NATIONAL RESEARCH UNIVERSITY
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THE INFLUENCE OF FINANCIAL CONSTRAINTS AND ATTITUDE TOWARDS RISK IN CORPORATE INVESTMENT DECISIONS

BASIC RESEARCH PROGRAM

WORKING PAPERS

SERIES: Financial Economics
WP BRP 36/FE/2014

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THE INFLUENCE OF FINANCIAL CONSTRAINTS AND ATTITUDE TOWARDS RISK IN CORPORATE INVESTMENT DECISIONS[2]

This paper presents evidence of the combined effect of financial constraints and attitudes towards risk in corporate investment. Using panel data on public companies functioning in developed countries, the author shows that demand uncertainty provokes a firm with limited resources to invest sub-optimally, compared to an unconstrained company. Also, with a given level of financial constraints, risk-taking companies tend to decrease investment to a lesser extent in comparison with risk-averse companies. To show this, an index of financial constraints has been constructed, and the optimal threshold values of the index and the risk aversion coefficient have been found.

JEL Classification: C12, C23, C24, D22.

Key words: investment decisions; index of financial constraints; attitude towards risk, demand uncertainty.

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[2] This study was carried out within The National Research University Higher School of Economics in Nizhny Novgorod Fund Program in 2014, research grant No. 2014-07.

1. Introduction

Investment fluctuations on the aggregate country level largely explain the future economic performance of a country. For this reason, the analysis of corporate investment decisions remains a constant object of methodological and empirical studies. Over the last decades, researchers have been investigating (partly) irreversible investment realized, 1) under capital market imperfections, when both information asymmetry problems and agency conflicts cause an increase in the gap between the costs of internal and external funds and force firms to suffer from financial constraints and; 2) under uncertainty surrounding a firm. An interest in the uncertainty effect can be explained by the following. Results concerning the significance and the sign of the relation between market uncertainty and capital expenditure are sometimes ambiguous. Literature on investment under uncertainty identifies several channels through which uncertainty affects capital investment. Most researchers find the effect of uncertainty on investment to be negative. However, it is still not fully clear which of the channels is the most significant, because it is quite difficult to single out and examine each factor separately (Bo and Sterken (2007)).

Although many authors examine either the first or the second type of issues, few analyse the problems as a whole. There are even fewer papers suggesting an empirical solution rather than theoretical constructions or numerical simulations. In this connection, by using theoretical groundwork and approaches to parameter construction of several authors (in particular, Bo and Sterken (2007) and Whited and Wu (2006)), we have combined the factors determining corporate investment decisions. These are investor attitude towards risk (as the channel of uncertainty affecting investment) and financial constraints (as an indicator of capital market imperfections). We will test the hypotheses about the impact of the two factors on company investment decisions under demand uncertainty. Importantly, we will show a change in the behaviour of investors facing financial constraints under the certainty and uncertainty of the business environment. To the best of our knowledge, this issue has not yet been discussed in literature.

Bo et al. (2003) analysed the combined influence of financial constraints and risk attitude on investment. However, the authors did not directly define attitude towards risk by associating high uncertainty with greater risks that a firm has to take. In this paper, we estimate the risk aversion coefficient (varying over time) based on the Arrow-Pratt Approximation (Bo, Sterken (2007)). Moreover, we adopt other methods of constructing: a) the uncertainty measure (the variance of the unpredictable part of an autoregressive process instead of calculating stock price/sales/employment volatility; b) the financial constraint level (constructing a financial constraint index instead of evaluating the sensitivity of investment to cash flow). Having estimated the combined impact of these factors on investment, we ranked the companies according to their capital expenditure under uncertainty (four combinations of parameters determine four investment positions). Thus, our work contributes to the empirical research on corporate investment decisions under uncertainty and capital market imperfections.

The rest of the article is organized as follows. Section 2 presents a literature review concerning the influence of financial constraints and attitude towards risk on investment. Section 3 outlines an investment model containing constraints on outside finance (Whited (1992, 1998), Whited and Wu (2006)). Section 4 discusses the procedures of constructing key variables of the model in order to compile the financial constraint index. Section 5 contains the data description and presents the specification of the financial constraint index, as well as a comparison between our index, the results achieved by Whited and Wu (2006) and the classification in Kaplan and Zingales (1997). In Sections 6 and 7 we briefly describe our approach to measuring demand uncertainty and attitude towards risk. In Section 8 we estimate the influence of demand uncertainty on investment by companies differing in financial constraints and attitude towards risk. Section 9 contains some concluding remarks.

2. Literature review

2.1 The impact of capital market imperfections on corporate investment

Modigliani and Miller (1958) show that with perfect and complete capital markets the type of financing does not affect the decision about whether an investment is worthwhile. In other words, the criterion for undertaking an investment project does not depend on the capital structure chosen. However, taking into consideration market failures, in particular, information asymmetries, several researchers argue that financial resources affect investment policy. For example, Myers and Majluf (1984), Greenwald et al. (1984) and Myers (1984) show that external funds are not perfect substitutes for internal ones. Internal sources of finance comprise about 80% of total funds. In addition, one of the propositions of the pecking order theory is that if a firm is looking for external funds, it starts with issuing the safest (and thus, the cheapest) instruments, such as debt, then uses hybrid instruments, and only after that, it might issue new equity (Myers (1984)). This hierarchy and, in particular, why raising external capital is more expensive than using internal resources, may be explained by transaction costs, taxes, agency problems, insolvency risks, and information asymmetries between managers and potential investors.

Jensen and Meckling (1976) invoke the moral hazard argument to explain agency costs involving high debt levels: large debts induce a firm to choose excessively risky investment projects. Such investment decisions guarantee higher mean returns to shareholders since they get a large income in a good scenario and zero in a bad one. Limited liability provisions in debt contracts provide an incentive to adopt this investment policy. However, a higher insolvency risk provokes investors either to demand an interest rate premium or to limit the company's use of debt in the future.

The adverse selection problem may also create costs of debt finance. Myers and Majluf (1984) show that if the managers have private information about the company's investment projects they are able to raise capital only by paying investors a premium to compensate them for possibly funding companies which launch projects with a negative net present value.

Fazzari et al. (1988) put forward the proposition that investment is susceptible to the influence of both availability of internal funds and accessibility of external ones. The researchers examine investment practices and funding in companies with different financial performance. The criterion for ranging firms in accordance with their financial constraints is the payout ratio: the lower the value of the parameter, the higher cost disadvantage and financial constraints. Results achieved by Fazzari et al. (1988) show that investments made by companies that pay fewer dividends are more sensitive to cash flow fluctuations than investments of mature companies, paying comparatively high dividends and facing no difficulties in raising capital. Thus, according to Fazzari et al. (1988), the sensitivity of investment to cash flows may be considered an indicator of financial constraints.

Kaplan and Zingales (1997) respond to Fazzari et al. (1988), calling into question the classification of companies as more or less financially constrained according to the payout ratio criterion and subsequently estimating the sensitivity of investment to cash flow fluctuations for each group. Using the sample of Fazzari et al., Kaplan and Zingales consider 49 companies that pay the lowest dividends. Based on the financial statement analysis these companies are classified into five groups from less to more financially constrained. In addition, the researchers corroborate their classification using the logit model. As a result, Kaplan and Zingales conclude that the sensitivity of investment to cash flows does not necessarily increase with the growth of financial constraints.

Whited and Wu (2006) examine the influence of financial constraints on assets returns. Based on an investment model, they compile an index of financial constraints which turns out to be more informative than the index by Kaplan and Zingales. The variables forming the index are the following: cash flow, dividend payment, ratio of long-term debt to total assets, the logarithm of total assets, as well as firm and industry sales growth.

2.2. The impact of risk attitude on corporate investment

Sandmo (1971) criticizes the assumption about firm risk-neutrality by showing that risk aversion causes a decrease in the optimal production output of a competitive firm under price uncertainty. Leland (1972) extends Sandmo's conclusion to imperfectly competitive firms which set the price and sales volume. Risk aversion leads to a drop in optimal production for quantity-setting firms, and lower optimal output and prices for companies setting both quantity and price before uncertainty is revealed. According to Nickell (1978), economic agents rejecting risk tend towards shrinking capital spending under increasing uncertainty, while less risk averse agents are inclined to higher investment. Nakamura (1999) derives the optimal investment rule as a function of output-price uncertainty, investor risk aversion and elasticity of output to labour in the Cobb-Douglas production function. Whether the impact of uncertainty on capital spending is positive, negative or zero depends on the relationship between elasticity and attitude towards risk. In particular, the negative effect occurs only if the relative risk aversion coefficient exceeds the elasticity value. Saltari and Ticchi (2005), criticizing Nakamura's choice of the value function used to derive the investment function, solve the problem by describing price as an identically and independently distributed stochastic parameter. The authors show that uncertainty leads to higher investment except for cases when the risk aversion coefficient is higher than the elasticity of output to labour level and does not exceed unity. According to Femminis (2008), the result obtained by Saltari and Ticchi (2005), in particular, for risk averse companies, depends on the prerequisite of complete capital depreciation after production. In this connection, Femminis (2008) takes a capital depreciation parameter changing from zero to unity. As a result, the author disputes the findings by Saltari and Ticchi (2005) by showing that companies with the relative a risk aversion coefficient higher than unity lower their investment under growing uncertainty. Bo and Sterken (2007), show by empirically testing the relationship between demand uncertainty and corporate investment, that, on the whole, risk averse companies respond to higher demand uncertainty by shrinking capital spending, while less risk averse companies tend to increase investment. A study of a sample of Russian firms (Aistov and Kuzmicheva (2012)) illustrates that investors rejecting risk are in favour of lowering capital expenditure under demand uncertainty, while risk-taking companies do not exhibit this tendency.

The analysis of the combined effect of financial constraints and risk attitude on investment is contained in Bo et al. (2003). However, it is necessary to point out that the parameter of attitude towards risk is not constructed directly. The authors suppose that growing uncertainty induces shareholders to launch riskier projects if investment is partly financed by debt: risk is distributed among both shareholders and debt holders. Thus, higher uncertainty is associated with the greater risks that a firm faces. In other words, uncertainty growth corresponds to a relatively low risk aversion coefficient. Debt holders, expecting such arguably opportunistic behaviour on the part of shareholders, increase the required risk premiums. For this reason, a firm tolerant to risk (that is, a firm functioning under high uncertainty) sees an increase in the difference between the costs of internal and external funds, or, in other words, suffers from financial constraints. To test the hypothesis, Bo et al. build a threshold regression model, where the threshold parameter switching regimes from relatively high to relatively low uncertainty is the level of stock price/sales/employment volatility. Under the two regimes, the influence of financial constraints on investment activity is estimated. Based on the approach by Fazzari et al. (1988), the authors measure capital market constraints through the sensitivity of investment to cash flow fluctuations. Evaluation results show that the impact of cash flows on investment injection depends on the uncertainty level surrounding a firm: the cash flows parameter under uncertainty exceeding the threshold value is positive and is about three times larger than the corresponding parameter for low uncertainty. The authors conclude that capital market constraints are more severe for relatively risk-taking economic agents.

The results of Bo et al. (2003) are built using indirect constructions for both the risk-attitude parameter and financial constraints measure. Instead of using the intensity of stock price volatility to characterize attitude towards risk, we apply a procedure involving the relation between risk-premium and the variance of a risk-factor (Arrow-Pratt approximation) to get a concrete estimation of investor risk aversion (see also Bo, Sterken (2007)). The questionable indicator of financial constraints (i.e. the sensitivity of investment to cash flow) is replaced by the financial constraints index derived from the Euler equation for investment (Whited and Wu (2006)). We show that with a given coefficient of risk aversion, the strengthening of capital market imperfections explains the difference in investment decisions made in certainty and under demand uncertainty. Uncertainty compels financially constrained firms to invest sub-optimally compared to their choice in a situation of certainty and the behaviour of unconstrained investors under uncertainty. Risk aversion analysis confirms the result of Bo and Sterken (2007) for Dutch non-financial firms. With a given level of financial constraints, companies rejecting risk tend to shrink investment much more than risk-taking economic agents. We also succeeded in ranking companies (a subsample of American and Canadian investors) by investment activity and found four combinations of factors determining corporate investment decisions under demand uncertainty and capital market imperfections.

3. Investment model

The construction of the financial constraints index is based on the standard partial-equilibrium investment model improved by Whited (1992, 1998), Whited and Wu (2006). It is assumed that a firm which faces constraints on outside finance maximizes the expected present discounted value of future dividends. The formula for dividends takes into account the adjustment of profit for investment injections made, including debt resources used, and the real costs of adjusting the capital stock. The firm takes factor prices, output prices and interest rates as given by the market.

Then, the first ordinary condition for the problem of a firm's value maximization taking into account the constraints on new share issue is:

$$E_{it}\left\{\beta_{t,t+1}\times\frac{(1+\lambda_{t+1})}{(1+\lambda_t)}\times\left[\pi_{K_{i,t+1}}-\psi'_{K,t+1}+(1-\delta)\times\left(\psi'_{I,t+1}+1\right)\right]\right\}=\psi'_{I,t}+1 \qquad (1)$$

where $\beta_{t,t+1}$ is the stochastic discount factor from time t to $t+1$; π_K is the marginal revenue product of capital; $\psi(K_{it}, I_{it})$ is the real cost of adjusting the capital stock, with $\psi'_K<0$, $\psi'_I>0$, $\psi''_{II}>0$; δ is the rate of economic depreciation; λ_{it} is the shadow cost associated with attracting new equity. For a financially constrained firm external financing is considered to be more expensive in comparison with internal financing.

4. The key explanatory variables of the empirical investment model

The marginal revenue product of capital π_K

To calculate the marginal revenue product of capital, net operating profit after tax is used as profit π; the balanced value of fixed assets (i.e. *property*, *plant*, *equipment*, *gross*) is taken as the capital stock of the firm's operating activity.

Discount factor $\beta_{t,t+1}$

The discount factor applied to obtain the present value of corporate cash flows earned in the period t is calculated according to the standard formula:

$$\beta_{0,t}=\frac{1}{(1+r_1)\times(1+r_2)\times(1+r_3)\times\ldots\times(1+r_t)} \qquad (2)$$

where r_t is the discount rate for the firm i in the period t.

Dividend discount models apply the cost on equity (the required rate of return on a stock) as a discount rate. The equity owners demand both that the company's value should grow (in particular, due to a growth in profits) and that dividends should be paid. Therefore, the required return rate *r* might be presented as the sum of the payout ratio and the growth rates of profits (Bo et al. (2006)):

$$r = b + \mu_\pi \tag{3}$$

where *b* is payout ratio; μ_π is the average growth rate of profits.

The current value μ_π is calculated as the average growth rates of NOPAT at present and over the whole sample period in the past. For example, the value of μ_π in 1993 is computed using the growth rate data for the years 1991, 1992 and 1993. Every subsequent period adds one observation for calculations. Thus, for example, in 2011 the parameter's value is calculated based on 1991-2011 observations.

Capital adjustment cost

To build the capital adjustment cost function we apply its traditional convex form. The function proposed in Whited (1992, 1998) and Whited and Wu (2006) was chosen:

$$\psi(I_t, K_t) = \left(\alpha_0 + \sum_{m=2}^{M} \frac{1}{m} \times \alpha_m \times \left(\frac{I}{K}\right)^m\right) \times K_t \tag{4}$$

where α_0, α_m, $m=2,\ldots,M$ are the parameters to be estimated. In accordance with Whited and Wu (2006), we use M=3.

Then, $$\psi'_K = \alpha_0 - \frac{1}{2} \times \alpha_2 \times \left(\frac{I}{K}\right)^2 - \frac{2}{3} \times \alpha_3 \times \left(\frac{I}{K}\right)^3 \tag{5}$$

$$\psi'_I = \alpha_2 \times \frac{I}{K} + \alpha_3 \times \left(\frac{I}{K}\right)^2 \tag{6}$$

The index of financial constraints

A firm is considered to be financially constrained if it sees an increase in the difference between the costs of internal and external funds. If a financially constrained firm faces either scarcity or fluctuations in internal resources, external funds are unlikely to be attracted to maintain a stable flow of investment. The variable λ_{it} describes this cost disadvantage; however, λ_{it} is not an observable parameter. To tackle the issue, λ_{it} is parameterized as a function of the observable characteristics of the firm (Whited (1992, 1998); Whited and Wu (2006)). The choice of explanatory variables for compiling the financial constraints index is based on Fazzari et al. (1988), Kaplan and Zingales (1997), and Whited and Wu (2006).

An analysis of different index specifications enables us to present the best variant in terms of quantity, combination and the significance of the variables forming the index of financial constraints:

$$\lambda_{it} = b_0 + b_1 \times LRDebt\_Assets_{it} + b_2 \times Payout_{it} + b_3 \times SG_{it} + b_4 \times Assets_{it} + b_5 \times Power_{it} + +b_6 \times Cash\_Assets_{it} \quad (7)$$

where b_0 is a free term; *LRDebt_Assets* is the ratio of long-term debt to total assets; *Payout* is an indicator that takes the value of 1 if the firm pays dividends in the year *t*; *SG* is the natural logarithm of the sum of 1 and sales growth; *Assets* is the natural logarithm of total assets; *Power* is the natural logarithm of the sum of 1 and the ratio of EBIT to sales (operating margin); *Cash_Assets* is the natural logarithm of the sum of 1 and the ratio of cash stock to total assets.

5. Data and empirical evaluation of the parameters of the financial constraints index

We use the database Thomson ONE to evaluate the parameters of the financial constraints index. The sample includes 1346 public nonfinancial companies, which according to ICB Industry Code belong to the following sectors: 1) basic materials, 2) consumer goods, 3) consumer services, 4) health care, 5) industrials, 6) oil & gas, 7) technology, 8) telecommunications, 9) utilities. The sample contains companies, operating in the following developed countries: Austria, Australia, Belgium, Canada, Denmark, Finland, France, Germany, Great Britain, Ireland, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the USA in 1990-2011. The choice of public firms from the developed nations is explained by the expectation of high quality audited financial data. By dealing with developed capital markets, we deliberately exclude the cases of severe external financial constraints that should be investigated separately, because of the possible high interconnection between a financial distress of a firm (in particular, low or no investment) and poor economic, institutional and political environment.

Figure 1 illustrates the sample in terms of sector distribution. Table 1 contains the descriptive statistics of the parameters illustrating the company turnover and capital injection, and the variables forming the index of financial constraints in accordance with (7). Since it was necessary to calculate the value of profit growth rate (μ_π) using data for the preceding years, the sample period was shortened to 1993-2011.

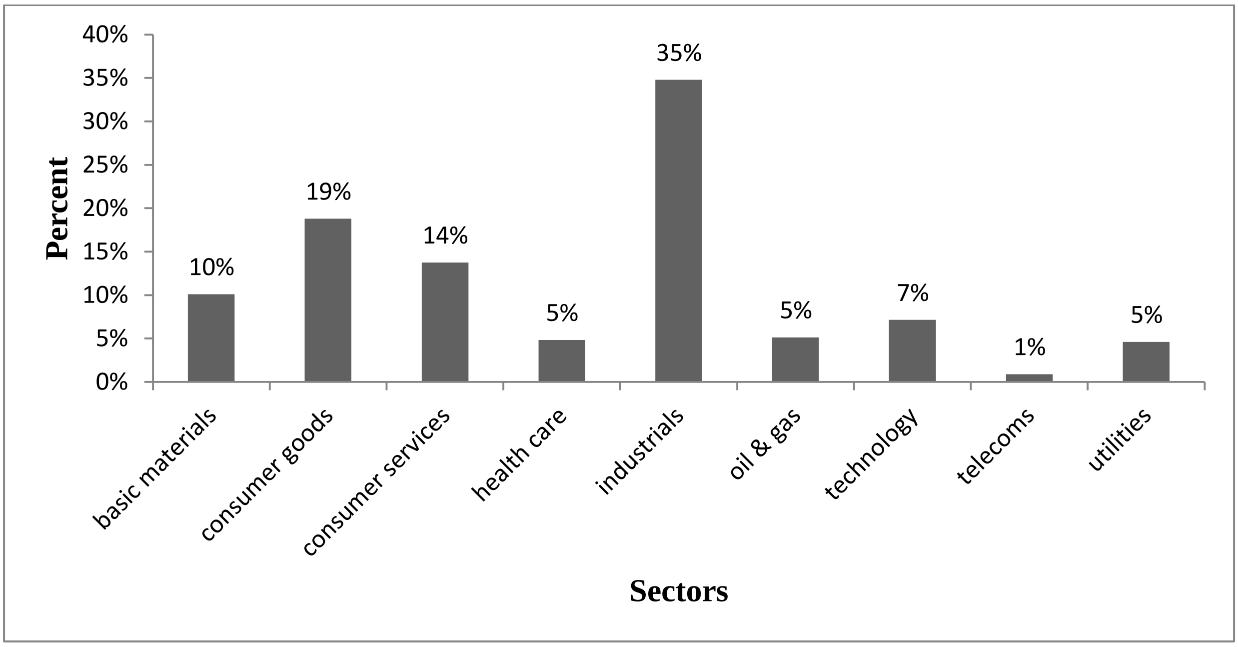

Fig. 1. The sector distribution of the sample analysed

Tab.1. Descriptive statistics of the parameters in 1993-2011

Variable	Mean	Std. Dev.	Skewness	Kurtosis	Min	Max	Observations
Sales	6797.626	19349.62	8.876	125.369	0.02	446950	25566
Capital Expenditure/ Total Assets	6.310	6.207	4.920	69.239	0	173.43	25566
ROA	5.574	10.064	3.725	459.924	-267.15	571.86	25566
LRDebt_Assets	0.176	0.149	1.843	17.618	0	3.162	25566
Payout	0.654	0.476	-0.649	1.421	0	1	25566
SG	0.063	0.241	-1.498	87.880	-8.136	5.346	25566
Assets	7.182	2.054	-0.089	2.636	-1.715	13.590	25566
Power	0.081	0.155	-9.920	276.206	-6.218	1.933	25489
Cash_ Assets	0.100	0.110	4.062	48.749	0	2.262	25566

Note: The mean, maximum and minimum values of *Sales, Payout, Assets* are in millions of USD.

To evaluate the coefficients of the equations (1), (5)-(7) we use the Generalized Method of Moments. The coefficients in (5), (6) proved to be insignificant and are excluded from (1). The econometric estimates of parameters forming the index of financial constraints according are presented in Table 2.

Tab.2. Econometric estimates of the model (1) parameters

Variables	λ (Index)
LRDebt_Assets	0.174* (0.096)
Payout	0.023 (0.185)
SG	-0.458** (0.181)
Assets	0.099*** (0.022)
Power	-0.319* (0.193)
Cash_ Assets	0.226 (0.226)
Cons	1.128*** (0.210)
Instruments	*LR Debt$_{(t-1)}$/Total Assets$_{(t-1)}$, SG(t-1), Payout$_{(t-1)}$, Total Assets$_{(t-1)}$, Cash$_{(t-1)}$/Total assets$_{(t-1)}$, Cash Flow$_{(t-1)}$/Sales$_{(t-1)}$, $\pi_{K(t-1)}$,CAPEX/Total Assets, Assets Turnover, Equity/Total Assets, Cash/Current Assets, Quick Ratio, ROA, Sales, Debt per Share, Ln(1+Cash/Inventory)*
Hansen's J statistic	$chi^2(10) = 18.055$, ($p = 0.054$)
Observations	22653

Note: standard errors are given in parentheses; the significance level is marked with asterisks: *p<0.1, **p<0.05, ***p<0.01.

The choice of instruments is aimed at finding the performance indicators which determine the level of financial constraints the firm faces. The instruments include the majority of lagged variables forming the financial constraints index according to (7). Without trying to resolve the disagreement between Fazzari et al. (1988) and Kaplan and Zingales (1997) on whether investment sensitivity to cash flows increases with the growth of financial constraints, we pay special attention to such liquidity parameters as cash flow and cash stocks in a company. Therefore, the weighed coefficients of *Cash$_{(t-1)}$/Total assets$_{(t-1)}$*, *Cash Flow$_{(t-1)}$/Sales$_{(t-1)}$*, *Cash/Current Assets*, *Ln(1+Cash/Inventory)* and *Quick Ratio* are used. Guided by Whited and Wu (2006) and Fama and French (2000) we add an indicator of profitability (ROA) to the list of instruments. Indicators illustrating dependence on loan proceeds are presented by the following instruments: *Debt per Share* and *Equity/Total Assets*. Combined with the coefficient of long term debt to total assets ratio (*LRDebt_Assets*), these instruments reflect the financial leverage. Given that the ability to raise capital and the investment activity are interconnected, we add the weighed coefficient of capital expenditure *(CAPEX/Total Assets)* to the list of instruments. We also include the coefficient of asset turnover to characterize the ability of the company to get revenue using current and noncurrent assets. On the whole, for the index specification (7) Hansen's overidentification test proves that the instruments employed are valid (see Table 2).

Let us clarify the results. As the long-term debt part of aggregate capital (*LRDebt_Assets*) increases, the ability of the firm to attract additional external funds decreases. This is accompanied by an increase in the cost of capital as a consequence of increased insolvency risk. Both tendencies cause a rise in costs λ_{it} (the coefficient *LRDebt_Assets* is significant and positive, which corresponds to the results achieved by Whited and Wu (2006) and the classification proposed by Kaplan and Zingales (1997)).

It is easier for expanding firms which demonstrate stable sales growth *(SG)* to raise external capital. Thus, the negative coefficient is justified. It corresponds to the results achieved by Whited and Wu (2006) and Kaplan and Zingales's classification (1997).

The sign of the total assets coefficient *(Assets)* is unexpected. Usually larger firms are associated with lower risk, particularly of insolvency ('too big to fail'); therefore, they are expected to enter capital markets more easily. However, according to the results, growth leads to an increase in the wedge between the costs of external and internal funds, in other words, to the growth of financial constraints. In the sample the variables *LRDebt_Assets* and *Assets* correlate substantially: the estimate of the correlation coefficient of 0,25 is statistically significant. The debt growth rate exceeds the growth rate of the company assets. Consequently, large companies accumulate heavy debts without sufficient asset backing, and face limitations on new loans. In this connection, the positive coefficient of *Assets* seems to be justified. Whited and Wu (2006) show a negative coefficient; Kaplan and Zingales (1997) do not consider total assets in their analysis.

The higher the operating margin (*Power*), the more effectively the firm functions and, other things being equal, the easier it provides the required return for both debtholders and shareholders. The coefficient is significant and negative. Whited and Wu (2006) and Kaplan and Zingales (1997) do not include the variable in their analysis.

Figure 2 presents the estimates of the density of the distribution of the constructed index λ. The index of financial constraints possesses positive values since the variable λ_{it} – the shadow costs – is greater than zero.

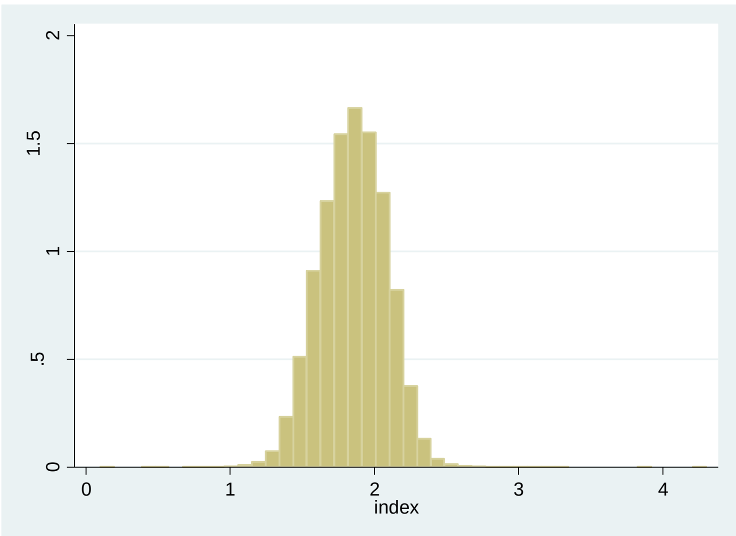

Fig. 2. The estimates of the index λ distribution density

6. Uncertainty measure

As far as empirical investigation is concerned, there are two classes of approaches to measure uncertainty: ex ante and ex poste techniques. The ex ante approach is built on the calculation of the volatility of estimates from survey data. Although high quality survey data require a large amount of respondents to be questioned, the uncertainty measure derived from such data reflects individual risk perception of economic agents (Lensink et al. (1999)). The easiest ex post approach is based on estimating daily stock return volatility. This kind of measure absorbs all relevant sources of risk for a firm. However, quoted price fluctuations on top of responding to a range of fundamental aspects of a firm's environment are often caused by noise effects, such as bubbles, fads, irrational behaviour, and speculative transactions (Leahy and Whited (1996)). To alleviate this problem, one may focus on the effect of changes in uncertainty on investment, because taking the difference removes the unobservable effect which is correlated with the variable (Xie (2009) and Bond and Cummins (2004)). Thus, firm-specific uncertainty is estimated based on stock price fluctuations with adjustment for market index changes. In other words, one builds a regression of a firm's stock return on the return on the corresponding market index. The standard deviation of residuals obtained from the regression model is considered as the idiosyncratic uncertainty of the firm. Further, a parameter increment is applied (Xie (2009)).

Many studies apply the GARCH-type modelling and/or estimate the variance of the unpredictable part of an autoregressive process for measuring uncertainty. From a theoretical point of view, if a specification of the conditional mean equation is chosen correctly, the GARCH-type modelling is considered to provide more precise estimates as it allows for the time dependence of the conditional variance of the parameter (Lensink et al. (1999)). Empirically, not only does the technique of estimating the variance of the unpredictable part of a stochastic process perform at least as well as the GARCH-model in respect to investment equations (Bo and Sterken (2002)), it also seems to be more flexible, placing no limitation on the observation period and permitting us to build any form of autoregressive process as long as the Markov property is complied with (Lensink et al. (1999)).

As we are not planning to measure uncertainty based on financial market data and thus have a limited observation length, estimating the variance of the unpredictable part of an autoregressive process seems to be the most reasonable approach for this application.

Stochastic demand is one of the crucial sources of uncertainty surrounding a firm (Guiso and Parigi (1999), and Bo and Sterken (2007)). In this connection, the measurement of the overall uncertainty may be limited to demand uncertainty. The forecast of future demand for a firm's product is based on sales history. Sales are described as a trend-stationary autocorrelated process AR(1):

$$Sales_t = c_0 + c_1 \times Trend_t + c_2 \times Sales_{t-1} + \varsigma_t \quad (8)$$

where c_0 is a constant, c_1 and c_2 are parameters, ς is an error term (demand shocks). The standard deviation of demand shocks estimated as residuals in the regression (8) is regarded as a proxy for demand uncertainty and is denoted as *UMS* (the approach is adopted by Ghosal and Loungani (2000), and Bo and Sterken (2007)). To eliminate the size effects, the standard deviation of the residuals is scaled by total assets, and further we use the logarithm of the variable. The standard deviation of the residuals for the year 1994 is based on the information over 1990-1994. Every subsequent year uses one more observation. Thus, demand uncertainty for the year 2011 is calculated using observations over 1990-2011.

7. Measurement of attitude towards risk

The risk-premium is the amount an investor is ready to pay to avoid a pure (zero-mean) risk. In accordance with the Arrow-Pratt Approximation, the risk-premium is proportional to the square of the risk factor:

$$Risk\ premium = \frac{1}{2} \times RC(W_0) \times E[y^2] + higher\ order\ conditions \quad (9)$$

where *RC* is the coefficient of absolute risk aversion; W_0 is initial wealth; $E[y^2]$ is the value of the variance of the risk factor *y* (for example, profit whose amount is not guaranteed).

Let us rewrite the equation (9): as Fisher and Hall (1969) point out, if a company follows optimal decision rules, its risk premium can be measured by the characteristics of the distribution of the net profits. Thus, let a firm maximize the utility function *(U)* from the profits earned *(π)* and the initial wealth *(W_0)*. Bo and Sterken (2007) show the results of the expansion of the utility function in a Taylor series around the point $(\pi" + W_0) = E(\pi + W_0)$:

$$U(\pi'' + W_0) - E[U(\pi + W_0)] = -\sigma_\pi^2 \times \frac{U''}{2!} \times (\pi'' + W_0) - \sigma_\pi^3 \times \frac{U'''}{3!} \times (\pi'' + W_0) + \cdots \quad (10)$$

The difference in the left side of equation (10) is the risk premium. Its magnitude is conditioned by the second, third and higher moments of the profit distribution. In accordance with Bo and Sterken's (2007) approach the difference between the realized and risk-adjusted profit is used as the proxy for the risk premium. Assuming that the risk-adjusted profit of firm *i* is constant over the observation period one may write down the risk premium for the year *t*:

$$Risk\ premium_t = \pi_t - \acute{\pi} \tag{11}$$

where π_t is the realized operating profit (earnings before interest and taxes (EBIT)) for the year *t*, $\acute{\pi}$ is the risk-adjusted profit. To eliminate the size effect, EBIT are scaled by total assets.

In view of the fact that the risk aversion coefficient *RC* in equation (9) is multiplied by the variance of the stochastic variable (profit), one may rewrite (10) in the following way:

$$Risk\ premium_t = RC \times SD_t + b \times SKEW_t \tag{12}$$

where SD_t is the standard deviation of operating profits (EBIT) scaled by total assets for year *t*; $SKEW_t$ is the third moment (skewness coefficient) of the distribution of EBIT scaled by assets.

Or in another way:

$$\pi_t = \acute{\pi} + RC \times SD_t + b \times SKEW_t \tag{13}$$

where $\acute{\pi}$ may be viewed as a constant that shows the external influence on the realized profits not reflected through the coefficients of standard deviation and skewness.

Although the coefficient of risk aversion built in such a way is a relative value, it allows us to determine whether or not investors are tolerant to risk. The division is based on the median value. That is, we consider a company having the risk coefficient *(RC)* lower than the median as risk-taking, and vice versa.

The estimation of regression (13) is performed by the ordinary least squares (OLS) method. The observation period covers the years 1990-2011. The minimal observation length used to calculate the standard deviation and skewness is 5 years. For example, for the year 1994 the values of EBIT over 1990-1994 are collected; subsequently, we increase the number of observations by one for each year. Thus, the *SD* and *SKEW* coefficients for the year 2011 are computed on the basis of EBIT over 1990-2011.

The evaluation of the risk coefficient is carried out in two ways:

1. We assume that the investor's attitude towards risk is formed based on the information concerning company performance and the uncertainty of the business environment (demand changes, stock price fluctuations, fuel/precious metal/currency prices, political risks, etc.) over the last five years. We use a sliding interval with the length of five years to estimate the *RC* coefficient in model (13) starting from 1998 (using data from 1994-1998) and ending with the year 2011 (using data from 2007-2011). Let the estimated parameter be denoted as *RC*.
2. Let the attitude towards risk be affected to a certain extent by the history of all the previous years. In this connection, to evaluate the risk coefficient each year, we increase the number of observations by one. Thus, starting from the year 1998 the calculated values of the standard deviation and skewness over 1994-1998 are applied; for 2011, the estimation is performed using the data over 1994-2011. Let the estimated variable be denoted as RC_{1by1}.

8. An empirical evaluation of the influence of financial constraints and attitude towards risk on corporate investment decisions

First of all, let us demonstrate that financial constraints discourage investment. We build a simple model of the effect of the financial constraints index on investment. Explanatory variables also include return on assets (*ROA)* and current liquidity coefficient *(Liq)*.

$$Investment_{it} = f_i + f_t + a_1 \times Index_{it} + a_2 \times ROA_{it} + a_3 \times Liq_{it} + \xi_{it} \qquad (14)$$

where f_i, f_t are fixed and time effects respectively; $Investment_{it}$ is calculated as the ratio of capital expenditure to total assets; ζ_{it} is the regression error. We use the Fixed Effects Model to estimate the parameters of (14). The choice of the method is based on Hausman's test results.

Because of the heterogeneity of the countries included in the sample we estimate regression (14) separately for country subsamples. The integration of capital markets may result in biased estimates because of the difference in financial constraints that companies face in different regions. We therefore form four blocs according to the geographical distribution: Europe, America, Japan and Australia. The relevance of the division has been proved by Chow's test. Figure 3 describes the sample in accordance with the geographical profile. Table 4 presents the descriptive statistics of the parameters forming models (14), (15), and also includes data characterising *Sales* and *Investment* in subsamples.

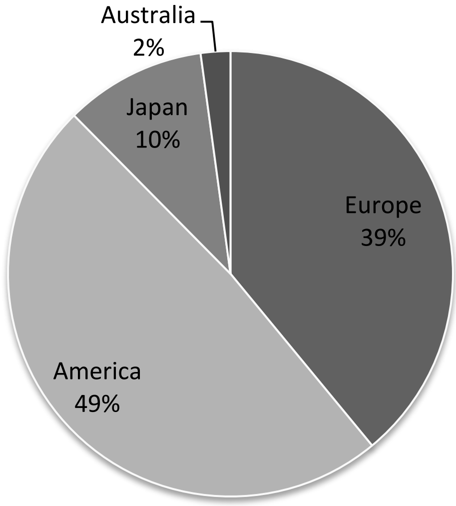

Fig. 3. The geographical distribution of the sample analysed

Because the observation period is quite long and covers the years 1993-2011 we carry out a structural change analysis. For every country bloc two sub-periods are separated out: from 1993 to 2008 inclusive and from 2009 (to take into account the effect of financial crisis). In addition, for Japan we also single out the year 1998 as a point causing a structural change (the influence of the Asian crisis is tested). To verify the hypothesis in the presence of structural changes we ran Chow's test for every country subsample. In each case, Chow's tests rejected the hypothesis of coefficient equality at 1% significance level (14% significance level for Australia).

The results of evaluation are presented in Table 3.

Tab.3. Empirical estimates of the effect of financial constraints on corporate investment

Variable	Europe, 1993-2008	Europe, 2009-2011	America, 1993-2008	America, 2009-2011	Japan, 1993-1998	Japan, 1999-2008	Japan, 2009-2011	Australia, 1993-2008	Australia, 2009-2011
Index	-7.753*** (0.462)	-0.959 (0.801)	-9.681*** (0.372)	-2.486*** (0.563)	0.622 (1.137)	0.793 (0.787)	2.230** (1.080)	-4.914*** (1.791)	12.824** (3.608)
ROA	0.062*** (0.008)	0.011 (0.013)	0.038*** (0.005)	0.022** (0.009)	0.230*** (0.050)	0.118*** (0.017)	-0.093*** (0.028)	0.083** (0.033)	-0.002 (0.055)
Current liquidity	-0.702*** (0.282)	-2.007*** (0.687)	-1.208** (0.253)	-0.971** (0.459)	-2.254** (1.043)	-1.738*** (0.567)	-3.282*** (1.061)	0.079 (1.246)	-1.622 (2.289)
Const	20.590*** (0.864)	7.661*** (1.576)	25.996*** (0.733)	10.620*** (1.130)	5.453** (2.478)	4.437** (1.656)	2.750 (2.329)	16.301*** (3.398)	-15.518** (6.818)
R-sq within	0.057	0.011	0.087	0.039	0.038	0.039	0.167	0.039	0.201
R-sq between	0.000	0.005	0.005	0.012	0.203	0.101	0.021	0.025	0.072
R-sq overall	0.015	0.005	0.033	0.017	0.135	0.075	0.035	0.002	0.096
F-statistic	156.47	3.79	310.69	17.34	9.01	16.91	18.28	5.8	4.60
Obs.	8363	1571	10440	1947	828	1380	414	459	87

Note: standard errors are given in parentheses; the significance level is marked with asterisks: *p<0.1, **p<0.05, ***p<0.01.

On the whole, our empirical evaluation shows the negative influence of financial constraints on corporate investment for different countries with the exception of Japan and Australia starting from 2009. The positive sign of the variable *Index* is possibly caused by the small number of observations. Thus, under certainty companies facing constraints on outside finance are compelled to lower capital spending. Does the behaviour of investors suffering from capital market imperfections change under uncertainty? We investigate the effect of demand uncertainty on the investment of economic agents differing in the gap between the cost of external and internal funds. Having rebuilt model (14) so that it takes into account the demand uncertainty factor, we would like to reveal the effect of the suboptimal investment policy pointed out by Boyle and Guthrie (2003). There are states when in comparison with an unconstrained firm making an investment, a constrained firm has to launch an investment project undervaluing the option to delay, because the risk of not being able to finance the project in the future outweighs the benefits of delaying investment in expectation of the resolution of the uncertainty.

We treat index of financial constraints as the threshold, a regime-switching parameter that changes the relation between demand uncertainty and investment as the level of financial constraint changes. The extended model takes the following form:

$$Investment_{it} = f_i + f_t + b_1 \times UMS_{it} \times I(Index_{it} \leq \phi) + b_2 \times UMS_{it} \times I(Index_{it} > \phi) + b_3 \times ROA_{it} + b_4 \times Liq + \varepsilon_{it} \quad (15)$$

where *I* is the indicator function taking the value of 1 if the argument is true and zero otherwise; *Index* is the index of financial constraints; *UMS* is the uncertainty measure; ϕ is the threshold value for the index of financial constraints to be estimated; ε is the regression error.

By setting the two regimes of financial constraints (the selection criterion is the optimal threshold value of ϕ), we expect the coefficients b_1 and b_2 in regression (15) to differ. To find the threshold value ϕ, we sorted the observations relative to the threshold variable and calculated the sums of squared residuals for all values of the threshold parameter. The minimum value of the sums corresponds to the optimal ϕ value (Hansen (1996) and Bo et al. (2006)). Taking ϕ into consideration, we estimate the regression coefficients (15) by applying the Fixed Effects Model (see Table 5). The choice of the method is based on Hausman's test results.

Tab.4. Descriptive statistics of the variables forming the models (14), (15) during 1994-2011

Variable	Mean	Std. Dev.	Skewness	Kurtosis	Min	Max	Observations
Sales Europe	5898.157	17491.670	7.667	93.107	0.050	362684.3	9446
Sales America	7225.319	21552.4	9.666	137.203	0.090	446950	11769
Sales Japan	10705.16	20139.37	4.981	39.090	212.650	264120.6	2484
Sales Australia	3827.115	8939.769	4.889	30.074	7.980	77578.44	522
Investment Europe	6.138	6.291	6.244	105.625	0	173.430	9446
Investment America	6.596	6.344	3.106	19.449	0	82.850	11769
Investment Japan	4.691	2.979	1.163	5.601	0.010	23.720	2484
Investment Australia	7.875	6.054	1.776	7.912	0.170	41.870	522
UMS Europe	-2.110	0.913	-0.067	5.348	-7.582	2.113	8918
UMS America	-2.387	0.977	-0.084	5.108	-10.207	2.148	11114
UMS Japan	-2.219	0.544	-0.209	11.060	-6.843	0.706	2346
UMS Australia	-1.972	1.218	0.623	7.879	-8.456	3.019	493
Index Europe	1.792	0.247	0.135	3.638	0.412	3.299	9411
Index America	1.875	0.218	0.252	6.078	0.098	4.303	11734
Index Japan	2.014	0.148	0.056	2.924	1.505	2.550	2484
Index Australia	1.819	0.203	-0.005	2.997	1.169	2.635	517
ROA Europe	5.854	9.524	-3.960	106.926	-267.15	132.83	9446
ROA America	6.059	11.473	7.219	549.197	-235.24	571.86	11769
ROA Japan	2.240	3.661	-1.236	13.305	-29.01	23.72	2484
ROA Australia	6.153	8.197	-1.421	13.180	-48.54	42.09	522
Liq Europe	0.924	0.316	3.857	95.141	0.113	10.519	9446
Liq America	1.035	0.397	1.140	6.035	0.049	4.024	11769
Liq Japan	0.933	0.323	1.525	6.719	0.182	2.881	2484
Liq Australia	0.903	0.269	1.787	10.380	0.385	2.883	522

Note: The mean, maximum and minimum values of *Investment* and *Sales* are in millions of USD.

Tab.5. Empirical estimates of the effect of financial constraints on corporate investment under demand uncertainty

Variable	Europe 1994-2008	Europe 2009-2011	America 1994-2008	America 2009-2011	Japan 1994-1998	Japan 1999-2008	Japan 2009-2011	Australia 1994-2008
UMS (Index≤ ϕ)	-0.144 (0.142)	-2.337*** (0.717)	-0.707*** (0.134)	-2.878*** (0.815)	-1.101* (0.619)	-1.246*** (0.378)	2.313** (0.892)	-0.800*** (0.179)
UMS (Index> ϕ)	0.346*** (0.113)	-2.060*** (0.686)	0.255*** (0.083)	-2.398*** (0.858)	-0.027 (0.082)	-1.374*** (0.406)	2.026** (0.940)	-0.078 (0.265)
ROA	0.090*** (0.023)	0.007 (0.008)	0.060*** (0.020)	0.020** (0.008)	0.150** (0.058)	0.096*** (0.023)	-0.094*** (0.030)	0.077** (0.031)
Liq	-0.945** (0.433)	-1.998** (0.903)	-1.839*** (0.617)	-1.028* (0.590)	-2.527** (1.117)	-1.627* (0.873)	-2.907 (1.762)	-0.196 (1.426)
Const	7.058*** (0.485)	1.173 (1.352)	8.637*** (0.622)	-0.914 (2.018)	6.943*** (1.058)	3.040*** (1.139)	12.015*** (3.071)	7.318*** (1.302)
R-sq within	0.027	0.034	0.044	0.091	0.032	0.062	0.189	0.037
R-sq between	0.048	0.041	0.023	0.037	0.153	0.103	0.000	0.013
R-sq overall	0.034	0.036	0.033	0.039	0.111	0.087	0.002	0.026
F-st.	12.81	3.15	17.78	9.12	4.09	7.33	8.04	7.04
Obs.	7871	1575	9808	1961	690	1380	414	435

Note 1: standard errors are given in parentheses; the significance level is marked with asterisks: *p<0.1, **p<0.05, ***p<0.01.

Note 2: The coefficients *UMS(Index≤ ϕ)* and *UMS(Index>ϕ)* for Australia over 2009-2011 are insignificant and excluded from Table 5.

Note 3: The difference between the coefficients *UMS(Index≤ ϕ)* and *UMS(Index>ϕ)* turns out to be insignificant for Europe 2009-2011, Japan 1999-2008 and 2009-2011.

Given the insignificant differences in the coefficients, the empirical evaluation shows that under demand uncertainty firms facing higher financial constraints (above the threshold ϕ) either intensify their investment activity or lower capital expenditure to a lesser extent compared to unconstrained companies (*Index*$\leq\phi$). The behavioural change of European and American financially constrained companies and both groups of Japanese investors after the 2008 crisis (the change of the sign from positive to negative, and vice versa for Japan) requires further investigation. It could be necessary to deepen the analysis, adding both fundamental and behavioural factors. The situation is likely to be clarified if we take into account the effect of the companies' attitude towards risk.

On the whole, the theoretical conclusion made in Boyle and Guthrie (2003) is corroborated: the behaviour of financially constrained firms seems to be suboptimal. The divergence is explained by the fact that such firms, when possessing money today, are confronted with the dilemma: to launch the project straightaway not taking into consideration high demand uncertainty, or to face probable difficulties in (or the impossibility of) attracting funds for the project in the future and being compelled not to invest at all. The opposite results obtained in models (14), (15) do not really contradict each other because the crucial parameter is the condition of demand certainty/uncertainty.

As far as other explanatory variables in (14), (15) are concerned, companies with a high ROA intensify capital investment. If the return on capital exceeds its costs there is no need to refuse worthwhile investment projects. The current liquidity coefficient *(Liq)* might be treated as a financial restraint on directing cash assets into investment projects. The negative dependence indicates that if there are more resources in the current assets, fewer funds are allocated for capital assets purchasing.

We would like to deepen the analysis by including the effect of investors' attitude towards risk into the model. We evaluate the influence of demand uncertainty on capital spending of companies different in financial constraints and risk aversion degree (see the regression (16)). The index of financial constraints is considered as the threshold. The optimal threshold value χ is found using Hansen's technique (Hansen (1996)). The threshold value of the parameter RC that switches the behavioural regimes from risk taking to risk averse (μ) is calculated with the formula for the median. The extended model takes the form:

$$Investment_{it} = f_i + f_t + b_1 \times UMS_{it} \times I(Index_{it} \leq \chi) \times J(RC_{it} > \mu) + b_2 \times UMS_{it} \times I(Index_{it} > \chi) \times J(RC_{it} > \mu) + b_3 \times UMS_{it} \times I(Index_{it} \leq \chi) \times J(RC_{it} \leq \mu) + b_4 \times UMS_{it} \times I(Index_{it} > \chi) \times J(RC_{it} \leq \mu) + b_5 \times ROA_{it} + b_6 \times Liq + \vartheta_{it} \qquad (16)$$

where I, J are the indicator functions taking the value of 1 if the argument is true and zero otherwise; RC is the coefficient of risk aversion; μ is the median of the risk aversion coefficient for the corresponding block of countries; $Index$ is the index of financial constraints; χ is the threshold value for the index of financial constraints to be estimated; ϑ is the regression error.

Let us clarify the meaning of the following cross terms in the model (16):

a) $UMS_{it} \times I(Index_{it} > \chi) \times J(RC_{it} > \mu)$ is the effect of demand uncertainty on a risk averse and comparatively financially constrained company;

b) $UMS_{it} \times I(Index_{it} \leq \chi) \times J(RC_{it} > \mu)$ is the effect of demand uncertainty on a risk averse and relatively unconstrained company;

c) $UMS_{it} \times I(Index_{it} > \chi) \times J(RC_{it} \leq \mu)$ is the effect of demand uncertainty on a risk taking and comparatively financially constrained company;

d) $UMS_{it} \times I(Index_{it} \leq \chi) \times J(RC_{it} \leq \mu)$ is the effect of demand uncertainty on a risk taking and relatively unconstrained company.

Taking into consideration the χ and μ values, we estimate regression coefficients (16) for each block of countries, applying the Fixed Effects Model (see Table 7, and Tables 9, 11 in Appendix). The choice of the method is based on Hausman's test results. To check the robustness of the results, we estimate model (16) for both specifications of the attitude towards risk coefficient.

By specifying the two regimes of financial constraints and two types of attitude towards risk we expect the coefficients b_1, b_2, b_3, and b_4 to differ. The results of such an analysis for the country subsamples, that is, the insignificant differences in the pairwise combinations of the coefficients, found for one or another observation period, are contained in Tables 8, 10, 12 (in Appendix). The estimates of the coefficients b_1, b_2, b_3, and b_4 for Australia turn out to be insignificant and are excluded from the tables. Table 6 contains the descriptive statistics of the risk attitude parameter.

Tab.6. Descriptive statistics of the "attitude towards risk" variable over 1998-2011

Variable	Mean	Median	Std. Dev.	Skewness	Kurtosis	Min.	Max.	Obs.
RC Europe	-0.257	-1.165	29.507	-1.233	77.451	-611.747	418.878	7349
RC_{1by1} Europe	-0.551	-0.933	6.465	-3.535	158.104	-204.699	118.745	7349
RC America	-1.847	-2.196	31.562	9.183	340.905	-594.427	1193.976	9154
RC_{1by1} America	-0.549	-1.187	6.563	-0.782	52.331	-132.64	91.214	9154
RC Japan	-3.315	-3.230	31.346	2.646	51.094	-251.243	461.353	1932
RC_{1by1} Japan	-2.365	-2.356	5.165	0.451	7.860	-25.369	39.200	1932
RC Australia	-0.901	-0.464	32.937	-0.707	17.923	-263.431	198.197	406
RC_{1by1} Australia	-1.179	-1.484	7.279	1.543	14.348	-31.148	51.779	406

Tab.7. Empirical estimates of financial constraints and risk attitude effects on corporate investment under demand uncertainty for Europe

Variable	RC_{1by1}, 1998-2011	RC_{1by1}, 1998-2008	RC_{1by1}, 2009-2011	RC, 1998-2011	RC, 1998-2008	RC, 2009-2011
UMS ($RC>\mu$, $Index>\chi$)	-0.166 (0.133)	0.332 (0.215)	-2.090*** (0.532)	-0.121 (0.131)	0.491** (0.214)	-2.012*** (0.519)
UMS ($RC>\mu$, $Index \leq \chi$)	-0.629*** (0.140)	-0.301* (0.163)	-2.535*** (0.523)	-0.606*** (0.136)	-0.303* (0.160)	-2.298*** (0.503)
UMS ($RC\leq\mu$, $Index > \chi$)	0.093 (0.135)	0.928*** (0.216)	-2.337*** (0.540)	0.032 (0.131)	0.733*** (0.207)	-2.152*** (0.524)
UMS ($RC\leq \mu$, $Index \leq\chi$)	-0.424*** (0.143)	-0.188 (0.164)	-2.282*** (0.511)	-0.436*** (0.139)	-0.174 (0.160)	-2.427*** (0.505)
ROA	0.046*** (0.007)	0.054*** (0.008)	0.008 (0.012)	0.048*** (0.007)	0.056*** (0.008)	0.007 (0.012)
Liq	-1.157*** (0.318)	-1.346*** (0.395)	-2.045*** (0.659)	-1.182*** (0.318)	-1.374*** (0.395)	-1.962*** (0.659)
Year2009	-1.652*** (0.208)	-	-	-1.651*** (0.208)	-	-
Year2010	-2.114*** (0.207)	-	-	-2.128*** (0.207)	-	-
Year2011	-1.888*** (0.206)	-	-	-1.895*** (0.206)	-	-
Const	6.386*** (0.389)	6.829*** (0.490)	0.964 (1.221)	6.401*** (0.389)	6.850*** (0.490)	1.098 (1.220)
Obs.	7345	5770	1575	7345	5770	1575
R-sq within	0.055	0.022	0.038	0.055	0.021	0.036
R-sq between	0.092	0.039	0.040	0.089	0.047	0.038
R-sq overall	0.063	0.030	0.036	0.061	0.032	0.034
F-statistic	43.96	19.97	6.90	43.76	19.04	6.55

Note: standard errors are given in parentheses; the significance level is marked with asterisks: *p<0.1, **p<0.05, ***p<0.01.

The empirical evaluation results presented in Tables 7-12 (see Appendix) imply the following:

a) Demand uncertainty discourages capital expenditure of all types of investors (the sign of the coefficients b_1, b_2, b_3, and b_4 is negative). Firms tend to lower their investment activity in expectation of the mitigation of the uncertainty.

b) The problem of the behavioural change after the 2008 crisis has been solved for the American subsample with the extension of the model, but it is still relevant for European and Japanese investors, and requires further investigation.

c) The risk attitude parameter included in the model does not change the conclusion that under demand uncertainty companies lacking external funding tend to lower investment in the current year less aggressively compared to financially unconstrained firms. The anxiety of not starting projects in the future because of capital market imperfections compels a constrained company to invest while it currently possesses enough resources, regardless of demand uncertainty.

d) Risk attitude is found to be an important factor in making corporate investment decisions under uncertainty. With a given level of financial constraints (the value of the *Index* either exceeds or is below the optimal threshold χ) risk-taking companies are inclined to lower investment less willingly compared to risk-averse firms. The results fully correspond to conclusions made in Bo and Sterken (2007) and Aistov and Kuzmicheva (2012).

e) The analysis of the entire observation period and the inclusion of the variables of the years 2009-2011 as control, makes it possible to evaluate the significant and negative influence of the crisis on corporate investment.

f) Taking into consideration the insignificant differences in the empirical estimates of the coefficients, we suggest a scheme which corporate investment decisions in the American subsample comply with. The investors may be ranked according to the extent of shrinking capital expenditure under growing demand uncertainty:

1. financially constrained and risk-taking companies;
2. financially constrained and risk-averse companies;
3. financially unconstrained and risk-taking companies;
4. financially unconstrained and risk-averse companies.

Consistently with the hierarchy proposed above, we do not corroborate the conclusion made in Bo et al. (2003) that capital market constraints are more severe for risk-taking economic agents. The evaluation results for the European and Japanese subsamples also do not provide arguments to confirm the position taken by Bo et al. (2003).

9. Conclusion

In this study we find the empirical estimates of the combined effect of financial constraints and attitude towards risk on investment made by public nonfinancial companies operating in developed countries in 1990-2011 under demand uncertainty. The proxy for investor attitude towards risk is built on the basis of the approach adopted by Bo and Sterken (2007). To assess the level of financial constraints a firm faces, we followed the investment model by Whited (1992, 1998) and Whited and Wu (2006) and have constructed the index specification. Thus, via the Generalized Method of Moments the investment Euler equation has been estimated. Its relatively high information content is shown by the comparative analysis of the index created with the indicators of financial performance, the results achieved by Whited and Wu (2006), and the classification proposed by Kaplan and Zingales (1997).

The index constructed and the risk coefficient are treated as the threshold parameters that switch both the level of capital market constraints from relatively high to relatively low and the risk attitude from risk-taking to risk-averse, correspondingly. With respect to the optimum threshold values found we have shown that: 1) under growing demand uncertainty investors are inclined to decrease capital spending; 2) under certainty the growth of capital market imperfections corresponds to the reduction in investment, whereas under demand uncertainty a company with straitened resources lowers capital expenditure to a lesser degree compared to an unconstrained firm; 3) with a given level of financial constraints, risk-taking companies are found to reduce the number of investment projects to a lesser extent in comparison with risk-averse companies.

The research results allow us to recommend investors to adjust their corporate investment policy to demand uncertainty and capital market imperfections a firm faces. In addition, to avoid the repetition of a liquidity crisis, investment decisions should take into account the size of internal funds a firm is able to generate. Incorporating some flexibility into investment projects, that is, real options to delay, expand, etc., seems a reasonable measure to take while waiting for uncertainty to decrease.

Since investment decisions undertaken by managers are inevitably influenced by behavioural effects (e.g. attitude towards risk), it is crucial to facilitate the process by using a combination of quantitative and qualitative methods. That is, including fuzzy multiple-criteria decision-making models and expert judgment in the system of existing quantitative approaches improves the quality of the decision making process.

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Appendix

Tab.8. Insignificant differences between coefficients b_1, b_2, b_3, and b_4 for Europe

	b_1–b_2	b_1–b_3	b_1–b_4	b_2–b_3	b_2–b_4	b_3–b_4
RC_{1by1}	-	2009-2011	2009-2011	2009-2011	1998-2008, 2009-2011	2009-2011
RC	-	1998-2008, 2009-2011	-	2009-2011	2009-2011	-

Tab.9. Empirical estimates of financial constraints and risk attitude effects on corporate investment under demand uncertainty for America

Variable	RC_{1by1}, **1998-2011**	RC_{1by1}, **1998-2008**	RC_{1by1}, **2009-2011**	RC, **1998-2011**	RC, **1998-2008**	RC, **2009-2011**
UMS (RC>μ, Index>χ)	-0.682*** (0.106)	-0.892*** (0.131)	-3.128*** (0.339)	-0.655*** (0.105)	-0.876*** (0.130)	-2.235*** (0.387)
UMS (RC>μ, Index≤ χ)	-1.289*** (0.120)	-1.772*** (0.166)	-6.085*** (0.883)	-1.269*** (0.119)	-1.741*** (0.164)	-2.867*** (0.327)
UMS (RC≤μ, Index>χ)	-0.412*** (0.109)	-0.616*** (0.136)	-2.889*** (0.327)	-0.480*** (0.105)	-0.681*** (0.131)	-2.604*** (0.393)
UMS (RC≤μ, Index≤χ)	-1.099*** (0.127)	-1.671*** (0.178)	-2.034*** (0.747)	-1.165*** (0.122)	-1.743*** (0.172)	-2.926*** (0.327)
ROA	0.036*** (0.004)	0.036*** (0.005)	0.022*** (0.007)	0.037*** (0.004)	0.037*** (0.005)	0.020*** (0.007)
Liq	-1.404*** (0.232)	-1.788*** (0.291)	-1.161** (0.460)	-1.412*** (0.232)	-1.791*** (0.291)	-1.046** (0.450)
Year2009	-1.321*** (0.166)	-	-	-1.329*** (0.166)	-	-
Year2010	-1.579*** (0.164)	-	-	-1.595*** (0.164)	-	-
Year2011	-1.033*** (0.164)	-	-	-1.032*** (0.164)	-	-
Const	5.915*** (0.333)	5.930*** (0.419)	-1.102 (0.923)	5.870*** (0.333)	5.872*** (0.419)	-0.949 (0.918)
Obs.	9150	7189	1961	9150	7189	1961
R-sq within	0.065	0.043	0.097	0.065	0.043	0.093
R-sq between	0.059	0.037	0.047	0.052	0.032	0.036
R-sq overall	0.061	0.039	0.047	0.057	0.036	0.037
F-statistic	65.95	49.13	23.28	65.57	49.25	22.23

Tab.10. Insignificant differences between coefficients b_1, b_2, b_3, and b_4 for America

	b_1–b_2	b_1–b_3	b_1–b_4	b_2–b_3	b_2–b_4	b_3–b_4
RC_{1by1}	-	-	2009-2011	-	1998-2008	2009-2011
RC	-	2009-2011	-	2009-2011	1998-2011, 1998-2008, 2009-2011	2009-2011

Tab.11. Empirical estimates of financial constraints and risk attitude effects on corporate investment under demand uncertainty for Japan

Variable	RC_{1by1}, **1998-2011**	RC_{1by1}, **1998-2008**	RC_{1by1}, **2009-2011**	RC**,** **1998-2011**	RC**,** **1998-2008**	RC**,** **2009-2011**
UMS (RC>μ, Index>χ)	-0.591*** (0.205)	-0.567** (0.230)	1.793* (0.981)	-1.093*** (0.295)	-0.588*** (0.228)	2.150** (0.969)
UMS (RC>μ, Index≤ χ)	-0.659*** (0.214)	-0.585** (0.238)	2.161** (0.964)	-0.574*** (0.204)	-0.555** (0.236)	2.424** (0.948)
UMS (RC≤μ, Index>χ)	-0.555*** (0.205)	-0.584** (0.229)	2.054** (0.958)	-0.767*** (0.269)	-0.550** (0.229)	2.054** (0.961)
UMS (RC≤μ, Index≤χ)	-0.284 (0.214)	-0.328 (0.237)	2.167** (0.952)	-0.492** (0.203)	-0.351 (0.236)	2.315** (0.957)
ROA	0.072*** (0.015)	0.092*** (0.017)	-0.099*** (0.025)	0.077*** (0.014)	0.097*** (0.017)	-0.094*** (0.024)
Current Liquidity	-1.711*** (0.428)	-1.425*** (0.536)	-2.858*** (1.055)	-1.600*** (0.428)	-1.394*** (0.539)	-2.983*** (1.046)
Year2009	0.206 (0.185)	-	-	0.181 (0.186)	-	-
Year2010	-0.923*** (0.186)	-	-	-0.953*** (0.186)	-	-
Year2011	-1.286*** (0.187)	-	-	-1.263*** (0.186)	-	-
Const	5.016*** (0.596)	4.706*** (0.702)	11.679*** (2.453)	4.922*** (0.598)	4.681*** (0.703)	12.273*** (2.431)
Obs.	1932	1518	414	1932	1518	414
R-sq within	0.075	0.038	0.196	0.073	0.038	0.192
R-sq between	0.091	0.136	0.000	0.113	0.159	0.001
R-sq overall	0.083	0.091	0.004	0.091	0.102	0.001
F-statistic	15.99	9.12	10.94	15.64	8.99	10.72

Tab.12. Insignificant differences between coefficients b_1, b_2, b_3, and b_4 for Japan

	b_1–b_2	b_1–b_3	b_1–b_4	b_2–b_3	b_2–b_4	b_3–b_4
RC_{1by1}	1998-2011, 1998-2008	1998-2011, 1998-2008, 2009-2011	2009-2011	1998-2011, 1998-2008, 2009-2011	2009-2011	2009-2011
RC	1998-2008	1998-2011, 1998-2008, 2009-2011	2009-2011	1998-2011, 1998-2008	-	1998-2011, 2009-2011

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