



# NATIONAL BANK OF BELGIUM

## WORKING PAPERS - RESEARCH SERIES

### FINANCE, UNCERTAINTY AND INVESTMENT: ASSESSING THE GAINS AND LOSSES OF A GENERALIZED NON LINEAR STRUCTURAL APPROACH USING BELGIAN PANEL DATA

---

Marcel Gérard<sup>(\*)</sup>  
Frédéric Verschueren<sup>(\*\*)</sup>

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

This paper is part of the research program on "New views on firms' investment and financial decisions" set up by the National Bank of Belgium for the years 2001-2002. Discussions with representatives of the Bank and the other member teams of the program are gratefully acknowledged. However the authors bear sole responsibility for the content of the paper.

---

<sup>(\*)</sup> Professor of Economics and Taxation, ARPEGE/FUCaM, Mons, Invited Professor, IAG/UCL, Louvain-la-Neuve, and CESifo, Munich; e-mail: marcel.gerard@fucam.ac.be

<sup>(\*\*)</sup> Postdoctoral Researcher, Belgian National Fund for Scientific Research, ARPEGE/FUCaM, Mons, and GREMARS, Lille III; e-mail: frederic.verschueren@fucam.ac.be

**Editorial Director**

Jan Smets, Member of the Board of Directors of the National Bank of Belgium

**Statement of purpose:**

The purpose of these working papers is to promote the circulation of research results (Research Series) and analytical studies (Documents Series) made within the National Bank of Belgium or presented by outside economists in seminars, conferences and colloquia organised by the Bank. The aim is thereby to provide a platform for discussion. The opinions are strictly those of the authors and do not necessarily reflect the views of the National Bank of Belgium.

**The Working Papers are available on the website of the Bank:**

<http://www.nbb.be>

Individual copies are also available on request to:

**NATIONAL BANK OF BELGIUM**

Documentation Service  
boulevard de Berlaimont 14  
B - 1000 Brussels

Imprint: Responsibility according to the Belgian law: Jean Hilgers, Member of the Board of Directors, National Bank of Belgium.

Copyright © National Bank of Belgium

Reproduction for educational and non-commercial purposes is permitted provided that the source is acknowledged.

ISSN: 1375-680X

## **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**

Using panel data for 2,329 Belgian firms observed between 1985 and 1999, this paper aims at getting a better understanding of Belgian firms' investment behavior. Two main and interrelated topics are investigated: the link between financial structure and investment decision, on the one hand, the effect of uncertainty on the level of investment, on the other hand. Such research sets forth the effect of some key variables, both in terms of level and volatility. The study is conducted within a structural approach but reduced form equations are also estimated. A generalised dynamic effect is investigated by introducing adjustment costs related through time. From that study, it clearly appears that small firms and high debt level firms are more sensitive to interest rate and cash flow. However, no role for investment price volatility is observed.

JEL Classification: C23; C33, E22

Keywords: Investment, debt constraint, panel data, GMM.



## **TABLE OF CONTENTS:**

<b>1. INTRODUCTION .....</b>	<b>2</b>
<b>2. SURVEY OF THE LITERATURE .....</b>	<b>3</b>
2.1 Financial structure and investment .....	3
2.2 Irreversibility, uncertainty and investment.....	4
<b>3. MODELING INVESTMENT BEHAVIOR .....</b>	<b>5</b>
3.1 The model.....	5
3.1.1 Financial constraints.....	6
3.1.2 Uncertainty.....	7
3.2 Alternative estimation strategies .....	7
3.2.1 Direct estimation of the structural parameters.....	7
3.2.2 Reduced form approach.....	8
<b>4. FINANCE, UNCERTAINTY AND INVESTMENT IN THE BELGIAN MANUFACTURING INDUSTRY (1985 - 1999).....</b>	<b>9</b>
4.1 The data set.....	9
4.2 Results and interpretations.....	10
4.2.1 Structural approach.....	10
4.2.2 Reduced form approach.....	14
4.3 Policy simulation: when specific interest rates are pushed downward .....	17
<b>5. CONCLUSION: LESSONS FROM THE ESTIMATION AND THE SIMULATION, AND AVENUES FOR FURTHER RESEARCH .....</b>	<b>19</b>
<b>REFERENCES .....</b>	<b>21</b>



## 1. Introduction

This research aims at getting a better understanding of Belgian firms' investment behavior, and to provide us with useful lessons regarding the best way to cope with individual investment in Belgium, both in terms of economic policy and research methodology.

It appears in the context of the recent flow of literature on the subject, although it is adapted to individual data, especially those based on annual accounts<sup>1</sup>. Two main and interrelated topics are investigated, explaining, at least theoretically, some stylized facts of today investment behavior. The first one is the link between financial structure and investment decision, in line with the family of contributions initiated by Fazzari, Hubbard and Petersen [1988] on the existence of capital markets imperfections and its possible implication for investment financing. The second topic is the effect of uncertainty on the level of investment, in line with Dixit and Pindyck's [1994] seminal contribution in the real approach tradition.

More specifically, the finance side of the research focuses on the validation of hypothesis regarding the sensitiveness of investment to the availability of internal funds and the existence of imperfections on the credit market, thus on reasons for including in investment equations such variables like cash flow, debt level and specific interest rates. It belongs to the range of studies where a financial constraint is introduced through an upper limit to indebtedness, which involves a risk premium associated to debt-specific interest rate (see Whited [1992] and Bond and Meghir [1994]). Recent related work on Belgian figures has been proposed for instance by Tychon [1997], Bond, Elston, Mairesse and Mulkay [1997] and Barran and Peeters [1998]. That finance side is extended by the introduction of uncertainty, specifically on investment goods price measured assuming stochastic processes - see Leahy and Whited [1996] or Peeters [1997] on Belgian data -. To tackle with the dynamic nature of investment, an augmented quadratic adjustment function is introduced, so that the costs due to any change in the stock of capital are related through time - see Sensenbrenner [1991].

Methodologically, two modeling strategies are used in the exercise.

The first one focuses on the evaluation of specifications already present in the literature or obtained in our effort of generalization; it is conducted in a Euler equations framework, the most usual approach in recent literature on investment (see the references above). However, the strong non-linearity at work in this class of models makes it difficult, or even impossible, to obtain solved reduced forms for investment equations needed to conduct economic policy exercises. Interactions between finance and investment in the framework of linear reduced forms have been examined in some recent studies. de Haan [1996] has estimated a system of simultaneous equations for investment, dividends and indebtedness. Stanca [1998] has proposed to use a vector autoregressive model while Chirinko, Fazzari and Meyer [1999] have more specifically studied the effect of the user cost of capital within a model inspired by the neoclassical approach of Eisner and Nadiri [1968], which is itself an extension of the seminal work by Jorgenson [1963].

So, in the second strategy, we investigate reduced forms based on our hypothesis regarding finance and uncertainty. An expected outcome is to isolate determinants which are specific to some classes of firms. Those models mainly come from a linearization of Euler equations used in the structural part of the study - see Chatelain [2000] for the case of financial constraints -.

---

<sup>1</sup>The availability of those data is a unique opportunity for the authors to go ahead with their research on investment in Belgium (see references); they are especially grateful to the National Bank of Belgium for that opportunity.

After the survey of literature of section 2, the paper elaborates on a model of investment behavior in section 3. The empirical exercise, conducted using a panel of 2,329 Belgian firms observed over 11 to 15 years (1985-1999), is reported in section 4; in that section, a simulation of the effect of a change in the specific interest rate is also proposed. Finally, section 5 concludes the study and suggests some directions for further research.

## 2. Survey of the literature

Unsurprisingly, two lines of literature are especially relevant for our research.

### 2.1. Financial structure and investment

Integration of the finance dimension in investment analysis remained for a long time a strictly empirical issue. Some authors, including Tinbergen [1939], Meyer and Kuh [1957] and Klein [1974] set among investment determinants a liquidity variable like profits, but they failed to provide a convincing link with economic theory. In a disequilibrium, or equilibrium with rationing context, Malinvaud [1981] showed that when profits are random, solvability constraint, i.e. the necessity to pay interests on debts and to refund debts at maturity, involves an upper limit to the rate of indebtedness which increases a.o. with the level of expected profits. As a consequence, such a constraint reduces opportunities for investment financing (see Artus and Muet [1984] for details).

A more recent line of literature tried to test the Modigliani and Miller [1958] hypothesis for which internal and external finance are perfect substitutes, so that investment decision is independent of the financing conditions of the firm. Such a view has been challenged by authors like Duesenberry [1958] but got renewed support from important contributors like Fazzari, Hubbard and Petersen [1988], Schiantarelli [1996] and Hubbard [1998] : for them, the existence of imperfections on financial markets can exert a strong influence on the financial structure of the firm.

Otherwise, Akerlof [1970], Myers and Majluf [1984] and Greenwald, Stiglitz and Weiss [1984] analyzed information asymmetry between lenders and borrowers in the framework of the principal-agent theory. Thus, it may be that banks decide on ceilings on their loans or on higher interest rates when they expect the borrower not to reveal some key information that he is the sole owner of, on e.g. the value of the firm or the risk of the investment project. Such asymmetry introduces a gap between external and internal sources of funds, which is translated into an agency cost. An agency cost related to the size of the debt has otherwise been investigated by Jensen and Meckling [1976], Myers [1977] and more recently Jaramillo, Schiantarelli and Weiss [1996].

Moreover, due to a high risk of bankruptcy, banks can refrain from agreeing to lend money. Then high bankruptcy costs increase the probability that unguaranteed debts will not be refunded when firm closes down (see Chatelain [1995], Bond and Meghir [1994] and Cuthbertson and Gasparro [1995]). By contrast, Ross [1977] and Leland and Pyle [1977] show that the size of the commercial debt can be interpreted by lenders as a signal of the stockholders' belief in the good health of the company, as argued by Biais and Gollier [1995].

Finally, important transaction costs linked to some sources of finance, e.g. issuing costs or tax discrimination - on the latter one see e.g. Gérard [1982b], King and Fullerton [1984], Poterba



and Summers [1983], Devereux, Keen and Schiantarelli [1994] - also have an effect on a firm's real decisions.

All those imperfections result in a possible, sometimes firm-specific, hierarchy among the sources of funds, which can in turn explain why investment expenditures can be limited by the capacity to use internal finance. Such a view provides a theoretical support to the frequently, and often significantly, observed relation between real investment expenditures and financial variables such as profit and cash flow.<sup>23</sup>

## 2.2. Irreversibility, Uncertainty and Investment

In a line of research initiated by Lucas and Prescott [1971], and renewed by Pindyck [1991], Dixit and Pindyck [1994] put together irreversibility of investment and sunk costs associated to disinvestment; in their analysis, demand uncertainty is modelled using a stochastic process on output price, deemed to be affected by random shocks. In such a context, it can pay off for an investor to postpone his decision and thus to wait in order to get additional information on future prospects. Then the option for waiting has a value, and the usual NPV rule is no longer valid. Therefore, a project will be considered if the value that it generates exceeds its purchase and installation cost by more than the value of the option for waiting; in fact, investment is compared to a call-type option in finance, and deciding on actually investing is similar to exercising the option. Abel and Eberly [1993, 1994] have also shown that investment irreversibility, translated into asymmetric adjustment costs, define an inaction where the sole optimal decision for the firm is to not invest (see also Abel and Eberly [1996] and Barnett and Sakellaris [1998])

Regarding the sign of the effect of uncertainty on investment decision, Bertola [1987], and then Pindyck [1988], stressed a negative relation when returns are decreasing or competition is imperfect, but without adjustment technology. That negative or irreversibility effect, is linked to a positive value of waiting, since accumulating too much capital can be costly if demand turns out to be actually weaker. By contrast, Hartman [1972] and Abel [1983, 1985] have shown a positive effect of uncertainty in a context of constant returns with convex adjustment costs. That effect is due to the convex relation between marginal profit and the parameter reflecting uncertainty such as prices; however, that view is not supported by the empirical results obtained by Leahy and Whited [1996].

The type of uncertainty is also a key issue. Uncertainty can be either microeconomic, based on firm-specific idiosyncratic shocks, or macroeconomic, and thus aggregate. Aggregation of investment behaviors subject to such uncertainties has been investigated a.o. by Bertola and Caballero [1991, 1994] and Caballero and Engel [1991]. It seems that absent aggregate uncertainty, distribution of aggregate investment cannot be characterized, a view recently extended by Caballero and Engle [1999]. Verschuere[n] [2000a] provides an original application of the aggregation process in the case of a strongly irreversible investment, using the indirect inference method of estimation.

---

<sup>2</sup>Manigart, Baeyens and Verschuere[n] [2002] studied the degree of information asymmetry by testing the sensitivity of investment to cash flow when Belgian unquoted companies receive venture capital.

<sup>3</sup>Cash flow sensitivity could also be analysed in the background of R&D investment. For the Belgian case, Cincera [2002] investigated the possible existence of liquidity constraints for Belgian investment both in capital and R&D. Bastin, Corhay, Hubner and Michel [2002] studied interactions between investment and financing decisions of R&D-intensive firms from biotechnology sector. Van Cayseele [2002] used the book value of R&D to deal with the corporate governance aspects of the investment cash-flow sensitivity.

Finally, Carruth, Dickerson and Henley [2000] surveyed the main empirical results regarding the evaluation of the effect of uncertainty on investment, at firm as well as at industry level.

### 3. Modeling Investment Behavior

In this section, we develop the theoretical model and discuss the estimation strategies.

#### 3.1. The model

The value of a firm  $i$  is defined as the discounted sum of present and expected dividend flows conditional to the available set of information and a discounting rate tentatively noted  $r_t$ . Using the equality between cash inflows and cash outflows, the dividend at time  $t$ ,  $D_{i,t}$  can be expressed as

$$D_{i,t} = (1 - \tau_t)(p_{i,t}F[K_{i,t-1}, L_{i,t}] - w_{i,t}L_{i,t} - i_{t-1}B_{i,t-1} - p_{i,t}^I G_{i,t}) + B_{i,t} - B_{i,t-1} - p_{i,t}^I I_{i,t} \quad (3.1)$$

with  $\tau_t$  the corporate income tax rate,  $p_{i,t}$  the output price,  $F[K_{i,t-1}, L_{i,t}]$  the total output produced with two inputs, capital stock  $K_{i,t-1}$  and the labor force  $L_{i,t}$ ,  $F$  being assumed to be homogenous of order one;  $w_{i,t}$  is wage rate,  $B_{i,t}$  the corporate debt,  $i_t$  the nominal interest rate on debt,  $p_{i,t}^I$  the price of investment goods,  $I_{i,t}$  total investment and  $G_{i,t}$  a convex installation function reflecting that modifying the level of capital stock is a costly activity. Cash flow is defined as  $CF_{i,t} = p_{i,t}F[K_{i,t-1}, L_{i,t}] - w_{i,t}L_{i,t}$ .

In order to add an uncertainty effect on prices, we introduce a stochastic shock  $\varepsilon_{i,t}$  which only affects the price of new investment<sup>4</sup>, not the adjustment in capital stock; then that price becomes  $\tilde{p}_{i,t}^I = p_{i,t}^I + \varepsilon_{i,t}$  with  $\varepsilon_{i,t} \sim N(0, \sigma_i^2)$ . Therefore, the last term in (3.1) is to be regarded as a variable investment costs with  $\tilde{p}_{i,t}^I I_{i,t}$  substituted for  $p_{i,t}^I I_{i,t}$ . We will return to the way  $\varepsilon_{i,t}$  can be constructed at the end of this subsection.

Since timing is an important feature in investment decision we want to capture some dynamics and, for that purposes, we choose the following specification for  $G_{i,t}$ , which is checked to be linearly homogenous in investment and capital stock (see Sensenbrenner [1991]),

$$G_{i,t} = \left( \alpha_0 \frac{I_{i,t}}{K_{i,t-1}} + \frac{\alpha_1}{2} \left( \frac{I_{i,t}}{K_{i,t-1}} \right)^2 - \sum_{m=1}^n \gamma_m \frac{I_{i,t}}{K_{i,t-1}} \frac{I_{i,t-m}}{K_{i,t-m-1}} \right) K_{i,t-1} \quad (3.2)$$

capital stock itself being constructed with the usual dynamic accumulation equation  $K_{i,t} = (1 - \delta)K_{i,t-1} + I_{i,t}$  where  $\delta$  is the deterioration rate of capital goods.

Moreover, to allow the output variable to play an active role, a common feature in most empirical work, we assume that firms have some market power, so that they face a demand curve with  $-\epsilon$  the elasticity of demand with respect to price.

---

<sup>4</sup>We could introduce other forms of uncertainty too, like uncertainty on the possibility to sell output or on output price.

### 3.1.1. Financial constraints

Two financial constraints are introduced. The first one is related to the non-negativity of dividend:  $D_{i,t} \geq 0$ . The second one makes sense when a firm is in a debt constrained regime, i.e.  $B_{i,t} \leq \bar{B}_{i,t}$  with  $\bar{B}_{i,t}$  the maximum amount that can be borrowed by firm  $i$ .

The optimization of the objective program with respect to labor, investment, accumulated capital and the size of the debt, thus the structure of corporate finance, subject to the constraints mentioned above, needs to use a generalized Lagrangian. For each period  $t$ , standard first-order conditions with respect to  $K$ ,  $I$  and  $L$  are easily derived. Since we have a constraint on the debt, we need the additional condition, from the first order derivative w.r.t.  $B$ , and this leaves us with

$$E_t \left\{ \frac{1}{1+r_t} \frac{1+\lambda_{i,t+1}^D}{1+\lambda_{i,t}^D} \right\} = \frac{1 - \frac{\lambda_{i,t}^B}{1+\lambda_{i,t}^D}}{1+i_t E_t \{1-\tau_{t+1}\}} \quad (3.3)$$

with  $r_t$  the discount rate, and  $\lambda_{i,t+j}^D$  and  $\lambda_{i,t+j}^B$  the multipliers associated with the constraint on dividend and on debt, respectively. Therefore, we obtain  $\lambda_{i,t}^D \geq 0$ ,  $D_{i,t} \geq 0$ ,  $\lambda_{i,t}^D D_{i,t} = 0$  and  $\lambda_{i,t}^B \geq 0$ ,  $(\bar{B}_{i,t} - B_{i,t}) \geq 0$ ,  $\lambda_{i,t}^B (\bar{B}_{i,t} - B_{i,t}) = 0$ .

In (3.3), the left hand term is actually the transformed discount rate of the model. Compared to an unconstrained firm, a firm facing a binding debt constraint will use a higher discounting rate for the flow of future earnings, since  $\lambda_{i,t}^B > 0$ . Assuming that this higher discounting rate is captured by the capital market mechanisms, the rate of interest on debt will be higher for this constrained firm.

At this stage, a major problem occurs since the theoretical model doesn't provide us with an analytical solution for the slackness parameters  $\lambda$ 's, so that they are unknown. To meet that problem, the direction chosen in this study consists in stating that the firm specific interest rate on debt,  $i_{i,t}$ , is such that,<sup>5</sup>

$$\frac{1 - \frac{\lambda_{i,t}^B}{1+\lambda_{i,t}^D}}{1+i_t E_t \{1-\tau_{t+1}\}} = \frac{1}{1+i_{i,t} E_t \{1-\tau_{t+1}\}} \quad (3.4)$$

To observe  $i_{i,t}$ , it is possible to use financial information given in panel data - see van Ees *et al.* [1997] -. Indeed, let the observed firm-specific average interest rate on interest-bearing debt,  $r_{i,t}$ , be defined as  $r_{i,t} = \eta_{i,t}(i_t^S + \nu_{i,t}) + (1-\eta_{i,t})(i_t^L + \nu_{i,t})$  where  $\eta_{i,t}$  is the ratio between short term and long term debt,  $i_t^S$  and  $i_t^L$  are risk free short-term and long-term corporate interest rates supposed equal across firms, and  $\nu_{i,t}$  is the firm-specific risk premium, assumed to be the same on long- and short-term debt. Then, since  $i_{i,t} = i_t + \nu_{i,t}$ , we get  $i_{i,t} = r_{i,t} - \eta_{i,t}(i_t^S - i_t^L)$ <sup>6</sup>.

<sup>5</sup> An alternative solution is proposed by Whited [1992], who expresses the unknown part of (3.4) as a quadratic form of two observable ratios. The first one is the ratio between the market value of the firm's debt and the market value of its total assets, named a debt-asset ratio or DAR. The second one, called the interest coverage ratio, or ICR, is the ratio of the firm's interest expenditures to the sum of interest expenditures and cash flow.

<sup>6</sup> Bond and Meghir [1994] write  $i_{i,t}$  as the sum of the market interest rate  $i_t$  and a risk premium, the latter being related to debt and capital by a quadratic functional form.

Substituting this observed specific interest rate in (3.4) and using the set of first order conditions, we are able to write the full structural model as

$$E_t \left\{ \frac{1}{1 + i_{i,t}(1 - \tau_{t+1})} (U_{i,t+1} + (1 - \delta) W_{i,t+1}) - W_{i,t} \right\} = 0 \quad (3.5)$$

with

$$U_{i,t+1} = (1 - \tau_{t+1}) \left[ \frac{CF_{i,t+1} + \epsilon^{-1} p_{i,t+1} Y_{i,t+1}}{K_{i,t}} + \frac{\alpha_1}{2} p_{i,t+1}^I \left( \frac{I_{i,t+1}}{K_{i,t}} \right)^2 \right]$$

$$W_{i,t+1} = \left[ (1 - \tau_{t+1}) \left( \alpha_0 + \alpha_1 \frac{I_{i,t+1}}{K_{i,t}} - \sum_{m=1}^n \gamma_m \frac{I_{i,t+1-m}}{K_{i,t-m}} \right) p_{i,t+1}^I + \tilde{p}_{i,t+1}^I \right]$$

### 3.1.2. Uncertainty

In order to take the effect of uncertainty on investment price into account, we consider an  $AR(a)$  representation for this variable,

$$p_{i,t}^I = \rho_0 + \rho_1 p_{i,t-1}^I + \dots + \rho_a p_{i,t-a}^I + \eta_{i,t} \quad (3.6)$$

with  $\eta_{i,t}$  an error term, or the unpredictable part of the investment price.

This error term  $\eta_{i,t}$  has a time part  $\eta_t$  and a idiosyncratic part  $\eta_i$ . A firm-specific uncertainty measure is built up using the estimate of the standard deviation of the  $\eta_i$ 's, denoted  $\hat{\sigma}_i$ . The latter effect has, however, no time dimension, so that it is common to weigh it with a time dependent ratio. We opt for the asset-to-equity ratio as in Peeters [1997]. The argument behind this view is that more (viz : less) uncertainty is expected to be faced by firms with higher (viz : lower) debt levels.<sup>7</sup> Denoting this ratio  $\theta_{i,t}$ , the uncertainty effect on prices becomes  $\hat{u}_{i,t} = \theta_{i,t} \hat{\sigma}_i$ . Then, relating the shock affecting investment price with this uncertainty measure, one gets  $\varepsilon_{i,t} = \kappa \hat{u}_{i,t} + \zeta_{i,t}$  with  $\zeta_{i,t}$  a white noise and  $\kappa$  a parameter.

## 3.2. Alternative estimation strategies

Two strategies can be adopted to estimate the model, first a *structural approach*, the a *reduced form approach*.

### 3.2.1. Direct estimation of the structural parameters

Under the rational expectations hypothesis, all expectations terms can be replaced by their observed values. This implies the introduction of a general expectation error,  $e_{i,t+1}$ , orthogonal to the set of information at period  $t$ . With such a decomposition, (3.5) becomes the dynamic non-linear structural model,

$$k'_{i,t+1} = \eta_c c_{i,t+1} + \eta_y y_{i,t+1} + \eta_s s_{i,t+1} + \eta_u u'_{i,t+1} + \sum_{m=1}^n \eta_{k,m} k''_{i,t-m} + d_i + d_{t+1} + e_{i,t+1} \quad (3.7)$$

<sup>7</sup>Alternatively, Leahy and Whited [1996] used the equity to debt ratio, so that uncertainty is related to leverage.

with

$$\begin{aligned}
k_{i,t+1} &= \frac{I_{i,t+1}}{K_{i,t}}, \quad b_{i,t+1} = \frac{1}{1 + i_{i,t}^L(1 - \tau_{t+1})} \\
k'_{i,t+1} &= \frac{b_{i,t+1}^{-1}}{1 - \tau_{t+1}}(1 - \tau_t)p_{i,t}^I k_{i,t} - (1 - \delta)p_{i,t+1}^I k_{i,t+1} - \frac{1}{2}p_{i,t+1}^I (k_{i,t+1})^2 \\
c_{i,t+1} &= \frac{p_{i,t+1}Y_{i,t+1} - w_{i,t+1}L_{i,t}}{K_{i,t}} = y_{i,t+1} - \omega_{i,t+1} \\
s_{i,t+1} &= \frac{b_{i,t+1}^{-1}}{1 - \tau_{t+1}}(1 - \tau_t)p_{i,t}^I - (1 - \delta)p_{i,t+1}^I \\
u'_{i,t+1} &= \frac{b_{i,t+1}^{-1}}{1 - \tau_{t+1}}\widehat{u}_{i,t} - (1 - \delta)\widehat{u}_{i,t+1} \\
k''_{i,t-m} &= \frac{b_{i,t+1}^{-1}}{1 - \tau_{t+1}}(1 - \tau_t)p_{i,t}^I k_{i,t-m} - (1 - \delta)p_{i,t+1}^I k_{i,t+1-m}, \quad m = 1, \dots, n
\end{aligned}$$

and

$$\eta_c = \frac{1}{\alpha_1}, \quad \eta_y = -\frac{\epsilon^{-1}}{\alpha_1}, \quad \eta_s = -\frac{1 - \alpha_0}{\alpha_1}, \quad \eta_u = -\frac{\kappa}{\alpha_1}, \quad \eta_{k,m} = \frac{\gamma_m}{\alpha_1}$$

The key determinants are the cash flow ratio ( $c$ ), the output ratio ( $y$ ), the user cost of capital ( $s$ ), the uncertainty effect ( $u'$ ) and the dynamics ( $k''_{t-m}$ ). The set of structural parameters is obtained by inverting the binding function,

$$\alpha_1 = \frac{1}{\eta_c}, \quad \alpha_0 = \frac{\eta_s + \eta_c}{\eta_c}, \quad \epsilon^{-1} = -\frac{\eta_y}{\eta_c}, \quad \kappa = -\frac{\eta_u}{\eta_c}, \quad \gamma_m = \frac{\eta_{k,m}}{\eta_c}$$

### 3.2.2. Reduced form approach

The second strategy is based on a reduced form approach, solving the model for investment. Unfortunately, an exact solution for (3.7) does not exist. So we need to use a linear approximation, assuming a constant rate of taxation over time<sup>8</sup> ( $\tau_{t+1} = \tau_t = \tau$ ) and retaining a linear evaluation for  $k'_{i,t}$  and  $k''_{i,t}$ . This leaves us with the linear dynamic model with rational expectations,

$$E_t \left\{ k_{i,t+1} - \sum_{m=0}^n \varphi_{k,m} k_{i,t-m} \right\} = E_t \{ \eta'_y y_{i,t+1} + \eta_\omega \omega_{i,t+1} + \eta_s s_{i,t+1} + \eta_u u''_{i,t+1} \} \quad (3.8)$$

with

$$y_{i,t} = \frac{p_{i,t}Y_{i,t}}{p_{i,t}^I K_{i,t}}, \quad \omega_{i,t} = \frac{w_{i,t}L_{i,t}}{p_{i,t}^I K_{i,t}}, \quad s_{i,t} = (i_{i,t}^L + \delta), \quad \widehat{u}_{i,t} = \frac{\widehat{u}_{i,t}}{p_{i,t}^I}$$

---

<sup>8</sup>Clearly that assumption removes any fiscal policy assessment, though taxation rate has been considered as a crucial determinant to investment in some part of the theoretical literature.

and parameters  $\varphi'_s$  coming from linearization.<sup>9</sup>

Interestingly, due to the linearity in variables, expectations can now be solved together with the investment scheme, allowing us to consider economic policy assessment. The solution, however, needs additional assumptions on the way exogenous variables behave over time. More particularly, these movements have to be modelled by autoregressive, or *AR*, processes - see Blanchard and Khan [1980] -. Bearing in mind the annual nature of the data and the dynamic links enlightened in the theoretical model, it seems realistic to retain *AR*(1) models for output-to-capital ratio, wage-to-capital ratio, user cost and uncertainty. Recalling our definition of uncertainty, we then assume that asset-to-equity ratio fits the *AR*(1) profile. Besides, to be able to conduct policy exercises on specific interest rates - see below -, we have to estimate the strength in the dynamics of the user cost of capital apart from the model. Previous studies - see a.o. Verschuere[n] [2000] on time series - have already suggested that interest rate fits a random walk process.

It is easily shown that these assumptions lead to a dynamic solution of (3.8) written as,<sup>10</sup>

$$k_{i,t} = \sum_{m=1}^n \gamma'_{km} k_{i,t-m} + \gamma_y y_{i,t} + \gamma_\omega \omega_{i,t} + \gamma_s s_{i,t} + \gamma_u \hat{u}''_{i,t} + d_i + d_t + e_{i,t} \quad (3.9)$$

#### 4. Finance, uncertainty and investment in the Belgian manufacturing industry (1985-1999)

This section first presents the data, further detail being provided in the appendix. Then it turns to the results and their interpretation before performing an economic policy simulation.

##### 4.1. The data set

Data used in this exercise come from the balance sheets reported accounts data base of the National Bank of Belgium. From the 15,000 firm data base, an unbalanced panel of 2,329 firms has been extracted, which is observed over between 11 and 15 years. A larger coverage in terms of firms is possible but then on a shorter length of time; we decided to give priority to the length of the series in order to go across possible economic cycles. We supplemented that data base by figures from the Belgian National Accounts, especially for prices (using output and investment deflators), while nominal interest rates come from the *Mémentos économiques et financiers*, a Kluwer publication, and the SNCI / NMKN, the National Company for Credit to Industry.

The data are presented with more details in the appendix where statistics on specific interest rates, debt-equity structures and specific tax rates are also provided.

<sup>9</sup>Therefore, structural parameters can not be retrieved from the  $\gamma$ 's since the binding functions with the structural parameters are unknown. However, an indirect inference procedure could be applied to overcome this problem, but this is beyond the scope of this study.

<sup>10</sup>As mentioned in Verschuere[n] and Gérard [2000], this dynamic equation could be transformed in order to separate the long- and short-run movements of investment and deal with non stationarity. Changes in investment are analyzed within an error correction (EC) model with first difference variables. We actually tried to conduct a cointegration inference adapted for panel data (see Pesaran and Smith [1995] or Harris et Tzavalis [1999]), but failed to get convincing results.

## 4.2. Results and interpretations

The estimation technique used in this paper is the GMM approach to unbalanced panel developed by Arellano and Bond [1991]. Unbalanced panel data refers to a sample in which consecutive observations on individuals are available, but the number of time periods available can vary according to individuals. Basically, in this approach, the unobserved individual effects are eliminated by applying a forward 'orthogonal deviations' transformation on all variables of the model. This ensures the absence of correlation between the transformed error terms and lagged values of the untransformed dependent variable, which can therefore be used as valid instruments. Actually, GMM estimators typically use more orthogonality conditions than their IV counterparts. Moreover, they take the covariance structure of the disturbances into account and are therefore asymptotically more efficient - see Kiviet [1995] -.

Equations (3.7) and (3.9) have been estimated in first differences, coping with the possible non-stationarity in regressors. For our instrument set we chose variables lagged at periods  $t - 2$  and  $t - 3$ . Two important statistics are provided. The Sargan statistics (SG) is the test of overidentifying restrictions, investigating whether the orthogonality conditions are respected. Under the null hypothesis, SG follows a  $\chi^2$  law, with the number of variables minus the number of instruments as number of degrees of freedom. On the other hand, the M1 statistics is a test for first-order serial correlation on residuals from the (first difference) specification; it is distributed  $\sim N(0, 1)$ .

Before assessing the empirical performance of the models, we have to conduct an estimation ruling out the price of investment, in order to get an estimate of the uncertainty measure of this variable. So, first of all, we estimate an autoregressive model like (3.6) to get a sector-specific value. As in Verschueren [2000a], there is a clear evidence that each  $p_{s,t}^I$  follows a simple random walk, so that  $\rho = 1$ . Next, a time-dependent and firm-dependent measure is built up using, as was done previously, equation  $\hat{u}_{i,t} = \theta_{i,t}\hat{\sigma}_i$ , with a normalization with respect to the asset-to-equity ratio.

### 4.2.1. Structural approach

Table 1 presents the estimation results of equation (3.7) for the whole set of data, i.e. for all firms. Since there is more to learn from the model by investigating regimes where specific (expected) behaviors can be observed, we first make a distinction between small and large firms in order to capture a size effect - tables 2a and 2b - and between firms with high and low leverage - tables 3a and 3b -. For the first breakdown, firms are distributed on the basis of their capital stock (low level versus high level of capital); the threshold value is the mean value from the panel, and it is compared to firms' mean values. The alternative analysis is based on leverage: high debt level firms are isolated from low debt level firms. Again the threshold is the average debt level.

Each table is split into two parts. On the left hand side, uncertainty on investment prices is not taken into account, i.e.  $\kappa = 0$ , while, on the right hand side, uncertainty parameter  $\hat{\eta}_u$  is estimated. On both sides, perfect and imperfect competition cases are investigated through the role of output (and hence  $\hat{\eta}_y$ ). Also, a dynamic effect is either absent or present through  $\hat{\eta}_{k,1}$ . Standard errors of estimated coefficients are given by  $\hat{\sigma}[\cdot]$ .

Finally Table 4 contains retrieved values for the set of structural parameters, based on the results obtained from the best equation for each regime.

Let us note that the SG-test is never significant and that a significant serial correlation in the residuals is detected in two cases only, which are not the ones used to compute the values of the structural parameters reported in table 4.

**Full sample.** From the full sample results, there is clear evidence that the cash flow variable matters since  $\hat{\eta}_c$  is always significantly different from zero. Also, a dynamic effect is at work, illustrated by significant dynamic coefficients of the adjustment function ( $\hat{\eta}_{k,1}$ ). The role of the interest rate, through the user cost of capital, is less obvious, although significant at 90 percent ( $\hat{\eta}_s$ ). It is interesting to observe that all signs are consistent with economic theory. However, imperfect competition on goods market cannot be retained, since the inclusion of output ratio does not actually improve the results ( $\hat{\eta}_y$ ). Finally, we are unable to retain a relation between price-uncertainty and investment since the estimated coefficient  $\hat{\eta}_u$  is never significantly different from zero.

Tab 1. Equation (3.7), full sample

$\hat{\eta}_c$	0.610*	0.672*	0.607*	0.679*	0.609*	0.672*	0.608*	0.677*
$\hat{\sigma}[\hat{\eta}_c]$	0.080	0.071	0.083	0.074	0.081	0.074	0.083	0.076
$\hat{\eta}_s$	-0.418 <sup>o</sup>	-0.411 <sup>o</sup>	-0.437 <sup>o</sup>	-0.412 <sup>o</sup>	-0.418 <sup>o</sup>	-0.412 <sup>o</sup>	-0.435 <sup>o</sup>	-0.411 <sup>o</sup>
$\hat{\sigma}[\hat{\eta}_s]$	0.235	0.222	0.231	0.222	0.235	0.224	0.233	0.221
$\hat{\eta}_y$	0	0	0.005	-0.053	0	0	-0.015	-0.060
$\hat{\sigma}[\hat{\eta}_y]$	-	-	0.051	0.050	-	-	0.052	0.047
$\hat{\eta}_{k,1}$	0	0.599*	0	0.601*	0	0.598*	0	0.623*
$\hat{\sigma}[\hat{\eta}_{k,1}]$	-	0.241	-	0.242	-	0.244	-	0.244
$\hat{\eta}_u$	0	0	0	0	2.133	0.154	1.276	1.332
$\hat{\sigma}[\hat{\eta}_u]$	-	-	-	-	5.34	5.13	5.29	5.19
<i>SG</i>	35.8	38.2	39.3	40.3	36.9	41.3	42.5	43.7
<i>M1</i>	-1.03	0.41	1.21	0.93	-1.02	-0.07	0.38	0.64

\* Significant at 95%    <sup>o</sup> Significant at 90%

**Size effect.** Very interesting features now appear. First, lower capital level firms are more sensitive to cash flow ( $\hat{\eta}_c$ ) than higher capital level firms. This is consistent with the hypothesis that small firms rely more on, or may be constrained by, internal funds. Second, the effect of the user cost of capital ( $\hat{\eta}_s$ ), the key neoclassical variable, is significantly different from zero at 95 percent for small firms, but it is hardly detected for large firms. The role of a specific interest rate is therefore more crucial for small firms, a slight change in that variable being expected to have a large effect on investment. The cash flow and the user cost effects do not matter so much for larger firms. We also notice that dynamics ( $\hat{\eta}_{k,1}$ ) is now a more significant determinant for small firms than for large firms. Moreover, the effects of output markets clearly depends on the size of the firm. Remember that from our model,  $\hat{\eta}_y$  significantly different from zero means that demand elasticity with respect to price is less than infinity, revealing market non-competitiveness. Such a feature only appears for larger firms. Besides, the model fails to detect any uncertainty impact of investment prices since  $\hat{\eta}_u$  is never significantly non-zero.



Tab 2a. Equation (3.7), small firms

$\hat{\eta}_c$	0.834*	0.895*	0.865*	0.879*	0.836*	0.895*	0.864*	0.881*
$\hat{\sigma}[\hat{\eta}_c]$	0.103	0.091	0.100	0.091	0.103	0.092	0.100	0.091
$\hat{\eta}_s$	-0.530*	-0.531*	-0.537*	-0.512*	-0.527*	-0.530*	-0.529*	-0.510*
$\hat{\sigma}[\hat{\eta}_s]$	0.267	0.248	0.269	0.230	0.267	0.249	0.270	0.231
$\hat{\eta}_y$	0	0	-0.000	-0.002	0	0	0.000	0.009
$\hat{\sigma}[\hat{\eta}_y]$	-	-	0.012	0.011	-	-	0.012	0.012
$\hat{\eta}_{k,1}$	0	0.691*	0	0.698*	0	0.692*	0	0.699*
$\hat{\sigma}[\hat{\eta}_{k,1}]$	-	0.201	-	0.199	-	0.202	-	0.199
$\hat{\eta}_u$	0	0	0	0	1.107	1.200	0.987	1.404
$\hat{\sigma}[\hat{\eta}_u]$	-	-	-	-	4.87	4.67	4.90	4.67
<i>SG</i>	30.6	31.1	31.6	33.5	33.4	33.7	34.1	34.9
<i>M1</i>	0.36	-0.59	0.06	0.98	2.01*	1.63	0.09	-1.00

\* Significant at 95%    ° Significant at 90%

Tab 2b. Equation (3.7), large firms

$\hat{\eta}_c$	0.517*	0.533*	0.520*	0.520*	0.517*	0.534*	0.520*	0.521*
$\hat{\sigma}[\hat{\eta}_c]$	0.067	0.060	0.067	0.058	0.067	0.060	0.067	0.059
$\hat{\eta}_s$	-0.301	-0.303	-0.308°	-0.302	-0.300	-0.303	-0.308°	-0.302
$\hat{\sigma}[\hat{\eta}_s]$	0.193	0.188	0.181	0.189	0.194	0.190	0.194	0.191
$\hat{\eta}_y$	0	0	-0.320*	-0.317*	0	0	-0.320*	-0.317*
$\hat{\sigma}[\hat{\eta}_y]$	-	-	0.112	0.110	-	-	0.112	0.111
$\hat{\eta}_{k,1}$	0	0.344°	0	0.351°	0	0.344°	0	0.351°
$\hat{\sigma}[\hat{\eta}_{k,1}]$	-	0.191	-	0.192	-	0.193	-	0.193
$\hat{\eta}_u$	0	0	0	0	0.055	0.195	0.007	0.067
$\hat{\sigma}[\hat{\eta}_u]$	-	-	-	-	3.12	3.11	3.12	3.11
<i>SG</i>	26.7	28.6	28.9	30.0	27.3	30.1	30.7	31.4
<i>M1</i>	-0.87	-0.00	0.87	-0.71	0.99	-0.87	1.23	0.03

\* Significant at 95%    ° Significant at 90%

**Leverage effect.** Inspection of tables 3a and 3b first reveals asymmetry in the cash flow effect ( $\hat{\eta}_c$ ). Higher indebted firms are indeed much more sensitive to changes in their internal source of funds. However, asymmetry is more critical for the user cost of capital ( $\hat{\eta}_s$ ). Estimated coefficients  $\hat{\eta}_s$  are always significant at 95 percent and get negative values for higher leverage. This is in line with the recognition of a key role for the specific interest rate. A slight upward move in that neoclassical variable has dramatic implications on investment, while a slight downward change is quite desirable because these firms are also expected to be cash flow constrained. Firms with high debt level also seem to be more sensitive to the dynamics ( $\hat{\eta}_{k,1}$ ) when deciding on investment schemes. Finally, and for the first time, an uncertainty effect is detected (significant at 90 percent) for higher indebted firms. Surprisingly, this only appears in the model which includes cash flow, user cost and dynamics together. The positive value of  $\hat{\eta}_u$  suggests that uncertainty in the price of investment acts as a disincentive to investment [see the binding function of (3.7), inducing a negative value for  $\kappa$ ]. But we have to be careful with such an assertion since both estimated values and estimated standard errors of the uncertainty parameter

do vary a lot across equations and regimes. Moreover, we notice that the detection of imperfect competition ( $\hat{\eta}_y$ ) for lower debt level firms is now only significant at 90 percent, while a perfect competition assumption fits higher debt level firms better. These results also tend to suggest that many small (*viz.* large) firms have relatively high (*viz.* low) debt level ; we could refer them to category 1 (small and highly indebted) firms *vs* category 2 (large with low debt level) firms.

Tab 3a. Equation (3.7), high debt level firms

$\hat{\eta}_c$	0.799*	0.791*	0.797*	0.790*	0.800*	0.783*	0.798*	0.788*
$\hat{\sigma}[\hat{\eta}_c]$	0.100	0.090	0.101	0.090	0.103	0.092	0.100	0.092
$\hat{\eta}_s$	-0.612*	-0.610*	-0.637*	-0.612*	-0.620*	-0.639*	-0.621*	-0.619*
$\hat{\sigma}[\hat{\eta}_s]$	0.280	0.261	0.282	0.260	0.280	0.259	0.280	0.262
$\hat{\eta}_y$	0	0	0.030*	0.015	0	0	0.019	0.010
$\hat{\sigma}[\hat{\eta}_y]$	-	-	0.013	0.013	-	-	0.017	0.016
$\hat{\eta}_{k,1}$	0	0.707*	0	0.709*	0	0.700*	0	0.695*
$\hat{\sigma}[\hat{\eta}_{k,1}]$	-	0.206	-	0.206	-	0.205	-	0.206
$\hat{\eta}_u$	0	0	0	0	2.070	2.301 <sup>o</sup>	0.987	2.004
$\hat{\sigma}[\hat{\eta}_u]$	-	-	-	-	2.01	1.40	2.12	1.50
<i>SG</i>	24.1	24.9	25.6	27.8	25.3	25.9	26.8	28.0
<i>M1</i>	2.08*	-0.05	0.64	0.08	-1.11	-0.49	1.13	0.56

\* Significant at 95%    <sup>o</sup> Significant at 90%

Tab 3b. Equation (3.7), low debt level firms

$\hat{\eta}_c$	0.467*	0.467*	0.483*	0.478*	0.499*	0.500*	0.487*	0.495*
$\hat{\sigma}[\hat{\eta}_c]$	0.073	0.072	0.070	0.070	0.074	0.073	0.073	0.073
$\hat{\eta}_s$	-0.171	-0.182	-0.170	-0.180	-0.164	-0.192	-0.160	-0.161
$\hat{\sigma}[\hat{\eta}_s]$	0.140	0.127	0.130	0.126	0.143	0.130	0.139	0.140
$\hat{\eta}_y$	0	0	-0.287 <sup>o</sup>	-0.281*	0	0	-0.273 <sup>o</sup>	-0.256 <sup>o</sup>
$\hat{\sigma}[\hat{\eta}_y]$	-	-	0.152	0.138	-	-	0.155	0.147
$\hat{\eta}_{k,1}$	0	0.279 <sup>o</sup>	0	0.300*	0	0.280 <sup>o</sup>	0	0.306 <sup>o</sup>
$\hat{\sigma}[\hat{\eta}_{k,1}]$	-	0.153	-	0.153	-	0.154	-	0.153
$\hat{\eta}_u$	0	0	0	0	1.090	-0.723	0.926	0.555
$\hat{\sigma}[\hat{\eta}_u]$	-	-	-	-	3.09	2.50	3.09	3.08
<i>SG</i>	29.9	30.4	30.6	31.6	29.8	34.7	35.2	36.8
<i>M1</i>	0.67	0.65	1.02	-1.44	1.63	1.00	-0.05	0.32

\* Significant at 95%    <sup>o</sup> Significant at 90%

**Structural parameters.** Table 4 contains retrieved values for the set of structural parameters, based on the results obtained from the best equation for each regime.

The first point to set forth is about adjustment costs, an important feature in our model. Firms belonging to category 1 appear to be more sensitive to cash flow, which implies that the quadratic parameter of adjustment technology ( $\alpha_1$ ) is lower. Moreover, dynamics more matters for these firms ( $\gamma$ ). The cost of adding one extra unit of investment [see equation (3.2)] is estimated using a static value for the rate of investment equal to the rate of deterioration ( $\bar{k} = \delta = 0.10$ ) [last line in the table]. At first glance, it seems that, for category 2 firms, that cost

is larger than for category 1 firms, especially firms with a low leverage. One explanation could be that the rate of investment of category 2 firms is lower and does not vary much between two successive periods, while it is more volatile for category 1 firms. Taken as a whole, adjustment costs get realistic values. Otherwise, (minus) demand elasticity with respect to output price,  $\varepsilon$ , is estimated around 1.7 for category 2 firms, putting forward a realistic imperfect competition effect for that category. Finally,  $\kappa$  refers to uncertainty, a feature only significantly different from zero, and still at 90 percent level, for firms with higher leverage.

Table 4. Structural parameters, equation (3.7)

	Full sample	Small firms	Large firms	High leverage	Low leverage
$\alpha_0$	0.388	0.406	0.419	0.183	0.624
$\alpha_1$	1.488	1.117	1.923	1.277	2.092
$\gamma$	0.891	0.772	0.675	0.894	0.627
$\varepsilon$	$\infty$	$\infty$	1.640	$\infty$	1.701
$\kappa$	0	0	0	-2.933	0
$G_I[\bar{k} = .10]$	0.447	0.440	0.543	0.221	0.770

#### 4.2.2. Reduced form approach

Our reduced form (3.9) model has been estimated for alternative regimes: (i) the whole set of data, (ii) small versus large firms and (iii) high versus low leverage firms. Results are summarized in tables 5, 6a and 6b, and 7a and 7b, respectively. Estimated coefficients, standard errors, and statistics related to instruments and serial correlation tests are presented as in the previous tables. Notice that, since the cash flow variable has been splitted between output on the one hand and wages on the other hand, we have to include the output variable as a necessary regressor in the model, so that the null hypothesis of parameter  $\eta'_y$  will not be considered.

**Full sample.** In table 5 a user cost (hence interest rate) impact and a dynamic effect are detected when the sample is taken as a whole. Indeed both  $\hat{\gamma}_s$  and  $\hat{\gamma}_{k,1}$  are significantly different from zero at 95 percent in the second column of results. Also, the output variable (through  $\hat{\gamma}_y$ ) plays a significant role in explaining investment rates. Unfortunately, to explain this output effect we are now unable to discriminate between a financial reason (through a cash flow constraint) and an economic reason (through imperfect competition) since the wage rates coefficient ( $\hat{\gamma}_\omega$ ) is never significantly different from zero. Also, notice that results do not vary when introducing uncertainty, due to non-significant  $\hat{\gamma}_u$ .

Tab 5. Equation (3.9), full sample

$\hat{\gamma}_\omega$	-0,028	<b>-0,037</b>	-0,030	-0,038
$\hat{\sigma}[\hat{\gamma}_\omega]$	0,090	<b>0,089</b>	0,091	0,091
$\hat{\gamma}_s$	-0,144 <sup>o</sup>	<b>-0,181*</b>	-0,144 <sup>o</sup>	-0,183*
$\hat{\sigma}[\hat{\gamma}_s]$	0,081	<b>0,076</b>	0,081	0,080
$\hat{\gamma}_y$	0,217*	<b>0,200*</b>	0,218*	0,202*
$\hat{\sigma}[\hat{\gamma}_y]$	0,050	<b>0,043</b>	0,051	0,046
$\hat{\gamma}_{k,1}$	0	<b>0,253*</b>	0	0,255*
$\hat{\sigma}[\hat{\gamma}_{k,1}]$	-	<b>0,090</b>	-	0,092
$\hat{\gamma}_u$	0	<b>0</b>	-0,023	0,010
$\hat{\sigma}[\hat{\gamma}_u]$	-	-	0,451	0,388
<i>SG</i>	20,1	<b>17,9</b>	20,7	18,3
<i>M1</i>	0,37	<b>0,01</b>	-1,07	0,15

\* Significant at 95%    <sup>o</sup> Significant at 90%

Tab 6a. Equation (3.9), small firms

$\hat{\gamma}_\omega$	-0,036	<b>-0,050</b>	-0,042	-0,049
$\hat{\sigma}[\hat{\gamma}_\omega]$	0,085	<b>0,083</b>	0,086	0,086
$\hat{\gamma}_s$	-0,215*	<b>-0,201*</b>	-0,214*	-0,201*
$\hat{\sigma}[\hat{\gamma}_s]$	0,086	<b>0,081</b>	0,087	0,085
$\hat{\gamma}_y$	0,281*	<b>0,269*</b>	0,283*	0,270*
$\hat{\sigma}[\hat{\gamma}_y]$	0,073	<b>0,067</b>	0,072	0,070
$\hat{\gamma}_{k,1}$	0	<b>0,287*</b>	0	0,287
$\hat{\sigma}[\hat{\gamma}_{k,1}]$	-	<b>0,093</b>	-	0,093
$\hat{\gamma}_u$	0	<b>0</b>	0,003	0,016
$\hat{\sigma}[\hat{\gamma}_u]$	-	-	0,320	0,294
<i>SG</i>	17,2	<b>16,3</b>	17,8	16,2
<i>M1</i>	-0,00	<b>0,34</b>	0,99	0,71

\* Significant at 95%    <sup>o</sup> Significant at 90%

Tab 6b. Equation (3.9), large firms

$\hat{\gamma}_\omega$	-0,014	<b>-0,029</b>	-0,017	-0,025
$\hat{\sigma}[\hat{\gamma}_\omega]$	0,089	<b>0,085</b>	0,092	0,090
$\hat{\gamma}_s$	-0,187*	<b>-0,177*</b>	-0,187*	-0,177*
$\hat{\sigma}[\hat{\gamma}_s]$	0,076	<b>0,075</b>	0,077	0,077
$\hat{\gamma}_y$	0,193*	<b>0,181*</b>	0,192*	0,183*
$\hat{\sigma}[\hat{\gamma}_y]$	0,050	<b>0,040</b>	0,053	0,044
$\hat{\gamma}_{k,1}$	0	<b>0,212*</b>	0	0,210*
$\hat{\sigma}[\hat{\gamma}_{k,1}]$	-	<b>0,085</b>	-	0,086
$\hat{\gamma}_u$	0	<b>0</b>	-0,003	-0,049
$\hat{\sigma}[\hat{\gamma}_u]$	-	-	0,267	0,258
<i>SG</i>	16,8	<b>16,0</b>	16,8	16,3
<i>M1</i>	0,42	<b>-0,11</b>	1,30	0,66

\* Significant at 95%    <sup>o</sup> Significant at 90%

**Size effect** Asymmetries appear in the estimates when splitting firms according to their size (see tables 6a and 6b). Firms with lower capital stock tend to be more sensitive to the user cost of capital as well as to the output ratio. Interestingly, a larger difference between regime estimates is observed for the output variable [ $\hat{\gamma}_y = 0,269$  for small firms while  $\hat{\gamma}_y = 0,181$  for large firms]. Since we have again to reject a significant impact of wages on investment, the role detected for output rests on a (unknown) mix of the two effects (financial and economic) highlighted before.<sup>11</sup> Next, although dynamics matters for each size of firms, it seems that the time dimension is more able to explain investment for small firms than for large firms. Finally, a link between uncertainty and investment is again questioned as our model is unable to estimate it significantly.

**Leverage effect** Results when firms are discriminated on a leverage basis are presented in tables 7a and 7b. Clearly, the gap in terms of user cost (interest rate) and output sensitivity to investment is larger when category 1 firms (see the structural approach) are spread according to their debt levels rather than their size. Indeed, estimated coefficients jump from -0,201 to -0,247 (user cost effect) and from 0,269 to 0,299 (output effect). Also dynamic parameters get larger estimated values. Firms with low leverage appear to be less sensitive to user cost and output than firms with high indebtedness. Actually, estimated reduced form coefficients are very close when the large firms are compared with the low leverage ones (both category 2 firms). But it is worth noticing that  $\hat{\gamma}_s$  is now significant at 90 per cent only, for firms with low leverage. When turning to the remaining parameters, a persistent absence of impact of both wages and uncertainty is observed again. The price-uncertainty effect highlighted only in the structural approach for high leverage firms is therefore not confirmed.

Tab 7a. Equation (3.9), high debt level firms

$\hat{\gamma}_\omega$	-0,084	<b>-0,100</b>	-0,129	-0,131
$\hat{\sigma}[\hat{\gamma}_\omega]$	0,099	<b>0,083</b>	0,101	0,090
$\hat{\gamma}_s$	-0,251*	<b>-0,247*</b>	-0,253*	-0,250*
$\hat{\sigma}[\hat{\gamma}_s]$	0,107	<b>0,103</b>	0,111	0,105
$\hat{\gamma}_y$	0,343*	<b>0,299*</b>	0,343*	0,300*
$\hat{\sigma}[\hat{\gamma}_y]$	0,092	<b>0,079</b>	0,092	0,080
$\hat{\gamma}_{k,1}$	0	<b>0,313*</b>	0	0,315*
$\hat{\sigma}[\hat{\gamma}_{k,1}]$	-	<b>0,134</b>	-	0,134
$\hat{\gamma}_u$	0	<b>0</b>	0,072	0,054
$\hat{\sigma}[\hat{\gamma}_u]$	-	-	0,387	0,326
<i>SG</i>	18,3	<b>15,1</b>	18,4	14,3
<i>M1</i>	-0,92	<b>1,00</b>	1,03	0,17

\* Significant at 95%    ° Significant at 90%

<sup>11</sup>But, as small firms are more likely to be in a perfect competition position, the significance of output is probably connected to a high correlation between this variable and cash flow, inducing the detection of a regime where (small) firms are constrained by their internal funds.

Tab 7b. Equation (3.9), low debt level firms

$\widehat{\gamma}_\omega$	-0,000	<b>-0,004</b>	-0,071	-0,003
$\widehat{\sigma}[\widehat{\gamma}_\omega]$	0,039	<b>0,022</b>	0,072	0,024
$\widehat{\gamma}_s$	-0,188 <sup>o</sup>	<b>-0,162<sup>o</sup></b>	-0,189 <sup>o</sup>	-0,161 <sup>o</sup>
$\widehat{\sigma}[\widehat{\gamma}_s]$	0,100	<b>0,095</b>	0,102	0,098
$\widehat{\gamma}_y$	0,181*	<b>0,175*</b>	0,186*	0,175*
$\widehat{\sigma}[\widehat{\gamma}_y]$	0,047	<b>0,043</b>	0,049	0,044
$\widehat{\gamma}_{k,1}$	0	<b>0,204*</b>	0	0,204*
$\widehat{\sigma}[\widehat{\gamma}_{k,1}]$	-	<b>0,100</b>	-	0,101
$\widehat{\gamma}_u$	0	<b>0</b>	0,016	-0,009
$\widehat{\sigma}[\widehat{\gamma}_u]$	-	-	0,210	0,194
<i>SG</i>	18,1	<b>17,7</b>	18,9	17,0
<i>M1</i>	-1,30	<b>0,33</b>	0,08	0,65

\* Significant at 95%    <sup>o</sup> Significant at 90%

### 4.3. Policy simulation: when specific interest rates are pushed downward

Using the reduced form approach of this study, we are able to analyze the impact of a change in specific interest rates - and by extension, of a change in the user cost -. We first notice that at period  $T$ , the rate of investment is estimated through

$$\widetilde{k}_{i,T} = \widehat{\gamma}'_{k1} k_{i,T-1} + \widehat{\gamma}_y y_{i,T} + \widehat{\gamma}_\omega \omega_{i,T} + \widehat{\gamma}_s s_{i,T} + \widehat{\gamma}_u \widehat{u}''_{i,T} \quad (4.1)$$

with different values according to regimes.

The scenario proposed to study the dynamic effect of specific interest rate on future investment is standard. First of all, all variables but  $s_{i,T}$  remain constant during the simulation horizon. At time  $T + 1$ , a specific shock ( $\widetilde{\xi}_{T+1}$ ) is supposed to affect specific interest rates through their specific random walk equation. For the remaining periods, interest rates do not vary anymore so that investment evolves towards its new steady state value.

Then,

$$\begin{cases} \widetilde{i}^L_{i,T+1} = i^L_{i,T} + \widetilde{\xi}_{T+1} \\ \widetilde{i}^L_{i,T+j} = \widetilde{i}^L_{i,T+1}, \quad j > 1 \end{cases} \quad (4.2)$$

It is easy to show that the dynamic path of investment taken after this single shock is given by

$$\widetilde{k}_{i,T+j} = (\widehat{\gamma}'_{k1})^j \widetilde{k}_{i,T} + \frac{1 - (\widehat{\gamma}'_{k1})^j}{1 - \widehat{\gamma}'_{k1}} \left[ \widehat{\gamma}_y y_{i,T} + \widehat{\gamma}_\omega \omega_{i,T} + \widehat{\gamma}_p \widetilde{i}^L_{i,T+1} + \widehat{\gamma}_p \delta + \widehat{\gamma}_u \widehat{u}''_{i,T} \right] \quad (4.3)$$

In the long run, i.e. as  $j \rightarrow \infty$ , the rate of investment converges to its new equilibrium value

$$\widetilde{k}_{i,\infty} = \frac{\widehat{\gamma}_y y_{i,T} + \widehat{\gamma}_\omega \omega_{i,T} + \widehat{\gamma}_p \widetilde{i}^L_{i,T+1} + \widehat{\gamma}_p \delta + \widehat{\gamma}_u \widehat{u}''_{i,T}}{1 - \widehat{\gamma}'_{k1}} \quad (4.4)$$

Figure 1a: Impulse response to specific interest rate shock

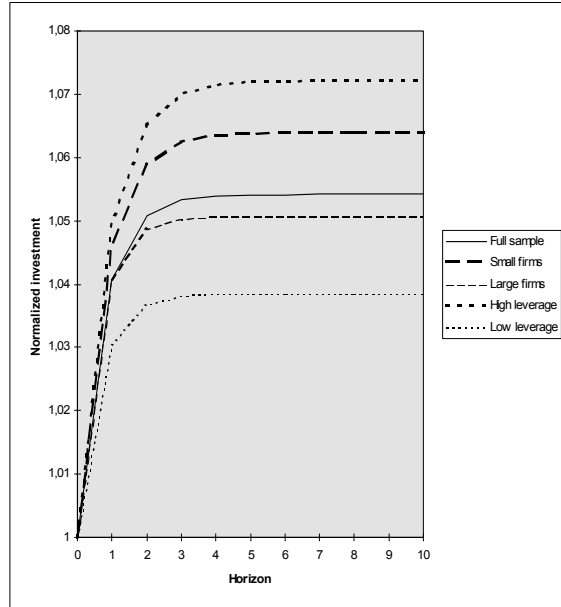
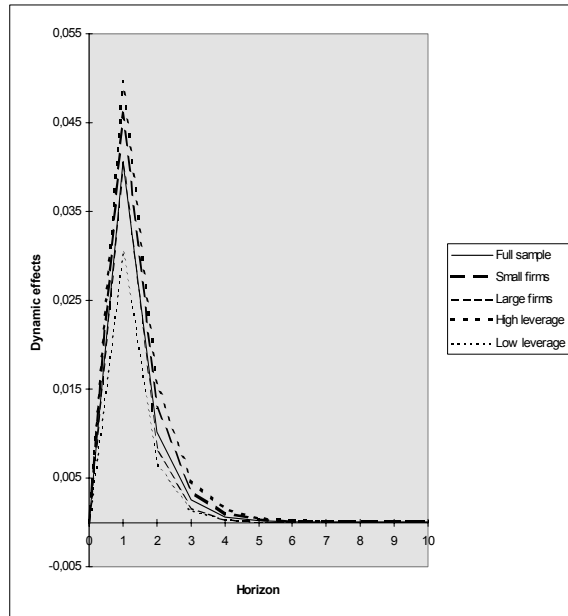


Figure 1b: Dynamic paths before new equilibrium



To implement this simulation, we consider the 10-years response of investment to a 10 percent downward movement in each specific interest rates in the year 2000 ( $\xi$ -levels are adapted to fit this policy).

Figure 1a compares the resulting simulated paths according to alternative regimes. Investment levels have been normalized with respect to their values estimated in 1999 (hence receiving unitary values for that period). Figure 1b shows the dynamic paths followed by investment before reaching its new equilibrium value related to the target-specific interest rate level regime.

Unsurprisingly firms with a high leverage are those which benefit most from the cut in their specific interest rate, followed by relatively small sized firms. On the contrary the reaction of large firms and above all of little indebted firms is below the average.

## 5. Conclusion: Lessons from the estimation and the simulation, and avenues for further research

Taken as a whole, the opportunity to use individual firm data turns out to provide encouraging and consistent results.

The *dynamic nature of investment* is confirmed both in the structural approach and in the reduced form approach. Not only this pattern is validated for the representative firm hypothesis, but, in the case of specific regimes, the analysis can be refined. The dynamic effect is indeed more important for small firms and high leverage firms (category 1) than for large firms and low leverage firms (category 2). Moreover, a less significant impact is detected for category 2 firms through structural modeling. However, the explanation for this dynamics, related to the adjustment costs of capital by a Euler equation approach, is less obvious in the solved version of the model.

The *user cost of capital*, a key variable of this study, gets a different explanatory power according to the way economic theory is validated. In the structural approach, the user cost of capital is a relevant variable to explain investment only for category 1 firms (small - high debt), while not significant for category 2 firms (large - low debt). In the reduced form approach, although the user cost is significant in all regimes, a change in this variable has more impact on investment for category 1 firms than for category 2 firms. High leverage firms are shown to be the most sensitive to the interest rate, therefore more likely to be in a debt constraint regime. Clearly, a linear link between the rate of investment and the interest rate (i.e. the second econometric approach) is favorable to an interest rate policy whatever the regime can be.

Asymmetry in the *sensitivity of investment to cash flow* has also been detected in the structural approach. Actually, category 1 firms are more sensitive to cash flow than category 2 firms. Moreover, this asymmetry is sharper for high debt level firms. These firms, for which the interest rate matters a lot, are therefore also very much dependent on the availability of internal funds.

A *role for output* is highlighted in all equations but the ability to provide a precise interpretation of that role depends on the econometric approach. In the structural approach, there is strong evidence that category 2 firms are characterized by an imperfect competition position, while perfect competition fits only the category 1 profile (note this is also the case for the full sample average). However, in the solved equation, we are unable to relate the significance of output to the existence of either a finite price elasticity or a cash flow constraint, due to the



*non-significant impact of wages* in all regressions. But category 1 firms seem to be more sensitive to output than category 2 firms.

Finally, *investment price uncertainty* has never been retained to explain investment rates, except for high leverage firms in the structural modeling where a negative sign appears.<sup>12</sup>

Regarding the *simulation exercise*, unsurprisingly firms with high leverage are those which benefit most from the *cut in their specific interest rate, fed by a cut in the market interest rate*, followed by relatively small-sized firms. On the contrary, the reaction of large firms and above all of little indebted firms is below the average.

To sum up, the empirical exercise conducted in this paper primarily aimed at testing the possibility to estimate structural and reduced forms of investment functions on a large panel of Belgian firms observed over a relatively long period, in order to evaluate the effect of a monetary policy under the assumption that such an effect can differ according to firms' characteristics.

For that purposes, we made a distinction among firms based on their size, measured by their stock of assets, on the one hand, and on their degree of leverage on the other hand. Unsurprisingly, the results that we obtained support the view that small firms, and still more highly indebted firms, are especially sensitive to the user cost of capital and to the level of their cash flow. By contrast, large and relatively less indebted firms are more likely to face non competitiveness on their market, which make them sensitive to output, and thus to the demand for the goods that they produce. The dynamic character of investment is also strongly supported by the data. However, the role of uncertainty received little empirical support, maybe due to the type of uncertainty that we introduced, i.e. uncertainty on the price of investment goods, which is however a way to introduce some business cycle effect since investment goods can be regarded as rather sensitive to economic fluctuations.

The simulation of a decrease in the firms specific interest rate, possibly fed by a cut in the interest rate decided by monetary authorities, confirms the lessons from the estimation exercise.

The data base we used in this research is especially rich and could be used for a series of *further exercises*. First of all it would be useful to complete the present work with a companion investigation aiming at discussing the impact on the different categories of firms of a *cut in the specific effective tax rate, fed by a cut in the corporate tax rate* decided by fiscal authorities. Beyond that, a huge amount of other exercises using that panel of firms has now been made possible, which can aim either at testing theories and econometric methods or at providing economic policy-makers with relevant information as to the possible impact of considered policy orientations.

---

<sup>12</sup>Cassimon, Engelen, Meersman and Van Wouwe [2002] observed a significant relation between volatility and investment for Belgian manufacturing firms, with a larger effect when considering irreversible investment. Alternatively, uncertainty could be measured from directly available expectation data, as in Butzen, Fuss and Vermeulen [2002], who found that uncertainty depresses firms investment in Belgium. These studies, however, did not consider the financing constraint issue.

## References

- Abel B., 1983, "Optimal Investment under Uncertainty", *American Economic Review*, 73(1), pp. 228-233.
- Abel B., 1985, "A Stochastic Model of Investment, Marginal q, and the Market Value of the Firm", *International Economic Review*, 26(2), pp. 305-322.
- Abel B. and J. C. Eberly, 1993, "An Exact Solution for the Investment and Market Value of a Firm Facing Uncertainty", *NBER Working Paper* n°4412.
- Abel B. and J. C. Eberly, 1994, "A Unified Model of Investment under Uncertainty", *American Economic Review*, 84, pp. 1369-1384.
- Abel B. and J. C. Eberly, 1996, "Optimal Investment with Costly Reversibility", *Review of Economic Studies*, 63, pp. 581-593.
- Akerlof G., 1970, "The Market for Lemon: Quality, Uncertainty and the Market Mechanism", *Quarterly Journal of Economics*, 84, pp. 488-500.
- Arellano M. and S. Bond, 1991, "Some Tests of Specification for Panel Data : Monte Carlo Evidence and Application to Employment Equations", *Review of Economic Studies*, 58, pp 277-297.
- Artus P. and P.-A. Muet, 1984, "Un panorama des développements récents de l'économétrie de l'investissement", *Revue Economique*, 5, pp 791-830.
- Barnett S. A. and P. Sakellaris, 1998, "Nonlinear response of firm investment to Q: Testing a model of convex and non convex adjustment costs", *Journal of Monetary Economics*, 42, pp 261-288.
- Barran F. and M. Peeters, 1998, "Internal Finance and Corporate Investment : Belgian Evidence with Panel Data", *Economic Modelling*, 15, pp 67-89.
- Bastin V., A. Corhay, G. Hubner and P.-A. Michel, 2002, Development path and capital structure of Belgian biotechnology firms, *National Bank of Belgium Working paper*, forthcoming.
- Bertola G., 1987, "Irreversible Investment", *unpublished manuscript*, M.I.T.
- Bertola G. and R. J. Caballero, 1991, "Kinked Adjustment Costs and Aggregate Dynamics", *NBER Macroeconomics Annual*, pp 237-295.
- Bertola G. and R. J. Caballero, 1994, "Irreversibility and Aggregate Investment", *Review of Economic Studies*, 61, pp 223-246.
- Biais B. and C. Gollier, 1995, "Trade Credit and Credit Rationing", *mimeo*, Université de Toulouse.
- Blanchard O. J. and C. M. Khan, 1980, "The Solution of Linear Difference Models under Rational Expectations", *Econometrica*, 48, pp 1305-1311.
- Bond S., J. Elston, J. Mairesse and B. Mulkey, 1997, "Financial Factors and Investment in Belgium, France, Germany and the U.K. : a Comparison Using Company Panel Data", *NBER working paper* n°5900.
- Bond S. and C. Meghir, 1994, "Dynamic Investment Models and the Firm's Financial Policy", *Review of Economic Studies*, 61(2), pp 197-222.
- Butzen P., C. Fuss and P. Vermeulen, 2002, The impact of uncertainty on investment plans: a survey data approach, *National Bank of Belgium Working paper*, forthcoming.
- Caballero R. J. and E. M. Engel, 1991, "Dynamic (S,s) Economies", *Econometrica*, 59, pp 1659-1686.
- Caballero R. J. and E. M. Engel, 1999, "Explaining Investment Dynamics in U.S. Manufacturing : A Generalized (S,s) Approach", *Econometrica*, 67(4), 783-826.

- Carruth A., A. Dickerson and A. Henley, 2000, "What do we know about investment ?", *Journal of Economic Surveys*.
- Cassimont D., Engelen P.J., Meersman H. and Van Wouwe M., 2002, The impact of uncertainty on firms' investment decisions in Belgium. A micro-economic panel data approach, *National Bank of Belgium Working paper*, forthcoming.
- Cattier J. and M. Gérard, 1981a, "L'incidence des mouvements économiques sur les coefficients économétriques d'une fonction d'investissement : les retards échelonnés variables", *Prévision et Analyse Economique*, 2(2), pp. 91-114.
- Cattier J. and M. Gérard, 1981b, "La dynamisation des coefficients économétriques : application à des données sectorielles belges", *Cahiers Economiques de Bruxelles*, 91, pp. 447-473.
- Chatelain J.-B., 1995, "Investissement irréversible, taux d'utilisation des capacités et coûts de faillites", *Recherches Economiques de Louvain*, 61(2), pp. 217-241.
- Chatelain J.-B., 2000, "Explicit Lagrange Multiplier for firms facing a debt ceiling constraint", *Economics Letters*, 67, pp. 153-158.
- Chirinko R.S., S.M. Fazzari and A .P. Meyer, 1999, "How responsible is business capital formation to its user cost ?", *Journal of Public Economics*, 74 (1), pp. 53-80.
- Cincera M., 2002, Financing constraints, fixed capital and R&D investment decisions of Belgian firms, *National Bank of Belgium Working paper*, forthcoming.
- Cuthbertson K. and D. Gasparro, 1995, "Fixed investment decisions in UK manufacturing: the importance of Tobin's Q, output and debt", *European Economic Review*, 39, pp. 919-941.
- Devereux M. P., M. Keen and F. Schiantarelli, 1994, "Corporation tax asymmetries and investment", *Journal of Public Economics*, 53, pp. 395-418.
- Dixit A. K. and R. S. Pindyck, 1994, *Investment under Uncertainty*, Princeton University Press, 468p.
- Duesenberry J. S., 1958, *Business Cycle and Economic Growth*, McGraw Hill, NY.
- van Ees H., H. Garretsen, L. de Haan and E. Sterken, 1997, Investment and debt constraints: evidence from Dutch panel data, *DNB-Staff report* n°10/1997.
- Eisner R. and M. F. Nadiri, 1968, "Investment behavior and neoclassical theory", *Review of Economics and Statistics*, 50(3), pp. 369-382.
- Fazzari S. M., R. G. Hubbard and B. C. Petersen, 1988, "Financing constraint and corporate investment", *Brookings Papers on Economic Activity*, (1), pp. 141-195.
- Gérard M., 1979, "Investissement dans les branches d'activité , conjoncture et politique économique, une étude économétrique pour la Belgique (1953-1976)", *Cahiers Economiques de Bruxelles*, 82, pp. 167-192.
- Gérard, M., 1982a, "Sectoral Investment, Business Cycle and Economic Policy, an Econometric Study for Belgium (1953-1976)", chap. 14 in G. Charatsis (ed.), *Selected Papers on Contemporary Econometric Problems*, The Athens School of Business Administration, Athens, pp. 305-331.
- Gérard M., 1982b, *Le financement des investissements, leur volume et l'impôt*, Presses Universitaires de Namur, Namur, 320p.
- Gérard M., 1993, "Cost of Capital, Investment Location and Marginal Effective Tax Rates", in A. Heimler et D. Meulders (eds.), *Empirical Approaches to Fiscal Policy*, Chapman and Hall, London, pp. 61-80.
- Gérard M. and C. Vanden Berghe, 1984, "Econometric Analysis of Sectoral Investment in Belgium", *Recherches Economiques de Louvain*, 50(1-2), pp. 89-118, reproduced in D. Weiserbs

- (ed.), 1985, *Industrial Investment in Europe : Economic Theory and Measurement*, International Studies in Economics and Econometrics, Kluwer, Dordrecht.
- Gérard M. and C. Vanden Berghe, 1988, "An endogenously time-varying parameter (TVP) model of investment behaviour : theory and an application to Belgian data", chap. 10 in H. Motamen (ed.), *Economic Modelling in the OECD Countries*, International Studies in Economic Modelling, Chapman and Hall, London, pp. 183-201.
- Gérard M., and F. Verschueren, 2000, "The Neo-classical Synthesis of Investment Behaviour and the Co-integration Challenge, an Experimentation with Belgian Industry Data", *Cahiers Economiques de Bruxelles*, 167, pp. 299-344.
- Greenwald B., J. E. Stiglitz and A. Weiss, 1984, "Information Imperfections in the Capital Market and Macroeconomic Fluctuations", *American Economic Review*, 74, pp. 194-199.
- De Haan L., 1996, "The empirical relationship between investment, dividend and financing decisions of Dutch firms", *DNB - Staff report* n°2.
- Harris R. D. F. and E. Tzavalis, 1999, "Inference for unit roots in dynamic panels where the time dimension is fixed", *Journal of Econometrics*, 9, pp. 201-226.
- Hartman R., 1972, "The Effect of price and Cost Uncertainty on Investment", *Journal of Economic Theory*, 5, pp. 258-266.
- Hubbard R. G., 1998, "Capital Market Imperfections and Investment", *Journal of Economic Literature*, pp. 193-225.
- Jaramillo F., F. Schiantarelli and A. Weiss, 1996, "Capital Market Imperfections before and after Financial Liberalization : An Euler equation approach to panel data for Ecuadorian firms", *Journal of Development Economics*, 51, pp. 367-386.
- Jensen M. and W. Meckling, 1976, "Theory of the firm : Managerial behaviour, agency costs and ownership structure", *Journal of Financial Economics*, 3, pp. 305-360.
- Jorgenson D.W., 1963, "Capital Theory and Investment Behavior", *American Economic Review*, 53(May), pp. 247-259.
- King M. A. and D. Fullerton, 1984, *The Taxation of Income from Capital*, University of Chicago Press, Chicago.
- Kiviet J.F., 1995, "On bias, inconsistency, and efficiency of various estimators in dynamic panel data models", *Journal of Econometrics*, 68, 53-78.
- Klein L.R., 1974, "Issues in Econometric Studies of Investment Behavior", *Journal of Economic Literature*, 12(1).
- Leahy J. V. and T. M. Whited, 1996, "The Effect of Uncertainty on Investment : Some Stylized Facts", *Journal of Money, Credit and Banking*, 28(1), pp. 64-83.
- Leland H. E. and D. H. Pyle, 1977, "Informational Asymmetries, Financial Structure and Financial Intermediation", *Journal of Finance*, 32, pp. 371-388.
- Lucas R. E. and E. C. Prescott, 1971, "Investment under uncertainty", *Econometrica*, 39, pp. 659-681.
- Manigart S., K. Baeyens and I. Verschueren, 2002, "The role of venture capital in financing unquoted companies", *National Bank of Belgium Working paper*, forthcoming.
- Malinvaud E., 1981, *Théorie macro-économique, tome 1*, Dunod, Paris.
- Meyer J. R. and E. Kuh, 1957, *The investment decision: An empirical study*, Harvard University Press, Cambridge, Mass.
- Modigliani F. and M. H. Miller, 1958, "The cost of Capital, Corporation Finance and the theory of investment", *American Economic Review*, 48(3), 261-297.

- Myers S. C. and N. S. Majluf, 1984, "Corporate Financing and Investment Decisions when Firms have Information that Investors do not have", *Journal of Financial Economics*, 13, pp. 187-221.
- Myers S. C., 1977, "Determinants of corporate borrowing", *Journal of Financial Economics*, 5, pp. 147-175.
- Peeters M., 1997, "Does demand and price uncertainty affect Belgian and Spanish corporate investment ?", *DNB - Staff report n°13*.
- Pesaran M. H. and R. Smith, 1995, "Estimating long-run relationships from dynamic heterogeneous panels", *Journal of Econometrics*, 68(1), pp. 79-113.
- Pindyck R. S., 1988, "Irreversible Investment, Capacity Choice and the Value of the Firm", *American Economic Review*, 78(5), pp. 969-985.
- Pindyck R. S., 1991, "Irreversibility, Uncertainty and Investment", *Journal of Economic Literature*, 29(3), pp. 1110-1148.
- Poterba J. M. and L. H. Summers, 1983, "Dividend Taxes, Corporate Investment, and Q", *Journal of Public Economics*, 22, pp. 135-167.
- Ross S. A., 1977, "The Determination of Financial Structure : The incentive-Signalling Approach", *Bell Journal of Economics*, 8, pp. 23-40.
- Schiantarelli F., 1996, "Financial Constraints and Investment : Methodological Issues and International Evidence", *Oxford Review of Economic Policy*, 12(2), pp70-89.
- Sensenbrenner, G., 1991, Aggregate Investment, the Stock Market, and the Q Model : Robust Results for Six OECD Countries, *European Economic Review* 35, pp. 769-832.
- Stanca L., 1998, "The Dynamic Relation between Financial Positions and Investment : Evidence from Company Account Data", *working paper*.
- Tinbergen J., 1939, *A Method and its application to Investment Activity, in Statistical testing of business cycles theory*, vol. 1, League of Nations, Geneva.
- Tychon P., 1997, "The Structure of Corporate Finance in Belgium : An Empirical Investigation", *IREES discussion paper n° 9719*.
- Van Cayseele P., 2002, Investment, R&D and liquidity constraints: a corporate governance approach to the Belgian evidence, *National Bank of Belgium Working paper n° 33*.
- Verschuere F., 2000, *Essais en économétrie de l'investissement*, thèse de doctorat, ARPEGE, FUCaM, Mons and GREMARS, Lille, 245p.
- Verschuere F. and M. Gérard, 2000, "Dealing with Output in Investment-Q Models, a Structural versus Reduced Form Approach", *Working Paper*, ARPEGE, FUCaM.
- Whited T. M., 1992, "Debt, Liquidity Constraints and Corporate Investment : Evidence from Panel Data", *Journal of Finance*, 47(4), pp. 1425-1460.
- Whited T. M., 1998, "Why Do Investment Euler Equations Fail ?", *Journal of Business and Economic Studies*, 16(4), pp. 479-488.

## A. The data set

Data used in this exercise come from the balance sheets reported accounts data base of the National Bank of Belgium. We decided to extract from that data base, an unbalanced panel of 2329 firms observed between 11 and 15 years. A larger coverage would have been possible but then on a shorter length of time; we decided to give priority to the length of the series in order to go across possible economic cycles.

### A.1. Definitions

Data come from three different sources and thus are firm-specific, sector-specific or market-specific.

#### A.1.1. Firm-specific data

These data come from firms' reported accounts and have been provided by the National Bank of Belgium. Each item between brackets corresponds to the codes used by the National Bank of Belgium's *Centrale des Bilans*. Distinctions are introduced when the definitions differ depending on the accounting pattern (abridged accounts *vs* complete accounts).

**Investment** ( $p_{i,t}^I I_{i,t}$ ) : Acquisitions of fixed assets, including produced fixed assets [8169] - Sales and disposals [-8179] + Acquisitions of revaluation gains from third parties [8229] - Depreciation and amounts written down cancelled owing to sales [-8309]

**Output, or value added** ( $p_{i,t} Y_{i,t}$ ) : (i) Abridged accounts : Operating profit [70/61] + Operating loss [61/70]; (ii) Complete accounts : Operating income [70/74] - Raw materials and consumables [60, p. C4] - Services and other goods [61, p. C4]

**Wage costs** ( $w_{i,t} L_{i,t}$ ) : Remuneration, social security and pensions (i) Abridged accounts : [-62]; (ii) Complete accounts : [62]

**Dividends** ( $D_{i,t}$ ) : [694]

**Long-term debt** ( $B_{i,t}^L$ ) : (i) Abridged accounts : *Etablissement de crédit, dettes de location-financement et assimilés* [172/3, p. A3]; (ii) Complete accounts : *Dettes de location-financement* [172, p. C3] + *Etablissement de crédits* [173, p. C3]

**Short-term debt** ( $B_{i,t}^S$ ) : Financial debt in credit institutions payable within one year [430/8, p. A3/C3] + Debt at over one year falling due [42, p. A3]

**Interest expenses** ( $IE_{i,t}$ ) : (i) Abridged accounts : Financial charges [-65, p. A4] - Interest subsidies granted by public authorities and recorded as income [9126, p. A10]; (ii) Complete accounts : Debt charge [650, p. C4] - Interest subsidies granted by public authorities and recorded as income [9126, p. C16]

**Asset** ( $A_{i,t}$ ) : Total assets [20/58]

**Equity** ( $E_{i,t}$ ) : Capital [10] + Share premium account [11] + Revaluation surplus [12] + Reserves [13]

**Corporate tax rate** ( $\tau_{i,t}$ ) : Income tax [-67/77] / (Profit for the period [70/67] + Loss for the period [67/70] + Income tax [-67/77] )

#### A.1.2. Sector-specific data

Those data come from Belgian National Accounts, database *Belgostat*.

**Price of investment** ( $p_{s,t}^I$ ) : Deflator of Gross fixed capital formation. This is actually the specific price of investment when this last variable is dealt with separately.

**Price of output** ( $p_{s,t}$ ) : Deflator of Gross value added

#### A.1.3. Market-specific data

These data come a.o. from the *Mémentos économiques et financiers*, a Kluwer publication.

**Long-term interest rate** ( $i_t^L$ ) : Interest rate charged by SNCI/NMKN on investment credits

**Short-term interest rate** ( $i_t^S$ ) : *Moyenne du taux d'intérêt sur crédits de caisse et du taux d'intérêt sur avances à 1 mois ou 3 mois.*

#### A.1.4. Other variables

**Cash flow** ( $CF_{i,t}$ ) :  $p_{i,t}Y_{i,t} - w_{i,t}L_{i,t}$

**Capital stock at replacement cost** ( $p_{i,t}^I K_{i,t}$ ) : Capital stock has been constructed using the perpetual inventory formula

$$(p_{i,t}^I K_{i,t}) = (1 - \delta)(p_{i,t}^I K_{i,t-1}) \frac{p_{s,t}^I}{p_{s,t-1}^I} + (p_{i,t}^I I_{i,t})$$

As a starting value, we use the capital stock at historic cost, i.e. fixed assets [22/27]. Based on previous studies on investment in Belgium, the rate of deterioration has been fixed at 10%.

**Average interest rate** ( $r_{i,t}$ ) :  $r_{i,t} = \frac{IE_{i,t}}{B_{i,t}^S + B_{i,t}^L}$

**Long-term interest rate** ( $i_{i,t}^L$ ) :  $i_{i,t}^L = r_{i,t} - \frac{B_{i,t}^S}{B_{i,t}^L} (i_t^S - i_t^L)$

**Uncertainty ratio** ( $\theta_{i,t}$ ) :  $\theta_{i,t} = \frac{A_{i,t}}{E_{i,t}}$

## A.2. Sample selection

Before undertaking any empirical analysis, we have to remove inconsistent data and outliers.

### A.2.1. Inconsistent data.

All the firms belong to the manufacturing industry. In order to be consistent with our economic model, we exclude firms with negative investment and negative output. We select only firms with positive long-run debt and positive interest expenses. For the record, we expect these quantities to exist in order to build the specific long-run interest rate. Also we only keep firms with a tax rate and a long-run interest rate between 0 and 1. Finally, we select firms with data available for at least 11 years, since dynamics effects are considered in our model.

### A.2.2. Outliers.

Our way of treating outliers consists in removing the first and last percentile of the rate of investment, the cash flow ratio, the output ratio and the user cost of capital. This procedure is rather random, but has the advantage of keeping asymmetries in the distributions unaltered.

### A.3. Some statistical results and figures

First of all, we present the number of firms after the selection stage of the data. Our final data set is an unbalanced panel of 2329 firms observed between 11 and 15 years.

Table 0. Number of firms

<i>years</i>	<i>N</i> $\geq$ <i>years</i>
15	253
14	692
13	1131
12	1685
11	2329

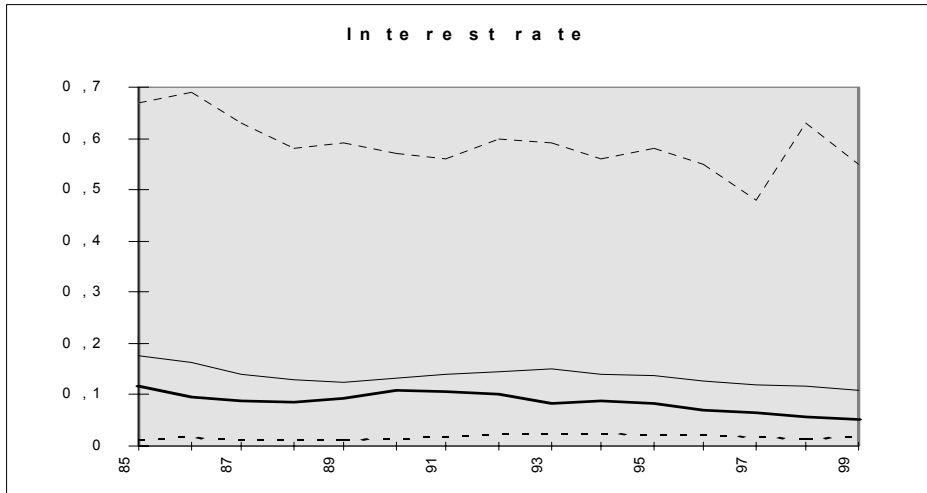
Next, univariate statistics for two key variables are provided, namely the specific interest rate and a percentage measure of financing source [total debt / (total debt + equity)]. They are both summarized in statistical tables 1 and 2, while graphics are presented in figures 2 and 3. We also present statistics related to the specific tax rate in statistical table 3.



Statistical Table 1. Specific interest rate

$i_{i,t}^L$	mean	minimum	maximum	std. dev.	skewness	kurtosis
1985	0.1768	0.0135	0.6724	0.124	2.27	7.44
1986	0.1632	0.0174	0.6989	0.121	2.53	9.13
1987	0.1411	0.0136	0.6313	0.113	2.89	12.23
1988	0.1295	0.0145	0.5896	0.106	3.12	14.34
1989	0.1244	0.0144	0.5912	0.102	3.65	17.34
1990	0.1328	0.0159	0.5717	0.106	3.31	15.78
1991	0.1408	0.0181	0.5693	0.107	3.27	13.91
1992	0.1440	0.0253	0.6019	0.099	3.16	14.61
1993	0.1501	0.0255	0.5930	0.103	3.32	16.63
1994	0.1394	0.0257	0.5620	0.092	2.83	11.67
1995	0.1387	0.0233	0.5837	0.101	3.52	18.06
1996	0.1287	0.0234	0.5586	0.095	3.35	16.27
1997	0.1206	0.0188	0.4872	0.087	2.92	12.17
1998	0.1172	0.0150	0.6334	0.103	3.85	20.56
1999	0.1086	0.0183	0.5540	0.101	3.64	17.99

Figure 2. Specific and market interest rate

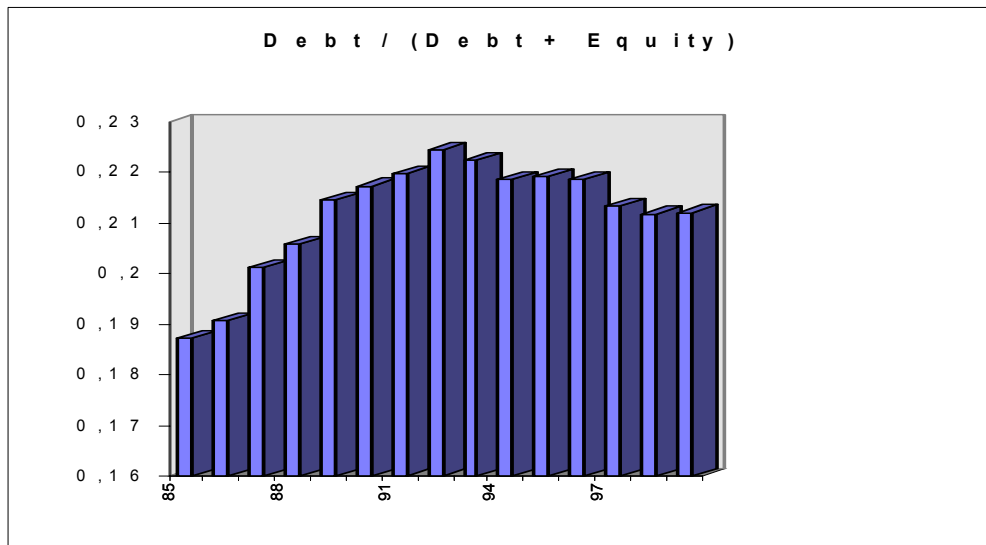


The normal line is the observed specific interest rate, the bold line is the SNCI/NMKN interest rate, and the dotted lines are the extreme values observed for the specific interest rate

Statistical Table 2. debt vs equity

$B_{i,t}/(E+B)_{i,t}$	mean	minimum	maximum	std. dev.	asymmetr.	kurtosis
1985	0.1875	0.0199	0.4098	0.095	0.34	-0.51
1986	0.1909	0.0134	0.4176	0.098	0.29	-0.59
1987	0.2013	0.0189	0.4228	0.100	0.20	-0.59
1988	0.2058	0.0169	0.4251	0.100	0.19	-0.62
1989	0.2146	0.0156	0.4334	0.099	0.08	-0.57
1990	0.2173	0.0193	0.4186	0.098	0.01	-0.75
1991	0.2198	0.0211	0.4200	0.099	0.02	-0.73
1992	0.2245	0.0236	0.4341	0.100	-0.02	-0.72
1993	0.2223	0.0242	0.4337	0.101	0.04	-0.72
1994	0.2185	0.0223	0.4303	0.099	0.08	-0.58
1995	0.2192	0.0203	0.4291	0.099	0.04	-0.60
1996	0.2186	0.0215	0.4397	0.102	0.01	-0.66
1997	0.2134	0.0187	0.4409	0.103	0.11	-0.45
1998	0.2118	0.0156	0.4306	0.103	0.11	-0.53
1999	0.2121	0.0127	0.4283	0.105	0.06	-0.74

Figure 3. Financial structure



Statistical Table 3. Specific tax rate

$\tau_{i,t}$	mean	minimum	95%	maximum	std. dev.	asymmetr.	kurtosis
1985	0.1566	0	0.5179	0.8040	0.1987	1.22	1.06
1986	0.1621	0	0.5017	0.8027	0.1958	1.15	1.04
1987	0.1567	0	0.4860	0.8140	0.1912	1.27	1.59
1988	0.1472	0	0.4632	0.7937	0.1845	1.36	1.97
1989	0.1715	0	0.5379	0.8327	0.2043	1.11	0.87
1990	0.1948	0	0.5964	0.8771	0.2219	0.95	0.34
1991	0.1909	0	0.6357	0.9082	0.2283	1.06	0.56
1992	0.1961	0	0.6426	0.9055	0.2319	1.11	0.59
1993	0.1826	0	0.6613	0.9116	0.2404	1.14	0.47
1994	0.2107	0	0.7021	0.9261	0.2486	0.93	0.01
1995	0.2109	0	0.6909	0.9221	0.2458	0.92	0.03
1996	0.2114	0	0.6925	0.9237	0.2455	0.92	0.06
1997	0.2108	0	0.6519	0.9008	0.2357	0.85	0.01
1998	0.2111	0	0.6478	0.8978	0.2330	0.85	0.08
1999	0.2162	0	0.6517	0.9165	0.2324	0.85	0.18

## NATIONAL BANK OF BELGIUM - WORKING PAPERS SERIES

1. "Model-based inflation forecasts and monetary policy rules" by M. Dombrecht and R. Wouters, *Research Series*, February 2000.
2. "The use of robust estimators as measures of core inflation" by L. Aucremanne, *Research Series*, February 2000.
3. "Performances économiques des Etats-Unis dans les années nonante" by A. Nyssens, P. Butzen, P. Bisciari, *Document Series*, March 2000.
4. "A model with explicit expectations for Belgium" by P. Jeanfils, *Research Series*, March 2000.
5. "Growth in an open economy: some recent developments" by S. Turnovsky, *Research Series*, May 2000.
6. "Knowledge, technology and economic growth: an OECD perspective" by I. Visco, A. Bassanini, S. Scarpetta, *Research Series*, May 2000.
7. "Fiscal policy and growth in the context of European integration" by P. Masson, *Research Series*, May 2000.
8. "Economic growth and the labour market: Europe's challenge" by C. Wyplosz, *Research Series*, May 2000.
9. "The role of the exchange rate in economic growth: a euro-zone perspective" by R. MacDonald, *Research Series*, May 2000.
10. "Monetary union and economic growth" by J. Vickers, *Research Series*, May 2000.
11. "Politique monétaire et prix des actifs: le cas des Etats-Unis" by Q. Wibaut, *Document Series*, August 2000.

12. "The Belgian industrial confidence indicator: leading indicator of economic activity in the euro area?" by J.J. Vanhaelen, L. Dresse, J. De Mulder, *Document Series*, November 2000.
13. "Le financement des entreprises par capital-risque" by C. Rigo, *Document Series*, February 2001.
14. "La nouvelle économie" by P. Bisciari, *Document Series*, March 2001.
15. "De kostprijs van bankkredieten" by A. Bruggeman and R. Wouters, *Document Series*, April 2001.
16. "A guided tour of the world of rational expectations models and optimal policies" by Ph. Jeanfils, *Research Series*, May 2001.
17. "Attractive Prices and Euro - Rounding effects on inflation" by L. Aucremanne and D. Cornille, *Documents Series*, November 2001.
18. "The interest rate and credit channels in Belgium: an investigation with micro-level firm data" by P. Butzen, C. Fuss and Ph. Vermeulen, *Research series*, December 2001.
19. "Openness, imperfect exchange rate pass-through and monetary policy" by F. Smets and R. Wouters, *Research series*, March 2002.
20. "Inflation, relative prices and nominal rigidities" by L. Aucremanne, G. Brys, M. Hubert, P. J. Rousseeuw and A. Struyf, *Research series*, May 2002.
21. "Lifting the burden: fundamental tax reform and U.S. economic growth" by D. Jorgenson and Kun-Young Yun *Research series*, May 2002.
22. "What do we know about investment under uncertainty?" by L. Trigeorgis, *Research series*, May 2002.
23. "Investment, uncertainty and irreversibility: evidence from Belgian accounting data" by D. Cassimon, P.-J. Engelen, H. Meersman, M. Van Wouwe, *Research series*, May 2002.

24. "The impact of uncertainty on investment plans" by P. Butzen, C. Fuss, Ph. Vermeulen, *Research series*, May 2002.
25. "Investment, protection, ownership, and the cost of capital" by Ch. P. Himmelberg, R. G. Hubbard, I. Love, *Research series*, May 2002.
26. "Finance, uncertainty and investment: assessing the gains and losses of a generalized non-linear structural approach using Belgian panel data", by M. Gérard, F. Verschueren, *Research series*, May 2002.
27. "Capital structure, firm liquidity and growth" by R. Anderson, *Research series*, May 2002.
28. "Structural modelling of investment and financial constraints: where do we stand?" by J.-B. Chatelain, *Research series*, May 2002.
29. "Financing and investment interdependencies in unquoted Belgian companies: the role of venture capital" by S. Manigart, K. Baeyens, I. Verschueren, *Research series*, May 2002.
30. "Development path and capital structure of Belgian biotechnology firms" by V. Bastin, A. Corhay, G. Hübner, P.-A. Michel, *Research series*, May 2002.
31. "Governance as a source of managerial discipline" by J. Franks and C. Mayer, *Research series*, May 2002.
32. "Financing constraints, fixed capital and R&D investment decisions of Belgian firms" by M. Cincera, *Research series*, May 2002.
33. "Investment, R&D and liquidity constraints: a corporate governance approach to the Belgian evidence" by P. Van Cayseele, *Research series*, May 2002.