has to be clarified that we do not pursue the strategy of research adopted by Cummins et al. (1994, 1996) that stretched this line of identification as far as to measure investment elasticities to the user cost in

the data set description we are confident that the sample chosen are quite representative of the firms' characteristics in each country; moreover, also with respect to other contributions on panel analysis we have panels that are quite long.

After motivating the scope of the paper, it is necessary to give a picture of the main real and financial characteristics of these countries. The observation of significant heterogeneities has often motivated the analysis of the transmission mechanism with the aim of uncovering the presence of asymmetries in the reaction observed across countries. In effect, a high degree of heterogeneity seems to characterise these economies in particular as regards firms' financial structure, the availability of external funds and the industrial structure. Table 1a illustrates some of these differences.

On the real side the distribution of firms by size turns out to be quite dissimilar: in Germany only 48 per cent of total turnover of non financial firms pertained to firms with less than 250 employees, whereas, at the other extreme, in Italy accounted for 71 per cent.

As to financial structure, firms differ markedly both for the availability of external funds and in the composition of their financial debt. Data collected by the Monetary Transmission Network show for example that the reliance on bank credit is the highest in Italy, partly reflecting the more limited role of equity in firm financing; it is much more limited in the other countries. Spain, a country in an intermediate position as to dependence on bank debt, shows also a high share of equity financing, both looking at the share of capital and reserves on firms' total liabilities and to stock market capitalisation in percentage of GDP. More importantly for the transmission of monetary policy impulses the share of short-term debt differs markedly across countries, with higher values in Italy and Spain. Looking at recent transaction data, flows in bank loans have substantially exceeded flows in shares and other equity in Germany, Italy and Spain. France is the exception to this pattern. It seems to be the country with a lower dependence on bank debt, as it is corroborated by its relatively high stock market capitalisation.

One obvious question that arises when looking at cross-country differences is then if these broad institutional characteristics are conducive to a different reaction to monetary

years of major tax reform. It is anyway important for us to be sure of having a sufficient amount of variability

policy. It has to be clarified that the research strategy adopted in this paper is only able to address partially the issue of asymmetries across countries. We are in fact mainly interested in documenting the importance of the different transmission mechanisms in each country. Our research strategy is the following: we first estimate investment equations for each country; this gives us the sensitivity of investment to its main determinants: the user cost, sales and cash flow. This permits an assessment of the relative importance of the different channels in each country. Moreover, by calculating the response of investment determinants to monetary policy we obtain a measure of the elasticity of investment to monetary policy. The comparison of the results obtained across countries is needed to understand how the transmission of monetary impulses takes place at the country level. Moreover, it gives a rough indication of the presence/absence of asymmetries, since cross-country comparisons are not performed on a pooled data set, thus impeding a test on the significance of the differences.

We believe though that examining the main channels of transmission in each country is only a first step for the assessment of the relevance of asymmetries. Consider the case of the broad credit channel: if financial variables prove to be important in some country, then there is evidence that the differences in the access to financial markets in this country play a role. But, at the stage of country by country analysis, finding larger effects of financial variables in one country does not mean that a broad credit channel is at work. One way to partly address this issue consists in performing a test of the differences in reaction to investment determinants for firms that are more likely to be subject to information asymmetries. The detection of significant differences in each country permits to highlight how widespread heterogeneous behaviour is in the countries we examine. What future research in the field should try to do is to carefully assess the quantitative importance of the eventual differences found and try to trace back the differences observed to the presence of heterogeneity in behaviour or in the composition of the firms in the economy.

Table 1a

**FINANCIAL STRUCTURE, CAPITAL MARKETS AND REAL INDICATORS
IN THE EURO AREA**

	Germany	France	Italy	Spain
Financial structure of manufacturing firms (1) as a % of total liabilities; 1997				
Bank credit	6.2	7.2	21.2	11.0
Of which:				
Maturity of less than 1 year	3.7	3.3	14.3	6.6
Maturity of more than 1 year	2.5	3.9	6.9	4.4
Bonds	0.2	1.9	0.9	0.1
Capital and reserves	32.9	38.0	28.1	45.7
External financing transactions of non-financial corporations (2) as a % of nominal GDP; Average 1996-1999				
Loans	4.5	2.0	2.0	5.4
Securities other than shares	-0.1	0.6	0.0	-0.1
Shares and other equity	1.5	3.4	1.3	2.7
Other liabilities	0.8	0.7	1.2	6.3
Capital markets (2) As a % of nominal GDP; 1997				
Total financial liabilities of non financial firms	128.8	268.4	135.0	209.6
Stock-market capitalisation	39.9	49.5	30.6	56.2
Bonds of non financial firms	0.1	..	1.6	2.7
Real indicators				
Investment/GDP % average 1996-2000 (3)	22.2	19.0	19.4	23.3
Share of total non financial firms turnover attributable to firms with less than 250 employees 1997 (2)	48.0	56.0	71.0	62.0

Source: BACH data set (European Commission).

Source: Eurostat.

Source: OECD and Eurostat.

3. The theoretical framework

The investment model we use is derived from the neo-classical demand for capital. It is estimated recently on panel data by, among others, Bond, Elston, Mairesse and Mulkey (1997), Chirinko, Fazzari and Meyer (1999), and Mairesse, Hall and Mulkey (1999, 2001). Abstracting from irreversibility, uncertainty, delivery lags, costs of adjustment, the first order condition for a firm's optimisation problem leads to the equality between the marginal product of capital and the user cost of capital UC_{it} :

$$F_K(K_{it}, L_{it}) = UC_{it}, \quad (1)$$

where i stands for firm i and t stands for time.

Following Auerbach (1983) and Hayashi (2000), we obtain a weighted-average definition of the user cost of capital where the cost of debt is weighted by its share of the liabilities and the cost of equity is weighted by its share of the liabilities. We use the accounting proportions of debt or of equity which matters for taxation (the denominator for leverage is accounting debt and equity instead of the stock of capital computed by the perpetual inventory method):

$$UC_{it} = \frac{p_{st}^I (1 - itc_t - \mathbf{t}_t z_s)}{p_{st} (1 - \mathbf{t}_t)} \left[AI_{it} \left(\frac{D_{it}}{D_{it} + E_{it}} \right) (1 - \mathbf{t}_t) + (LD_t) \left(\frac{E_{it}}{D_{it} + E_{it}} \right) - (1 - \mathbf{d}_s) \frac{\Delta P_{st+1}^I}{P_{st}^I} + \mathbf{d}_s \right] \quad (2)$$

with s sector-specific index, p_{st} is the price of final goods, p_{st}^I is the sectorial price of capital goods; \mathbf{t}_t is the corporate income tax rate, against which interest payments and depreciation are assumed to be deductible, z present value of depreciation allowances, itc the investment tax credit. AI is the apparent interest rate, measured as interest payment over gross debt, LD is the long term debt rate used as a proxy for the opportunity cost of equity and E book value of equity and \mathbf{d}_s is the industry rate of economic depreciation.

By contrast with the King and Fullerton's (1984) approach, as used by Harhoff and Ramb (2001) and von Kalckreuth (2001), this user cost of capital does not take into account the differences for dividends and retained earnings for households income tax and the distinction between different capital goods for the computation of the net present value of depreciation allowances.⁴

Following Eisner and Nadiri (1968), we parameterise the production function by a constant elasticity of substitution production function:

$$F(K_{it}, L_{it}) = TFP_i A_i \left[\mathbf{b}_i L_{it}^{\frac{s-1}{s}} + \mathbf{a}_i K_{it}^{\frac{s-1}{s}} \right]^{\frac{s}{s-1}}, \quad \mathbf{a}_i + \mathbf{b}_i = 1, \quad (3)$$

⁴ The user cost variable used in von Kalckreuth (2001) takes better into account the specificities of the German taxation system. However results in this paper are qualitative very similar with results presented here.

where σ is the elasticity of substitution between capital and labour, ν represents returns to scale, $TFP_i A_t$ is total factor productivity which we assumed to have two components: a firm specific one and a year specific one. Substituting the marginal productivity of capital in equation (1) yields:

$$\log K_{it} = \mathbf{q} \log Y_{it} - \mathbf{s} \log UC_{it} + \log H_{it}, \quad (4)$$

$$\text{with} \quad \mathbf{q} = \left(\mathbf{s} + \frac{1-\mathbf{s}}{\mathbf{n}} \right) \text{ and } H_t = (TFP_i A_t)^{\frac{\mathbf{s}-1}{\mathbf{n}}} \cdot (\mathbf{n} \mathbf{a}_i)^{\mathbf{s}}. \quad (5)$$

Y_{it} represents sales. The variable H_{it} depends on the time varying term A_t and the firm specific term TFP_i . The elasticity of capital to sales is unity ($\theta = 1$), if the production function has constant returns to scale ($\nu = 1$), or if its elasticity of substitution is unity ($\sigma = 1$), that is, in the Cobb-Douglas case.

We don't assume that (4) always holds, rather we assume (6), with K^* the long run target value of the capital stock:

$$\log K^*_{it} = \mathbf{q} \log Y_{it} - \mathbf{s} \log UC_{it} + \log H_{it}, \quad (6)$$

The long run target value for capital, K^* is not observable, so that to go from (6) to an empirical specification, we need to specify an adjustment process. We specify an autoregressive distributed lag model (ADL(3,3)) similar to the one used in Bond, Elston, Mairesse and Mulkay (1997):

$$k_{it} = \mathbf{w}_1 k_{it-1} + \mathbf{w}_2 k_{it-2} + \mathbf{w}_3 k_{it-3} + \mathbf{q}_0 y_{it} + \mathbf{q}_1 y_{it-1} + \mathbf{q}_2 y_{it-2} + \mathbf{q}_3 y_{it-3} - \mathbf{s}_0 uc_{it} - \mathbf{s}_1 uc_{it-1} - \mathbf{s}_2 uc_{it-2} - \mathbf{s}_3 uc_{it-3} + \mathbf{f}_0 h_{it} + \mathbf{f}_1 h_{it-1} + \mathbf{f}_2 h_{it-2} + \mathbf{f}_3 h_{it-3} \quad (7)$$

where we have used lower case letters to refer to the corresponding level variables in logs. At this stage, the literature on panel data splits in two models. A first strategy consists of transforming the ADL model as an error correction model, as done in the macro-economic time series literature (e.g. Hall, Mairesse and Mulkay (1999)). A second strategy consists of first differencing the ADL model (e.g. Chirinko, Fazzari and Meyer (1999)). The possibility

of firm specific effect not only on the level of productivity, but also on its growth rate may justify this second strategy on panel data. For simplicity, we will only use the second strategy. We leave the possible comparison between the two approaches to companion country papers of the Monetary Transmission Network. First-differencing and using the approximation $\log K_t - \log K_{t-1} = I_t / K_{t-1} - \delta$, and replacing productivity by time dummies, a firm-specific effect f and a random term ε , yields:

$$\begin{aligned} \frac{I_{it}}{K_{it-1}} = & \omega_1 \frac{I_{it-1}}{K_{it-2}} + \omega_2 \frac{I_{it-2}}{K_{it-3}} + \omega_3 \frac{I_{it-3}}{K_{it-4}} + \theta_0 \Delta y_{it} + \theta_1 \Delta y_{it-1} + \theta_2 \Delta y_{it-2} + \theta_3 \Delta y_{it-3} \\ & - \sigma_0 \Delta uc_{it} - \sigma_1 \Delta uc_{it-1} - \sigma_2 \Delta uc_{it-2} - \sigma_3 \Delta uc_{it-3} + \text{time dummies} + \varepsilon_{it} + f_i \end{aligned} \quad (8)$$

We estimate this equation (8). The long run user cost elasticity with respect to the stock of capital is given by $\sigma_{LT} = (\sigma_0 + \sigma_1 + \sigma_2 + \sigma_3) / (1 - \omega_1 - \omega_2 - \omega_3)$ and the long run sales elasticity with respect to the stock of capital is $\theta_{LT} = (\theta_0 + \theta_1 + \theta_2 + \theta_3) / (1 - \omega_1 - \omega_2 - \omega_3)$.

In addition, we consider an important extension of equation (8). It has been frequently argued that a measure of liquidity related to the credit channel of monetary policy should enter the model to account for access to internal funds that affect investment. In this model, liquidity is measured as cash-flow (CF). For comparison with the existing literature and, to avoid unit problems, cash flow enters relative to the existing capital stock.

$$\begin{aligned} \frac{I_{it}}{K_{it-1}} = & \omega_1 \frac{I_{it-1}}{K_{it-2}} + \omega_2 \frac{I_{it-2}}{K_{it-3}} + \omega_3 \frac{I_{it-3}}{K_{it-4}} + \theta_0 \Delta y_{it} + \theta_1 \Delta y_{it-1} + \theta_2 \Delta y_{it-2} + \theta_3 \Delta y_{it-3} \\ & - \sigma_0 \Delta uc_{it} - \sigma_1 \Delta uc_{it-1} - \sigma_2 \Delta uc_{it-2} - \sigma_3 \Delta uc_{it-3} + \text{time dummies} + \varepsilon_{it} + f_i \\ & + \theta_0 \frac{CF_{it}}{p_{st}^I K_{i,t-1}} + \theta_1 \frac{CF_{i,t-1}}{p_{s,t-1}^I K_{i,t-2}} + \theta_2 \frac{CF_{i,t-2}}{p_{s,t-2}^I K_{i,t-3}} + \theta_3 \frac{CF_{i,t-3}}{p_{s,t-3}^I K_{i,t-4}} \end{aligned} \quad (9)$$

One has to note that in this case the parameters θ are no longer elasticities with respect to the stock of capital but investment cash-flow sensitivities with obviously a constant elasticity of cash-flow with respect to investment. This specification has the following drawbacks: (i) the long run elasticity of the stock of capital with respect to cash-flow is

implicitly constrained to one, (ii) the elasticities of capital with respect to user cost and sales are affected by the presence of the cash-flow term, particularly in the medium and long run, so that the formulas for long run elasticities holding for equation (8) do not exactly hold for equation (9). These issues are dealt with in the simulations provided in section 7 of this paper.

4. Data set description

In this section an overview is given of the individual country data used in the regressions. Definitions of the variables used were made as comparable as possible between the different countries.

National data sets do differ in many respects. First of all the way in which data are collected in each country is not the same. The fact that the prerequisites for entering in the sample are different implies that the representativeness of each sample differs across countries. In general, the samples are skewed towards larger firms. Moreover, since all the samples are open they differ in the degree of firm turnover.

In Germany, the Bundesbank's corporate balance sheet database constitutes the largest collection of accounting data for German non-financial firms⁵; the collection of financial statements originated from the Bundesbank's function of performing credit assessments within the scope of its rediscount operations. On the whole, every year around 70,000 annual accounts were collected, on a strictly confidential basis, by the Bundesbank's branch offices. The German data-set is probably skewed towards large firms since, according to the turnover tax statistics, these firms represented roughly 75 per cent of the total turnover of the West German manufacturing sector, albeit only 8 per cent of the total number of firms.

In France, the data source consists of compulsory accounting tax forms⁶ and of additional information taken from surveys collected by the Banque de France (the database

⁵ A detailed description is contained in Deutsche Bundesbank (1998), see also Friderichs and Sauvé (1999), and Stöss (2001).

⁶ They are collected by the Banque de France in the database FIBEN.

“Centrale des Bilans”). Since these data are collected only from firms who are willing to provide them, also French data are skewed towards large firms.⁷

Data for Italy are drawn from the Italian Company Accounts Data Service (Centrale dei bilanci), that, considering the whole period 1983-1999 and all non financial enterprises contains 692,000 observations, with more or less than 40,000 firms per year. Also for Italy there exists a bias towards large firms, since firms are not randomly drawn: in fact, the prerequisite for entering the sample is that each firm has to be indebted with a bank; moreover preference is given to firms with multiple lending relationships.⁸

The Spanish data were obtained from the Central Balance Sheet Office of the Banco de España (CBBE), and, in particular from the Annual Central Balance Sheet Database (CBA); this database is compiled through the voluntary collaboration of non-financial firms and is edited by means of contacts with them. Thus, it only covers those firms that voluntarily complete the questionnaire and it is biased towards large and manufacturing firms. The initial database included 115,980 observations corresponding to 22,014 firms over the 1983-1999 period. In 1994, its coverage of the non-financial firms sector, in terms of value added, was around 35 per cent.⁹

For the econometric analysis a smaller data set was used in each country. The loss in observations was due to the following reasons. Firstly, we concentrated the analysis on the manufacturing sector, for which data for the calculation of the capital stock at replacement cost appeared to be more reliable. Second, applying the perpetual inventory formula and using investment over lagged capital as a regressor meant dropping the first year-firm observations. Third, trimming (see appendix) and selecting firms which are consecutively present in the sample at least during five years in order to use a sufficient number of lags as explanatory variables led to the final sample in each country.

⁷ Small firms of less than 20 employees are under-represented. No statistical sampling procedure has been used to correct this bias.

⁸ Moreover, since the information collected is meant to be a service for banks in deciding their credit policies, the sample is biased towards firms that are creditworthy.

⁹ For a more detailed description of this database, see Banco de España (2000).

Some specificities in each country are worth to be mentioned: for the German sample, that originally contained also unincorporated businesses, we excluded sole proprietorships and unincorporated partnerships because of differences in accounting rules¹⁰; this permits a higher degree of comparability with the other countries. Again for reasons of comparability, we only consider West German manufacturing firms, and we confine ourselves to the years 1988 - 1997.¹¹ In Italy, we discarded the firms for which information to construct the user cost (i. e. fiscal data) was not available.

In general, we ended up with samples, that though skewed towards larger firms are still representative of the manufacturing sector of each economy. Moreover, very often, balance sheet data only contain large and listed firms, whereas in our sample the median number of employees is 118 in Germany, 31 in Italy, 50 in Spain, and 55 in France. This means also that the data-set covers quite well unlisted companies, which are probably the best candidates to test for balance sheet effects: listed companies represent less than 4 per cent of the sample in Spain, less than 2 in Italy, and less than 6 in Germany and France. Moreover, firms are spread throughout the sectors of manufacturing¹².

In each country, the period covered by the samples used in estimation is 1985-1999, with the exception of Germany for which the time period available for estimation is 1988-1997. The total number of observations and the number of years available are comparable to or higher than those of the sample used by Chirinko et al. (1999) for US firms.¹³ For the European samples, coverage, calculated on the total number of employees in the manufacturing sector, ranges from 19 per cent for Spain to 45 per cent for Germany¹⁴.

¹⁰ Also all publicly owned enterprises were discarded, as they might not be profit oriented.

¹¹ Earlier years are affected by the radical regulatory changes in accounting introduced in 1985, triggered by an EU directive on the harmonisation of financial statements.

¹² The wider time dimension of these databases makes them preferable to other data-sets containing a larger number of firms which are often available in the countries examined. For example in Italy the CERVED database contains information on balance sheet and profit and loss accounts of all firms excluding sole proprietorships (more or less 500,000 firms), but the first year available is 1993.

¹³ They had a sample of 26,071 observations ranging from 1981 to 1991 with a total number of firms of 4,095.

¹⁴ For Germany, coverage calculated over total turnover of the sector in 1996 was 38.4 per cent of the turnover of the whole sector. The analysis of the distribution by size indicates that a large portion of small and

Table 1b shows the investment-capital ratio, real sales growth, real user cost growth, cash flow on capital, and log of the user cost level in each country. Overall as is usually the case with panel data there is a wide dispersion of the variables used in all countries.

Table 1b

SUMMARY STATISTICS
Complete cleaned data-sets

Var	Country	Mean	Std. Dev.	Minimum	25%	Median	75%	Maximum
It/Kt-1								
	Germany	0.181	0.219	0.000	0.059	0.116	0.216	2.291
	France	0.122	0.141	0.000	0.039	0.080	0.151	1.430
	Italy	0.124	0.155	0.000	0.040	0.080	0.151	3.300
	Spain	0.186	0.217	-0.033	0.049	0.117	0.240	1.560
Δlog St								
	Germany	0.021	0.158	-0.596	-0.058	0.021	0.107	0.828
	France	0.029	0.153	-1.780	-0.051	0.029	0.112	1.360
	Italy	0.034	0.196	-2.400	-0.060	0.035	0.131	3.000
	Spain	0.043	0.171	-0.660	-0.051	0.041	0.136	0.780
Δlog Uct								
	Germany	0.025	0.110	-0.356	-0.044	0.025	0.091	0.422
	France	-0.087	0.140	-0.339	-0.107	-0.014	0.089	0.362
	Italy	-0.012	0.263	-2.100	-0.150	-0.008	0.126	1.700
	Spain	0.006	0.150	-0.380	-0.107	0.011	0.113	0.510
CFt/Kt-1								
	Germany	0.276	0.464	-1.191	0.109	0.188	0.325	9.268
	France	0.330	0.330	-0.450	0.160	0.260	0.410	4.320
	Italy	0.196	0.220	-1.200	0.090	0.152	0.244	4.500
	Spain	0.370	0.469	-1.100	0.126	0.256	0.471	5.000
Log Uct								
	Germany	-1.865	0.182	-2.572	-1.984	-1.859	-1.738	-1.126
	France	-1.770	0.140	-2.260	-1.860	-1.770	-1.670	-1.270
	Italy	-1.870	0.272	-3.500	-2.000	-1.860	-1.710	-0.900
	Spain	-1.742	0.185	-3.351	-1.851	-1.736	-1.613	-0.984
		No Obs.	No firms	Years				
	Germany	40362	5876	1989-1997				
	France	61237	6946	1985-1999				
	Italy	94523	8019	1985-1999				
	Spain	19025	2034	1985-1999				

medium sized enterprises that make up the core of West German industry is present in the sample. Moreover, the sample mirrors the West German industrial structure relatively well.

Looking at the means, investment over capital is higher in Germany and Spain, lower, on similar values, in France and Italy; the dispersion of the variable is higher in Germany and Italy. As to the other variables it is interesting to note that, on average, the ratio of cash flow over capital is higher in France and Germany than in Spain and Italy. The average level of the user cost is higher in the Spanish and French samples; its dispersion is higher in Italy and Spain, probably reflecting the wider dispersion in firms' size.

5. Regression results

In this section we present regression results for the specifications reported in equations (8) and (9). We first present estimation results using the WITHIN estimator. We then present estimation results using the GMM estimator developed by Arellano and Bond (1991).

Table 2 reports the results obtained with the WITHIN estimator. We include a full set of time dummies. These will capture the effect of macro influences on firm individual investment. We dropped the lagged dependent variable for two reasons. First, it is known that the WITHIN estimator is biased with certainty when lagged dependent variables are present (Nickell, 1981). This bias is due to the correlation of the fixed effect with the lagged dependent variable. Second, in this way we can compare directly our WITHIN estimation results with those obtained for U.S. data by Chirinko, Fazzari and Meyer (1999) using a panel of 4095 manufacturing and non-manufacturing firms from 1981-1991, that represented 48 per cent of aggregate U.S. non-residential investment in 1987. (See their Table 2 at page 62 for the WITHIN results.)

For all countries, sales have a substantial effect in the long run on the capital stock. We obtain long term sales elasticities ranging from 0.407 in Germany to 0.228 in Italy. Also for all countries, the contemporaneous effect of sales is the largest, ranging from 0.126 in Germany to 0.075 in Italy. All lags of sales growth (up to t-3) have a significant effect on investment. This could be due to many different reasons, including installation lags or adjustment cost. Chirinko et al. (1999) found a rather similar long run sales elasticity of 0.322 with a contemporaneous effect of 0.120 for the U.S.

For all countries except Spain, also the user cost has a significant effect on the capital stock in the long run. We obtain user cost elasticities ranging from -0.63 in Germany to -0.318 in Italy¹⁵. Chirinko et al. (1999) found a long run user cost elasticity of -0.721 . In every country (including the U.S.), except for Spain, these long-term user cost elasticities are even higher than the long-term sales elasticities. Again, the contemporaneous effect is the largest and past user cost changes are generally significant. This provides evidence against simple sales-accelerator models that only include sales and exclude user costs. It is important to note that even for Spain, although the long-run user cost elasticity (UCE) is not significant, the contemporaneous user cost effect is clearly negative and significant. Moreover, in a more parsimonious specification, removing the insignificant lags, the point estimates of the remaining regressors do not significantly change and the long run user cost elasticity is larger, in absolute value, and significant.

Table 2

MODELS OF INVESTMENT DEMAND
3 Lags Within Estimates, Dependent Variable: $I_{i,T}/K_{i,T-1}$

Explanatory Variable	GERMANY	FRANCE	ITALY	SPAIN
$\Delta \log S_{i,t}$	0.126 (0.008)**	0.107 (0.005)**	0.075 (.004)**	0.080 (0.014)**
$\Delta \log S_{i,t-1}$	0.121 (0.009)**	0.099 (0.005)**	0.072 (0.003)**	0.077 (0.013)**
$\Delta \log S_{i,t-2}$	0.097 (0.097)**	0.059 (0.005)**	0.048 (0.004)**	0.042 (0.013)**
$\Delta \log S_{i,t-3}$	0.064 (0.008)**	0.040 (0.005)**	0.031 (0.003)**	0.038 (0.012)**
Long term Sales elasticity	0.407 (0.022)**	0.305 (0.011)**	0.228 (0.010)**	0.237 (0.033)**
$\Delta \log UC_{i,t}$	-0.230 (0.013)**	-0.211 (0.0074)**	-0.144 (0.003)**	-0.187 (0.029)**
$\Delta \log UC_{i,t-1}$	-0.213 (0.014)**	-0.110 (0.0073)**	-0.095 (0.003)**	0.024 (0.030)
$\Delta \log UC_{i,t-2}$	-0.107 (0.013)**	-0.046 (0.0070)**	-0.052 (0.003)**	0.048 (0.030)
$\Delta \log UC_{i,t-3}$	-0.080 (0.080)**	-0.015 (0.0060)*	-0.020 (0.002)**	0.023 (0.026)
Long term User cost elasticity	-0.630 (0.022)**	-0.382 (0.013)**	-0.318 (0.01)**	-0.092 (0.064)
No. obs.	22,734	33,453	62,447	8,855
No. Firms	5,876	6,946	8,019	2,034

¹⁵ The sign and dimension of these two effects are similar to those obtained using specifications with a different lag structure and are similar to that reported in the paper by Gaiotti and Generale that employ a data set that contains also non-manufacturing Italian firms.

Although the WITHIN estimate of the UCE is less than -1 (which is the value it would have in a Cobb Douglas world), there are theoretical arguments suggesting that this within estimate is biased towards zero (see Mankiw and Summers, 1988, or Chirinko et al., 1999). As already noted, Chirinko et al. point out that “*positive investment shocks can cause positive movements in output and the demand for credit that affect the required rates of return on debt and equity*”.

The WITHIN estimator could further be biased due to endogeneity of sales and user cost. Therefore we also present the results using the GMM-first difference estimator of Arellano-Bond (1991). This time we include the lagged dependent variable. We use as instruments the lagged variables used in the regression from $t-2$ onwards. The results are in Table 3.

For all countries, with the partial exception of Spain, the long-run sales elasticities are similar to the WITHIN results. The point estimates increase somewhat for Germany, France and Italy, they decrease for Spain, but the effect of sales on capital remains statistically significant. The effect of sales on investment is clearly a robust feature in every country.

Striking however, is how the point estimates of the long run user cost elasticities change when moving to GMM. These differences are non-uniform across countries. The GMM results show a slightly higher point estimate of the long-run user cost elasticity for Germany (-0.663), a dramatic lower one for France (-0.106) and Italy (-0.111) and a dramatic higher one for Spain (-.259).

So far these are the results obtained not only by means of a common specification, but also by using a common set of instruments. Before proceeding it is worth mentioning some robustness checks made for each country. Comparison with other results is obtained either by running regressions with a slightly modified set of instruments (results not shown) or by taking stock of the results presented in the companion papers of the Monetary Transmission project.

Table 3

ADL MODELS OF INVESTMENT DEMAND3 Lags Gmm Estimates, Dependent Variable: $I_{i,T}/K_{i,T-1}$

Explanatory Variable	GERMANY	FRANCE	ITALY	SPAIN
$I_{i,t-1}/K_{i,t-2}$	0.142 (0.017)**	0.024 (0.061)	0.176 (0.007)**	0.123 (0.019)**
$I_{i,t-2}/K_{i,t-3}$	0.010 (0.009)	0.050 (0.011)*	0.022 (0.005)**	-0.004 (0.014)
$I_{i,t-3}/K_{i,t-4}$	0.008 (0.007)	0.029 (0.006)*	0.017 (0.005)**	0.001 (0.012)
$\Sigma I_{i,t-n}/K_{i,t-n-1}$	0.160 (0.026)**	0.103 (0.031)*	0.215(0.013)**	0.120(0.035)**
$\Delta \log S_{i,t}$	0.162 (0.053)**	0.073 (0.035)*	0.117 (0.032)*	0.038 (0.064)
$\Delta \log S_{i,t-1}$	0.106 (0.013)**	0.086 (0.009)*	0.062 (0.040)**	0.041 (0.017)**
$\Delta \log S_{i,t-2}$	0.069 (0.011)**	0.137 (0.008)*	0.033 (0.005)**	0.027 (0.014)*
$\Delta \log S_{i,t-3}$	0.042 (0.010)**	0.014 (0.006)*	0.013 (0.0054)**	0.018 (0.012)
$\Sigma \Delta \log S_{i,t-n}$	0.379 (0.062)**	0.310 (0.024)*	.224(0.039)**	0.124(0.075)*
long term Sales elasticity	0.452 (0.073)**	0.346 (0.036)*	.286(0.049)**	0.141 (0.085)*
$\Delta \log UC_{i,t}$	-0.286 (0.089)**	-0.055 (0.026)*	-0.045 (0.016)**	-0.274 (0.135)**
$\Delta \log UC_{i,t-1}$	-0.170 (0.029)**	-0.045 (0.019)*	-0.027 (0.008)**	-0.003 (0.041)*
$\Delta \log UC_{i,t-2}$	-0.072 (0.021)**	-0.002 (0.011)	-0.011 (0.005)*	0.032 (0.035)
$\Delta \log UC_{i,t-3}$	-0.029 (0.015)	0.007 (0.007)	-0.004 (0.004)	0.017 (0.028)
$\Sigma \Delta \log UC_{i,t-n}$	-0.557 (0.134)**	-0.095 (0.037)*	-.087(0.030)**	-0.228(0.177)
long term User cost elasticity	-0.663 (0.167)**	-0.106 (0.048)*	-.111(0.039)**	-0.259 (0.201)
No. Obs.	16858	33453	62447	8855
No. Firms	5876	6946	8019	2034
Sargan-Hansen test	69.81 (p=0.289)	105.12 (p=0.09)	126.8 (p=0.093)	127.26 (p=0.088)
AR(1)	13.74	-6.514 ***	-30.9 **	-14.37**
AR(2)	-2.034 (p=0.042)*	-2.174 (p=0.030)	0.08 (p=0,99)	-0.19 (p=0.849)

Estimation method: 2-step GMM estimates, time dummies.

Instruments: Germany: lags 2 and earlier of I/K, $\Delta \log S$ and $\Delta \log UC$; Spain: lags 2 to 5 of I/K, $\Delta \log S$ and $\Delta \log UC$; Italy: instruments used I/K lags 2 to 6; $\Delta \log S$ and $\Delta \log UC$ lags 2 to 4; France: instruments used I/K lags 3 to 5; $\Delta \log S$ lags 2 to 4 and $\Delta \log UC$ lags 2 to 5.

For Germany the AR(2) statistics in the specification presented in Table 3 shows that there might be an autocorrelation problem in the residuals. It is interesting to note that, using King-Fullerton user costs, von Kalckreuth (2001) obtains a smaller user cost elasticity of

0.522 for the same model. In France the significance level of the elasticity of I/K to the user cost turns out to be dependent on the choice of instrument. For Italy, a sensitivity analysis of the results obtained with this specification was conducted by trying different instrument sets. By using a more parsimonious set of instruments, excluding lags 2 and 3 of the user cost, the long run effect of the user cost is -0.234 , more similar to the outcome of the WITHIN regression. Moreover, the Sargan test accepts the set of instruments at a higher confidence level. The effect of sales is similar to the one observed in Table 3. In Spain, the use of a more parsimonious specification leads again to more precise estimates. When removing insignificant lags, the point estimates of the remaining regressors do not significantly vary and the standards errors for the long-run elasticities are significantly lower. In particular, the point estimate for the long run sales elasticity is 0.098 with a standard error of 0.039 , and the point estimate of the long run user cost elasticity is -0.273 with a standard error of 0.131 .

We also wanted to check whether the sales and user cost elasticities are sensitive to adding cash flow to the regression. Since Fazzari, Hubbard and Petersen (1988) it is usual to enter cash flow in the regression to allow for liquidity constraints. The results, estimated by GMM are presented in Table 4.

As is generally the case in the empirical literature, the cash flow capital ratio enters significantly and with a positive sign. The total effect of cash flow on I/K ranges from a low 0.079 in Germany to a high 0.301 in Italy. The higher coefficient with respect to those obtained in the other countries could indicate that firms' balance sheet conditions are relatively important in Italy.¹⁶ Also the sales elasticity goes down substantively for all countries. Since cash flow proxies for future profitability and future sales this result was to be expected. Likewise in the former regression, the sales variable might have picked up some effects that should really have been attributed to liquidity and profits. The long-run user cost elasticities are different with respect to the former GMM results. They are lower

¹⁶ On the other hand, as it is well discussed by Bond et al. (1997), a positive effect of cash flow on investment does not necessarily reflect the presence of financial constraints. If higher cash flows are a good predictor of high activity in the future, it may very well be that a positive relationship between investment and cash flow does not reflect the existence of financial constraints. To partially address this critique the regression for Italy was re-run using liquidity stock as a measure of firms' balance sheet conditions. This variable should be less correlated with expectations of future demand conditions: results (not reported) indicate that also

for Germany and Italy if for this country we compare the results obtained using the same set of instruments; they are close to zero for France and turn out to be higher for Spain.

Table 4

ADL MODELS OF INVESTMENT DEMAND

3 Lags Including Cash Flow Gmm Estimates, Dependent Variable: $I_{i,T}/K_{i,T-1}$

Explanatory Variable	GERMANY	FRANCE	ITALY	SPAIN
$I_{i,t-1}/K_{i,t-2}$	0.124 (0.017)**	0.086(0.01)**	.168(.011)**	0.120(0.021)**
$I_{i,t-2}/K_{i,t-3}$	0.002 (0.009)	0.016(0.007)*	.024(.006)**	0.007 (0.014)
$I_{i,t-3}/K_{i,t-4}$	0.005 (0.007)	0.014(0.006)*	.018(.005)**	0.010 (0.012)
$\Sigma I_{i,t-n}/K_{i,t-n-1}$	0.131 (0.026)**	0.116 (0.033)**	.206(0.016)**	0.137 (0.038)**
$\Delta \log S_{i,t}$	0.142 (0.054)**	0.031 (0.04)	.045(.033)	-0.043 (0.063)
$\Delta \log S_{i,t-1}$	0.097 (0.014)**	0.055(0.009)**	.039(.006)**	0.028 (0.018)
$\Delta \log S_{i,t-2}$	0.061 (0.011)**	0.017 (0.007)*	.018(.005)**	0.014 (0.014)
$\Delta \log S_{i,t-3}$	0.036 (0.010)**	0.007 (0.005)	.007(.004)	0.016 (0.013)
$\Sigma \Delta \log S_{i,t-n}$	0.338 (0.068)**	0.110 (0.039)**	.109(.040)**	0.015(0.075)
Long term Sales elasticity	0.387 (0.077)**	0.124 ((0.046)**	.138(.050)**	0.018(0.087)
$\Delta \log UC_{i,t}$	-0.220 (0.080)**	0.002 (0.03)	-.079(.021)**	-0.279(0.126)**
$\Delta \log UC_{i,t-1}$	-0.151 (0.028)**	-0.03 (0.03)	-.055(.017)**	-0.018 (0.040)
$\Delta \log UC_{i,t-2}$	-0.060 (0.020)**	0.002 (0.013)	-.021(.013)	0.036 (0.034)
$\Delta \log UC_{i,t-3}$	-0.021 (0.015)	0.002 (0.007)	-.006(.005)	0.021 (0.027)
$\Sigma \Delta \log UC_{i,t-n}$	-0.452 (0.124)**	-0.024 (0.032)	-.161(.048)**	-0.240(0.171)
Long term User cost elasticity	-0.521 (0.148)**	-0.027 (0.039)	-.204(.060)**	-0.278(0.198)
$CF_{i,t}/K_{i,t-1}$	0.043 (0.036)	0.056 (0.03)*	.255(.035)**	0.121 (0.032)**
$CF_{i,t-1}/K_{i,t-2}$	0.011 (0.012)	0.091 (0.015)**	-.025(.019)	0.037 (0.022)*
$CF_{i,t-2}/K_{i,t-3}$	0.011 (0.006)	0.018 (0.007)**	.008(.007)	-0.019(0.009)**
$CF_{i,t-3}/K_{i,t-4}$	0.004 (0.005)	0.008 (0.005)	.000(.006)	-0.006 (0.008)
$\Sigma CF_{i,t-n}/K_{i,t-n-1}$	0.069 (0.027)*	0.173 (0.030)**	.238 (.022)**	0.133(0.032)**
Long term Cash flow sensitivity	0.079 (0.031)*	0.196 (0.039)**	.301 (.028)**	0.153 (0.037)**
No. Obs.	16858	33,453	62447	8855
No. Firms	5876	6946	8019	2034
Sargan-Hansen test	91.80 (p=0.288)	133.4 (p=0.43)	127.2(p=.40)	149.81 (p=0.17)
AR(1)	13.72**	-24.6**	-30.1**	-14.62**
AR(2)	2.079(p=0.038)*	1.207 (p=0.228)	-.18(p=.86)	0.13 (p= 0.90)

Instruments:

Germany: lags 2 and earlier of all explanatory variables.

Italy: instruments used I/K lags 2 to 6; $\Delta \log S$ lags 2 to 4; $\Delta \log UC$ lag 4; CF/K lags 2 to 5.

Spain: lags 2 to 5 of I/K, CF/K and $\Delta \log UC$, and lags 2 to 4 of $\Delta \log S$.

France: lags 2 to 5 of I/K, CF/K and $\Delta \log S$, and lags 3 to 5 of $\Delta \log UC$.

liquidity has a positive and significant effect on capital formation; in the regression the sign and significance of sales and the user cost remain unchanged.

The change in the long run user cost elasticity when cash flow is entered into the regression can be explained by how the user cost was constructed. The apparent interest rate variable used for constructing the user cost of capital is interest payments divided by the amount of debt. This induces a correlation with cash flow, in which interest payments also are an important part. As noted by Chirinko, Fazzari and Meyer (1999) “*in the regression without cash flow the estimated sum of coefficients of the user cost captures both the conventional substitution effect as well as the income effect induced by financing constraints, which affect investment in the same direction*”.

Overall, the results in Tables 2, 3 and 4 suggest that sales, user cost and cash flow are all three important determinants of investment. That user cost enters significantly in investment regressions is an important finding, since it is the prerequisite for an interest rate channel. The finding that (for most countries) the user cost elasticity varies substantially according to estimation method and specification is less satisfying. (Note that this is also the case for the U.S. in Chirinko, Fazzari and Meyer (1999)). However, given that the user cost is a pretty elusive variable this is not too surprising.

6. The broad credit channel in the euro area

In this section we test whether small and large firms show different investment behaviour. We are especially interested in differences in the coefficient estimates of the cash flow capital ratio. By testing whether the long run effect of the cash flow capital ratio are significantly different for small firms, we are able to compare the behaviour of firms that are likely characterised by weaker balance sheets with that of other firms.

As it is well known: “*models that incorporate financial frictions are more relevant for certain types of agents, certain classes of borrowers, and certain sectors of the economy (Gilchrist and Zakrajsek, 1995)*”. Moreover, as these authors note: “*because of the difficulties associated with formulating and estimating true structural models, empirical exercises seeking to establish the validity of either a credit channel or a financial accelerator must make comparisons against benchmarks where such credit effects are less likely to be relevant*”.

Sample comparisons using size as a discriminating characteristic of the balance sheet conditions of firms are commonly used in the empirical literature that has examined the link between financial constraints and investment spending (see Schiantarelli, 1995 for a discussion). Smaller firms are more likely to be less collateralized, to be more opaque towards external investors and, as far as age is correlated with small size, have less established contacts with lenders, thus making the screening between good and bad firms more difficult. Other characteristics that have been commonly used in these tests are the dividend payout behavior, group membership, the nature of the bank-firm relationship, the degree of ownership concentration. In particular circumstances and in some countries, these characteristics may very well be more important than size. In fact, as Schiantarelli (1995) notes, one problem with splitting the sample along one firm characteristic is that “[this] *single indicator may or may not be a sufficient statistic for the existence of liquidity constraints*”.

The analysis of the institutional characteristics that in each country can blur the relevance of the size split is beyond the scope of this paper. In the companion papers that focus on single country evidence other firm characteristics that might prove relevant for the transmission of monetary policy shocks via the balance sheet are analyzed. (See, for example, Chatelain and Tiomo (2001) for France, von Kalckreuth (2001) for Germany, Valderrama (2001) for Austria, Butzen, Fuss and Vermeulen (2001) for Belgium and Gaiotti and Generale (2001) for Italy). We present here only the size split results since these are probably the more easily comparable across countries.

Table 5

LONG TERM ELASTICITY OF SALES AND USER COST AND LONG TERM EFFECT OF CASH FLOW ON LARGE AND SMALL FIRMS

Gmm ADL3 with CF

	GERMANY	FRANCE	ITALY	SPAIN
$\Delta \log S$ large firms	0.337 (0.086)**	0.073 (0.032)*	0.108(0.051)*	0.040(0.012)**
Diff. Small – Large	-0.029 (0.125)	0.042 (0.04)	0.027(0.079)*	-0.031 (0.021)
$\Delta \log UC_i$ large firms	-0.512 (0.173)**	-0.053 (0.04)	-0.238(0.060)**	-0.153 (0.082)*
Diff. Small – Large	0.063 (0.255)	0.057 (0.18)	0.024(0.098)	0.072 (0.167)
CF/K large firms	0.092 (0.038)*	0.221(0.03)**	0.196 (0.027)**	0.116(0.021)**
Diff. Small – Large	-0.050 (0.050)	-0.035(0.031)	0.144 (0.045)**	0.030 (0.033)

Table 5 contains the regression results of equation (9) when allowing for different coefficients for user cost growth, sales growth and the cash flow capital ratio for large and small firms. With the exception of Italy, we find no systematic differences between large and small firms across countries. This is the case for both the sales and user cost elasticities and for the effect of cash flow. The point estimates of the differences in elasticities are non-systematically positive or negative and usually non-significant.

For Italy, the coefficient for small firms cash flow results significantly higher than that obtained for large firms. The fact that balance sheet conditions are more important for firms that are more probably exposed to problems of information asymmetries seems to confirm the existence of a broad credit channel in Italy. These results seem robust to different model specifications, such as the error correction model estimated in Gaiotti and Generale (2001).

We think however it would be too early to conclude that the broad credit channel is only operative in Italy. Clearly, more sophisticated sample splits might provide significant differences across firms belonging to different groups. The results in Table 5 do indicate that identifying the broad credit channel by only taking into account the size classification might be too much an oversimplification in most euro area countries. Size might not be a sufficient or even correct indicator for some countries of informational asymmetries that are the basis for broad credit channel effects.

Indeed, as already noted above the companion papers of this research project address the issue of heterogeneity across firms under many other different dimensions. For Germany, when firms' ratings are used as a proxy of financial constraints, it turns out that those with a lower rating are more sensitive to financial variables (von Kalckreuth, 2001). For France, firms belonging to the equipment goods sector, firms with a lower rating and firms with a high share of trade credit in the balance sheet are also more sensitive to cash flow (Chatelain and Tiomo, 2001). In addition, for France, the introduction of dummy variables which isolate firms more sensitive to cash flow has the effect of shifting back the user cost elasticity to its level obtained without cash flow, i.e. a significant value below -0.1. For Italy, firms with a high share of intangible assets over total assets, an indication of the extent of asymmetric information, respond more to variables that approximate their financial condition (Gaiotti and Generale, 2001). Moreover, results for other countries, that we do not analyze by means of a common specification, point to the presence of heterogeneity. For

Austria, the presence of a “hausbank” (main bank) significantly affects the transmission of monetary impulses. Valderrama (2001) finds that firms with tighter relationships with the main bank react less to cash flow and more to the user cost, than firms with less “intense” relationships. In Luxembourg younger firms seem more exposed to liquidity constraints, measured by means of various financial ratios (Lünemann and Mathä, 2001). For Belgium, Butzen, Fuss and Vermeulen (2001) document a high degree of heterogeneity in firms’ reaction to monetary policy depending on the sectors in which the firm operates.

7. User cost, cash flow, sales and monetary policy: a simulation exercise¹⁷

In this section, we first analyse the dynamics of the regression equation. We then perform a more complicated simulation exercise to determine the elasticity of investment w.r.t user cost, sales and cash flow. We finally determine the elasticity of investment w.r.t the market interest rate.

We use the point estimates of the coefficients as presented in Table 4. In the following, we present the short run time profile of the investment rate I/K in the presence of simple shocks to the explanatory variables (user cost growth, sales growth, CF/K) and compare these profiles over the four European countries.

Consider the following experiment. Imagine a firm for which user cost growth, sales growth, CF/K and the I/K ratio are all at their steady state path. Imagine next, one single shock at time t to user cost growth, e.g. user cost growth at time t is equal to its steady state path value+0.01, and that after time t user cost growth is again at its steady state path. What happens to the I/K rate at time t , $t+1$, etc, *assuming the paths of the other variables i.e. real sales growth and CF/K are held constant at their steady state path?* A similar experiment can be performed for real sales growth (holding again the other variables at their steady state), or for CF/K .

Note that one could object to this type of analysis on multiple grounds. First, user cost growth, sales growth and CF/K are all endogenous implying that shocks to one variable might have immediate or lagged effects on the other variables. Basically, the regression

equation is just 1 equation describing the I/K ratio. In reality, the behaviour of all relevant variables should be described with a multi-equation system. This is however out of the scope of this paper. Second, the regression equation contains the capital stock at both the left-hand side and right-hand side (I/K and CF/K). Since movements in I/K will ultimately move K, CF/K will also change (unless CF moves in the same amount of K). In this first exercise, we also abstract from this second objection (hence implicitly letting CF move at the same rate of K when holding CF/K constant.).

Given the above two objections, we still believe the experiment to be of value. First, the experiment provides a description of the dynamics of the equation concentrating on one variable at a time. Second, more complicated experiments in which shocks to certain variables coincide with (lagged) shocks to other variables are just linear combinations of the above simple experiments. E.g. if one considers a simultaneous shock to sales growth and CF/K then one can simply add the effects on I/K.

We consider two types of shocks for this experiment. We first consider a shock of 1 per cent (i.e the explanatory variable at time t has the value of its steady state+0.01). We next consider a shock which has a magnitude of one (“1”) standard deviation of the within firm variation of the variable. We find this last shock especially appealing because it represents a shock relative to the ‘normal’ variation present in the variable in our data. We indeed find that the within firm variation of user cost growth, sales growth and CF/K is much larger than 1 per cent and differs substantially across variables and across countries.

Tables 6.1-6.3 present the deviation of the I/K-ratio from its steady state path after those two types of shocks, adopting as a benchmark the specification presented in Table 4. Table 6.1 shows the change in I/K after both a 1 per cent (column 1) or 1 standard deviation shock (column 2) in user cost growth. Most of the effects are within the first two year. A 1 per cent increase in user cost growth has the largest effect in Spain and Germany. Misleadingly, the magnitude of the effect seems small. However, in the data, a 1 standard deviation change in the user cost growth rate is much larger than 1 per cent, it is 10.6 per cent in Germany, 26.1 per cent in Italy and 14.5 per cent in Spain. In the first period, a rise

¹⁷ We want to thank Daniele Terlizzese for a patient and productive discussion of the issues involved.

in the user cost growth in Germany of 1 standard deviation depresses the I/K ratio by 2.33 per cent. Given the level of average gross investment per unit of capital of 0.181 in Germany, this translates into a drop to 0.1577. Similar larger effects can be observed in Italy and Spain. The comparison between columns 1 and 2 reveal some interesting features of the data and the regression result. Understand the regression equation as a description of investment behaviour in the period of investigation. Then it is clear that this behaviour was determined by two distinct features. First, the magnitude of the reaction of the I/K ratio to shocks to the explanatory variables. Second, the magnitude of those shocks. For instance, whereas the contemporaneous reaction to identical user cost growth shocks in Italy was much smaller than in Germany (as evidenced in column 1), Italian user cost growth shocks were on average much larger than German ones. Combining those two features implies similar behaviour of the I/K ratio after 1 standard deviation shocks (as evidenced in column 2). Note that our regressions are conditional on the historical variation in the data. This historical variation could be quite different from future variation.

Table 6.1

CHANGE IN I/K AFTER A ONE TIME 1 PER CENT OR 1 STANDARD DEVIATION INCREASE IN THE USER COST GROWTH AT TIME T

	Germany		France		Italy		Spain	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
t	-0.22	-2.33	0.00	0.03	-0.08	-2.06	-0.28	-4.05
t+1	-0.18	-1.88	-0.03	-0.41	-0.07	-1.78	-0.05	-0.75
t+2	-0.08	-0.84	0.00	-0.01	-0.03	-0.90	0.03	0.40
t+3	-0.04	-0.38	0.00	0.02	-0.01	-0.39	0.02	0.31
A 1 standard deviation increase in the user cost growth is equal to 0.106 in Germany, 0.137 in France, 0.261 in Italy and 0.145 in Spain.								
Figures in columns (1) represent the deviation of I/K after a 1 per cent increase of the user cost growth.								
Figures in columns (2) represent the deviation of I/K after a 1 standard deviation increase.								

Table 6.2 shows the change in I/K after both a 1 per cent (column 1) or 1 standard deviation shock (column 2) in sales growth. Again the largest effects can be observed in the first two years. The sales effect is the largest in Germany. A 1 standard deviation increase in the growth rate of sales increases the I/K ratio by 2.26 per cent in the same year.

Table 6.3 shows the change in I/K after both a 1 per cent (column 1) or 1 standard deviation shock (column 2) in the CF/K ratio. The contemporaneous effects are quite large. They are the smallest in Germany. Investment in Italian and Spanish firms in particular seems to move quite strongly simultaneously with CF/K movements.

Table 6.2

**CHANGE IN I/K AFTER A ONE TIME 1 PER CENT OR 1 STANDARD
DEVIATION INCREASE IN SALES GROWTH AT TIME T**

	Germany		France		Italy		Spain	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
t	0.16	2.26	0.03	0.44	0.05	0.84	-0.04	-0.68
t+1	0.12	1.77	0.06	0.81	0.05	0.87	0.02	0.36
t+2	0.08	1.16	0.02	0.32	0.03	0.50	0.02	0.26
t+3	0.04	0.59	0.01	0.15	0.01	0.25	0.02	0.28
A 1 standard deviation increase in sales growth is equal 0.145 in Germany, 0.141 in France, 0.187 in Italy and 0.159 in Spain.								
Figures in columns (1) represent the deviation of I/K after a 1 per cent increase in sales growth.								
Figures in columns (2) represent the deviation of I/K after a 1 standard deviation increase.								

Table 6.3

**CHANGE IN I/K AFTER A ONE TIME 1 PER CENT OR 1 STANDARD
DEVIATION INCREASE IN CF/K AT TIME T**

	Germany		France		Italy		Spain	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
t	0.04	1.28	0.06	1.29	0.26	3.90	0.12	3.74
t+1	0.02	0.47	0.10	2.21	0.02	0.27	0.05	1.59
t+2	0.01	0.40	0.03	0.63	0.02	0.26	-0.01	-0.37
t+3	0.01	0.17	0.01	0.29	0.01	0.12	-0.01	-0.18
A 1 standard deviation increase in the user cost growth is equal to 0.305 in Germany, 0.231 in France, 0.153 in Italy and 0.309 in Spain.								
Figures in columns (1) represent the deviation of I/K after a 1 per cent increase in CF/K.								
Figures in columns (2) represent the deviation of I/K after a 1 standard deviation increase.								

The regression equation ‘explains’ the I/K ratio in terms of user cost growth, sales growth and the CF/K ratio. However, the reader might it more natural to think of the level of investment in terms of the level of user cost, sales or cash flow. After some algebra, the regression equation can also be used to calculate the elasticity of investment (I) w.r.t either the user cost, sales or cash flow. E.g. with the elasticity of investment w.r.t the user cost we

mean the percentage change of investment (i.e. I , not I/K) due to a ‘permanent’ 1 per cent change (from base path) in the user cost level. The wording ‘permanent’ is important here. In terms of our regression, a permanent change in the user cost level (from base path) corresponds to a one time 1 per cent change in the growth rate (from base path) of user costs. Since the regression is written in terms of the investment capital ratio and the CF/K ratio, calculating this elasticity is somewhat more involved. Appendix C provides details about the calculation.

Table 7.1-7.-3 provide the elasticity of investment w.r.t respectively user cost growth, sales growth and cash flow. A substantive elasticity of investment w.r.t its user cost is a necessary condition for an interest channel to be operative. As evidenced in Table 7.1, the elasticity of contemporaneous investment w.r.t the user cost is quite large in Germany (-1.21), Italy (-0.63) and Spain (-1.49). It is negligible in France (0.02), but becomes non-negligible in the year after (-0.24). The elasticity at time $t+1$ remains substantive in Germany, Italy and in Spain, but is smaller. Overall, Table 7.1 provides evidence of a strong and rapid reaction of investment to user cost changes.

Table 7.1

ELASTICITY OF INVESTMENT WITH RESPECT TO THE USER COST

	Germany	France	Italy	Spain
t	-1.21	0.02	-0.63	-1.49
t+1	-1.17	-0.24	-0.59	-0.48
t+2	-0.79	-0.03	-0.36	-0.05
t+3	-0.61	0.00	-0.21	-0.06

In Table 7.2, the elasticity of investment w.r.t. sales is presented. The contemporaneous elasticities are 0.86 for Germany, 0.25 for France, 0.36 for Italy and -0.23 for Spain. Surprisingly in Germany, Italy and Spain, investment seems to have a lower contemporaneous elasticity w.r.t. sales than w.r.t its user cost. Given the emphasis on the sales accelerator model and the general ignoring of user cost in the investment literature this is a provocative result. Although undeniably sales growth does have a positive effect on investment, one should not ignore user costs.

Table 7.2

ELASTICITY OF INVESTMENT WITH RESPECT TO SALES

	Germany	France	Italy	Spain
t	0.86	0.25	0.36	-0.23
t+1	0.82	0.50	0.40	0.09
t+2	0.69	0.25	0.27	0.08
t+3	0.54	0.15	0.17	0.10

Table 7.3 provides the elasticity of investment w.r.t cash flow. Due to the past CF/K ratios in the regression, the effect of a permanent increase in cash flow gradually evolves and accumulates over time. The picture that emerges is mixed. In Germany and France the elasticity is generally lower than the sales elasticity. In Italy and Spain it is generally higher.

Table 7.3

ELASTICITY OF INVESTMENT WITH RESPECT TO CF

	Germany	France	Italy	Spain
t	0.06	0.15	0.40	0.24
t+1	0.10	0.42	0.46	0.38
t+2	0.13	0.54	0.52	0.39
t+3	0.16	0.60	0.55	0.42

To understand the effect of monetary policy on investment Tables 7.1-7.3 are not sufficient. A relevant question is: ‘How do market interest rates affect user costs and cash flow in those four euro area countries?’¹⁸ Essentially, the interest channel or ‘cash flow channel’ works through two sequences. In the first sequence, the market interest rate has to change firm fundamentals (user cost, and cash flow). In the second sequence, these firm

¹⁸ Another relevant question is: ‘How do market interest rates affect sales?’ We do not attempt to answer that question. Interest rate shocks do not have a ‘mechanical’ effect on sales in the same way as interest rates shocks have on user cost and cash flow (interest rates are part of user costs, and interest payments are part of cash flow). Although interest rates can influence firm individual demand (e.g for investment goods or durable consumer goods producing firms), this demand effect is much more difficult to quantify. Trying to do this here would require a whole new paper.

fundamentals have an effect on investment with the elasticities as presented in Tables 7.1-7.3. Below we present some evidence on the first sequence and show how combined with the second sequence the channels of monetary policy are different across countries.

We first investigate the effect of market interest rate changes on the user cost. The first important fact that should be noted is that interest rates form a part of the user cost of capital. The importance or weight on this part depends on the importance of the other parts like depreciation and relative price changes. Since the user cost contains directly an interest rate in its definition, the elasticity of the user cost with respect to the interest rate can therefore be calculated directly. It is equal to:

$$\frac{\partial UC_{it}}{\partial i} * \frac{i}{UC_{it}} = \frac{AI_{it} \left(\frac{D_{it}}{D_{it} + E_{it}} \right) (1 - \tau_t) + (LD_{it}) \left(\frac{E_{it}}{D_{it} + E_{it}} \right)}{AI_{it} \left(\frac{D_{it}}{D_{it} + E_{it}} \right) (1 - \tau_t) + (LD_{it}) \left(\frac{E_{it}}{D_{it} + E_{it}} \right) - (1 - \delta_s) \frac{\Delta P_{st+1}^I}{P_{st}^I} + \delta_s}$$

The elasticity is simply the weight of the interest rate in the user cost definition. Hence, if depreciation or changes in relative prices are large, interest changes will have small effects on the user cost. Table 8 shows the relative importance of the interest rate in the user cost definition in the different countries for an average firm in the data set. It is relatively high in Spain and Italy, somewhat lower in France and lowest in Germany. Therefore, market interest rate changes will have larger effects on user cost in Italy and Spain than in France and Germany.

Table 8

IMPORTANT ELASTICITIES				
	Germany	France	Italy	Spain
(1) $\frac{\partial uc}{\partial i} * \frac{i}{uc}$	0.32	0.58	0.70	0.65
(2) $\frac{\partial CF}{\partial i} * \frac{i}{CF}$	-0.32	-0.28	-0.60	-0.47

We now consider the effect of a permanent 1 per cent change in the market interest rate through the user cost. Note that by this we mean e.g. a change in the interest rate from 5 per cent to 5.05 per cent, not from 5 per cent to 6 per cent. Table 8 shows us how much the

user cost will change permanently. So e.g. a 1 per cent permanent increase in the market interest rate leads to a user cost change of 0.32 per cent in Germany and 0.70 per cent in Italy. Combining this with the results of Table 7.1 renders us the dynamic effects on investment of a 1 per cent change in the market interest rate. The results are presented in Table 9.

We find relatively large effects in Germany, Italy and Spain. If one were to consider e.g. a 50 basis points increase of a market interest rate of 5 per cent to 5.50 per cent, one would have to multiply the numbers in Table 9 by 10. Such a policy experiment would lead to contemporaneous 3.9 per cent decrease in investment in Germany, 4.5 per cent in Italy, 9.8 per cent in Spain and no effect in France.

Table 9

ELASTICITY OF INVESTMENT WITH RESPECT TO THE MARKET INTEREST RATE THROUGH THE USER COST

	Germany	France	Italy	Spain
t	-0.39	0.01	-0.44	-0.97
t+1	-0.38	-0.14	-0.41	-0.31
t+2	-0.25	-0.02	-0.25	-0.04
t+3	-0.19	0.00	-0.15	-0.04

We also investigate the effect of a permanent change in the market interest rate on cash flow. Since interest payments are a flow, they decrease cash flow. When firms have higher interest payments to make, they have lower cash flow, *ceteris paribus*. The elasticity of cash flow with respect to the interest rate can also be calculated directly. It is equal to:

$$\frac{\partial CF_t}{\partial i_{t-1}} * \frac{i_{t-1}}{CF_t} = - \frac{(1-\tau)i_{i,t-1}D_{i,t-1}}{(1-\tau)(pY - Costs - i_{i,t-1}D_{i,t-1})}$$

The elasticity is equal to the inverse coverage ratio, i.e. interest payments over cash flow. The higher the inverse coverage ratio is, the higher will be the effect of interest payments on cash flow. Table 8 shows the elasticity of cash flow w.r.t to the market interest rate for the average firm in the samples. Italy and Spain display again higher values of this elasticity. Presumably this is due to high nominal interest rates for both countries during the years of investigation. Also, the term structure of debt of the firms has played a role. In Italy,

e.g. firms historically were financed with expensive short-term debt. In the future, given the unified interest rates, this might possibly change dramatically.

Table 10 presents the effect on the growth rate of the capital stock (or investment) of a transitory increase of 1 per cent of the interest rate through the effect on cash flow. The effects are in general relatively small in all countries. Consider again a 50 basis points increase of a market interest rate of 5 per cent to 5.50 per cent. Such a policy experiment would lead, after the first year, to a contemporaneous 0.2 per cent decrease in investment in Germany, 0.4 per cent in France, 2.4 per cent in Italy and 1.1 per cent in Spain.

Table 10

**ELASTICITY OF INVESTMENT WITH RESPECT TO THE MARKET
INTEREST RATE THROUGH CASH FLOW**

	Germany	France	Italy	Spain
t	-0.02	-0.04	-0.24	-0.11
t+1	-0.03	-0.12	-0.28	-0.18
t+2	-0.04	-0.15	-0.31	-0.18
t+3	-0.05	-0.17	-0.33	-0.20

8. Conclusion

This paper presents a comparable set of results on the monetary transmission channels on firm investment for the four largest countries of the euro area. We focus on two different channels that affect investment. The interest channel is operative when market interest fluctuations change the user cost of capital and hence investment. The broad credit channel is operative when market interest fluctuations change the balance sheet condition and the available cash flow of firms and through this investment. This paper is the first to provide an investigation of those two channels for the four largest economies of the euro area, based on results from a unique comparative study using large firm databases for each country, containing in total over 215,000 observations from 1985 to 1999. Its emphasis on using large micro-datasets makes this exercise an important complement to the vast macro-literature in which euro area countries are compared.

We find investment to be sensitive to user cost changes in all those four countries. Most of the effect of user cost changes is born within the first two years. This implies an operative interest channel in these euro area countries. We also find investment in all those

countries to be quite sensitive to sales and cash flow movements. We have further investigated whether significant differences exist between large and small firms in investment behaviour. We find that only in Italy smaller firms react more to cash flow movements. We argue that size might not be the right indicator in all countries to investigate the broad credit channel.

Appendix

A: Cleaning of the Samples:

All the samples were cleaned for outliers by removing percentiles from the variables used in the regression. More details can be found in von Kalckreuth (2001), Gaiotti and Generale (2001), Chatelain and Tiomo (2001).

B. Definition of the User cost variable

The user cost is constructed as,

$$UC = \frac{P_{st}^I}{P_{st}} \frac{(1 - itc_t - \tau_t z_s)}{(1 - \tau_t)} \left[AI_{it} \left(\frac{D_{it}}{D_{it} + E_{it}} \right) (1 - \tau_t) + (LD_i) \left(\frac{E_{it}}{D_{it} + E_{it}} \right) - (1 - \delta_s) \frac{\Delta P_{st+1}^I}{P_{st}^I} + \delta_s \right]$$

with

i: firm specific,

s: sector-specific,

t: time-varying,

P^I the investment price, P the value-added price,

τ the highest marginal corporate tax rate,

δ the depreciation rate,

AI: apparent interest rate, as interest payment over gross debt,

D: gross debt,

LD: long term debt rate,

E: book value of equity,

z : present value of depreciation allowances,

itc: investment tax credit.

C. Simulation

In this appendix we explain the calculation of the elasticity of investment w.r.t user cost, sales and cash flow. It is largely based on an idea developed and explained to us by Daniele Terlizzese.

Start from the estimated equation (where we have dropped the subscripts i):

$$\begin{aligned} \frac{I_t}{K_{t-1}} = & f + \omega_1 \frac{I_{t-1}}{K_{t-2}} + \omega_2 \frac{I_{t-2}}{K_{t-3}} + \omega_3 \frac{I_{t-3}}{K_{t-4}} + \theta_0 \Delta y_t + \theta_1 \Delta y_{t-1} + \theta_2 \Delta y_{t-2} + \theta_3 \Delta y_{t-3} + \\ & - \sigma_0 \Delta uc_t - \sigma_1 \Delta uc_{t-1} - \sigma_2 \Delta uc_{t-2} - \sigma_3 \Delta uc_{t-3} + \gamma_1 \frac{CF_t}{K_{t-1}} + \gamma_2 \frac{CF_{t-1}}{K_{t-2}} + \gamma_3 \frac{CF_{t-2}}{K_{t-3}} + \gamma_4 \frac{CF_{t-3}}{K_{t-4}} \\ & \text{time dummies} + \varepsilon_t \end{aligned}$$

and the capital accumulation equation:

$$K_t = (1 - \delta)K_{t-1} + I_t$$

Define $g_t \equiv \frac{K_t - K_{t-1}}{K_{t-1}} \equiv \frac{I_t}{K_{t-1}} - \delta$. Then we can rewrite the estimated equation by:

$$\begin{aligned} g_t = & f + \delta(\omega_1 + \omega_2 + \omega_3 - 1) + \omega_1 g_{t-1} + \omega_2 g_{t-2} + \omega_3 g_{t-3} + \theta_0 \Delta y_t + \theta_1 \Delta y_{t-1} + \theta_2 \Delta y_{t-2} + \theta_3 \Delta y_{t-3} + \\ & - \sigma_0 \Delta uc_t - \sigma_1 \Delta uc_{t-1} - \sigma_2 \Delta uc_{t-2} - \sigma_3 \Delta uc_{t-3} + \gamma_1 \frac{CF_t}{K_{t-1}} + \gamma_2 \frac{CF_{t-1}}{K_{t-2}} + \gamma_3 \frac{CF_{t-2}}{K_{t-3}} + \gamma_4 \frac{CF_{t-3}}{K_{t-4}} \\ & \text{time dummies} + \varepsilon_t \end{aligned}$$

$$\eta_{t+\tau} \equiv \frac{K_{t+\tau}^s - K_{t+\tau}}{K_{t+\tau}}$$

Consider now, starting in period t, a shock to Δuc_t of 1 per cent (0.01) and define g_t^s as the corresponding new value of g_t and define $K_{t+\tau}^s$ as the corresponding new value of $K_{t+\tau}$.

Define also $\eta_{t+\tau} \equiv \frac{K_{t+\tau}^s - K_{t+\tau}}{K_{t+\tau}}$. Some algebra shows that:

$$\eta_t = \frac{(g_t^s - g_t)}{(1 + g_t)} \text{ and } \eta_{t+\tau} = \eta_{t+\tau-1} \frac{(1 + g_{t+\tau}^s)}{(1 + g_{t+\tau})} + \frac{(g_{t+\tau}^s - g_{t+\tau})}{(1 + g_{t+\tau})}$$

It is immediately clear that : $g_t^s - g_t = -\sigma_0 * 0.01$. And after some algebra that:

$$g_{t+1}^s - g_{t+1} = \omega_1(g_t^s - g_t) - \sigma_1 * 0.01 - \gamma_1 \frac{CF_{t+1}}{K_t} \frac{\eta_t}{1 + \eta_t},$$

$$g_{t+2}^s - g_{t+2} = \omega_1(g_{t+1}^s - g_{t+1}) + \omega_2(g_t^s - g_t) - \sigma_2 * 0.01 - \gamma_1 \frac{CF_{t+2}}{K_{t+1}} \frac{\eta_{t+1}}{1 + \eta_{t+1}} - \gamma_2 \frac{CF_{t+1}}{K_t} \frac{\eta_t}{1 + \eta_t},$$

$$g_{t+3}^s - g_{t+3} = \omega_1(g_{t+2}^s - g_{t+2}) + \omega_2(g_{t+1}^s - g_{t+1}) + \omega_3(g_t^s - g_t) - \sigma_3 * 0.01 - \gamma_1 \frac{CF_{t+3}}{K_{t+2}} \frac{\eta_{t+2}}{1 + \eta_{t+2}} - \gamma_2 \frac{CF_{t+2}}{K_{t+1}} \frac{\eta_{t+1}}{1 + \eta_{t+1}} - \gamma_2 \frac{CF_{t+1}}{K_t} \frac{\eta_t}{1 + \eta_t},$$

and so onwards. Given a baseline path for CF/K and g, these equations allow to compute recursively all values of $\eta_{t+\tau}$. The elasticity of the capital stock is then given by $100 * \eta_{t+\tau}$.

The elasticity of investment can be easily recovered from that of capital. Define

$$\eta_{t+\tau}^I \equiv \frac{I_{t+\tau}^s - I_{t+\tau}}{I_{t+\tau}}, \text{ then we have using the capital accumulation equation,}$$

$$\eta_{t+\tau}^I = \eta_t \frac{K_t}{I_t} \text{ for period } t, \text{ and } \eta_{t+\tau}^I = \eta_{t+\tau} \frac{K_{t+\tau}}{I_{t+\tau}} - (1 - \delta) \eta_{t+\tau-1} \frac{K_{t+\tau-1}}{I_{t+\tau}}$$

To use these equations we need the baseline paths for $\frac{K_t}{I_t}$, and $\frac{K_{t+\tau-1}}{I_{t+\tau}}$ as well as the values

of the depreciation rate. To keep the calculations as simple as possible we assumed all these variables to be constant. To recover δ we used the following identity $\delta = \frac{I_t}{K_{t-1}} - g$

where g is assumed to be equal to the average growth of sales in each country; given δ we then have:

$$\frac{K_t}{I_t} = (1 - \mathbf{d}) \frac{K_{t-1}}{I_t} + 1.$$

We also used the baseline path of CF/K to be the sample average of this variable in each country.

Now consider a 1 per cent shock to cash flow; in period t we will have:

$$g_t^s - g_t = \mathbf{g}_1 \left(\frac{CF^s_t}{K_{t-1}} - \frac{CF_t}{K_{t-1}} \right) = 0.01 \mathbf{g}_1 c_t$$

where $c = \text{CF}/K$. In period t+1 it will be:

$$g_{t+1}^s - g_{t+1} = \mathbf{a}_1 (g_t^s - g_t) + \mathbf{g}_1 c_{t+1} \frac{(0.01 - \mathbf{h}_t)}{(1 + \mathbf{h}_t)} + 0.01 \mathbf{g}_2 c_t$$

$$g_{t+2}^s - g_{t+2} = \mathbf{a}_1 (g_{t+1}^s - g_{t+1}) + \mathbf{a}_2 (g_t^s - g_t) + \mathbf{g}_1 c_{t+2} \frac{(0.01 - \mathbf{h}_{t+1})}{(1 + \mathbf{h}_{t+1})} + \mathbf{g}_2 c_{t+1} \frac{(0.01 - \mathbf{h}_t)}{(1 + \mathbf{h}_t)} + 0.01 \mathbf{g}_3 c_t$$

and so on. We assume that c remains constant in the baseline.

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