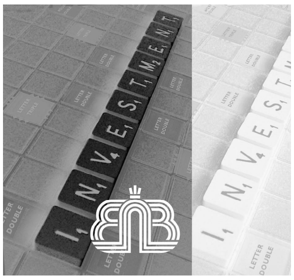

# NATIONAL BANK OF BELGIUM

## WORKING PAPERS - RESEARCH SERIES

# FINANCING CONSTRAINTS, FIXED CAPITAL AND R&D INVESTMENT DECISIONS OF BELGIAN FIRMS

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The views expressed in this paper are those of the author and do not necessarily reflect the views of the National Bank of Belgium.

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## Editorial

On May 27-28, 2002 the National Bank of Belgium hosted a Conference on *"New views on firms' investment and finance decisions"*. Papers presented at this conference are made available to a broader audience in the NBB Working Papers no 21 to 33.


## Abstract

This paper aims at assessing the relationship between the possible existence of financial constraints and the decisions of Belgian private firms as regards their investments in both capital and R&D investments over the last decade. The main system GMM estimates from the error-correction equations indicate that the sensitivity of both types of investments to cash flow variations are rather differentiated. On the whole, these effects are more important for investments in ordinary assets, young small-scale firms located in the Walloon region that are not part of a multinational. Firms that perform R&D on a permanent basis and that receive public funds to support these activities appear to be less cash constraints.



**JEL classification**: C23, E22, O31

**Keywords**: financial constraints, investments in capital and R&D, Belgian private companies, error-correction investment equations, system GMM panel data econometric models.

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## 1. INTRODUCTION

The existence of capital market imperfections such as asymmetric information between lenders and borrowers affects the firms' capital investment decisions and introduces possible financing constraints, i.e. credit rationing by lenders. Such constraints, actually, may even be more pronounced in the case of intangible investments such as Research and Development (R&D) since these activities are more risky by essence and typically provide less collateral to lenders than capital goods do. Based on a new sample of Belgian manufacturing firms active in R&D activities over the last decade, this study aims at assessing the impact of financing constraints on both capital and R&D investment decisions. In particular, the extent to which these constraints differ across firms is investigated from different perspectives, e.g. industry sectors, firms' size and age, regions, domestic firms versus subsidiaries of foreign groups, quoted versus unquoted firms on the stock market. The impact of public support to R&D is also taken into account allowing to gauge the interactions between public interventions and financing constraints.

The empirical analysis is based on a representative sample of about 11000 firms in the manufacturing sector over the period 1991-2000. The sources of this information are the bi-annual "Inventaire permanent du potentiel scientifique" surveys organised by the OSTC in collaboration with the regional authorities as well as the Belgian Central Balance Sheet Office gathering financial information, among which the financial structure that the firms operates. The econometric framework rests on two non-structural models based on an investment accelerator specification and an error-correction one for both types of investments[1]. Given the panel structure of the data set, these econometric specifications use system GMM estimators that allow one to deal with possibly correlated firms' specific unobserved fixed effects and weak exogeneity of the right-hand side variables[2].

The paper is organised as follows. Section 2 briefly reviews some theoretical aspects of the literature on firms' investment in R&D as well as the main empirical findings results of some selected previous studies. The construction of the data set, the different samples estimated and their main features are documented in Section 3. Section 4 presents the framework implemented for the econometric analysis. Section 5 discusses the main estimation results. Section 6 covers conclusions and suggestions for future work.

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[1] See Bond and Meghir (1994) and Harhoff (1998).

[2] See Arellano and Bond (1991, 1998).

## 2. REVIEW OF ISSUES AND EMPIRICAL FINDINGS

It is widely agreed that given the existence of asymmetric information between firms and lenders and other agency costs or moral hazard problems, investments in physical capital and more particularly in Research and Development must be primarily funded by internal resources of firms[3]. Investments in intangible such as R&D are riskier by essence than ordinary investments and R&D managers often have better information regarding the likelihood of the success of their R&D projects than outside investors or lenders. Furthermore, R&D provide less collateral to outsiders since they can not make accurate appraisals of the values associated with this type of investment[4]. As a result, R&D firms may encounter credit rationing by potential lenders and be constraint if they do not have enough internal resources to finance their R&D projects[5].

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[3] On the theoretical side, Stiglitz and Weiss (1981) and Myers and Majluf (1984) developed formal models of moral hazard problems in debt and equity markets. On the empirical side, since the pioneering work of Fazzari, Hubbard and Petersen (1988), many studies have examined the extent of liquidity constraints in the financing of physical investment. The agency costs between the shareholders and the R&D management, i.e. risk-adverse R&D managers will under-invest in risky R&D projects and managers tend to spend on activities that benefit them, can be avoided by leveraging the firm. However, the costs of the external funds to finance the R&D projects will be higher (Jensen and Meckling, 1976).

[4] The output of R&D activities consists of new products and processes, which are typically hard to use as collateral. According to Himmelberg and Petersen (1994) who refer to Ackerlof's (1970) classic example of a car market with asymmetric information and adverse selection problems, "*A potential buyer of a used car can, at relatively low cost, hire a mechanic to assess the car's true quality. In contrast, a potential investor might have to hire a team of scientists to make an accurate appraisal of the potential value of a firm's R&D projects.*"

[5] For Schumpeter (1942), the profits generated by ex-ante market power provide internal resources, which can be allocated to innovative activities without calling on external funds. Capital market imperfections can prevent firms to access to these external funds at least at the same costs than the internal resources. As stressed by Harhoff (1998), "*If providers of finance face greater uncertainty with respect to R&D than to investment projects, they will require a higher lemon's premium for the former type of investment. Hence, even without rationing behaviour on behalf of banks and other financial institutions, there will be a premium to be paid for obtaining external funding.*"

Besides the risks and uncertainties inherent to R&D activities, strategic considerations are another source of asymmetric information between the borrower and lender. Inventors may indeed be reluctant to fully or partly disclose to the outside world information as regards the contents and the objectives of their technological activities since this knowledge could leak out to rivals. This imperfect appropriability of the returns of innovative activities arises from the non-rival and partially excludable property of the knowledge good. Non rivalry means that the use of an innovation by an economic agent does not preclude others from using it, while partial excludability implies that the owner of an innovation can not impede other to benefit from it free of charge[6].

Another essential characteristics of R&D that makes it different from ordinary investment, is the presence of high adjustment costs and sunk costs[7]. Indeed the wages of the R&D personnel represent more than 50% of R&D expenditures and training, firing or re-hiring this highly specialised personnel embedded in the firm's intangible asset implies substantial costs[8]. Hence the levels of R&D expenditures associated to any innovation projects are unlikely to change substantially from years to years. This feature makes it difficult to assess empirically the relationship between possible liquidity constraints and expenses in R&D investments since the changes in the costs of this type of capital can be weak in the short term.

The reminder of this section reviews the main empirical findings of some selected studies that have investigated the relationship between internal finance and R&D[9]. There have been only a few studies examining financing constraints and R&D. The studies of Hall (1992), Hao and Jaffe (1993) and Himmelberg and Petersen (1994) are based on samples

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6 Conversely, firms will try to free ride as much as possible from the public stock of knowledge without having to finance it (Nelson, 1959).

7 As emphasised by Arrow (1962), given the time it takes to succeed, a typical R&D project involves important fixed set-up costs. This 'indivisible' aspect of R&D as an input views R&D activities mainly as a fixed factor of production.

8 In Belgium in 1995, the distribution of intramural R&D expenditures by type of costs was as follows: 58% for the R&D personnel, 9% for investment and 33% for the organisation of these activities (Cincera, 2002).

9 Schiantarelli (1996) and Hubbard (1998) provide recent reviews of the literature regarding the role of financial constraints on firms' investment activities on fixed capital. Mairesse, Mulkay and Hall (1999) discuss and compare alternative modelling specifications, i.e. simple accelerator and error correction specifications, as well as panel data econometric methodologies, i.e. traditional between and within firm estimation versus GMM estimators, for estimating firms investment equations.

of US firms. Harhoff (1998) uses German data. Bond, Harhoff and Van Reenen (1999) try to identify whether differences exist in the impact of financial variables on R&D between German and British firms. Hall, Mairesse, Brandstetter and Crépon (1999) and Mulkay, Hall and Mairesse (2001) do the same by presenting comparative results between French, Japanese and US firms.

In an older study, Kamien and Schwartz (1982) offer a survey of the empirical literature that examine the relationship between internal finance and R&D. These studies are based on cross sections of large firms or industries. In Scherer (1965), Mueller (1967) and Elliott (1971) no significant impact of liquidity constraints or profitability on R&D is found while an opposite result is reported in Grabowski (1968), Branch (1974) and Switzer (1984).

The study of Hall (1992) explores the differences in the relationship between investment, R&D and cash flow by taking into account firms specific unobserved fixed effects and simultaneity. The data consist of an unbalanced panel of 1247 US large publicly traded manufacturing firms from 1973 to 1987. The results point to a positive impact of cash flow on both types of investments, although more significant for physical investment, hence indicating the presence of liquidity constraints in addition to just future demand expectations. Another result of this analysis is the strong negative correlation between R&D and the level of leverage which suggests that debt is not the preferred source to finance R&D.

On the basis of a sample of 179 US small firms in high-tech industries, Himmelberg and Petersen (1994) estimate the relationship between R&D investment, physical capital and internal finance. The results support the schumpeterian hypothesis, which states that internal finance is an important determinant of R&D expenditures. As stressed by Arrow (1962), moral hazard problems hinder external financing of highly risky business activities such as innovation. The absence of collateral value for investment like R&D creates adverse incentives and selection problems in debt and equity markets. The authors estimate several econometric specifications, which allow them to take into account firm unobserved (fixed) effects (within firm estimates) and a differential response of R&D to the permanent and transitory components of cash flow (error-correction model). The latter specification is estimated by a GMM Instrumental Variables estimator and controls for the downward bias induced by high adjustment costs for R&D. The results indicate an important impact of internal finance on R&D investments.

The paper by Hall, Mairesse, Brandstetter and Crépon (1999) uses three panel of 953 French, 424 Japanese and 863 US companies in the high tech sector[10] for the period 1978-1989 to estimate the causal relationship between cash flow and sales and cash flow and R&D and investment by means of a panel data version of the vector auto regressive methodology. The results indicate that investment and R&D are sensitive to cash flow in the USA only and show evidence of a positive impact of both investment and R&D in predicting sales and cash flow for the US firms while the results are somewhat more mixed in France and Japan. In a nutshell, these results support the hypothesis of softer budget constraints on investment in Japan and continental Europe as compared to the USA.

Harhoff (1998) estimate a structural Euler equation and two non structural accelerator and error-correction specifications for a panel of 236 large manufacturing German firms over the period 1990-1994 in order to investigate the relationship between R&D, physical capital and financing constraints. The results show important sensitivity of R&D and investment to cash flow for the accelerator and error-correction equations, though significant results are found for small firms only for the latter specification. No conclusion for R&D can be drawn from the Euler equation model probably because the sample is too small for a precise estimation.

Bond, Harhoff and Van Reenen (1999) estimate the impact of cash flow on both physical and R&D investments using two panels of 263 British and 246 German firms in the high tech sector over the period 1985-1994. The econometric specification rests on a simple error-correction model which allow for different dynamics and costs of adjustment. The main drawback of such an approach is that the estimated dynamics combine effects from both capital adjustment and expectations-formation mechanisms. This issue is addressed by testing the extent to which cash flow is a proxy for liquidity constraints or for expectations of future demand. The results lead one to conclude that the differences between the two countries in the effects of cash flow cannot be simply explained by a greater role of this variable in predicting future sales.

[10] Chemicals, Pharmaceuticals, Electrical Machinery, Computing Equipment, Electronics and Scientific Instruments.

On the whole, the empirical findings indicate that financial constraints are significant in the UK economy while no effect is found for German firms which can be explained by the institutional differences across the financial systems in the two countries[11]. Furthermore cash flow has an impact on the decision to engage in R&D rather than on the levels of R&D expenditures. According to the authors, the important sunk costs associated with the establishment of a R&D program and the high adjustment costs linked to large fluctuations in the level of spending of existing research projects imply that "*financial constraints if they are significant at all, may manifest themselves more in the decision to set up R&D facilities, rather than in decisions about the year to year levels of spending in existing research programs*".

The paper by Mulkay, Hall and Mairesse (2001) estimates a dynamic specification of an error corrected investment model for both physical and R&D investments. Output as measured by sales and cash flows are used as predictors for investments. The investment and R&D behaviour of firms is compared for two samples of about 500 large manufacturing firms in France and in the USA over the period 1982-1993. The investment equations are estimated by means of least squares within firm and (first difference and system) GMM estimators. The former estimates are similar to the GMM ones, which are much more imprecise because of the weak power of the instruments in the GMM estimation. On the whole, the authors do not find any significant differences (for both countries) in the effects of output on physical and R&D investments. Yet, cash flow or profit appears to have a much higher impact on both types of investments in the USA than in France. Hence the impact of financial factors on investment and R&D do not differ within a country but rather across them. This finding indicates that it is the financial market environment specific to a country, which matters in explaining the impact of financial factors on investment.

## 3. DATASET CONSTRUCTION

The primary source used to construct the dataset consists in the annual accounts of (almost) all companies with activities in Belgium that are legally bound to file their annual accounts

[11] Quoting the authors, "*Shareownership in Germany tends to be more concentrated than in Britain, which may mitigate asymmetric information and conflicts of interest between shareholders and managers. Bank representation on supervisory boards and long-term repeated relationships between banks and firms in Germany may mitigate asymmetric information between lenders and borrowers. Large German firms are more likely to remain unquoted, hostile takeovers are extremely rare, and dividend payout ratios tend to be both lower and less rigid in German firms than in British firms.*"

at the Central Balance Sheet Office. The Belgian biannual R&D surveys, jointly organised by the federal Office for Scientific, Technical and Cultural Affairs (OSTC) and the regional authorities in charge of the S&T policy, are the second source which gathers information on the R&D activities carried out by Belgian firms in the private business sector. An important feature of these surveys is that the questionnaires are sent to the firms with 10 employees or more. Then, as a result of the regionalisation of S&T policy in the beginning of the nineties, no R&D survey have been organised for the years 1990 and 1991. Furthermore, the surveys since 1992 are based on a new developed methodology, which introduces a statistical break in the firms R&D series after 1990-1991 and before[12]. For these reasons and in order to have a homogenous sample in terms of size and coverage, the period retained for the present analysis covers the period 1991-2000 and the firms considered are those ones active in the private business sector and with more than 10 employees under the period investigated. Table 1 lists the variables that have been extracted from these two data sources and for the period 1991-2000[13].

All the flow variables are expressed in 1995 constant BEF and have been deflated with several prices indices. For the added value, sales and cash flow, output price indices at the sectoral level (NACEBEL two digits) have been used. For investment, the price index of the total gross fixed capital formation, also at the sectoral level, has been used. R&D expenditures have been deflated with the GDP price index[14].

**Table 1. List of the main variables**

| variable | definition |
|---|---|
| VAT | VAT number of the firm |
| ZIP | ZIP code of the firm |
| LS | Legal situation of the firm |
| TS | Type of scheme of the firm |
| DATE | Date of creation of the firm |
| IND | Firms' NACEBEL codes and description |
| QUOT | Quotation (yes=1, no=0) |
| I | Investment in tangible fixed assets |
| $C_0$ | Net book value of the firm fixed assets |
| CF | Cash flow |
| Y | Net added value |
| S | Turnover |
| L | Average number of employees |
| R | Total intra-mural R&D and development expenditures |
| PUBL | Part of intra mural R&D expenditures financed by Belgian public authorities (yes=1, no=0) |

Source: Belfirst DVD, version of November 2001 and Belgian national bi-annual R&D surveys.

12 See Capron et al. (1999) for more details.

13 See Appendix 1 for the exact definition.

14 The construction of these price indices is documented in Appendix 2.

The following variables have been constructed[15]:

C: Stock of firm's physical capital;
K: Stock of firm's R&D capital;
I/C: Investment-physical capital stock ratio;
CF/C: Cash flow-physical capital stock ratio;
R/K: R&D expenditures-R&D capital stock ratio.

Table 2 gives the size (in terms of the number of firms) of the initial data set and the different criteria retained for the construction of the raw data sample (before the trimming and merging procedures). As discussed before, only firms with at least 10 employees and more have been retained in the analysis. For the period 1998-2001, there are 15021 such firms in the Belgian economy. In terms of net added value, these firms account for about 30% of the Belgian GDP in 2000. When we impose this criterion for each year of the whole period the number of firms shrinks to 12080 units. Furthermore, only limited or private limited liability companies without any particular legal status[16] and operating in the private business sector have been selected. Finally imposing to have at least two years of information for the basic variables leads to a sample of 10841 firms or about 72% of the initial data set.

**Table 2. Size of the initial data set and criteria used for the sample construction**

| Criteria | # of firms | % of initial sample |
|---|---|---|
| Firms with 10 employees and more for each year of the period 1998-2001 | 15021 | 100% |
| Firms with 10 employees and more for each year of the whole period 1991-2001 | 12080 | 80.4% |
| Firms without any particular legal status | 11924 | 79.4% |
| Firms operating in the private business sectors (NACEBEL codes 01 to 74) | 11424 | 76.1% |
| Limited companies and private limited liability companies[a] | 11042 | 73.5% |
| At least one year of information for added value, cash-flow, investment and tangible fixed assets[b] | 10868 | 72.4% |

Notes: a) excluding co-operative companies, limited or general partnership companies, public organisations and economic interest group based in Belgium.
b) and strictly positive value for investment and added value.

[15] The details regarding the construction procedure are documented in Appendix 5.
[16] See Appendix 6 for more details as regards the different legal status.

**Table 3. Size of samples after trimming**

| | # of firms | # of obs. | Average # of years |
|---|---|---|---|
| **TRIMMING** | | | |
| All firms | | | |
| I/C | 10855 | 93570 | 8.62 |
| Y/C | 10828 | 93287 | 8.58 |
| CF/C | 10786 | 93556 | 8.67 |
| ΔI | 10778 | 78700 | 7.30 |
| ΔC | 10776 | 78932 | 7.32 |
| ΔCF | 10868 | 88435 | 8.14 |
| ΔY | 10841 | 88394 | 8.15 |
| ΔS | 8551 | 59160 | 6.92 |
| ΔL | 10675 | 67817 | 6.35 |
| Firms with R&D activities | | | |
| R | 1049 | 3304 | 3.15 |
| R/K | 1049 | 3245 | 3.09 |
| **MERGING (a)** | | | |
| All firms | | | |
| Sample 1: I/C, CF/C, ΔI, ΔCF, ΔY | 10201 | 59908 | 5.75 |
| Firms with R&D activities | | | |
| Sample 2: I/C, CF/C, ΔI, ΔCF, ΔY, R | 548 | 1849 | 3.37 |

In order to trim the variables for outliers, observations for which the following variables were below the lower centile or beyond the upper centile have been excluded: I/C, Y/C, CF/C, ΔI, ΔC, $\Delta C^0$, ΔCF, ΔY, ΔS, ΔL and R/K. Note that this procedure as been done on a yearly basis rather than on the whole period. For the R&D variables, since several consistency criteria and tests have already been performed to the raw survey-data used, the trimming procedure has been implemented only for the R&D-knowledge stock ratio[17]. Table 3 gives some information as regards the number of information available for each variable after the implementation of the cleaning procedure and Table 4 some descriptive statistics as regards the main variables.

[17] Among these tests, we can mention the ratio of R&D activities to the firm's turnover and employment, the equality between different components of these activities, e.g. product vs. process R&D, research vs. development, the costs components of R&D expenditures, to total R&D expenses or the annual growth rates of these variables. This cleaning procedure is documented in Capron et al. (1999).

**Table 4. Descriptive statistics on variables (after trimming)**

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|
| I/C | | | | | | | | | | |
| Median | .0212 | .0321 | .0453 | .0523 | .0589 | .0656 | .0704 | .0742 | .0556 | .0659 |
| Min | .0115 | .0114 | .0121 | .0123 | .0132 | .0132 | .0132 | .0137 | .0117 | .0124 |
| Max | .4944 | .8894 | 1.651 | 2.127 | 2.502 | 3.050 | 2.359 | 2.884 | 2.042 | 3.067 |
| Standard error | .0442 | .089 | .1545 | .1947 | .2345 | .2667 | .2383 | .2777 | .1993 | .2811 |
| CF/C | | | | | | | | | | |
| Median | .4628 | .3223 | .2426 | .2065 | .1792 | .1577 | .1507 | .1400 | .1703 | .1614 |
| Min | -1.214 | -1.003 | -1.073 | -.8001 | -.6839 | -.5678 | -.6041 | -.6341 | -1.130 | -.9607 |
| Max | 14.09 | 9.491 | 7.889 | 5.411 | 4.976 | 4.361 | 4.601 | 4.144 | 1.183 | 6.931 |
| Standard error | 1.053 | .7042 | .5308 | .4372 | .4007 | .3706 | .3601 | .3388 | .877 | .5938 |
| Δ log (I) | | | | | | | | | | |
| Median | | -.0841 | -.1395 | .0343 | .0187 | .0112 | .0237 | .0553 | .0442 | -.0293 |
| Min | | -.9745 | -.9788 | -.9750 | -.9781 | -.9763 | -.9730 | -.9762 | -.9671 | -.9746 |
| Max | | 25.99 | 29.28 | 4.53 | 36.99 | 35.85 | 36.72 | 39.56 | 54.46 | 39.87 |
| Standard error | | 2.862 | 3.029 | 3.970 | 3.652 | 3.550 | 3.793 | 3.953 | 4.617 | 3.733 |
| Δ log (CF) | | | | | | | | | | |
| Median | | -.0511 | -.0820 | -.0258 | -.0318 | -.0491 | .0091 | .0078 | -.0162 | -.0026 |
| Min | | -7.262 | -8.053 | -7.414 | -8.451 | -8.500 | -1.321 | -9.712 | -8.601 | -8.613 |
| Max | | 7.846 | 8.071 | 9.018 | 7.900 | 8.640 | 1.615 | 9.019 | 8.466 | 8.473 |
| Standard error | | 1.044 | 1.129 | 1.196 | 1.181 | 1.195 | 1.391 | 1.293 | 1.260 | 1.282 |
| Δ log (VA) | | | | | | | | | | |
| Median | | .0224 | -.0037 | .0146 | .0096 | -.0341 | .0233 | .0233 | .0197 | .03132 |
| Min | | -.4919 | -.4730 | -.4812 | -.4626 | -.5465 | -.4877 | -.5088 | -.5325 | -.5715 |
| Max | | 1.431 | 1.468 | 1.354 | 1.418 | 1.226 | 1.663 | 1.275 | 1.170 | 1.202 |
| Standard error | | .2129 | .2128 | .2027 | .2096 | .2091 | .2310 | .2096 | .2022 | .2121 |
| Δ log (S) | | | | | | | | | | |
| Median | | .0136 | -.0150 | .0197 | .0202 | .0022 | .0402 | .0272 | .0136 | .04956 |
| Min | | -.4968 | -.5189 | -.5216 | -.4938 | -.4864 | -.4570 | -.5333 | -.5242 | -.5580 |
| Max | | 1.822 | 1.398 | 1.337 | 1.444 | 1.298 | 1.486 | 1.380 | 1.141 | 1.231 |
| Standard error | | .2231 | .2110 | .2075 | .2103 | .2103 | .2170 | .2102 | .1990 | .2038 |
| L | | | | | | | | | | |
| Median | 28 | 28 | 28 | 28 | 28 | 27 | 27 | 28 | 29 | 29 |
| Min | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Max | 17966 | 25895 | 24092 | 16921 | 16605 | 16598 | 16238 | 16256 | 16063 | 15568 |
| Standard error | 477.9 | 511.3 | 474.3 | 388.5 | 386.3 | 363.0 | 38.1 | 403.3 | 401.3 | 396.5 |
| Δ log (L) | | | | | | | | | | |
| Median | | .0370 | -.0107 | .0156 | .0205 | -.0488 | .0222 | .0357 | .0357 | .0333 |
| Min | | -.3913 | -.4167 | -.4432 | -.3667 | -.4615 | -.3478 | -.3478 | -.3243 | -.3579 |
| Max | | 1.0421 | .9592 | .9130 | .8182 | .8182 | .7917 | .7297 | .5455 | .6087 |
| Standard error | | .1809 | .1708 | .1667 | .1581 | .1745 | .1505 | .1358 | .1241 | .1297 |
| Log (R)[a] | | | | | | | | | | |
| Median | | 4.216 | 4.130 | 4.192 | 4.241 | 4.287 | 4.244 | 4.261 | | |
| Standard error | | .9362 | .9123 | .8874 | .8565 | .7760 | .7825 | .7654 | | |

Note: a) the minimum and maximum values could not be reported because of confidentiality of data.

The next step consists in merging the main variables to be used in the empirical analysis. The objective is to set an unique data set that integrates the information for all variables for the same firms and years of observation. This operation is done on the basis of the VAT number of firms[18]. In order to estimate the different investment equations for both ordinary and R&D capital, two samples have been constructed. These samples jointly optimise the number of firms as well as the number of time periods.

Tables 5 and 6 gives an idea of the representativeness for the two samples constructed of the variables added value and intra-mural R&D expenditures with respect to the corresponding aggregates reported in the national accounts. It follows from these tables that the two samples are representative of 11.7 to 25.5% for added value and 31.8% to 50.6% for R&D over the period investigated.

**Table 5. Representativeness of Sample 1: Added value with respect to the national corresponding aggregate (in %) by industry sector**

| Industries[a] | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | # of firms |
|---|---|---|---|---|---|---|---|---|---|
| Agriculture | 2.5 | 2.6 | 2.8 | 2.7 | 2.8 | 2.1 | 2.3 | 2.3 | 87 |
| Energy product, water | 53.2 | 52.9 | 51.8 | 47.8 | 50.5 | 0.6 | 0.7 | 0.6 | 18 |
| Metal and non metallic product | 61.8 | 69.5 | 67.5 | 68.3 | 68.9 | 46.9 | 45.0 | 48.3 | 899 |
| Chemical products | 97.0 | 98.5 | 94.4 | 88.2 | 88.2 | 35.4 | 31.9 | 39.9 | 211 |
| Machinery and equipment | 66.7 | 76.2 | 74.7 | 74.0 | 77.2 | 35.5 | 34.6 | 34.4 | 449 |
| Transport equipment | 57.3 | 58.1 | 61.4 | 68.4 | 64.7 | 31.7 | 35.2 | 38.0 | 120 |
| Food | 56.3 | 61.2 | 64.3 | 59.4 | 57.3 | 19.2 | 18.9 | 23.7 | 488 |
| Textile | 45.7 | 50.8 | 57.0 | 56.4 | 60.9 | 27.6 | 28.4 | 35.4 | 475 |
| Paper | 45.1 | 49.9 | 49.8 | 52.2 | 54.8 | 25.8 | 26.5 | 27.9 | 364 |
| Rubber | 59.2 | 72.0 | 67.9 | 68.8 | 66.4 | 37.7 | 35.7 | 48.0 | 192 |
| Wood and other manufacturing | 37.9 | 42.9 | 43.0 | 42.5 | 40.3 | 23.4 | 21.6 | 22.2 | 392 |
| Construction | 28.7 | 30.8 | 30.2 | 30.3 | 31.3 | 17.4 | 17.5 | 18.2 | 1613 |
| Wholesale and retail trade | 26.7 | 30.1 | 31.7 | 32.1 | 32.0 | 11.8 | 12.9 | 13.5 | 2862 |
| Hotels et restaurants | 20.3 | 22.9 | 21.1 | 21.0 | 20.6 | 12.7 | 13.6 | 13.7 | 274 |
| Transports and communications | 17.7 | 20.4 | 21.2 | 18.5 | 18.8 | 13.3 | 15.9 | 15.9 | 916 |
| Financial intermediation | 2.4 | 2.6 | 2.7 | 2.8 | 3.1 | 1.6 | 1.9 | 2.2 | 76 |
| Real estate and other business services | 6.2 | 6.4 | 6.4 | 6.6 | 5.8 | 2.7 | 3.2 | 3.4 | 765 |
| Total | 22.9 | 25.1 | 25.3 | 25.0 | 25.5 | 11.4 | 11.7 | 12.9 | 10201 |

Note: a) see Appendix X for the full definition.
Source: Institute for National Accounts (2001) and own calculation.

**Table 6. Representativeness of sample 2: R&D expenditures (10^9 BEF of 1995) with respect to the national corresponding aggregate**

| | | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998p |
|---|---|---|---|---|---|---|---|---|
| 1 | Raw data set | 57.131 | 49.813 | 45.760 | 51.983 | 56.582 | 52.184 | 50.499 |
| 2 | Sample 2 | 47.483 | 40.185 | 39.888 | 44.114 | 43.983 | 40.471 | 37.426 |
| 3 | BERD[a] | 93.780 | 94.500 | 96.802 | 99.695 | 106.619 | 114.298 | 117.568 |
| 1 / 2 | % | 60.9 | 52.7 | 47.3 | 52.1 | 53.1 | 45.7 | 43.0 |
| 1 / 3 | % | 50.6 | 42.5 | 41.2 | 44.2 | 41.3 | 35.4 | 31.8 |

Note: a) BERD = Total intramural business enterprise R&D expenditures.
Source: Belgian and Office for Scientific, Technical and Cultural Affairs (2001) and own calculation.

[18] More details regarding these procedures can be found in Capron et al. (1999) and Cincera and Veugelers (2000).

# 4. ECONOMETRIC FRAMEWORK

This section aims at presenting the investment accelerator model and the error-correction equation as well as the econometric methodology to be implemented for estimating the relationship between cash flow, R&D and physical investments. The methodological framework is close to that in Harhoff (1998), Bond, Harhoff and Van Reenen (1999), Mairesse, Hall and Mulkay (1999) and Mulkay, Hall and Mairesse (2001). Following the neo-classical long run model (Jorgenson, 1963), the logarithm of the desired (or long run) stock of fixed capital is proportional to the logarithm of output and of the user cost of capital:

$$\log(C_{it}) = \alpha_t + \beta \log(Y_{it}) - \sigma \log(UCC_{it}) \tag{1}$$

This model can be derived by assuming a profit maximising firm with a CES production function with elasticity $\sigma$. Equation (1) taken in first difference leads to:

$$\frac{I_{it}}{C_{it-1}} = \delta + \beta \, \Delta\log(Y_{it}) - \sigma \log(UCC_{it}) \tag{2}$$

by applying the usual approximation $\Delta\log(C_{it}) \approx I_{it}/C_{it-1} - \delta$.

The user cost of capital, $UCC_{it} = \left(P_t^I/P_t\right)\left(r_t \, P_{t-1}^I/P_t^I + \delta_i - \Delta P_t^I/P_t^I\right)$, as noted by Mulkay, Hall and Mairesse (2001), is difficult to measure at the firm level given the absence (in general) of the output $P_t$ and investment $P_t^I$ prices at such a disaggregated level. This problem is in general addressed by assuming that the variations in the user costs can be proxied by time dummies and firms' specific fixed (over time) effects[19]. Following Fazzari, Hubbard and Petersen (1988), if we assume that investments of credit-constrained firms are more sensitive to the availability of internal finance, equation (2) can be augmented by cash flow effects to test for the presence of financial constraints:

$$\frac{I_{it}}{C_{it-1}} = \eta \frac{I_{it-1}}{C_{it-2}} + \beta_1 \Delta\log(Y_{it}) + \beta_2 \Delta\log(Y_{it-1}) + \beta_3 \frac{CF_{it}}{C_{it-1}} + \beta_4 \frac{CF_{it-1}}{C_{it-2}} + \alpha_i + \lambda_t + \varepsilon_{it} \tag{3}$$

A similar equation is obtained for the R&D investment:

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19 See however the recent study by Butzen, Fuss and Vermeulen (2001) for an application that estimates the user cost of capital.

$$\frac{R_{it}}{K_{it-1}} = \eta \frac{R_{it-1}}{K_{it-2}} + \beta_1 \Delta \log(Y_{it}) + \beta_2 \Delta \log(Y_{it-1}) + \beta_3 \frac{CF_{it}}{K_{it-1}} + \beta_4 \frac{CF_{it-1}}{K_{it-2}} + \alpha_i + \lambda_t + \varepsilon_{it} \qquad (4)$$

It should be noted that as claimed by Kaplan and Zingales (1997, 2000), the interpretation of the estimated coefficient associated to the cash flow ratio can be misleading since cash flow can be correlated with current profitability. In this case, cash flow will also proxying profit or demand expectations and this variable cannot be interpreted directly as evidence of financing constraints[20]. In this paper, we follow the view point of Himmelberg and Petersen (1994), which states that changes in output, i.e. $\Delta Y_{it}$ and $\Delta Y_{it-1}$ in equations (3) and (4), are better proxies for changes in demand than the cash flow variable and thus allow to control, even if imperfectly, for the expectations role played by this variable. Equation (3) and (4) can also be augmented with the Tobin's q to control for investment opportunities. As noted by Van Cayseele (2002), this approach is not well suited for Belgium which is characterised by an European financial system where a few firms are listed on the stock exchange and external finance comes primarily from bank loans. Another possibility is to consider the projections of future profits on past variables and use them as implicit proxies for the expectations of future profits (Abel and Blanchard, 1986) or implement a structural Euler equation model derived from the firm's intertemporal maximisation problem (Bond and Meghir, 1994). However, as pointed out by Butzen, Fuss and Vermeulen (2001) among others, this last approach, while more appropriate from a theoretical point of view, has often failed to produce significant and correctly signed adjustment costs parameters.

Following Bond and Meghir (1994) and Harhoff (1998), equation (3) and (4) can be rewritten in an error correction framework:

$$\frac{I_{it}}{C_{it-1}} = \eta \frac{I_{it-1}}{C_{it-2}} + \beta_1 \Delta \log(Y_{it}) + \beta_2 \Delta \log(Y_{it-1}) + \rho(\log(C_{it-2}) - \log(Y_{it-2})) + \beta_3 \frac{CF_{it}}{C_{it-1}} + \beta_4 \frac{CF_{it-1}}{C_{it-2}} + \alpha_i + \lambda_t + \varepsilon_{it} \qquad (5)$$

$$\frac{R_{it}}{K_{it-1}} = \eta \frac{R_{it-1}}{K_{it-2}} + \beta_1 \Delta \log(Y_{it}) + \beta_2 \Delta \log(Y_{it-1}) + \rho(\log(C_{it-2}) - \log(Y_{it-2})) + \beta_3 \frac{CF_{it}}{K_{it-1}} + \beta_4 \frac{CF_{it-1}}{K_{it-2}} + \alpha_i + \lambda_t + \varepsilon_{it} \qquad (6)$$

These equations nest equation (1), which represents their long run solution. These equations can be estimated in first differences in order to remove the firm specific unobserved effect, $\alpha_i$, which is assumed to be constant over the period under investigation,

[20] For Fazzari, Hubbard and Petersen (2000), however, the theoretical model of Kaplan and Zingales fails to capture the approach used in this literature and therefore does not provide a relevant critique.

and which may be correlated with other regressors. The ability of the R&D personnel to find new inventions is one example of such an unobserved effect specific to the firm[21]. These unobservables are likely to be 'transmitted' to the R&D decision since firms with higher technological opportunities or abilities of their scientists and engineers will generally invest more in research activities. Hence, we are in the presence of a (positive) correlation between these unobservables and the R&D which invalidates the inference which can be made from equation (5). Another solution to get ride of the fixed effect is to apply the so called within transformation by taking deviations from individual means.

While the within and first differences estimators take care of the biases arising from possible correlated effects, it should be noted however that these estimators could still be biased for three other possibly important reasons. The first source of bias rests in possible random measurement errors in the right hand side variables. These errors typically tend to be magnified when applying the first difference or within transformations (Griliches and Hausman, 1986). The two other sources of bias refer to the simultaneity between the contemporaneous regressors and the disturbances and the endogeneity of the contemporaneous regressors and the past disturbances. A solution to these three potential sources of biases consists in using an instrumental variable approach by choosing an appropriate set of lagged value of the regressors for the instruments. Such an approach can be implemented by means of a GMM framework such as the one developed by Arellano and Bond (1991) among others. If the original error term follow a white noise process, then values in levels of these variables lagged two or more periods will be admissible instruments.[22]. The validity of the instruments is generally verified by the classical Sargan test of the over-identifying restrictions[23].

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[21] R&D opportunity or managerial skills may also be mentioned. Quoting Salter (1969), "*Differences in the personal skill, effort, intelligence and co-operation of labour may alone lead to substantial inter-plant variations in productivity. Equally, if not more, important are variations in the efficiency of management which are not reflected in the managers' salaries; an efficiently managed firm employing outmoded capital equipment may achieve lower operating costs than a poorly managed firm using modern equipment. Other special advantages, such as favourable location, access to ancillary services, trade goodwill, ect., may also contribute to inter-plant differences in operating costs and productivity. Barriers to the diffusion of knowledge, especially the patent system, are also relevant in this context. Some plants may employ outmoded methods, not because replacement is unprofitable, but simply because patent restriction prevent the use of the best methods. Other restrictions, such as imperfect channels for the diffusion of technical knowledge, ignorance and inertia, may have the same effects.*"

[22] As noted by Bond et al. (1997), if the error term in levels is serially uncorrelated, then the error term in first difference has a moving average structure of order 1 (MA(1)) and only instruments lagged two periods or more will be valid. If the error term in levels has already a moving average structure, then longer lags will have to be considered.

[23] The DPD software developed by Arellano and Bond (1991) and (1998) proposes a number of tests statistics that can be used for testing the validity of various assumptions among which the serial correlation and the validity of the chosen set of instruments.

More recently Arellano and Bover (1995) and Blundell and Bond (1998) developed a system GMM estimator, which combines the instruments of the first difference equation with additional instruments of the untransformed equation in level. Given the higher number of instruments, the system GMM estimator can lead to dramatic improvements in terms of efficiency as compared to the first difference GMM estimator[24]. The validity of these additional instruments, which consist of past first difference values of the regressors, can again be tested through Difference Sargan over-identification tests.

## 5. EMPIRICAL FINDINGS

### *5.1. error correction models of investments in physical capital and R&D*

Table 7 exhibits four regression results as regards the physical capital error correction model: first difference, within, first difference GMM and system GMM estimates. For the GMM estimates, the test statistics do not suggest any problems with the choice of instruments and their time structure. The Sargan test is not statistically significant at the 5% level and the same holds for the second order correlation test. This last result is not confirmed for the first two models and as consequence the first difference OLS and within estimates are biased. For the first difference GMM estimates, the error correction term has the expected negative sign and is statistically significant at the 5% level. The coefficient of output lagged two periods is not significant. This suggests that there are constant returns to scale. Cash flow effects appear to have a positive and significant effect on investment (the long run effect is about .160 for the first difference GMM and .245 for the system GMM) and this indicates the presence of liquidity constraints[25].

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[24] More fundamentally, as shown by Blundell and Bond (1998), when the autoregressive parameter is high and the number of time periods is small, the first difference GMM estimator can be subject to serious finite sample biases as a result of the weak explanatory power of the instruments.

[25] The study of Butzen, Fuss and Vermeulen (2001) is based on a sample of about 30000 Belgian companies. The first difference GMM long run estimated effect of cash flow on investment reported in this study is also .160.

**Table 7. Error correction model for physical capital**

| Model[a] | WITHIN | F.D. OLS | F.D. GMM[b] | GMM SYS[b] |
|---|---|---|---|---|
| C | .24 (.006)* | -.26 (.005)* | .00 (.009) | .16 (.022)* |
| $I_{t-1}/C_{t-2}$ | -.12 (.006)* | -.36 (.006)* | .06 (.014)* | .06 (.011)* |
| $CF_t/C_{t-1}$ | .25 (.015)* | .25 (.014)* | .14 (.051)* | .22 (.040)* |
| $CF_{t-1}/C_{t-2}$ | .12 (.011)* | .19 (.010)* | .01 (.018) | .01 (.015) |
| $\Delta\log(Y_t)$ | .34 (.012)* | .87 (.020)* | -.17 (.092)* | -.11 (.067) |
| $\Delta\log(Y_{t-1})$ | .17 (.011)* | .60 (.021)* | -.13 (.092) | .03 (.024) |
| $\log(C_{t-2})- \log(Y_{t-2})$ | .43 (.010)* | 1.2 (.020)* | -.18 (.044)* | -.01 (.014) |
| $\log(Y_{t-2})$ | .13 (.012)* | .55 (.024)* | -.18 (.100) | -.01 (.025) |
| Wald test of joint signif. | 2239 [.000] | 6654 [.000] | 191 [.000] | 576 [.000] |
| Wald test time dummies | 2441 [.000] | 3189 [.000] | 14.4 [.044] | 99.7 [.000] |
| Wald test for CF | 432 [.000] | 506 [.000] | 22.4 [.000] | 53.7 [.000] |
| Sargan test | | | 109 [.725] | 183 [.058] |
| Test M1 | -27.5 [.000] | 22.9 [.000] | -27.1 [.000] | -28.5 [.000] |
| Test M2 | -10.5 [.000] | -7.2 [.000] | .47 [.640] | -.46 [.634] |
| # of obs. (firms) | 58880 (10049) | | | |

Notes:

a) Estimation performed using the DPD98 software (Arellano and Bond, 1998); all equations include time dummies; Heteroskedastic-consistent standard errors in bracket; P values in square brackets; M1 and M2: tests for first order and second order serial correlation in the first difference residuals.

b) b) Two-step estimates; instruments used: observations dated t-2, t-3, t-4 and t-5 for Xt (GMM F.D. and GMM SYS) and t-1 for □Xt (GMM SYS).

The results from the error correction specification for R&D are reported in Table 8. The first order serial correlation test invalidates the first difference OLS and to a lesser extent the first difference estimates. Conversely, the second order serial correlation test does not point do any misspecification for these models. The Sargan test for the additional instruments implied by the GMM system is only significant at the 10% level. The error correction term has the expected negative sign and the positive and significant coefficient associated with the changes in added value suggest positive expectations of future profitability to the extent that these variables are a proxy of firm's investment opportunities. The test statistic for the joint test of the cash flow effects is significant for the last three models. However the cash flow coefficients appear to be very small as compared to the investment equation. The system (First difference) GMM estimates indicate a long-term effect of cash-flow effects of .245 (.160) for investments against .007 (.005) for R&D[26]. Interestingly this smoother pattern of investment rates for R&D as compared to physical capital has already been brought to the fore in previous studies, e.g. Harhoff (1988), Bond, Harhoff and Van Reenen (1999), Mulkay, Hall and Mairesse (2001), or Audretsch and Weigand (1999). These authors explain this result by the presence of high adjustment costs for R&D, which makes responses to transitory movements in cash flow expensive.

26 As can be seen in Appendix 7, this result is not a consequence of the sample composition. Cash flow effects for the investment equation estimated on the R&D sample, i.e. sample 2, are still much larger and significant than the corresponding ones obtained for the R&D equation.

**Table 8. Error correction model for R&D capital**

| Model[a] | WITHIN | F.D. OLS | F.D. GMM[b] | GMM SYS[b] |
|---|---|---|---|---|
| C | -.078 (.0266)* | .078 (.0156)* | .000 (.0200) | .088 (.0646) |
| $R_{t-1}/K_{t-2}$ | -.517 (.1061)* | -.606 (.0465)* | .004 (.0617) | .025 (.0304) |
| $CF_t/K_{t-1}$ | .001 (.0019) | .001 (.0013) | .001 (.0004) | .001 (.0003)* |
| $CF_{t-1}/K_{t-2}$ | .004 (.0024) | .002 (.0012)* | .004 (.0004)* | .006 (.0003)* |
| $\Delta\log(Y_t)$ | .042 (.0327) | .012 (.0245) | .105 (.0272)* | .195 (.0119)* |
| $\Delta\log(Y_{t-1})$ | .037 (.0259) | .002 (.0206) | -.012 (.0179) | .000 (.0146) |
| $\log(K_{t-2})- \log(Y_{t-2})$ | -.855 (.1920)* | -.894 (.1559)* | -.322 (.0504)* | -.317 (.0231)* |
| $\log(Y_{t-2})$ | -.900 (.2395)* | -.937 (.1769)* | -.342 (.0603)* | -.337 (.0258)* |
| Wald test of joint signif. | 88.1 [.000] | 865 [.000] | 519 [.000] | 3162 [.000] |
| Wald test time dummies | 12.2 [.016] | 27.0 [.000] | 33.3 [.000] | 46.9 [.000] |
| Wald test for CF | 3.2 [.200] | 17.5 [.000] | 115 [.000] | 441 [.000] |
| Sargan test | | | 26.6 [.541] | 36.1 [.726] |
| Test M1 | 1.2 [.238] | 1.8 [.075] | -2.0 [.045] | -1.7 [.098] |
| Test M2 | 1.3 [.186] | 1.0 [.296] | 1.6 [.112] | 1.1 [.265] |
| # of obs. (firms) | 375 (160) | | | |

Notes:

a) Estimation performed using the DPD98 software (Arellano and Bond, 1998); all equations include time dummies; Heteroskedastic-consistent standard errors in bracket; P values in square brackets.
M1 and M2: tests for first order and second order serial correlation in the first difference residuals.

b) Two-step estimates; instruments used: observations dated t-2, t-3, t-4 and t-5 for $X_t$ (GMM F.D. and GMM SYS) and t-1 for $\Delta X_t$ (GMM SYS).

### 5.2. *Error correction models of R&D investment: permanent R&D and publicly funded R&D*

As noted by Bond, Harhoff and Van Reenen (1999), the presence of high adjustment costs associated with the establishment of R&D projects may imply that financial constraints, may they be present at all, are more likely to affect the decision to start new R&D activities rather than just their year-to-year level of spending. In order to examine this point, a interaction term has been added in the R&D investment equation, which picks-up the permanent versus occasional nature of the R&D activities carried out by the firms in the sample. The results are displayed in Table 9. It follows from the test statistics that only the GMM estimates can be interpreted. On the whole, the estimated coefficients do not change as compared to the previous table. The first difference GMM estimates of the R&D status interaction terms with cash flow are not significant. Yet, a negative coefficient is found for the system GMM model, which suggests that firms with permanent R&D activities are less subject to financial constraints than firms engaged in such activities on an occasional basis. This result confirms the findings of Bond, Harhoff and Van Reenen (1999). According to the authors, "*The R&D performing firms are a self selected group who choose to make long term commitments to R&D programmes, partly on the basis that they do not expect to be seriously affected by financial constraints – this is why cash-flow tends to matter less for these firms' investment decisions than for other companies*".

**Table 9. Error correction model for R&D: Permanent vs. occasional R&D**

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | -.078 (.0252)* | .077 (.0154)* | -.005 (.0229) | .079 (.1060) |
| $R_{t-1}/K_{t-2}$ | -.514 (.1005)* | -.606 (.0431)* | .039 (.0661) | .043 (.0383) |
| $CF_t/K_{t-1}$ | .001 (.0023) | -.001 (.0015) | .001 (.0004) | .001 (.0004) |
| $CF_t/K_{t-1}$*PERMA | .004 (.0094) | .000 (.0064) | -.012 (.0064) | -.014 (.0045)* |
| $CF_{t-1}/K_{t-2}$ | .004 (.0032) | .002 (.0015) | .005 (.0006)* | .006 (.0004)* |
| $CF_{t-1}/K_{t-2}$*PERMA | .002 (.0111) | .002 (.0071) | .001 (.0042) | .001 (.0034) |
| $\Delta\log(Y_t)$ | .038 (.0343) | .012 (.0262) | .152 (.0441)* | .237 (.0365)* |
| $\Delta\log(Y_{t-1})$ | .034 (.0285) | .001 (.0234) | -.023 (.0209) | -.012 (.0206) |
| $\log(K_{t-2})- \log(Y_{t-2})$ | -.895 (.2203)* | -.931 (.1588)* | -.305 (.0644)* | -.306 (.0352)* |
| $\log(Y_{t-2})$ | -.848 (.1704)* | -.889 (.1398)* | -.298 (.0538)* | -.291 (.0319)* |
| Wald test of joint signif. | 6714 [.000] | 2320 [.000] | 786.6 [.000] | 24154 [.000] |
| Wald test time dummies | 15.8 [.003] | 28.0 [.000] | 32.9 [.000] | 35.5 [.000] |
| Wald test for CF | 8.7 [.013] | 50.4 [.000] | 11.8 [.003] | 218 [.000] |
| Sargan test | | | 24.9 [.527] | 30.3 [.810] |
| Test M1 | 1.2 [.222] | 1.8 [.069] | -2.1 [.033] | -1.5 [.122] |
| Test M2 | 1.3 [.182] | 1.1 [.286] | 1.5 [.124] | 1.1 [.262] |
| # of obs. (firms) | 375 (160) | | | |

Notes:

a) Estimation performed using the DPD98 software (Arellano and Bond, 1998); all equations include time dummies; Heteroskedastic-consistent standard errors in bracket; P values in square brackets.
M1 and M2: tests for first order and second order serial correlation in the first difference residuals.

b) Two-step estimates; instruments used: observations dated t-2, t-3, t-4 and t-5 for $X_t$ (GMM F.D. and GMM SYS) and t-1 for $\Delta X_t$ (GMM SYS).

As discussed before, R&D activities are inherently risky and this leads firms to invest to little in this activity. Moreover, since firms cannot fully appropriate the benefits of the research activities undertaken, the incentives to engage in R&D are reduced and this creates a gap between the socially desirable level of R&D and the private one[27]. This market failure has been acknowledged since a long time (Arrow, 1962) and justifies the public intervention to support R&D and reduce this underinvestment problem. Given the costs of external finance are higher for R&D as compared to ordinary investments, it is also worth examining to what extent the provision of public funds can affect the possible financing constraints faced by the firms[28]. The results of this investigation are shown in Table 10.

**Table 10. Error correction model for R&D: Impact of publicly funded R&D**

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | -.076 (.0154)* | .073 (.0153)* | -.009 (.0197) | .067 (.0904) |
| $R_{t-1}/K_{t-2}$ | -.516 (.0315)* | -.605 (.0470)* | .010 (.0601) | .021 (.0376) |
| $CF_t/K_{t-1}$ | .001 (.0027) | -.001 (.0014) | .000 (.0006) | .001 (.0004)* |
| $CF_t/K_{t-1}$*PUBL | .004 (.0175) | .008 (.0035)* | .060 (.0386) | .096 (.0353)* |
| $CF_{t-1}/K_{t-2}$ | .004 (.0025) | .002 (.0012)* | .004 (.0004)* | .005 (.0003)* |
| $CF_{t-1}/K_{t-2}$*PUBL | -.002 (.0203) | -.003 (.0074) | -.013 (.0189) | -.044 (.0185)* |
| $\Delta\log(Y_t)$ | .041 (.0353) | .009 (.0250) | .036 (.0373) | .120 (.0362)* |
| $\Delta\log(Y_{t-1})$ | .037 (.0396) | .002 (.0209) | .005 (.0182) | -.004 (.0195) |
| $\log(K_{t-2})- \log(Y_{t-2})$ | -.900 (.0511)* | -.939 (.1776)* | -.341 (.0581)* | -.353 (.0345)* |
| $\log(Y_{t-2})$ | -.855 (.0380)* | -.895 (.1557)* | -.322 (.0495)* | -.310 (.0278)* |
| PUBL | .011 (.0287) | .022 (.0132) | -.001 (.0189) | -.033 (.0151)* |
| Wald test of joint signif. | 822 [.000] | 864 [.000] | 754 [.000] | 27992 [.000] |
| Wald test time dummies | 53.4 [.000] | 24.4 [.000] | 29.8 [.000] | 44.4 [.000] |
| Wald test for CF | 2.9 [.240] | 16.4 [.000] | .94 [.623] | 252 [.000] |
| Sargan test | | | 23.2 [.805] | 29.1 [.786] |
| Test M1 | 3.0 [.003] | 1.8 [.075] | -2.2 [.025] | -2.0 [.051] |
| Test M2 | 1.1 [.256] | 1.1 [.282] | 1.8 [.075] | 1.4 [.171] |
| # of obs. (firms) | 375 (160) | | | |

Notes:

a) Estimation performed using the DPD98 software (Arellano and Bond, 1998); all equations include time dummies; Heteroskedastic-consistent standard errors in bracket; P values in square brackets.
M1 and M2: tests for first order and second order serial correlation in the first difference residuals.

b) Two-step estimates; instruments used: observations dated t-2, t-3, t-4 and t-5 for $X_t$ (GMM F.D. and GMM SYS) and t-1 for $\Delta X_t$ (GMM SYS).

[27] The imperfect appropriability of the innovation's benefits generates externalities or knowledge spillovers that can occur via different channels, e.g. imitation, reverse engineering, R&D personnel mobility or transfers of technology. Cincera and van Pottelsberghe (2001) provide a recent review on international spillovers. The impacts of R&D spillovers on the productivity performance of large companies inside the Triad is examined in Capron and Cincera (1998).

[28] See Capron, Cincera and Dumont (1999) for a description of the different policies and instruments used in the field of S&T activities by the Belgian federal and regional authorities. Another instrument is Venture Capital. The contribution of Manigart, Baeyens and Verschueren (2002) examine the role of these external resources in financing young unquoted Belgian companies.

The estimates associated with the current and one year lagged value of the cash flow R&D stock ratio are not statistically different from the ones reported in the basic R&D error correction equation. The contemporaneous effect of the interaction term between this variable and the dummy variable PUBL, which reflects that parts of the firm's intra mural R&D expenditures have been financed by Belgian public authorities, is negative and significantly different from zero while an opposite result is found for the one year lagged coefficient. The more important magnitude of the coefficient associated with the one year lagged cash flow variable suggests that financial constraints are less binding for firms that receive public funds. This result is not surprising since a large share (more than 80%) of the public funds consists of subsidies for all R&D costs related to basic research performed by firms or by universities and research centres in collaboration with firms as well as reimbursable loans for research activities of a more applied nature.

### *5.3. Physical investment error correction models: additional results*

The results of the error correction equations presented so far point to important sensitivities of physical investment to cash flow effects hence indicating the presence of liquidity constraints. This appears to be also the case for R&D though the cash flow dependency is much weaker[29]. This section presents additional results that shed further light on the differences between financial constraints for investments in tangible assets of firms belonging to different groups. More precisely, the extent to which these constraints differ across firms is investigated from different perspectives, e.g. size of firms, domestic firms versus subsidiaries of foreign groups, listed versus unquoted firms on the stock market, age of the firms, their regions and industry sectors. The full results are displayed in Appendix 9 to 14 and the main conclusions as regards the effects of cash flow are summarised hereafter.

Several studies have shown the central role played by firms' size in explaining the sensitivity of capital investment to cash flow variations[30]. Small firms are more dependent upon internal resources since the loan rates charged by commercial banks tend to be higher[31]. Conversely larger firms can finance capital expenditures from internal resources, issuance of equity or debt. In a similar vein, liquidity constraints should be less important for firms listed on the stock market. The long run effect of cash flow on physical investment reported in Appendix 9 corroborate these arguments. While the long term cash

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[29] As can be seen from tables in Appendix 8, all these conclusions remain valid when an investment accelerator specification is used.

[30] See Schiantarelli (1996) for a survey of the empirical literature on this subject.

[31] See for example Stoll (1984) for the US credit market.

flow coefficients are not statistically different for medium and large firms, i.e. firms with more than 25 and 200 employees respectively, they appear to be considerably smaller than the corresponding one for small firms (system GMM estimates of .116, .138 and .344 for large, medium and small firms respectively)[32]. Furthermore, the possibilities of issuing new equity for firms quoted on the stock market should alleviate their financing constraints. The results shown in Appendix 10 support this hypothesis. Indeed the long run cash flow coefficient of .106 is relatively smaller for quoted companies than for the other firms (estimated parameter of .232).

As discussed before, the existence of asymmetric information problems between lenders and borrowers tend to increase the likelihood of credit rationing and the impact of liquidity constraints on the firm's investment behavior. Such informational asymmetries are higher in global capital markets and multinational enterprises are typically viewed as a means to provide alternative investment opportunities to shareholders that are constrained by restrictions on international capital markets[33]. The availability of financial resources from the mother company should alleviated the liquidity constraints faced by their subsidiaries. The findings in Appendix 11 are consistent with these predictions. Long run cash flow effects are higher for the domestic firms (estimated coefficient of .242) than for firms that are part of a foreign group (estimated coefficient of .139). As regards the age of the firm, as noted by Harhoff (1998), young firms are likely to have more limited access to external finance[34]. These firms have less collateral in terms of existing assets and lenders may have less information to distinguish between good and bad managers or investment opportunities. Here also the results reported in Appendix 12 confirm these arguments. The long run cash flow measure is about .450 for the younger firms, i.e. firms created less than 10 years ago, against .175 for the ones that are between 10 and 20 years old. However, these effects appear to be more important for the oldest firms in the sample (long run cash flow effect of .258). These firms belong more to the manufacturing sector, which is more capital intensive than the services industry.

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[32] These results are in line with the findings reported in Butzen, Fuss and Vermeulen (2001). The authors report a cash flow sensitivity that is about 3.5 times smaller for large firms as compared to small ones.

[33] Quoting Kogut (1983), "*The primary advantage of the multinational firm, as differentiated from a national corporation, lies in the flexibility to transfer resources across borders through a globally maximising network*".

[34] See also the discussion in Manigart, Baeyens and Verschueren (2002).

**Table 11. Long run cash flow effects: Differences across industry sectors and regions**

| | LT effect of CF | Capital Intensity (%) | Ranking | Share of small firms (%) | Ranking |
|---|---|---|---|---|---|
| Industry sector | | | | | |
| 16 Financial services | .100 | .24 | 1 | .18 | 5 |
| 3 Metal | .118 | .51 | 9 | .23 | 10 |
| 17 Other services | .152 | .24 | 2 | .22 | 9 |
| 15 Transport and communication | .214 | .64 | 13 | .30 | 12 |
| 13 Retail and wholesale | .226 | .42 | 7 | .40 | 15 |
| 10 Rubber | .250 | .76 | 14 | .18 | 6 |
| 9 Paper | .264 | .56 | 10 | .22 | 8 |
| 5 Electrical machinery | .270 | .37 | 5 | .15 | 2 |
| 11 Other manufacturing | .304 | .43 | 8 | .27 | 11 |
| 12 Construction | .390 | .36 | 3 | .31 | 13 |
| 7 Food | .435 | .81 | 15 | .20 | 7 |
| 8 Textile | .478 | .41 | 6 | .16 | 4 |
| 4 Chemicals | .482 | .63 | 12 | .07 | 1 |
| 14 Hotels and restaurants | .523 | .59 | 11 | .38 | 14 |
| 6 Motor vehicles | .635 | .36 | 4 | .15 | 3 |
| 1 Agriculture | .773 | .84 | 16 | .47 | 16 |
| Belgian regions | | | | | |
| Brussels Capital | .143 | .29 | 1 | .23 | 1 |
| Flanders | .253 | .46 | 2 | .28 | 2 |
| Wallonia | .313 | .47 | 3 | .31 | 3 |

Sources: Appendix 13 and 14 and own calculations.

The last set of results examine the extent of differences in financing constraints and firms' investment behaviours across 16 industry sectors of the economy as well as between the three Belgian regions. Full results are presented in Appendix 13 and 14 and summarised in Table 11. The long run cash flow measures range between .100 for the sector of financial services to .773 for agriculture and .143 in the Brussels-Capital region to .313 in the Walloon region. It should be noted that the financial services sector is the only one for which the coefficients associated with cash flow effects are not statistically different from zero. Table 11 provides additional information as regards the capital intensity and the share of small firms by industry sector and region. The higher importance of services in the Belgian capital can explain the relative smaller capital intensity in this region and as a result the lower sensitivity of physical investment to cash flow variations. The higher share of large companies in this region is another explanation. For the breakdown by branch of activity, the size and the capital intensity provide a more clouded explanation of the differences observed in the cash flow effects.

## 6. CONCLUSION

Based on two newly constructed samples of Belgian private companies, this paper investigate the impact of financing constraints on both capital and R&D investment decisions over the last decade. R&D activities are more risky by essence and typically provide less collateral to lenders as compared to investments in capital goods. As a result financing constraints may even be more pronounced in the case of such intangible investments. However, given the existence of high adjustment costs and sunk costs associated with this kind of investment, firms will engage in R&D activities if they do not expect to be seriously affected by financial constraints. As such cash flow effects tend to matter less for these firms' investment decisions than for other companies. Moreover the provision of public support to R&D may also interfere with the firm's investment decision by alleviating liquidity constraints problems, may they be present at all.

The results based on two non structural investment accelerator and error correction equations have been performed by using the recently developed system GMM estimator which compared to the usual first difference GMM estimator produce in general more precise estimates and reduce the possible biases arising from the weak explanatory power of the instruments and high values of the autoregressive parameter. Traditional within and first difference panel data estimates are also reported. Although these models allow one to deal with correlated firms' specific and unobserved effects with the right hand side variables, they are not suited when these variables are weakly exogenous and contain random measurement errors.

The main empirical findings indicate a positive impact of cash flow effects in the firms' investment decisions. These effects appear to play a considerably more important role for investment in physical capital than for R&D investments. These conclusions confirm the results of the investment accelerator specifications and the findings of previous studies. Furthermore, firms that perform R&D on a permanent basis and that receive public funds are found to be less subject to liquidity constraints. As additional results, the importance of these constraints on the investment behaviour of firms of different groups have also been examined. On the whole, large firms, firms listed on the stock market, subsidiaries of foreign MNE's are less likely to experience liquidity constraints. Conversely younger and to some extent older firms appear to be more liquidity constrained. Finally the impacts of these constraints are rather differentiated according to the firm's industry sector and region.

As stressed before, cash flow effects can be correlated with firms' demand expectations and investment opportunities that are not captured by changes in output and as such this variable can not be interpreted as a direct measure of the presence of liquidity constraint in the firm's investment decision mechanisms. In order to get a clearer picture, it would be useful to try to disentangle between these two effects. One approach consists in adding proxies of investment opportunities such as the Tobin's q for instance. However, this method does not appear to be well suited for the Belgium economy given the few firms listed on the stock market[35]. Another approach rests in the estimation of forecasting equations to predict future sales with cash flow[36]. Finally, the Euler equations approach allows one to explicitly model the firm's investment behaviour but results based on this structural framework are generally weak and mitigated.

Another interesting extension of this work would be to investigate the interactions between the level of competition in the firms' product market, the level of outside finance and the level of managerial effort. The agency model of Aghion, Dewatripont and Rey (2000) adresses this question and leads to interesting predictions that could be tested empirically. Among these conclusions, we can mention the following ones. The incentives of the managers to work first decrease and then increase with the need for external finance, the relation between market size and market concentration is negative when the industry rely more on outside finance, firms that rely more on internal resources will invest more in response to a positive shock on demand and firms relying more on external finance will invest relatively more in tangible vs. intangible investments.

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35 As an alternative of Tobins' q, the method proposed by Abel and Blanchard (1986) is worth being mentioned.

36 This is what is done in Bond, Harhoff and Van Reenen (1999) who estimate a VAR specification and find that cash flow does not play any role in predicting future sales in the UK which is not the case in Germany. For the authors, however, these results do not alter their conclusion as regards the impact of liquidity constraints on investment: the differences between the two countries in the effects of cash flow cannot be simply explained by a greater role of this variable in predicting future sales.

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**APPENDIX 1**. Definition of variables

| | |
|---|---|
| **Investment** | Sales and disposals of tangible fixed assets (8179) + Revaluation surpluses of tangible fixed assets acquired from third parties (8229) - Cancelled depreciation & amounts written down of tangible fixed assets (8309) + Acquisitions of tangible & fixed assets (8169) |
| **Employees** | Average number of employees (A001) |
| ***Sales*** | *Turnover (70)* |
| **Cash flow** | (70/67+630) |
| **Netbook value** | Tangible fixed assets (2227) |
| **Net added value** | Net value added (70/74-60-61) – Operating subsidies & compensating amounts (740) |

**APPENDIX 2.** Construction of the price deflators for the added value and the total gross fixed capital formation

The adaptations of sources, methods of calculation and methodology following the introduction of the ESA[37] 1995 create a break in the series of the price indices for added value by industry sector (at the two digit level) and gross fixed capital formation[38]. The publication of long series concerning these aggregates recomputed on the basis of ESA 1995 not being yet available, they have been built by grouping together some industry sectors of the series ESA 79 and ESA 95 according to the table of conversion listed in Appendix 3. Once these series at constant price obtained, the annual growth rate of the series ESA 79 (1970-1995) and SEC 95 (1995-2000) have been performed for each sub-period. The two series of growth rates are joined by using those of SEC 95 as from the year 1996. The series in level are then performed by using the value of 2000 as a starting point and by retro-polating by means of the growth rates calculated previously. The new constructed series are reported in Appendix 4.

[37] ESA = European System of National and Regional Accounts.

[38] Among these changes, the classification of activities is modified, the added value is expressed at the basic prices, i.e. with the amount less invoiced the balance of the taxes and subsidies on products (ICN 1995).

**APPENDIX 3**. Concordance table between ESA 1979 and ESA 1995

| | ESA 79 (NACE Rev.3 1970) | | ESA 95 (NACEBEL) |
|---|---|---|---|
| 01 | Agricultural, forestry and fishery products | 01-02<br>05 | Agriculture, hunting and forestry<br>Fishing |
| 03<br>05<br>07<br>09<br>11 | Water<br>Electric power. Gas, steam and water<br>Other energy products | 10<br>11<br>12<br>23<br>40<br>41 | Mining of coal and lignite ; extraction of peat<br>Extraction of crude petroleum and natural gas;<br>Mining of uranium and thorium ores<br>Manufacture of coke, refined petroleum products and nuclear fuel<br>Electricity, gas, steam and hot water supply<br>Collection, purification and distribution of water |
| 13<br>15<br>19 | Ferrous and non-ferrous ores and metals<br>Non-metallic mineral products<br>Metal products except machinery and transport equipment | 13<br>14<br>26<br>27<br>28 | Mining of metal ores<br>Other mining and quarrying<br>Manufacture of other non-metallic mineral products<br>Manufacture of basic metals<br>Manufacture of fabricated metal products, except machinery |
| 17 | Chemical products | 24 | Manufacture of chemicals and chemical products |

**APPENDIX 3**. Concordance table between ESA 1979 and ESA 1995 (continued).

| | | | |
|---|---|---|---|
| 21<br>23<br>25 | Agricultural and industrial machinery<br>Office and data processing machines; precision and optical instruments<br>Electrical goods | 29<br>30<br>31<br>32<br>33 | Manufacture of machinery and equipment, not elsewhere classified<br>Manufacture of office, accounting and computing machinery<br>Manufacture of electrical machinery and apparatus, not elsewhere classified<br>Manufacture of radio, television and communication equipment<br>Manufacture of medical, precision and optical instruments, watches |
| 27<br>29 | 27 Motor vehicles<br>29 Other transport equipment | 34<br>35 | Manufacture of motor vehicles, trailers and semi-trailers<br>Manufacture of other transport equipment |
| 31<br>33<br>35<br>37<br>39 | Meat preparations and preserves, other products from slaughtered animals<br>Milk and dairy products<br>Other food products<br>Beverages<br>Tobacco products | 15<br>16 | Manufacture of food products and beverages<br>Manufacture of tobacco products |
| 41<br>43 | Textiles and clothing<br>Leathers, leather and skin goods, footwear | 17<br>18<br>19 | Manufacture of textiles<br>Manufacture of wearing apparel; dressing and dyeing of fur<br>Tanning and dressing of leather; manufacture of luggage, |
| 47 | Paper and printing products | 21<br>22 | Manufacture of paper and paper products<br>Publishing, printing and reproduction of recorded media |
| 49 | Rubber and plastic products | 25 | Manufacture of rubber and plastic products |
| 45<br>51 | Timber, wooden products and furniture<br>Other manufacturing products | 20<br>36 | Manufacture of wood and of products of wood and cork,<br>Manufacture of furniture; manufacturing, not elsewhere classified |
| 53 | Building and construction | 45 | Construction |
| 55<br>57 | 55 Recovery and repair services<br>57 Wholesale and retail trade | 37<br>50-52 | Recycling<br>wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods |
| 59 | Lodging and catering services | 55 | Hotels and restaurants |
| 61<br>63<br>65<br>67 | Inland transpon services<br>Maritime and air transport services<br>Auxiliary transpon services<br>Communication services | 60<br>61<br>62<br>63<br>64 | Transport, storage and communications |
| 69 | Services of credit and insurance institutions | 65-67 | Financial intermediation |
| 71<br>73<br>75<br>79 | Business services provided to enterprises<br>Services of renting of immovable goods<br>Market services of education and research<br>Recreational and cultural services, personal services, other market services n.e.c. | 70-74<br>90-93 | Real estate, renting and business activities<br>Other service activities |
| 77<br>89 | Market services of health<br>Non-market services of health provided by general government and private non-profit institutions | 85 | Health and social work |
| 81 | General public services | 75 | Public administration |
| 85 | Non-market services of education and research provided by general government and private non-profit institutions | 80 | Education |
| 93 | Domestic services and other non-market services nec | 95 | Domestic services |
| | Charged production of banking services; statistical adjustment | | Financial intermediation services (indirectly measured) (SIFIM) |
| | Total | | Total |

**APPENDIX 4**. Price deflators of value added and physical capital investment

| Price deflator of added value | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture, hunting and forestry, fishing | 1.4351 | 1.2541 | 1.1448 | 1.2075 | 1.0000 | 1.0579 | 1.0691 | .9822 | .8370 | .9326 |
| Extraction of crude petroleum and natural gas, manufacture of coke, refined petroleum products and nuclear fuel, electricity, gas, steam and hot water supply | .8798 | .9198 | .9616 | .9933 | 1.0000 | .9786 | .9918 | 1.0117 | .9453 | .9877 |
| Manufacture of other non-metallic mineral products, manufacture of basic metals | .8711 | .9332 | .9463 | .9713 | 1.0000 | .9956 | .9717 | 1.0100 | .9508 | .9940 |
| Manufacture of chemicals and chemical products | .9083 | .9049 | .8939 | .9240 | 1.0000 | .9726 | .9148 | .9124 | .9014 | .9030 |
| Manufacture of machinery and equipment, office, accounting and computing machinery, electrical machinery, radio, television and communication equipment, medical, precision and optical instruments | .8660 | .8861 | .9766 | .9851 | 1.0000 | .9933 | .9613 | .9626 | .9318 | .8428 |
| Manufacture of motor vehicles, trailers and semi-trailers, manufacture of other transport equipment | .8690 | .8841 | .9733 | .9857 | 1.0000 | .9280 | .8937 | .8613 | .8608 | .8691 |
| Manufacture of food products and beverages and tobacco products | .9161 | .9502 | .9610 | .9873 | 1.0000 | .9920 | 1.0688 | 1.0174 | 1.0828 | 1.1128 |
| Manufacture of textiles, wearing apparel, tanning and dressing of leather; manufacture of luggage | .9218 | .9319 | .9261 | .9718 | 1.0000 | .8949 | .8204 | .7836 | .8072 | .8617 |
| Manufacture of paper and paper products, publishing, printing and reproduction of recorded media | .9369 | .9387 | .9077 | .9144 | 1.0000 | 1.0342 | 1.0496 | 1.1015 | 1.1198 | 1.1672 |
| Manufacture of rubber and plastic products | 1.0065 | 1.0230 | .9859 | .9721 | 1.0000 | 1.0455 | 1.0101 | 1.0291 | 1.0828 | .9969 |
| Manufacture of wood, furniture; manufacturing, not elsewhere classified | .8970 | .9211 | .9474 | .9675 | 1.0000 | .9898 | .9776 | .9826 | 1.0112 | 1.0262 |
| Construction | .8973 | .9403 | .9554 | .9812 | 1.0000 | .9951 | 1.0021 | 1.0414 | 1.0949 | 1.0680 |
| Recycling, wholesale and retail trade; repair of motor vehicles and personal and household goods | .9169 | .9529 | .9789 | .9988 | 1.0000 | 1.0519 | 1.0793 | 1.1208 | 1.1811 | 1.2093 |
| Hotels and restaurants | .8358 | .9121 | .9501 | .9798 | 1.0000 | 1.0283 | 1.0511 | 1.0946 | 1.1669 | 1.2118 |
| Transport, storage and communications | .8946 | .9128 | .9398 | .9785 | 1.0000 | 1.0071 | 1.0587 | 1.0796 | 1.0373 | 1.0055 |
| Financial intermediation | .9894 | .9979 | .9833 | 1.0050 | 1.0000 | 1.0378 | .9667 | 1.0270 | 1.0368 | 1.0791 |
| Real estate, renting and business activities, other service activities | .8574 | .9022 | .9474 | .9779 | 1.0000 | 1.0198 | 1.0396 | 1.0528 | 1.0783 | 1.0970 |
| Health and social work | .7995 | .8459 | .9123 | .9506 | 1.0000 | 1.0419 | 1.0592 | 1.1132 | 1.1343 | 1.1452 |
| Total | .8921 | .9276 | .9647 | .9832 | 1.0000 | 1.0118 | 1.0253 | 1.0416 | 1.0543 | 1.0685 |

| Price deflator of investment in physical capital | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture, hunting and forestry, fishing | .3842 | .4330 | .4412 | .5002 | .5245 | .5521 | .5815 | .5996 | .6254 | .6399 |
| Extraction of crude petroleum and natural gas, manufacture of coke, refined petroleum products and nuclear fuel, electricity, gas, steam and hot water supply | .3534 | .3812 | .4028 | .4635 | .4998 | .5421 | .5789 | .5919 | .6231 | .6480 |
| Manufacture of other non-metallic mineral products, manufacture of basic metals | .4701 | .4940 | .5142 | .5829 | .6037 | .6271 | .6492 | .6575 | .6799 | .6981 |
| Manufacture of chemicals and chemical products | .4636 | .4849 | .5074 | .5738 | .5935 | .6218 | .6507 | .6697 | .6942 | .7047 |
| Manufacture of machinery and equipment, office, accounting and computing machinery, electrical machinery, radio, television and communication equipment, medical, precision and optical instruments | .4481 | .4725 | .5030 | .5730 | .5889 | .6180 | .6490 | .6644 | .6883 | .7019 |
| Manufacture of motor vehicles, trailers and semi-trailers, manufacture of other transport equipment | .4200 | .4372 | .4626 | .5303 | .5558 | .6033 | .6312 | .6590 | .6772 | .6931 |
| Manufacture of food products and beverages and tobacco products | .4435 | .4636 | .4886 | .5538 | .5706 | .6026 | .6282 | .6480 | .6709 | .6828 |
| Manufacture of textiles, wearing apparel, tanning and dressing of leather; manufacture of luggage | .4586 | .4787 | .5000 | .5670 | .5865 | .6194 | .6444 | .6624 | .6838 | .6949 |
| Manufacture of paper and paper products, publishing, printing and reproduction of recorded media | .4799 | .4981 | .5230 | .5938 | .5890 | .6292 | .6517 | .6665 | .6889 | .6992 |
| Manufacture of rubber and plastic products | .4570 | .4755 | .4950 | .5667 | .5868 | .6167 | .6486 | .6611 | .6859 | .6976 |
| Manufacture of wood, furniture; manufacturing, not elsewhere classified | .4169 | .4389 | .4595 | .5249 | .5476 | .5947 | .6118 | .6365 | .6622 | .6772 |
| Construction | .4395 | .4596 | .4746 | .5383 | .5564 | .5851 | .6107 | .6237 | .6470 | .6591 |
| Recycling, wholesale and retail trade; repair of motor vehicles and personal and household goods | .3639 | .3819 | .4023 | .4612 | .4926 | .5272 | .5588 | .5771 | .6032 | .6218 |
| Hotels and restaurants | .3270 | .3439 | .3719 | .4365 | .4761 | .5183 | .5552 | .5796 | .6143 | .6411 |
| Transport, storage and communications | .4414 | .4501 | .4762 | .5631 | .6129 | .6251 | .6590 | .6903 | .7236 | .6469 |
| Financial intermediation | .3286 | .3478 | .3762 | .4427 | .4903 | .5349 | .5699 | .5984 | .6308 | .6591 |
| Real estate, renting and business activities, other service activities | .2550 | .2670 | .2880 | .3469 | .4172 | .4581 | .4936 | .5223 | .5528 | .5977 |
| Health and social work | .2881 | .3016 | .3295 | .3787 | .4344 | .4756 | .4989 | .5167 | .5379 | .6152 |
| Total | .3346 | .3499 | .3719 | .4328 | .4819 | .5134 | .5425 | .5667 | .5951 | .6284 |

| | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture, hunting and forestry, fishing | .6384 | .6955 | .7646 | .7861 | .8167 | .8153 | .8200 | .8397 | .8807 | .9145 |
| Extraction of crude petroleum and natural gas, manufacture of coke, refined petroleum products and nuclear fuel, electricity, gas, steam and hot water supply | .6898 | .7338 | .7678 | .7983 | .8288 | .8279 | .8247 | .8433 | .8803 | .9032 |
| Manufacture of other non-metallic mineral products, manufacture of basic metals | .7252 | .7685 | .8039 | .8294 | .8512 | .8637 | .8614 | .8725 | .9028 | .9237 |
| Manufacture of chemicals and chemical products | .7244 | .7655 | .7981 | .8300 | .8508 | .8635 | .8621 | .8738 | .9037 | .9236 |
| Manufacture of machinery and equipment, office, accounting and computing machinery, electrical machinery, radio, television and communication equipment, medical, precision and optical instruments | .7223 | .7665 | .8019 | .8295 | .8495 | .8607 | .8590 | .8723 | .9012 | .9216 |
| Manufacture of motor vehicles, trailers and semi-trailers, manufacture of other transport equipment | .7247 | .7688 | .8050 | .8326 | .8497 | .8620 | .8610 | .8727 | .9014 | .9218 |
| Manufacture of food products and beverages and tobacco products | .7120 | .7546 | .7932 | .8179 | .8416 | .8539 | .8539 | .8648 | .8979 | .9191 |
| Manufacture of textiles, wearing apparel, tanning and dressing of leather; manufacture of luggage | .7171 | .7599 | .7994 | .8258 | .8478 | .8608 | .8592 | .8710 | .9011 | .9215 |
| Manufacture of paper and paper products, publishing, printing and reproduction of recorded media | .7256 | .7666 | .8035 | .8299 | .8481 | .8624 | .8604 | .8732 | .9024 | .9228 |
| Manufacture of rubber and plastic products | .7207 | .7679 | .8022 | .8257 | .8527 | .8615 | .8621 | .8712 | .9005 | .9209 |
| Manufacture of wood, furniture; manufacturing, not elsewhere classified | .7036 | .7483 | .7889 | .8191 | .8409 | .8516 | .8511 | .8650 | .8957 | .9184 |
| Construction | .6886 | .7270 | .7720 | .8034 | .8293 | .8431 | .8396 | .8580 | .8911 | .9172 |
| Recycling, wholesale and retail trade; repair of motor vehicles and personal and household goods | .6461 | .6937 | .7431 | .7795 | .8123 | .8221 | .8256 | .8442 | .8832 | .9120 |
| Hotels and restaurants | .6800 | .7291 | .7565 | .7886 | .8258 | .8229 | .8211 | .8382 | .8780 | .9023 |
| Transport, storage and communications | .6812 | .7378 | .7782 | .8067 | .8321 | .8377 | .8392 | .8583 | .8925 | .9185 |
| Financial intermediation | .6989 | .7489 | .7812 | .8106 | .8419 | .8474 | .8442 | .8591 | .8952 | .9168 |
| Real estate, renting and business activities, other service activities | .6530 | .6659 | .6840 | .7140 | .7491 | .7687 | .7963 | .8142 | .8542 | .8796 |
| Health and social work | .6723 | .7420 | .7618 | .7946 | .8259 | .8176 | .8135 | .8320 | .8720 | .8924 |
| Total | .6741 | .7176 | .7472 | .7771 | .8050 | .8142 | .8219 | .8387 | .8755 | .8996 |

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture, hunting and forestry, fishing | .9252 | .9331 | .9360 | .9842 | 1.0000 | 1.0165 | 1.0187 | 1.0213 | 1.0419 | 1.0597 |
| Extraction of crude petroleum and natural gas, manufacture of coke, refined petroleum products and nuclear fuel, electricity, gas, steam and hot water supply | .9209 | .9445 | .9581 | .9783 | 1.0000 | 1.0032 | 1.0123 | 1.0209 | 1.0547 | 1.1193 |
| Manufacture of other non-metallic mineral products, manufacture of basic metals | .9452 | .9637 | .9746 | .9838 | 1.0000 | 1.0046 | 1.0119 | 1.0064 | 1.0420 | 1.0800 |
| Manufacture of chemicals and chemical products | .9449 | .9634 | .9731 | .9841 | 1.0000 | 1.0053 | 1.0130 | 1.0156 | 1.0522 | 1.1025 |
| Manufacture of machinery and equipment, office, accounting and computing machinery, electrical machinery, radio, television and communication equipment, medical, precision and optical instruments | .9422 | .9614 | .9726 | .9837 | 1.0000 | 1.0058 | 1.0134 | 1.0205 | 1.0568 | 1.0689 |
| Manufacture of motor vehicles, trailers and semi-trailers, manufacture of other transport equipment | .9427 | .9603 | .9704 | .9834 | 1.0000 | 1.0023 | 1.0115 | 1.0178 | 1.0547 | 1.1019 |
| Manufacture of food products and beverages and tobacco products | .9400 | .9597 | .9704 | .9837 | 1.0000 | 1.0041 | 1.0119 | 1.0292 | 1.0531 | 1.0542 |
| Manufacture of textiles, wearing apparel, tanning and dressing of leather; manufacture of luggage | .9426 | .9614 | .9719 | .9847 | 1.0000 | 1.0086 | 1.0107 | .9934 | 1.0333 | 1.0766 |
| Manufacture of paper and paper products, publishing, printing and reproduction of recorded media | .9434 | .9620 | .9731 | .9834 | 1.0000 | 1.0044 | 1.0130 | .9988 | 1.0367 | 1.0834 |
| Manufacture of rubber and plastic products | .9417 | .9600 | .9710 | .9833 | 1.0000 | 1.0083 | 1.0135 | .9703 | 1.0216 | 1.0659 |
| Manufacture of wood, furniture; manufacturing, not elsewhere classified | .9405 | .9614 | .9725 | .9840 | 1.0000 | 1.0077 | 1.0140 | 1.0103 | 1.0446 | 1.0733 |
| Construction | .9423 | .9660 | .9740 | .9868 | 1.0000 | 1.0047 | 1.0116 | 1.0198 | 1.0570 | 1.0944 |
| Recycling, wholesale and retail trade; repair of motor vehicles and personal and household goods | .9369 | .9652 | .9780 | .9905 | 1.0000 | 1.0046 | 1.0126 | 1.0189 | 1.0453 | 1.1262 |
| Hotels and restaurants | .9192 | .9438 | .9609 | .9803 | 1.0000 | 1.0044 | 1.0073 | 1.0131 | 1.0519 | 1.0715 |
| Transport, storage and communications | .9420 | .9624 | .9686 | .9841 | 1.0000 | 1.0013 | 1.0148 | 1.0232 | 1.0543 | 1.1118 |
| Financial intermediation | .9363 | .9564 | .9693 | .9832 | 1.0000 | 1.0041 | 1.0117 | 1.0223 | 1.0355 | 1.0690 |
| Real estate, renting and business activities, other service activities | .8961 | .9314 | .9524 | .9797 | 1.0000 | 1.0198 | 1.0297 | 1.0362 | 1.0528 | 1.0843 |
| Health and social work | .9058 | .9355 | .9521 | .9811 | 1.0000 | 1.0039 | 1.0103 | 1.0175 | 1.0386 | 1.0961 |
| Total | .9188 | .9457 | .9612 | .9827 | 1.0000 | 1.0105 | 1.0195 | 1.0252 | 1.0495 | 1.0920 |

Source: Institute for National Accounts (2001) and own calculation.

**APPENDIX 5**. Data construction

- **Stock of firm's physical capital**

The net physical capital stock (in constant 1995 BEF) has been computed by applying a perpetual inventory method with a depreciation of 8 percent[39] per year for all years following the first year for which historic costs data are available:

$$C_{it} = (1-\delta)C_{it-1} + I_{it}$$

where:

$C_{it}$ = stock of physical capital for firm i at time t;
$I_{it}$ = tangible investments in fixed assets deflated by the total gross fixed capital formation deflator at the two digits industry level;
$\delta$ = rate of depreciation.

The starting value is based on the net book value of tangible fixed capital assets, $C_{i0}$, in the first observation within the sample period, adjusted for previous years inflation. This value is obtained by multiplying $C_{i0}$, by the ratio of the total gross fixed capital formation deflator at the two digits industry level in the current year by the one AA years ago, where AA is the estimated average age of each firm's physical capital stock. AA is computed as the difference between the year of the firm's creation, DATE, and the year for which the starting value, $C_{i0}$, is available, with a maximum of 16 years if we assume that the full depreciation of physical capital takes 16 years for accounting purposes.

- **Stock of firm's R&D capital**

The stock of R&D capital has also been built on the basis of the permanent inventory method originally proposed by Griliches (1979). Actually this method is the most commonly used for constructing the firm's knowledge capital. This method assumes that the current state of knowledge is a result of present and past R&D expenditures:

$$\begin{aligned} K_{it} &= (1-\delta)K_{it-1} + R_{it} \\ &= R_{it} + (1-\delta)R_{it-1} + (1-\delta)^2 R_{it-2} + \ldots) \\ &= \sum_{\tau=0}^{\infty} (1-\delta)^{\tau} R_{it-\tau} \end{aligned}$$

---

[39] This is the depreciation rate generally assumed in the previous studies.

where:

$K_{it}$ = knowledge capital or own R&D stock of firm i at time t;

$R_{it}$ = intra-mural Research and Development expenditures deflated by the GDP deflator;

$\delta$ = rate of depreciation.

This formulation raises at least three questions. First, we have very little idea about the magnitude of the depreciation rate (should it be constant across firms and time periods). Hence, it is not clear which value to retain. Second, since the available history of R&D is usually not very long, we need a way to construct the initial knowledge stock. Finally, constructing the knowledge stock as in the above equation supposes a particular distribution of the R&D effects over time. Regarding the value of the depreciation rate, Bosworth (1978) has estimated, on the basis of patent renewal data, a value ranging from .1 to .15. Indeed, most studies assume a depreciation rate of 15%. Moreover, several authors, e.g. Hall and Mairesse (1995), have experimented with different values of $\delta$ and report very small changes if not at all in the estimated effects of R&D capital[40]. The initial knowledge capital is constructed as above and by assuming a growth rate of presample R&D equal to g:

$$K_{i0} = R_{i0} \sum_{\tau=0}^{\infty} \frac{(1-\delta)^{\tau}}{(1-g)} = \frac{R_{i0}}{(g+\delta)}$$

Here also, a presample growth rate of 5% is usually assumed. As Hall and Mairesse (1995) point out, the precise choice of growth rate only affects the initial stock which in turn declines in importance as time passes.

***APPENDIX 6***. *Legal status of firms*

| | |
|---|---|
| Without any particular legal status | 11924 |
| Absorption by another company | 69 |
| Early dissolution – liquidation | 27 |
| Bankruptcy | 17 |
| Official approval of legal composition | 16 |
| Other incidents of solvability | 10 |
| Scission into several companies | 12 |
| Closing of a liquidation | 3 |
| Merger with another company to form a third one | 2 |
| TOTAL | 12080 |

40 This arises from the log-log functional form of the Cobb-Douglas function used in these studies. Indeed, the log of K varies as the log of R in the cross section when the depreciation rate and growth rate are roughly constant over time at the firm level. In that case, log $K_{it} \approx$ log $[R_{it}/(g+\delta)]$ = log $R_{it}$ - c where c = log $(g+\delta)$. This will not be true if ones does not take the log of K.

**APPENDIX 7**. Error correction model: physical capital and sample 2

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .10 (.0216)* | -.14 (.0211)* | -.07 (.0270)* | .36 (.1442)* |
| $I_{t-1}/C_{t-2}$ | -.35 (.0845)* | -.48 (.0696)* | -.27 (.0849)* | -.20 (.0468)* |
| $CF_t/C_{t-1}$ | .27 (.0658)* | .21 (.0540)* | .32 (.1288)* | .68 (.0889)* |
| $CF_{t-1}/C_{t-2}$ | .22 (.0587)* | .19 (.0651)* | .24 (.0577)* | .19 (.0540)* |
| $\Delta\log(Y_t)$ | .43 (.1165)* | .81 (.0899)* | .44 (.1436)* | -.17 (.0628)* |
| $\Delta\log(Y_{t-1})$ | .28 (.1131)* | .65 (.1012)* | .52 (.1880)* | -.11 (.0763) |
| $\log(C_{t-2})- \log(Y_{t-2})$ | .53 (.1101)* | .98 (.0905)* | .51 (.1526)* | .30 (.0827)* |
| $\log(Y_{t-2})$ | .29 (.1093)* | .62 (.1188)* | .57 (.2113)* | -.11 (.1010) |
| Wald test joint signif. | 48.8 [.000] | 164 [.000] | 45.6 [.000] | 956 [.000] |
| Wald test time dummies | 38.4 [.000] | 63.2 [.000] | 19.3 [.001] | 17.4 [.002] |
| Wald test for CF | 29.9 [.000] | 18.5 [.000] | 21.9 [.000] | 90.6 [.000] |
| Sargan test | | | 20.7 [.840] | 39.0 [.605] |
| Test M1 | -1.7 [.082] | 2.1 [.033] | -1.8 [.068] | -3.2 [.001] |
| Test M2 | -1.5 [.123] | .62 [.536] | -1.4 [.163] | -1.7 [.097] |
| # of obs. (firms) | 375 (160) | | | |

**APPENDIX 8**. Accelerator model for physical and R&D capital

## Accelerator model for investments in physical capital

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .01 (.0168) | -.01 (.0233) | .03 (.0228) | .13 (.0476)* |
| $I_{t-1}/C_{t-2}$ | -.25 (.0841)* | -.45 (.0857)* | -.17 (.1921) | -.31 (.1484)* |
| $CF_t/C_{t-1}$ | .20 (.0668)* | .22 (.0669)* | .55 (.1256)* | .42 (.1026)* |
| $CF_{t-1}/C_{t-2}$ | .15 (.0487)* | .16 (.0576)* | .18 (.0872)* | .17 (.0605)* |
| $\Delta\log(Y_t)$ | .03 (.0533) | .02 (.0521) | -.11 (.1265) | -.15 (.0837) |
| $\Delta\log(Y_{t-1})$ | -.02 (.0488) | -.01 (.0480) | -.07 (.0530) | .00 (.0306) |
| Wald test joint signif. | 34.1 [.000] | 51.5 [.000] | 72.1 [.000] | 131.6 [.000] |
| Wald test time dummies | 5.7 [.224] | 4.8 [.000] | 13.7 [.008] | 12.8 [.012] |
| Wald test for CF | 18.6 [.000] | 15.2 [.000] | 32.3 [.000] | 37.7 [.000] |
| Sargan test | | | 13.9 [.837] | 27.9 [.576] |
| Test M1 | -2.5 [.012] | -2.7 [.006] | -6.4 [.000] | -2.3 [.021] |
| Test M2 | -1.9 [.052] | -2.3 [.020] | -2.5 [.013] | -1.7 [.083] |
| # of obs. (firms) | 303 (143) | | | |

## Accelerator model for investments in R&D capital

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .08 (.0300)* | -.02 (.0158) | -.03 (.0265) | .12 (.0186)* |
| $R_{t-1}/K_{t-2}$ | -.22 (.0693)* | -.40 (.0416)* | .41 (.0343)* | .41 (.0100)* |
| $CF_t/K_{t-1}$ | .02 (.0081)* | .01 (.0059) | .00 (.0012) | .00 (.0003)* |
| $CF_{t-1}/K_{t-2}$ | .03 (.0127)* | .02 (.0082) | .01 (.0009)* | .01 (.0003)* |
| $\Delta\log(Y_t)$ | .08 (.0577) | .03 (.0277) | .13 (.1020) | .20 (.0286)* |
| $\Delta\log(Y_{t-1})$ | .04 (.0437) | .01 (.0278) | -.01 (.0293) | -.02 (.0141) |
| Wald test joint signif. | 13.8 [.017] | 129.5 [.000] | 211.6 [.000] | 18498 [.000] |
| Wald test time dummies | 16.9 [.002] | 17.5 [.000] | 40.2 [.008] | 57.8 [.012] |
| Wald test for CF | 5.6 [.062] | 3.9 [.142] | 41.0 [.000] | 530 [.000] |
| Sargan test | | | 21.9 [.344] | 35.0 [.881] |
| Test M1 | 1.0 [.312] | 1.2 [.215] | -1.3 [.204] | -1.4 [.174] |
| Test M2 | .32 [.789] | .84 [.426] | 1.1 [.253] | 1.2 [.249] |
| # of obs. (firms) | 375 (160) | | | |

Notes:

a) Estimation performed using the DPD98 software (Arellano and Bond, 1998); all equations include time dummies; Heteroskedastic-consistent standard errors in bracket; P values in square brackets.
M1 and M2: tests for first order and second order serial correlation in the first difference residuals.

b) Two-step estimates; instruments used: observations dated t-2, t-3, t-4 and t-5 for $X_t$ (GMM F.D. and GMM SYS) and t-1 for $\Delta X_t$ (GMM SYS).

**APPENDIX 9**. Physical investment error correction model by firm size

### small size firms

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .27 (.0100)* | -.27 (.0077)* | .00 (.0132) | .22 (.1146) |
| $I_{t-1}/C_{t-2}$ | -.13 (.0095)* | -.37 (.0086)* | .05 (.0184)* | .04 (.0159)* |
| $CF_t/C_{t-1}$ | .27 (.0275)* | .25 (.0241)* | .30 (.0500)* | .33 (.0428)* |
| $CF_{t-1}/C_{t-2}$ | .14 (.0181)* | .21 (.0158)* | .00 (.0186) | .00 (.0161) |
| $\Delta\log(Y_t)$ | .35 (.0200)* | .91 (.0252)* | -.10 (.0975) | -.13 (.0738) |
| $\Delta\log(Y_{t-1})$ | .15 (.0186)* | .61 (.0286)* | .04 (.1170) | .01 (.0297) |
| $\log(C_{t-2})$- $\log(Y_{t-2})$ | .48 (.0144)* | 1.2 (.0202)* | -.08 (.0536) | .00 (.0162) |
| $\log(Y_{t-2})$ | .12 (.0198)* | .56 (.0324)* | .03 (.1295) | -.02 (.0318) |
| Wald test of joint signif. | 1227 [.000] | 5183 [.000] | 132 [.000] | 301 [.000] |
| Wald test time dummies | 1331 [.000] | 2674 [.000] | 9.1 [.244] | 65.7 [.000] |
| Wald test for CF | 184 [.000] | 207 [.000] | 49.1 [.000] | 80.1 [.000] |
| Sargan test | | | 134 [.621] | 166 [.246] |
| Test M1 | -18.0 [.000] | 18.4 [.000] | -5.3 [.000] | -21.2 [.000] |
| Test M2 | -8.1 [.000] | -6.9 [.000] | -2.7 [.483] | -1.1 [.265] |
| # of obs. (firms) | 3133 (1039) | | | |

### medium size firms

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .22 (.0081)* | -.25 (.0082)* | -.02 (.0116) | -.07 (.1004) |
| $I_{t-1}/C_{t-2}$ | -.12 (.0079)* | -.34 (.0087)* | .06 (.0173)* | .06 (.0155)* |
| $CF_t/C_{t-1}$ | .25 (.0192)* | .27 (.0166)* | .14 (.0368)* | .13 (.0365)* |
| $CF_{t-1}/C_{t-2}$ | .12 (.0138)* | .19 (.0138)* | .00 (.0188) | .00 (.0177) |
| $\Delta\log(Y_t)$ | .33 (.0159)* | .83 (.0320)* | -.20 (.0839)* | -.07 (.0684) |
| $\Delta\log(Y_{t-1})$ | .17 (.0156)* | .57 (.0320)* | -.01 (.0830) | .06 (.0349) |
| $\log(C_{t-2})$- $\log(Y_{t-2})$ | .42 (.0147)* | 1.1 (.0357)* | -.04 (.0465) | .01 (.0171) |
| $\log(Y_{t-2})$ | .13 (.0167)* | .52 (.0361)* | -.05 (.0890) | .02 (.0364) |
| Wald test of joint signif. | 1026 [.000] | 2709 [.000] | 106 [.000] | 370 [.000] |
| Wald test time dummies | 1025 [.000] | 1156 [.000] | 27.0 [.000] | 93.3 [.000] |
| Wald test for CF | 224 [.000] | 309 [.000] | 26.1 [.000] | 25.9 [.000] |
| Sargan test | | | 117 [.915] | 158 [.402] |
| Test M1 | -19.5 [.000] | 13.4 [.000] | -19.1 [.000] | -19.5 [.000] |
| Test M2 | -7.0 [.000] | -4.6 [.000] | -.20 [.845] | -.01 [.992] |
| # of obs. (firms) | 23720 (5053) | | | |

### large size firms

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .19 (.0155)* | -.26 (.0131)* | -.07 (.0115)* | -.28 (.1099)* |
| $I_{t-1}/C_{t-2}$ | -.07 (.0243)* | -.35 (.0302)* | .04 (.0075)* | .05 (.0106)* |
| $CF_t/C_{t-1}$ | .13 (.0259)* | .12 (.0231)* | .09 (.0143)* | .09 (.0100)* |
| $CF_{t-1}/C_{t-2}$ | .07 (.0343) | .10 (.0235)* | .04 (.0058)* | .02 (.0044)* |
| $\Delta\log(Y_t)$ | .29 (.0463)* | .78 (.0784)* | .08 (.0228)* | .02 (.0215) |
| $\Delta\log(Y_{t-1})$ | .20 (.0394)* | .62 (.0687)* | .03 (.0133)* | .01 (.0146) |
| $\log(C_{t-2})$- $\log(Y_{t-2})$ | .31 (.0372)* | 1.0 (.0623)* | .14 (.0210)* | -.02 (.0118) |
| $\log(Y_{t-2})$ | .17 (.0449)* | .59 (.0665)* | -.02 (.0158) | -.02 (.0164) |
| Wald test of joint signif. | 104 [.000] | 535 [.000] | 215 [.000] | 929 [.000] |
| Wald test time dummies | 179 [.000] | 468 [.000] | 216 [.000] | 141 [.000] |
| Wald test for CF | 27.2 [.000] | 29.1 [.000] | 65.2 [.000] | 98.7 [.000] |
| Sargan test | | | 152 [.229] | 173 [.136] |
| Test M1 | -6.4 [.000] | 5.0 [.000] | -7.1 [.000] | -7.1 [.000] |
| Test M2 | -1.0 [.306] | -.68 [.494] | .59 [.556] | -.37 [.713] |
| # of obs. (firms) | 2753 (622) | | | |

Notes:

a) Estimation performed using the DPD98 software (Arellano and Bond, 1998); all equations include time dummies; Heteroskedastic-consistent standard errors in bracket; P values in square brackets.
M1 and M2: tests for first order and second order serial correlation in the first difference residuals.

b) Two-step estimates; instruments used: observations dated t-2, t-3, t-4 and t-5 for $X_t$ (GMM F.D. and GMM SYS) and t-1 for $\Delta X_t$ (GMM SYS).

**APPENDIX 10**. Physical investment error correction model: Unquoted vs. quoted firms

**non quoted firms**

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .24 (.0060)* | -.26 (.0054)* | .00 (.0095) | .17 (.0542)* |
| $I_{t-1}/C_{t-2}$ | -.12 (.0060)* | -.36 (.0060)* | .06 (.0140)* | .05 (.0123)* |
| $CF_t/C_{t-1}$ | .25 (.0155)* | .25 (.0139)* | .15 (.0514)* | .23 (.0399)* |
| $CF_{t-1}/C_{t-2}$ | .12 (.0110)* | .19 (.0101)* | .01 (.0185) | -.01 (.0150) |
| $\Delta\log(Y_t)$ | .34 (.0122)* | .87 (.0204)* | -.18 (.0939) | -.11 (.0681) |
| $\Delta\log(Y_{t-1})$ | .17 (.0116)* | .60 (.0212)* | -.15 (.0946) | .02 (.0242) |
| $\log(C_{t-2})-\log(Y_{t-2})$ | .43 (.0100)* | 1.18 (.0205)* | -.17 (.0450)* | -.01 (.0142) |
| $\log(Y_{t-2})$ | .13 (.0124)* | .55 (.0239)* | -.19 (.1026) | .00 (.0246) |
| Wald test joint signif. | 2229 [.000] | 6630 [.000] | 196 [.000] | 567 [.000] |
| Wald test time dummies | 2441 [.000] | 3169 [.000] | 15.8 [.038] | 102 [.000] |
| Wald test for CF | 425 [.000] | 499 [.000] | 24.4 [.000] | 57.4 [.000] |
| Sargan test | | | 105 [.815] | 180 [.076] |
| Test M1 | -27.4 [.000] | 22.9 [.000] | -26.8 [.000] | -28.6 [.000] |
| Test M2 | -10.6 [.000] | -7.2 [.000] | .35 [.725] | -.58 [.564] |
| # of obs. (firms) | 58616 (10002) | | | |

**firms listed on the stock market**

| Model | WITHIN | F.D. OLS |
|---|---|---|
| C | .17 (.0605)* | -.26 (.0449)* |
| $I_{t-1}/C_{t-2}$ | .00 (.0674) | -.41 (.0601)* |
| $CF_t/C_{t-1}$ | .09 (.0737) | .07 (.0445) |
| $CF_{t-1}/C_{t-2}$ | .09 (.0504) | .08 (.0351)* |
| $\Delta\log(Y_t)$ | .37 (.1224)* | .77 (.1241)* |
| $\Delta\log(Y_{t-1})$ | .23 (.1285) | .62 (.1424)* |
| $\log(C_{t-2})-\log(Y_{t-2})$ | .37 (.1156)* | .95 (.1618)* |
| $\log(Y_{t-2})$ | .30 (.1414)* | .70 (.1933)* |
| Wald test joint signif. | 39.0 [.000] | 96.1 [.000] |
| Wald test time dummies | 32.4 [.000] | 59.7 [.000] |
| Wald test for CF | 3.3 [.195] | 5.8 [.055] |
| Sargan test | | |
| Test M1 | -1.7 [.085] | 2.0 [.042] |
| Test M2 | 1.0 [.304] | -.40 [.687] |
| # of obs. (firms) | 217 (47) | |

Notes:

a) Estimation performed using the DPD98 software (Arellano and Bond, 1998); all equations include time dummies; Heteroskedastic-consistent standard errors in bracket; P values in square brackets.
M1 and M2: tests for first order and second order serial correlation in the first difference residuals.

b) Two-step estimates; instruments used: observations dated t-2, t-3, t-4 and t-5 for $X_t$ (GMM F.D. and GMM SYS) and t-1 for $\Delta X_t$ (GMM SYS).

**APPENDIX 11**. Physical investment error correction model: domestic firms vs. subsidiaries

## domestic firms

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .24 (.0063)* | -.26 (.0056)* | .00 (.01) | .18 (.0558)* |
| $I_{t-1}/C_{t-2}$ | -.12 (.0062)* | -.36 (.0062)* | .06 (.0144)* | .05 (.0128)* |
| $CF_t/C_{t-1}$ | .29 (.0162)* | .28 (.0138)* | .16 (.0595)* | .24 (.0462)* |
| $CF_{t-1}/C_{t-2}$ | .12 (.0118)* | .19 (.0111)* | .01 (.0205) | -.01 (.0173) |
| $\Delta\log(Y_t)$ | .33 (.0126)* | .86 (.0211)* | -.17 (.096) | -.12 (.0684) |
| $\Delta\log(Y_{t-1})$ | .16 (.0121)* | .59 (.0221)* | -.09 (.1023) | .03 (.0244) |
| $\log(C_{t-2})$- $\log(Y_{t-2})$ | .44 (.0102)* | 1.2 (.0213)* | -.16 (.0488)* | -.01 (.0146) |
| $\log(Y_{t-2})$ | .12 (.0129)* | .53 (.0248)* | -.13 (.1109) | .01 (.0248) |
| Wald test joint signif. | 2205 [.000] | 6379 [.000] | 186 [.000] | 570 [.000] |
| Wald test time dummies | 2268 [.000] | 2880 [.000] | 14.3 [.045] | 96.1 [.000] |
| Wald test for CF | 440 [.000] | 498 [.000] | 25.8 [.000] | 55.8 [.000] |
| Sargan test | | | 113 [.642] | 178 [.087] |
| Test M1 | -26.7 [.000] | 22.2 [.000] | -26.4 [.000] | -28.4 [.000] |
| Test M2 | -10.3 [.000] | -7.2 [.000] | .12 [.902] | -.57 [.572] |
| # of obs. (firms) | 46066 (9408) | | | |

## subsidiaries of foreign multinationals

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .21 (.0202)* | -.26 (.0147)* | -.08 (.0171)* | -.10 (.1474) |
| $I_{t-1}/C_{t-2}$ | -.13 (.0244)* | -.34 (.025)* | -.05 (.0178)* | -.01 (.0124) |
| $CF_t/C_{t-1}$ | .08 (.0253)* | .11 (.0261)* | .12 (.0155)* | .10 (.0120)* |
| $CF_{t-1}/C_{t-2}$ | .11 (.0240)* | .13 (.0192)* | .05 (.0069)* | .04 (.0049)* |
| $\Delta\log(Y_t)$ | .35 (.0375)* | .92 (.0428)* | .04 (.0504) | -.08 (.0315)* |
| $\Delta\log(Y_{t-1})$ | .22 (.0338)* | .72 (.0423)* | .01 (.0484) | -.10 (.0252)* |
| $\log(C_{t-2})$- $\log(Y_{t-2})$ | .42 (.0418)* | 1.2 (.0469)* | .22 (.0406)* | .09 (.0189)* |
| $\log(Y_{t-2})$ | .19 (.0378)* | .73 (.0518)* | -.03 (.0501) | -.16 (.0245)* |
| Wald test joint signif. | 126 [.000] | 725 [.000] | 91.2 [.000] | 501 [.000] |
| Wald test time dummies | 156 [.000] | 432 [.000] | 74.8 [.000] | 115 [.000] |
| Wald test for CF | 23.8 [.000] | 48.8 [.000] | 79.1 [.000] | 118 [.000] |
| Sargan test | | | 155 [.015] | 187 [.036] |
| Test M1 | -6.5 [.000] | 6.3 [.000] | -7.4 [.000] | -7.7 [.000] |
| Test M2 | -2.2 [.031] | -.32 [.751] | -2.0 [.047] | -1.2 [.217] |
| # of obs. (firms) | | | | |

Notes:

a) Estimation performed using the DPD98 software (Arellano and Bond, 1998); all equations include time dummies; Heteroskedastic-consistent standard errors in bracket; P values in square brackets.
M1 and M2: tests for first order and second order serial correlation in the first difference residuals.

b) Two-step estimates; instruments used: observations dated t-2, t-3, t-4 and t-5 for $X_t$ (GMM F.D. and GMM SYS) and t-1 for $\Delta X_t$ (GMM SYS).

**APPENDIX 12**. Physical investment error correction model by firms' age

## AGE < 10 years

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .13 (.0255)* | -.12 (.0238)* | -.05 (.0218)* | .09 (.1069) |
| $I_{t-1}/C_{t-2}$ | -.23 (.0227)* | -.43 (.0211)* | -.16 (.0334)* | -.11 (.0298)* |
| $CF_t/C_{t-1}$ | .35 (.0471)* | .29 (.0439)* | .34 (.0467)* | .35 (.0425)* |
| $CF_{t-1}/C_{t-2}$ | .17 (.0373)* | .21 (.0311)* | .19 (.0278)* | .15 (.0211)* |
| $\Delta\log(Y_t)$ | .37 (.0378)* | .71 (.0521)* | .04 (.0575) | .02 (.0432) |
| $\Delta\log(Y_{t-1})$ | .22 (.0334)* | .48 (.0462)* | -.12 (.0606)* | -.18 (.0457)* |
| $\log(C_{t-2})- \log(Y_{t-2})$ | .60 (.0450)* | 1.1 (.0496)* | .28 (.0470)* | .15 (.0302)* |
| $\log(Y_{t-2})$ | .23 (.0372)* | .50 (.0476)* | -.18 (.0661)* | -.25 (.0495)* |
| Wald test joint signif. | 244 [.000] | 1004 [.000] | 134 [.000] | 341 [.000] |
| Wald test time dummies | 157 [.000] | 297 [.000] | 35.4 [.000] | 7.3 [.400] |
| Wald test for CF | 70.7 [.000] | 59.8 [.000] | 104 [.000] | 134 [.000] |
| Sargan test | | | 135 [.152] | 164 [.266] |
| Test M1 | -3.3 [.001] | 6.3 [.000] | -5.3 [.000] | -6.7 [.000] |
| Test M2 | -3.7 [.000] | -1.7 [.089] | -2.7 [.008] | -2.2 [.030] |
| # of obs. (firms) | 3133 (1039) | | | |

## AGE < 20 years

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .19 (.0092)* | -.20 (.0085)* | -.01 (.0117) | .14 (.0764) |
| $I_{t-1}/C_{t-2}$ | -.13 (.0096)* | -.36 (.0109)* | .05 (.0186)* | .03 (.0152)* |
| $CF_t/C_{t-1}$ | .23 (.0213)* | .24 (.0190)* | .17 (.0455)* | .17 (.0407)* |
| $CF_{t-1}/C_{t-2}$ | .11 (.0182)* | .17 (.0156)* | .00 (.0220) | .00 (.0190) |
| $\Delta\log(Y_t)$ | .33 (.0196)* | .82 (.0387)* | -.09 (.0891) | .02 (.0605) |
| $\Delta\log(Y_{t-1})$ | .16 (.0196)* | .55 (.0384)* | -.11 (.1006) | .03 (.0278) |
| $\log(C_{t-2})- \log(Y_{t-2})$ | .40 (.0173)* | 1.1 (.0434)* | -.10 (.0494)* | -.01 (.0173) |
| $\log(Y_{t-2})$ | .10 (.0204)* | .48 (.0434)* | -.16 (.1085) | -.02 (.0291) |
| Wald test joint signif. | 703 [.000] | 1733 [.000] | 78.2 [.000] | 340 [.000] |
| Wald test time dummies | 665 [.000] | 733 [.000] | 11.1 [.134] | 64.2 [.000] |
| Wald test for CF | 136 [.000] | 185 [.000] | 22.5 [.000] | 30.5 [.000] |
| Sargan test | | | 147 [.038] | 195 [.014] |
| Test M1 | -3.3 [.001] | 10.9 [.000] | -17.1 [.000] | -17.8 [.000] |
| Test M2 | -3.7 [.000] | -4.1 [.000] | -.31 [.760] | -.44 [.663] |
| # of obs. (firms) | 16226 (3200) | | | |

## AGE > 19 years

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .27 (.0081)* | -.30 (.0072)* | -.02 (.0124) | .24 (.0614)* |
| $I_{t-1}/C_{t-2}$ | -.12 (.0079)* | -.35 (.0074)* | .08 (.0141)* | .07 (.0121)* |
| $CF_t/C_{t-1}$ | .25 (.0212)* | .24 (.0186)* | .26 (.0459)* | .25 (.0387)* |
| $CF_{t-1}/C_{t-2}$ | .13 (.0137)* | .19 (.0128)* | -.01 (.0167) | -.01 (.0137) |
| $\Delta\log(Y_t)$ | .35 (.0168)* | .94 (.0254)* | -.07 (.0954) | -.07 (.0737) |
| $\Delta\log(Y_{t-1})$ | .18 (.0157)* | .65 (.0273)* | .16 (.1065) | .05 (.0319) |
| $\log(C_{t-2})- \log(Y_{t-2})$ | .46 (.0128)* | 1.2 (.0242)* | .02 (.0530) | .03 (.0170) |
| $\log(Y_{t-2})$ | .13 (.0170)* | .58 (.0299)* | .16 (.1172) | .03 (.0330) |
| Wald test joint signif. | 1475 [.000] | 4872 [.000] | 153 [.000] | 317 [.000] |
| Wald test time dummies | 1661 [.000] | 2429 [.000] | 20.5 [.005] | 108 [.000] |
| Wald test for CF | 281 [.000] | 298 [.000] | 44.8 [.000] | 55.6 [.000] |
| Sargan test | | | 123 [.372] | 164 [.261] |
| Test M1 | -21.1 [.000] | 19.3 [.000] | 2.0 [.000] | -26.3 [.000] |
| Test M2 | -8.7 [.000] | -6.3 [.000] | 1.7 [.000] | -.05 [.961] |
| # of obs. (firms) | 33980 (5587) | | | |

Notes:

a) Estimation performed using the DPD98 software (Arellano and Bond, 1998); all equations include time dummies; Heteroskedastic-consistent standard errors in bracket; P values in square brackets.

M1 and M2: tests for first order and second order serial correlation in the first difference residuals.

b) Two-step estimates; instruments used: observations dated t-2, t-3, t-4 and t-5 for $X_t$ (GMM F.D. and GMM SYS) and t-1 for $\Delta X_t$ (GMM SYS).

**APPENDIX 13**. Physical investment error correction model by industry sector

## **Agriculture** (I1)

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .21 (.0667)* | -.24 (.0455)* | -.12 (.0170)* | .47 (.2561) |
| $I_{t-1}/C_{t-2}$ | -.17 (.0470)* | -.39 (.0430)* | -.16 (.0108)* | -.10 (.0202)* |
| $CF_t/C_{t-1}$ | .33 (.1778) | .42 (.1090)* | .66 (.0388)* | .81 (.0522)* |
| $CF_{t-1}/C_{t-2}$ | .24 (.1356) | .30 (.1098)* | .05 (.0180)* | .04 (.0313) |
| $\Delta\log(Y_t)$ | .15 (.0937) | .50 (.0883)* | .11 (.0328)* | .03 (.0444) |
| $\Delta\log(Y_{t-1})$ | -.02 (.0769) | .23 (.1229) | .08 (.0304)* | .03 (.0271) |
| $\log(C_{t-2})$- $\log(Y_{t-2})$ | .41 (.1006)* | .92 (.0733)* | .35 (.0308)* | .24 (.0310)* |
| $\log(Y_{t-2})$ | -.05 (.0877) | .20 (.1515) | .00 (.0287) | -.08 (.0232)* |
| Wald test joint signif. | 36.8 [.000] | 225.1 [.000] | 1704.8 [.000] | 944.0 [.000] |
| Wald test time dummies | 14.1 [.050] | 52.3 [.000] | 487.1 [.000] | 32.8 [.000] |
| Wald test for CF | 7.7 [.021] | 15.7 [.000] | 374.3 [.000] | 263.5 [.000] |
| Sargan test | | | 67.3 [1.00] | 60.0 [1.00] |
| Test M1 | -1.74 [.081] | 1.99 [.047] | -2.25 [.024] | -2.94 [.003] |
| Test M2 | -1.38 [.167] | -0.66 [.512] | -1.31 [.191] | -0.98 [.328] |
| # of obs. (firms) | 424 (82) | | | |

## **Metals** (I3)

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .19 (.0169)* | -.21 (.0161)* | -.01 (.0167) | .18 (.1244) |
| $I_{t-1}/C_{t-2}$ | -.17 (.0188)* | -.39 (.0188)* | -.02 (.0218) | -.01 (.0169) |
| $CF_t/C_{t-1}$ | .33 (.0484)* | .33 (.0417)* | .32 (.0538)* | .24 (.0384)* |
| $CF_{t-1}/C_{t-2}$ | .16 (.0324)* | .24 (.0380)* | .06 (.0217)* | .04 (.0173)* |
| $\Delta\log(Y_t)$ | .30 (.0416)* | .80 (.0786)* | .21 (.0849)* | -.01 (.0567) |
| $\Delta\log(Y_{t-1})$ | .15 (.0396)* | .55 (.0861)* | .39 (.0998)* | .01 (.0380) |
| $\log(C_{t-2})$- $\log(Y_{t-2})$ | .46 (.0344)* | 1.1 (.0688)* | .16 (.0515)* | .01 (.0225) |
| $\log(Y_{t-2})$ | .11 (.0419)* | .48 (.0972)* | .44 (.1170)* | .00 (.0406) |
| Wald test joint signif. | 215 [.000] | 834 [.000] | 58.7 [.000] | 134 [.000] |
| Wald test time dummies | 231 [.000] | 306 [.000] | 42.7 [.000] | 72.4 [.000] |
| Wald test for CF | 66.1 [.000] | 65.2 [.000] | 39.6 [.000] | 38.5 [.000] |
| Sargan test | | | 120 [.461] | 162 [.319] |
| Test M1 | -8.9 [.000] | 7.3 [.000] | -9.4 [.000] | -10.9 [.000] |
| Test M2 | -4.1 [.000] | -4.2 [.014] | -.81 [.417] | -.09 [.926] |
| # of obs. (firms) | 4419 (898) | | | |

## **Chemicals** (I4)

| Model | WITHIN | F.D. OLS |
|---|---|---|
| C | .14 (.0309)* | -.17 (.0245)* |
| $I_{t-1}/C_{t-2}$ | -.12 (.0369)* | -.36 (.0353)* |
| $CF_t/C_{t-1}$ | .36 (.0775)* | .39 (.0652)* |
| $CF_{t-1}/C_{t-2}$ | .18 (.0402)* | .27 (.0370)* |
| $\Delta\log(Y_t)$ | .32 (.0605)* | .83 (.0650)* |
| $\Delta\log(Y_{t-1})$ | .14 (.0511)* | .56 (.0712)* |
| $\log(C_{t-2})$- $\log(Y_{t-2})$ | .50 (.0702)* | 1.1 (.0616)* |
| $\log(Y_{t-2})$ | .08 (.0554) | .57 (.0854)* |
| Wald test joint signif. | 85.3 [.000] | 378 [.000] |
| Wald test time dummies | 46.7 [.000] | 140 [.000] |
| Wald test for CF | 39.5 [.000] | 54.8 [.000] |
| Sargan test | | |
| Test M1 | -3.7 [.000] | 3.7 [.000] |
| Test M2 | -2.6 [.009] | -1.2 [.237] |
| # of obs. (firms) | 937 (201) | |

Notes:

a) Estimation performed using the DPD98 software (Arellano and Bond, 1998); all equations include time dummies; Heteroskedastic-consistent standard errors in bracket; P values in square brackets.
M1 and M2: tests for first order and second order serial correlation in the first difference residuals.

b) Two-step estimates; instruments used: observations dated t-2, t-3, t-4 and t-5 for $X_t$ (GMM F.D. and GMM SYS) and t-1 for $\Delta X_t$ (GMM SYS).

**APPENDIX 13**. Physical investment error correction model by industry sector (con't)

**Electrical machinery** (I5)

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .20 (.0218)* | -.24 (.0171)* | -.03 (.0199) | .01 (.0983) |
| $I_{t-1}/C_{t-2}$ | -.12 (.024)* | -.37 (.0268)* | -.02 (.0127) | -.01 (.0108) |
| $CF_t/C_{t-1}$ | .27 (.0449)* | .22 (.0319)* | .14 (.0395)* | .17 (.0278)* |
| $CF_{t-1}/C_{t-2}$ | .09 (.0349)* | .15 (.0469)* | .11 (.0172)* | .08 (.0133)* |
| $\Delta\log(Y_t)$ | .29 (.0465)* | .93 (.0415)* | .13 (.0611)* | .03 (.0272) |
| $\Delta\log(Y_{t-1})$ | .21 (.0429)* | .72 (.0656)* | -.01 (.0778) | -.06 (.0317) |
| $\log(C_{t-2})$- $\log(Y_{t-2})$ | .43 (.0376)* | 1.2 (.0399)* | .10 (.0397)* | .06 (.0238)* |
| $\log(Y_{t-2})$ | .12 (.0518)* | .64 (.0698)* | -.10 (.0812) | -.14 (.0296)* |
| Wald test joint signif. | 181 [.000] | 1053 [.000] | 186 [.000] | 480 [.000] |
| Wald test time dummies | 160 [.000] | 378 [.000] | 36.6 [.000] | 62.1 [.000] |
| Wald test for CF | 54.4 [.000] | 49.1 [.000] | 88.6 [.000] | 146 [.000] |
| Sargan test | | | 111 [.680] | 170 [.178] |
| Test M1 | -6.5 [.000] | 5.6 [.000] | -7.0 [.000] | -7.3 [.000] |
| Test M2 | -4.1 [.000] | -1.9 [.062] | -2.5 [.013] | -2.7 [.007] |
| # of obs. (firms) | 2211 (444) | | | |

**Motor vehicles** (I6)

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .13 (.0422)* | -.17 (.0315)* | -.08 (.0163)* | .21 (.0876)* |
| $I_{t-1}/C_{t-2}$ | -.23 (.0435)* | -.41 (.0388)* | -.12 (.0066)* | -.04 (.0157)* |
| $CF_t/C_{t-1}$ | .24 (.0632)* | .25 (.0462)* | .65 (.0117)* | .56 (.0292)* |
| $CF_{t-1}/C_{t-2}$ | .42 (.0827)* | .37 (.0679)* | .12 (.0084)* | .10 (.0201)* |
| $\Delta\log(Y_t)$ | .41 (.0839)* | .74 (.0928)* | .31 (.0084)* | .24 (.0315)* |
| $\Delta\log(Y_{t-1})$ | .05 (.0762) | .33 (.0926)* | .25 (.0066)* | .11 (.0269)* |
| $\log(C_{t-2})$- $\log(Y_{t-2})$ | .63 (.1202)* | 1.2 (.1219)* | .89 (.0065)* | .75 (.0272)* |
| $\log(Y_{t-2})$ | .05 (.0758) | .31 (.0938)* | .16 (.0076)* | .01 (.0275) |
| Wald test joint signif. | 41.2 [.000] | 199 [.000]² | 63935 [.000] | 3861 [.000] |
| Wald test time dummies | 18.9 [.008] | 52.5 [.000] | 1252 [.000] | 451 [.000] |
| Wald test for CF | 26.0 [.000] | 34.5 [.000] | 3149 [.000] | 384 [.000] |
| Sargan test | | | 94.6 [.952] | 94.3 [1.00] |
| Test M1 | -.76 [.447] | 3.3 [.001] | -.06 [.956] | -2.4 [.017] |
| Test M2 | -2.8 [.005] | -.31 [.754] | -2.1 [.034] | -1.7 [.095] |
| # of obs. (firms) | 525 (114) | | | |

**Food** (I7)

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .19 (.0246)* | -.21 (.0231)* | -.10 (.0208)* | .22 (.0635)* |
| $I_{t-1}/C_{t-2}$ | -.06 (.0309) | -.32 (.0311)* | .06 (.0209)* | .08 (.0169)* |
| $CF_t/C_{t-1}$ | .38 (.1108)* | .45 (.0908)* | .48 (.0679)* | .40 (.0482)* |
| $CF_{t-1}/C_{t-2}$ | .21 (.0409)* | .30 (.0514)* | .01 (.0138) | .00 (.0116) |
| $\Delta\log(Y_t)$ | .30 (.0483)* | .70 (.0709)* | .12 (.0401)* | .04 (.0281) |
| $\Delta\log(Y_{t-1})$ | .12 (.0484)* | .41 (.0742)* | .05 (.0428) | -.08 (.0279)* |
| $\log(C_{t-2})$- $\log(Y_{t-2})$ | .44 (.0454)* | 1.0 (.0714)* | .21 (.0421)* | .04 (.0190)* |
| $\log(Y_{t-2})$ | .11 (.0444)* | .39 (.0775)* | .04 (.0453) | -.11 (.0295)* |
| Wald test joint signif. | 119 [.000] | 314 [.000] | 117 [.000] | 522 [.000] |
| Wald test time dummies | 102 [.000] | 164 [.000] | 63.3 [.000] | 92.4 [.000] |
| Wald test for CF | 29.6 [.000] | 35.1 [.000] | 51.2 [.000] | 78.2 [.000] |
| Sargan test | | | 137 [.125] | 168 [.211] |
| Test M1 | -5.1 [.000] | 3.3 [.001] | -7.6 [.000] | -8.0 [.000] |
| Test M2 | -1.8 [.080] | -2.2 [.026] | -1.7 [.095] | -1.4 [.155] |
| # of obs. (firms) | 2307 (483) | | | |

Notes:

a) Estimation performed using the DPD98 software (Arellano and Bond, 1998); all equations include time dummies; Heteroskedastic-consistent standard errors in bracket; P values in square brackets.
M1 and M2: tests for first order and second order serial correlation in the first difference residuals.

b) Two-step estimates; instruments used: observations dated t-2, t-3, t-4 and t-5 for $X_t$ (GMM F.D. and GMM SYS) and t-1 for $\Delta X_t$ (GMM SYS).

**APPENDIX 13**. Physical investment error correction model by industry sector (con't)

**Textile** (I8)

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .20 (.0240)* | -.26 (.0233)* | -.06 (.0233)* | .43 (.1182)* |
| $I_{t-1}/C_{t-2}$ | -.07 (.0285)* | -.29 (.0377)* | .02 (.0240) | .08 (.0161)* |
| $CF_t/C_{t-1}$ | .51 (.0754)* | .47 (.0598)* | .42 (.0701)* | .50 (.0516)* |
| $CF_{t-1}/C_{t-2}$ | .02 (.0627) | .11 (.0731) | .03 (.0335) | -.06 (.0228)* |
| $\Delta\log(Y_t)$ | .22 (.0544)* | .73 (.0905)* | .35 (.0689)* | .04 (.0393) |
| $\Delta\log(Y_{t-1})$ | .16 (.0409)* | .53 (.0813)* | .46 (.0634)* | .18 (.0277)* |
| $\log(C_{t-2})$- $\log(Y_{t-2})$ | .39 (.0420)* | 1.1 (.0939)* | .32 (.0537)* | .08 (.0261)* |
| $\log(Y_{t-2})$ | .10 (.0489)* | .46 (.0876)* | .45 (.0721)* | .13 (.0273)* |
| Wald test joint signif. | 168 [.000] | 387 [.000] | 153 [.000] | 392 [.000] |
| Wald test time dummies | 100 [.000] | 155 [.000] | 99.6 [.000] | 151 [.000] |
| Wald test for CF | 52.3 [.000] | 61.2 [.000] | 55.4 [.000] | 103 [.000] |
| Sargan test | | | 117 [.528] | 154 [.496] |
| Test M1 | -5.9 [.000] | 2.2 [.025] | -5.7 [.000] | -6.9 [.000] |
| Test M2 | -3.2 [.002] | -1.8 [.066] | -2.1 [.036] | -1.6 [.101] |
| # of obs. (firms) | 2206 (469) | | | |

**Paper** (I9)

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .30 (.0383)* | -.27 (.0404)* | -.13 (.0225)* | .20 (.1038)* |
| $I_{t-1}/C_{t-2}$ | -.13 (.0396)* | -.38 (.0207)* | -.12 (.0143)* | -.10 (.0111)* |
| $CF_t/C_{t-1}$ | .32 (.0642)* | .26 (.0649)* | .29 (.0149)* | .24 (.0135)* |
| $CF_{t-1}/C_{t-2}$ | .10 (.0390)* | .17 (.0359)* | .05 (.0090)* | .05 (.0071)* |
| $\Delta\log(Y_t)$ | .39 (.0750)* | .86 (.1619)* | .02 (.0573) | -.07 (.0328)* |
| $\Delta\log(Y_{t-1})$ | .15 (.0661)* | .54 (.1612)* | .18 (.0652)* | .03 (.0388) |
| $\log(C_{t-2})$- $\log(Y_{t-2})$ | .51 (.0601)* | 1.2 (.1719)* | .36 (.0342)* | .15 (.0164)* |
| $\log(Y_{t-2})$ | .19 (.0641)* | .53 (.1722)* | .16 (.0687)* | .00 (.0383) |
| Wald test joint signif. | 110 [.000] | 451 [.000] | 573 [.000] | 652 [.000] |
| Wald test time dummies | 92.8 [.000] | 180 [.000] | 177 [.000] | 293 [.000] |
| Wald test for CF | 31.8 [.000] | 24.1 [.000] | 423 [.000] | 400 [.000] |
| Sargan test | | | 132 [.189] | 165 [.252] |
| Test M1 | -5.7 [.000] | 5.3 [.000] | -7.2 [.000] | -7.9 [.000] |
| Test M2 | -2.1 [.038] | -2.5 [.013] | -2.4 [.016] | -1.7 [.082] |
| # of obs. (firms) | 1741 (357) | | | |

**Rubber** (I10)

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .21 (.0373)* | -.19 (.0283)* | -.16 (.0138)* | .03 (.0324) |
| $I_{t-1}/C_{t-2}$ | -.13 (.0383)* | -.40 (.0399)* | -.20 (.0035)* | -.12 (.0019)* |
| $CF_t/C_{t-1}$ | .28 (.1345)* | .28 (.0937)* | .12 (.0064)* | .08 (.0025)* |
| $CF_{t-1}/C_{t-2}$ | .23 (.0601)* | .33 (.0735)* | .21 (.0104)* | .20 (.0036)* |
| $\Delta\log(Y_t)$ | .34 (.0909)* | .89 (.0874)* | .61 (.0100)* | .09 (.0039)* |
| $\Delta\log(Y_{t-1})$ | .17 (.0810)* | .58 (.1013)* | .57 (.0090)* | -.06 (.0054)* |
| $\log(C_{t-2})$- $\log(Y_{t-2})$ | .52 (.0820)* | 1.2 (.0762)* | .81 (.0079)* | .29 (.0034)* |
| $\log(Y_{t-2})$ | .07 (.0798) | .52 (.1087)* | .48 (.0125)* | -.22 (.0062)* |
| Wald test joint signif. | 50.3 [.000] | 340 [.000] | 105144 [.000] | 111781 [.000] |
| Wald test time dummies | 53.3 [.000] | 141 [.000] | 4099 [.000] | 3836 [.000] |
| Wald test for CF | 20.7 [.000] | 20.7 [.000] | 486 [.000] | 3031 [.000] |
| Sargan test | | | 123 [.392] | 171 [.163] |
| Test M1 | -3.8 [.000] | 4.5 [.000] | -1.9 [.055] | -4.2 [.000] |
| Test M2 | -1.6 [.106] | -.46 [.644] | -1.6 [.111] | -2.0 [.049] |
| # of obs. (firms) | 929 (191) | | | |

Notes:

a) Estimation performed using the DPD98 software (Arellano and Bond, 1998); all equations include time dummies; Heteroskedastic-consistent standard errors in bracket; P values in square brackets.
M1 and M2: tests for first order and second order serial correlation in the first difference residuals.

b) Two-step estimates; instruments used: observations dated t-2, t-3, t-4 and t-5 for $X_t$ (GMM F.D. and GMM SYS) and t-1 for $\Delta X_t$ (GMM SYS).

**APPENDIX 13**. Physical investment error correction model by industry sector (con't)

## **Other manufacturing** (I11)

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .24 (.0256)* | -.23 (.0168)* | -.10 (.0171)* | .30 (.1102)* |
| $I_{t-1}/C_{t-2}$ | -.13 (.0231)* | -.40 (.0178)* | -.08 (.0175)* | -.02 (.0140) |
| $CF_t/C_{t-1}$ | .41 (.0932)* | .39 (.0525)* | .25 (.0141)* | .27 (.0125)* |
| $CF_{t-1}/C_{t-2}$ | .12 (.0389)* | .31 (.0353)* | .12 (.0127)* | .04 (.0100)* |
| $\Delta\log(Y_t)$ | .36 (.0586)* | .90 (.0445)* | .31 (.0534)* | -.07 (.0386) |
| $\Delta\log(Y_{t-1})$ | .14 (.0571)* | .58 (.0575)* | .27 (.0603)* | -.14 (.0445)* |
| $\log(C_{t-2})$- $\log(Y_{t-2})$ | .53 (.0433)* | 1.2 (.0394)* | .43 (.0350)* | .07 (.0173)* |
| $\log(Y_{t-2})$ | .11 (.0559)* | .53 (.0659)* | .24 (.0663)* | -.21 (.0484)* |
| Wald test joint signif. | 197 [.000] | 1534 [.000] | 642 [.000] | 879 [.000] |
| Wald test time dummies | 157 [.000] | 363 [.000] | 144 [.000] | 137 [.000] |
| Wald test for CF | 20.5 [.000] | 75.8 [.000] | 310 [.000] | 523 [.000] |
| Sargan test | | | 136 [.142] | 169 [.190] |
| Test M1 | -5.2 [.000] | 7.3 [.000] | -5.6 [.000] | -6.9 [.000] |
| Test M2 | -2.6 [.009] | -1.4 [.168] | -2.1 [.041] | -1.7 [.082] |
| # of obs. (firms) | 1998 (394) | | | |

## **Construction** (I12)

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .27 (.0155)* | -.27 (.0169)* | -.03 (.0172) | .32 (.1029)* |
| $I_{t-1}/C_{t-2}$ | -.14 (.0110)* | -.36 (.0120)* | .00 (.0188) | .00 (.0160) |
| $CF_t/C_{t-1}$ | .31 (.0425)* | .30 (.0258)* | .48 (.0878)* | .40 (.0686)* |
| $CF_{t-1}/C_{t-2}$ | .15 (.0186)* | .23 (.0176)* | -.01 (.0342) | -.01 (.0279) |
| $\Delta\log(Y_t)$ | .40 (.0265)* | .91 (.0611)* | .11 (.0968) | .02 (.0647) |
| $\Delta\log(Y_{t-1})$ | .19 (.0260)* | .61 (.0561)* | .25 (.0923)* | .12 (.0352)* |
| $\log(C_{t-2})$- $\log(Y_{t-2})$ | .46 (.0230)* | 1.2 (.0742)* | .12 (.0594)* | .05 (.0186)* |
| $\log(Y_{t-2})$ | .14 (.0275)* | .53 (.0612)* | .23 (.1031)* | .08 (.0395)* |
| Wald test joint signif. | 571 [.000] | 1312 [.000] | 120 [.000] | 202 [.000] |
| Wald test time dummies | 492 [.000] | 487 [.000] | 28.5 [.000] | 77.6 [.000] |
| Wald test for CF | 91.7 [.000] | 193 [.000] | 60.4 [.000] | 73.2 [.000] |
| Sargan test | | | 123 [.384] | 167 [.217] |
| Test M1 | -12.4 [.000] | 10.5 [.000] | -12.4 [.000] | -14.1 [.000] |
| Test M2 | -4.9 [.000] | -3.9 [.014] | -1.4 [.162] | -1.3 [.212] |
| # of obs. (firms) | 8673 (1624) | | | |

## **Retail and wholesale** (I13)

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .25 (.0125)* | -.26 (.0095)* | -.02 (.015) | .19 (.0980)* |
| $I_{t-1}/C_{t-2}$ | -.13 (.0111)* | -.37 (.0099)* | .08 (.021)* | .07 (.0163)* |
| $CF_t/C_{t-1}$ | .25 (.0213)* | .26 (.0212)* | .20 (.044)* | .22 (.0353)* |
| $CF_{t-1}/C_{t-2}$ | .14 (.0178)* | .20 (.0154)* | -.01 (.0194) | -.01 (.0155) |
| $\Delta\log(Y_t)$ | .33 (.0271)* | .89 (.0328)* | -.32 (.1008)* | -.17 (.0784)* |
| $\Delta\log(Y_{t-1})$ | .15 (.0291)* | .60 (.0365)* | -.20 (.1300) | -.06 (.0541) |
| $\log(C_{t-2})$- $\log(Y_{t-2})$ | .48 (.0205)* | 1.2 (.0322)* | -.07 (.0555) | .00 (.0210) |
| $\log(Y_{t-2})$ | .15 (.0327)* | .60 (.0405)* | -.23 (.1449) | -.07 (.0584) |
| Wald test joint signif. | 646 [.000] | 2402 [.000] | 91.6 [.000] | 227 [.000] |
| Wald test time dummies | 657 [.000] | 1302 [.000] | 22.1 [.002] | 58.4 [.000] |
| Wald test for CF | 171 [.000] | 201 [.000] | 26.0 [.000] | 43.6 [.000] |
| Sargan test | | | 122 [.412] | 166 [.245] |
| Test M1 | -13.8 [.000] | 13.9 [.000] | -15.8 [.000] | -17.4 [.000] |
| Test M2 | -4.5 [.000] | -3.1 [.002] | 1.1 [.280] | .83 [.406] |
| # of obs. (firms) | 13090 (2804) | | | |

Notes:

a) Estimation performed using the DPD98 software (Arellano and Bond, 1998); all equations include time dummies; Heteroskedastic-consistent standard errors in bracket; P values in square brackets.
M1 and M2: tests for first order and second order serial correlation in the first difference residuals.

b) Two-step estimates; instruments used: observations dated t-2, t-3, t-4 and t-5 for $X_t$ (GMM F.D. and GMM SYS) and t-1 for $\Delta X_t$ (GMM SYS).

**APPENDIX 13**. Physical investment error correction model by industry sector (con't)

**Hotels and restaurants** (I14)

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .17 (.0326)* | -.18 (.0258)* | -.08 (.0176)* | .42 (.0266)* |
| $I_{t-1}/C_{t-2}$ | -.05 (.0428) | -.30 (.0448)* | -.14 (.0099)* | -.12 (.0061)* |
| $CF_t/C_{t-1}$ | .30 (.0975)* | .36 (.1030)* | .32 (.0221)* | .28 (.0122)* |
| $CF_{t-1}/C_{t-2}$ | .23 (.0737)* | .32 (.0620)* | .15 (.0105)* | .13 (.0055)* |
| $\Delta\log(Y_t)$ | .22 (.0804)* | .81 (.068)* | .30 (.0448)* | .29 (.0222)* |
| $\Delta\log(Y_{t-1})$ | .05 (.1016) | .55 (.1032)* | .37 (.0561)* | .43 (.0260)* |
| $\log(C_{t-2})$- $\log(Y_{t-2})$ | .36 (.0576)* | 1.2 (.0687)* | .20 (.0303)* | .15 (.0140)* |
| $\log(Y_{t-2})$ | .04 (.1147) | .58 (.1176)* | .28 (.0487)* | .35 (.0221)* |
| Wald test joint signif. | 49.9 [.000] | 300 [.000] | 938 [.000] | 3739 [.000] |
| Wald test time dummies | 39.1 [.000] | 87.6 [.000] | 82.8 [.000] | 73.6 [.000] |
| Wald test for CF | 12.1 [.002] | 28.7 [.000] | 230 [.000] | 655 [.000] |
| Sargan test | | | 134 [.166] | 162 [.306] |
| Test M1 | -4.6 [.000] | 4.0 [.000] | -4.9 [.000] | -4.9 [.000] |
| Test M2 | -1.4 [.175] | -.76 [.448] | -2.8 [.005] | -2.5 [.013] |
| # of obs. (firms) | 1178 (261) | | | |

**Transport and communications** (I15)

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .25 (.0201)* | -.30 (.0169)* | -.11 (.0185)* | .07 (.1253) |
| $I_{t-1}/C_{t-2}$ | -.13 (.0191)* | -.35 (.0185)* | -.03 (.0192) | .02 (.0143) |
| $CF_t/C_{t-1}$ | .34 (.0674)* | .29 (.0673)* | .26 (.0461)* | .22 (.0442)* |
| $CF_{t-1}/C_{t-2}$ | .20 (.0346)* | .26 (.0404)* | .05 (.0201)* | -.01 (.0163) |
| $\Delta\log(Y_t)$ | .31 (.0316)* | .90 (.0411)* | .14 (.0686)* | .07 (.0485) |
| $\Delta\log(Y_{t-1})$ | .14 (.0306)* | .60 (.0457)* | -.01 (.0638) | .05 (.0277) |
| $\log(C_{t-2})$- $\log(Y_{t-2})$ | .42 (.0306)* | 1.2 (.0368)* | .34 (.0559)* | -.02 (.0193) |
| $\log(Y_{t-2})$ | .09 (.0333)* | .53 (.0498)* | -.06 (.0666) | .00 (.0286) |
| Wald test joint signif. | 221 [.000] | 1282 [.000] | 77.5 [.000] | 170 [.000] |
| Wald test time dummies | 253 [.000] | 645 [.000] | 90.9 [.000] | 82.5 [.000] |
| Wald test for CF | 41.8 [.000] | 43.6 [.000] | 49.0 [.000] | 27.7 [.000] |
| Sargan test | | | 130 [.234] | 176 [.113] |
| Test M1 | -8.4 [.000] | 6.8 [.000] | -8.7 [.000] | -10.7 [.000] |
| Test M2 | -4.4 [.000] | -3.6 [.014] | -3.1 [.002] | -2.2 [.029] |
| # of obs. (firms) | 4588 (909) | | | |

**Financial services** (I16)

| Model | WITHIN | F.D. OLS |
|---|---|---|
| C | .35 (.0898)* | -.37 (.0678)* |
| $I_{t-1}/C_{t-2}$ | -.19 (.0651)* | -.40 (.0358)* |
| $CF_t/C_{t-1}$ | .08 (.0471) | .07 (.0375) |
| $CF_{t-1}/C_{t-2}$ | .08 (.0391)* | .07 (.0367) |
| $\Delta\log(Y_t)$ | .82 (.1735)* | 1.2 (.1293)* |
| $\Delta\log(Y_{t-1})$ | .41 (.1243)* | .87 (.0841)* |
| $\log(C_{t-2})$- $\log(Y_{t-2})$ | .54 (.1273)* | 1.4 (.1667)* |
| $\log(Y_{t-2})$ | .46 (.1471)* | .98 (.1513)* |
| Wald test joint signif. | 43.3 [.000] | 263 [.000] |
| Wald test time dummies | 23.4 [.001] | 77.2 [.000] |
| Wald test for CF | 11.2 [.004] | 7.1 [.029] |
| Sargan test | | |
| Test M1 | -2.7 [.007] | 2.5 [.012] |
| Test M2 | .17 [.867] | -.62 [.533] |
| # of obs. (firms) | 296 (74) | |

Notes:

a) Estimation performed using the DPD98 software (Arellano and Bond, 1998); all equations include time dummies; Heteroskedastic-consistent standard errors in bracket; P values in square brackets.
M1 and M2: tests for first order and second order serial correlation in the first difference residuals.

b) Two-step estimates; instruments used: observations dated t-2, t-3, t-4 and t-5 for $X_t$ (GMM F.D. and GMM SYS) and t-1 for $\Delta X_t$ (GMM SYS).

**APPENDIX 13**. Physical investment error correction model by industry sector (con't)

**Other services** (I17)

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .26 (.0243)* | -.30 (.0186)* | -.14 (.0203)* | -.56 (.1695)* |
| $I_{t-1}/C_{t-2}$ | -.14 (.0175)* | -.33 (.0241)* | -.12 (.0236)* | -.05 (.0182)* |
| $CF_t/C_{t-1}$ | .11 (.0241)* | .14 (.0190)* | .13 (.0232)* | .12 (.0230)* |
| $CF_{t-1}/C_{t-2}$ | .07 (.0188)* | .11 (.0179)* | .06 (.0150)* | .04 (.0103)* |
| $\Delta\log(Y_t)$ | .33 (.0385)* | .85 (.0699)* | .20 (.0530)* | -.07 (.0541) |
| $\Delta\log(Y_{t-1})$ | .20 (.0402)* | .60 (.0737)* | .13 (.0643)* | -.09 (.0419)* |
| $\log(C_{t-2})-\log(Y_{t-2})$ | .40 (.0351)* | 1.2 (.0563)* | .45 (.0580)* | .10 (.0283)* |
| $\log(Y_{t-2})$ | .14 (.0418)* | .56 (.0877)* | .02 (.0680) | -.19 (.0438)* |
| Wald test joint signif. | 163 [.000] | 734 [.000] | 159 [.000] | 300 [.000] |
| Wald test time dummies | 187 [.000] | 419 [.000] | 111 [.000] | 86.4 [.000] |
| Wald test for CF | 39.8 [.000] | 67.3 [.000] | 55.5 [.000] | 98.9 [.000] |
| Sargan test | | | 132 [.199] | 164 [.279] |
| Test M1 | -7.2 [.000] | 4.6 [.000] | -6.4 [.000] | -8.9 [.000] |
| Test M2 | -3.4 [.001] | -2.4 [.018] | -2.5 [.013] | -1.5 [.145] |
| # of obs. (firms) | 3232 (728) | | | |

Notes:

a) Estimation performed using the DPD98 software (Arellano and Bond, 1998); all equations include time dummies; Heteroskedastic-consistent standard errors in bracket; P values in square brackets.
M1 and M2: tests for first order and second order serial correlation in the first difference residuals.

b) Two-step estimates; instruments used: observations dated t-2, t-3, t-4 and t-5 for $X_t$ (GMM F.D. and GMM SYS) and t-1 for $\Delta X_t$ (GMM SYS).

**APPENDIX 14**. Physical investment error correction model by firms' region

### Brussels Capital region

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .25 (.0158)* | -.28 (.0128)* | -.07 (.0194)* | .11 (.1043) |
| $I_{t-1}/C_{t-2}$ | -.13 (.0161)* | -.35 (.0161)* | -.04 (.0216) | -.05 (.0181)* |
| $CF_t/C_{t-1}$ | .16 (.0254)* | .17 (.0256)* | .15 (.0289)* | .16 (.0267)* |
| $CF_{t-1}/C_{t-2}$ | .08 (.0146)* | .12 (.0126)* | .02 (.0183) | -.01 (.0164) |
| $\Delta\log(Y_t)$ | .33 (.032)* | .89 (.0530)* | .00 (.0812) | .01 (.0591) |
| $\Delta\log(Y_{t-1})$ | .21 (.0329)* | .64 (.0648)* | -.11 (.0834) | -.04 (.0517) |
| $\log(C_{t-2})- \log(Y_{t-2})$ | .43 (.0246)* | 1.2 (.0389)* | .04 (.064) | -.03 (.0207) |
| $\log(Y_{t-2})$ | .18 (.0352)* | .61 (.0788)* | -.13 (.0853) | -.08 (.0532) |
| Wald test joint signif. | 353 [.000] | 1488 [.000] | 59.3 [.000] | 287 [.000] |
| Wald test time dummies | 365 [.000] | 811 [.000] | 53.1 [.000] | 67.8 [.000] |
| Wald test for CF | 94.1 [.000] | 119 [.000] | 43.9 [.000] | 48.2 [.000] |
| Sargan test | | | 141 [.080] | 173 [.136] |
| Test M1 | -9.8 [.000] | 7.8 [.000] | -10.6 [.000] | -10.7 [.000] |
| Test M2 | -3.2 [.001] | -3.1 [.002] | -1.2 [.241] | -1.5 [.129] |
| # of obs. (firms) | 5805 (1301) | | | |

### Flemmish region

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .23 (.0074)* | -.25 (.0071)* | .01 (.0112) | .20 (.0629)* |
| $I_{t-1}/C_{t-2}$ | -.11 (.0070)* | -.35 (.0073)* | .07 (.0158)* | .05 (.0134)* |
| $CF_t/C_{t-1}$ | .29 (.0193)* | .28 (.017)* | .17 (.0600)* | .23 (.0449)* |
| $CF_{t-1}/C_{t-2}$ | .12 (.0151)* | .20 (.015)* | .02 (.0204) | .01 (.0162) |
| $\Delta\log(Y_t)$ | .32 (.0148)* | .84 (.027)* | -.11 (.0942) | -.01 (.0681) |
| $\Delta\log(Y_{t-1})$ | .16 (.0141)* | .56 (.0271)* | -.21 (.1053)* | .03 (.0268) |
| $\log(C_{t-2})- \log(Y_{t-2})$ | .43 (.0127)* | 1.16 (.0286)* | -.18 (.0502)* | .00 (.0165) |
| $\log(Y_{t-2})$ | .11 (.0148)* | .51 (.0294)* | -.27 (.1160)* | .00 (.0278) |
| Wald test joint signif. | 1449 [.000] | 3970 [.000] | 157 [.000] | 417 [.000] |
| Wald test time dummies | 1580 [.000] | 1655 [.000] | 7.4 [.385] | 77.9 [.000] |
| Wald test for CF | 258 [.000] | 294 [.000] | 24.8 [.000] | 55.3 [.000] |
| Sargan test | | | 131 [.213] | 191 [.024] |
| Test M1 | -22.9 [.000] | 17.3 [.000] | -23.3 [.000] | -25.5 [.000] |
| Test M2 | -9.1 [.000] | -6.4 [.000] | .24 [.811] | -.79 [.431] |
| # of obs. (firms) | 32746 (6633) | | | |

### Walloon region

| Model | WITHIN | F.D. OLS | F.D. GMM | GMM SYS |
|---|---|---|---|---|
| C | .24 (.0126)* | -.25 (.0093)* | -.08 (.0155)* | .22 (.0803)* |
| $I_{t-1}/C_{t-2}$ | -.14 (.016)* | -.38 (.0137)* | .01 (.0235) | .04 (.0199) |
| $CF_t/C_{t-1}$ | .27 (.0408)* | .29 (.0320)* | .35 (.0627)* | .27 (.056)* |
| $CF_{t-1}/C_{t-2}$ | .18 (.0268)* | .25 (.0225)* | .03 (.0256) | .03 (.021) |
| $\Delta\log(Y_t)$ | .37 (.0264)* | .94 (.0228)* | .29 (.1071)* | -.06 (.072) |
| $\Delta\log(Y_{t-1})$ | .17 (.0258)* | .68 (.0284)* | .51 (.1274)* | .05 (.0458) |
| $\log(C_{t-2})- \log(Y_{t-2})$ | .46 (.0218)* | 1.2 (.0200)* | .31 (.0634)* | .01 (.0195) |
| $\log(Y_{t-2})$ | .15 (.0279)* | .65 (.0325)* | .53 (.142)* | .00 (.0491) |
| Wald test joint signif. | 520 [.000] | 3975 [.000] | 79.6 [.000] | 251 [.000] |
| Wald test time dummies | 547 [.000] | 1626 [.000] | 44.7 [.000] | 46.3 [.000] |
| Wald test for CF | 98.1 [.000] | 143 [.000] | 44.8 [.000] | 36.7 [.000] |
| Sargan test | | | 124 [.354] | 178 [.084] |
| Test M1 | -11.3 [.000] | 13.0 [.000] | -11.1 [.000] | -14.2 [.000] |
| Test M2 | -4.1 [.000] | -2.5 [.014] | -1.2 [.231] | -.43 [.666] |
| # of obs. (firms) | 10280 (2115) | | | |

Notes:

a) Estimation performed using the DPD98 software (Arellano and Bond, 1998); all equations include time dummies; Heteroskedastic-consistent standard errors in bracket; P values in square brackets.
M1 and M2: tests for first order and second order serial correlation in the first difference residuals.

b) Two-step estimates; instruments used: observations dated t-2, t-3, t-4 and t-5 for $X_t$ (GMM F.D. and GMM SYS) and t-1 for $\Delta X_t$ (GMM SYS).

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