



NATIONAL RESEARCH UNIVERSITY  
HIGHER SCHOOL OF ECONOMICS

*Ekaterina E. Kuzmicheva, Kirill E. Kuzmichev*

# **THE INFLUENCE OF FINANCIAL CONSTRAINTS AND REAL OPTIONS ON CORPORATE INVESTMENT DECISIONS**

BASIC RESEARCH PROGRAM

WORKING PAPERS

SERIES: FINANCIAL ECONOMICS  
WP BRP 17/FE/2013

This Working Paper is an output of a research project implemented at the National Research University Higher School of Economics (HSE). Any opinions or claims contained in this Working Paper do not necessarily reflect the views of HSE.

*Ekaterina E. Kuzmicheva<sup>1</sup>, Kirill E. Kuzmichev*

## **THE INFLUENCE OF FINANCIAL CONSTRAINTS AND REAL OPTIONS ON CORPORATE INVESTMENT DECISIONS<sup>2</sup>**

This paper presents evidence of the negative combined effect of financial constraints and real options on corporate investment. Using panel data on public companies functioning in developed countries, the authors prove that with increasing uncertainty surrounding a firm, the real options effect increases the influence of financial constraints on investment. To this end we have found the threshold value of the option multiple, which switches the uncertainty regimes from relatively high to relatively low, and we have constructed an index of financial constraints.

JEL Classification: C12, C23, C24, D22.

Key words: investment decisions; index of financial constraints; real options to delay.

---

<sup>1</sup> National Research University Higher School of Economics. Financial Management Department. Teacher; E-mail: ekuzmicheva@hse.ru

<sup>2</sup> This study was carried out within The National Research University Higher School of Economics in Nizhny Novgorod Fund Program in 2013, research grant No. 2013-05.

## 1. Introduction

Literature on investment under uncertainty identifies several channels through which uncertainty affects capital investment. However, whether uncertainty encourages or discourages corporate investment activity is ambiguous, as different approaches show conflicting results. In addition, 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)). In this article we consider the combined influence of financial constraints and real options on investment decisions. Despite its theoretical attractiveness, the testing of the real options model is not widespread in empirical research. The difficulty lies in constructing a proxy for the real options component (Bo et al. (2006)). Some examples of the investigation of financial constraints and real options effects in combination are a paper by Boyle and Guthrie (2003), who use computational modeling, and an empirical study by Xie (2008). The latter seems to have substituted measuring uncertainty based on stock price fluctuations for the real options estimation procedure. Thus, Xie's conclusions are more likely to apply to the relations between uncertainty, financial constraints and investment, rather than the triangle of real options, financial constraints and investment. In this regard our work, guided by the approach to constructing a proxy for real options effect shown in Dixit and Pindyck (1994) and Bo et al. (2006), fills this gap. We test the hypothesis that in conditions of growing uncertainty surrounding a company, real options to delay magnify the effect of financial constraints on investment made by public nonfinancial companies in developed countries in 1991–2011. Thus, our work contributes to the empirical research of corporate investment decisions under uncertainty.

The rest of the article is organized as follows. In section 2 we present a literature review concerning the influence of financial constraints and real options 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 constraints index. Section 5 contains data description; it also presents two specifications of the financial constraints index and a comparison of our index, the results achieved by Whited and Wu (2006) and the classification in Kaplan and Zingales (1997). In section 6 we briefly describe the construction method of a proxy variable for the real option to delay. In sections 7 we estimate the influence of financial constraints and real options on corporate investment activity. Section 8 contains 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. According to Ross et al. (1993), 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 a high debt level: 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 the given investment policy. However, a higher insolvency risk provokes investors either to demand an interest rate premium or to limit the company's debt use 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 a 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 following hypotheses were tested:

- 1) In the case where a firm which is not financially constrained faces either scarcity or fluctuations of internal resources, and if the wedge between the cost of external and internal

capital is not significant, then external funds are more likely to be used by the firm to maintain a stable flow of investment;

2) If the cost disadvantage is significant (that is, there are financial constraints), then corporate investment should be sensitive to fluctuations in cash flow.

The criterion for ranging firms in accordance with their financial constraints chosen by Fazzari et al. 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 classifying 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, total assets logarithm, as well as firm and industry sales growth.

## **2.2 Real options effect on investment**

The traditional criterion for corporate capital budgeting is the net present value (NPV) of the project. Decisions based on NPV are static, since there is no timing flexibility, and the investment has to be made 'now or never'. This approach assumes that the business environment stays invariable starting from the moment when the investment decision is made and further throughout the life span of the project. Moreover, managers are supposed to be passive and have no leeway to intervene in the project as it is being carried out. In reality, market conditions change frequently and unexpectedly. Real options allow managers to wait, abandon, expand or

alter the project to adapt to the varying environment. The value of real options depend on how much room the managers possess to respond appropriately to new information (Xie (2008)). This flexibility is determined, in particular, by the ability to raise capital in time and at low cost. The real options theory adjusts the NPV rule in the following way: a decision to invest immediately means the firm refuses to wait for new information to resolve uncertainty and, therefore, the option value is lost. In this connection, the decision to start the project should be made only if the benefits from investment outweigh the investment cost and the cost of investment opportunity.

Despite the theoretical attractiveness of the real options model, there are few empirical tests of it. The problem is in constructing a proxy for the real options component. One solution was found by Bo et al. (2006). Their approach, guided by the investment model by Dixit and Pindyck (1994), suggests that the option multiple might be defined by the average and the variance of profits earned by a project. Using the proxy created, Bo et al. (2006) test the threshold effect of uncertainty on investment.

Boyle and Guthrie (2003) extend the model by McDonald and Siegel (1986) simplified by Dixit and Pindyck (1994), adding the liquidity criterion to the analysis. By modeling numerical examples Boyle and Guthrie show, that under uncertainty a firm facing financial constraints has to follow a suboptimal investment policy. There are states when, in comparison with an unconstrained firm making an investment, a constrained firm has to be inactive and exercise an option to delay. Or on the contrary, a constrained firm has to launch an investment project, undervaluing the option, because the risk of not being able to finance the project in the future outweighs the benefits of delaying investment to wait for the resolution of the uncertainty.

Xie (2008) tests the effect of real options to delay on investment by firms possessing more or less managerial flexibility under uncertainty. Flexibility is determined by the size of the firm and the measure of financial constraints according to indexes by Kaplan and Zingales (1997) and Whited and Wu (2006). As a proxy for real options, the researcher uses uncertainty measured as the volatility of daily stock return. Thus, the uncertainty effect is, in fact, attributed to the influence of real options . Xie concludes that the real options impact is stronger for less constrained firms.

### 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 external financial constraints 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.

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

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

where  $\beta_{t,t+1}$  is the stochastic discount factor from time  $t$  to  $t+1$ ;  $\pi_K$  is marginal revenue product of capital;  $\psi(K_{it}, I_{it})$  is the real cost of adjusting the capital stock, with  $\psi'_K < 0$ ,  $\psi'_I > 0$ ,  $\psi''_{II} > 0$ ;  $\delta$  is the rate of economic depreciation;  $\lambda_{it}$  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. Key explanatory variables of the empirical model

*Marginal revenue product of capital  $\pi_K$*

To calculate the marginal revenue product of capital, net operating profit after tax is used as profit  $\pi$ ; the balanced value of fixed assets (items *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:

$$\beta_{0,t} = \frac{1}{(1+r_1)(1+r_2)(1+r_3)*\dots*(1+r_t)} \quad (2)$$

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

The classical methodology of distinguishing between investment and financing decisions when analyzing a projects' efficiency (by calculating the net present value) implies the investment project to be financed solely by equity. The equity owners – shareholders – 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)):

$$r = b + \mu_{\pi} \quad (3)$$

where  $b$  is payout ratio;  $\mu_{\pi}$  is the average growth rate of profits.

The current value  $\mu_{\pi}$  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  $\mu_{\pi}$  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:

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

where  $\alpha_0, \alpha_m, m=2, \dots, M$  are the parameters to be estimated. In accordance with Whited and Wu (2006), we use  $M=3$ .

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

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

#### *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. The variable  $\lambda_{it}$  describes this cost disadvantage; however,  $\lambda_{it}$  is not an observable parameter. To tackle the issue,  $\lambda_{it}$  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 variants in terms of quantity, combination and the significance of the variables forming the index of financial constraints:

$$\lambda_{it}^1 = b_0 + b_1 LRDebt\_Totass_{it} + b_2 Payout_{it} + b_3 SG_{it} + b_4 Totass_{it} + b_5 Power_{it} + b_6 Cash\_Totass_{it}; \quad (7)$$

$$\lambda_{it}^2 = b_0 + b_1 LRDebt\_Totass_{it} + b_2 Div\_Capex_{it} + b_3 SG_{it} + b_4 Totass_{it} + b_5 Power_{it} + b_6 CF\_Totass_{it}; \quad (8)$$

where  $b_0$  is a free term;  $LRDebt\_Totass$  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  $t$ ;  $Div\_Capex$  is the natural logarithm of the sum of 1 and the ratio of dividends paid to capital expenditure;  $SG$  is the natural logarithm of the sum of 1 and sales growth;  $Totass$  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);  $Cash\_Totass$  is the natural logarithm of the sum of 1 and the ratio of cash stock to total assets;  $CF\_Totass$  is the ratio of cash flow 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: basic materials, consumer goods, consumer services, health care, industrials, oil & gas, technology, telecommunications, 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 1991-2011.

To evaluate the coefficients of the equations (1), (5)-(8) we use the Generalized Method of Moments. The coefficients in (5), (6) proved to be insignificant and are excluded from (1).

Table 1 contains the descriptive statistics of the variables forming the indexes of financial constraints in accordance with (7), (8). As it was necessary to calculate the value of  $\mu_{\pi}$  using data for the preceding years the sample period 1991-2011 was shortened to 1993-2011.

**Tab.1. Descriptive statistics of the variables forming the index during 1993-2011**

Variable	Mean	Std. Dev.	Skewness	Kurtosis	Min	Max	Observations
<i>LRDebt_Totass</i>	0.176	0.149	1.843	17.618	0	3.162	25566
<i>Payout</i>	0.654	0.476	-0.649	1.421	0	1	25566
<i>Div_Capex</i>	0.348	0.439	3.208	21.452	0	6.880	25503
<i>SG</i>	0.063	0.241	-1.498	87.880	-8.136	5.346	25566
<i>Totass</i>	7.182	2.054	-0.089	2.636	-1.715	13.590	25566
<i>Power</i>	0.081	0.155	-9.920	276.206	-6.218	1.933	25489
<i>Cash_Totass</i>	0.100	0.110	4.062	48.749	0	2.262	25566
<i>CF_Totass</i>	9.515	8.164	-4.964	114.626	-257.330	80.153	25566

The econometric estimates of parameters forming the index of financial constraints according to (7) and (8) are presented in Table 2.

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

Variables	$\lambda 1$ (Index 1)	$\lambda 2$ (Index 2)
<i>LRDebt_Totass</i>	0.174* (0.096)	0.526** (0.236)
<i>Payout</i>	0.023 (0.185)	-
<i>Div_Capex</i>	-	-0.088 (0.088)
<i>SG</i>	-0.458** (0.181)	-0.231 (0.193)
<i>Totass</i>	0.099*** (0.022)	0.049** (0.024)
<i>Power</i>	-0.319* (0.193)	-0.324** (0.155)
<i>Cash_Totass</i>	0.226 (0.226)	-
<i>CF_Totass</i>	-	-0.012* (0.007)
<i>Cons</i>	1.128*** (0.210)	0.699*** (0.218)
<i>Instruments</i>	<i>LR Debt<sub>(t-1)</sub>/Total Assets<sub>(t-1)</sub>, SG(t-1), Payout<sub>(t-1)</sub>, Total Assets<sub>(t-1)</sub>, Cash<sub>(t-1)</sub>/Total assets<sub>(t-1)</sub>, Cash Flow<sub>(t-1)</sub>/Sales<sub>(t-1)</sub>, <math>\pi_{K(t-1)}</math>, CAPEX/Total Assets, Assets Turnover, Equity/Total Assets, Cash/Current Assets, Quick Ratio, ROA, Sales, Debt per Share, <math>\ln(1 + \text{Cash}/\text{Inventory})</math></i>	
<i>Hansen's J statistic</i>	$\chi^2(10) = 18.055, (p = 0.054)$	$\chi^2(11) = 16.0306, (p = 0.140)$
<i>Observations</i>	22653	22628

Notes: 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 firm's performance indicators that 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) and (8). Not 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 parameters of liquidity as cash flows and cash stocks in a company. Therefore, the weighed coefficients of *Cash<sub>(t-1)</sub>/Total assets<sub>(t-1)</sub>*, *Cash Flow<sub>(t-1)</sub>/Sales<sub>(t-</sub>*

1), *Cash/Current Assets*,  $\ln(1+\text{Cash/Inventory})$  and *Quick Ratio* are used. Guided by Whited and Wu (2006) and Fama and French (2000) we add an indicator of the firm's 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\_Totass*), these instruments reflect the firm's financial leverage quite fully. Given that the ability to raise capital and the firm's 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 in the instrument set to characterize the ability of the company to get revenue using current and noncurrent assets. On the whole, for both index specifications 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\_Totass*) increases, the ability of the firm to attract additional external funds decreases. This is accompanied by an increase in the cost of capital in consequence of the growth of insolvency risk. Both tendencies cause a rise in costs  $\lambda_{it}$  (the coefficient *LRDebt\_Totass* 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 (*Totass*) is unexpected. Usually larger firms are associated with lower risk, particularly of insolvency ('too big to fail'); therefore, they are expected to enter the 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\_Totass* and *Totass* 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 enough asset backing and face limitations on new loans. In this connection, the positive coefficient of *Totass* 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).

A high ratio of operating cash flow to total assets ( $CF_{Totass}$ ) is more likely to indicate that the firm has no difficulties with liquidity. Other things being equal, the firm is able to secure large sales volumes and maintain high receivables turnover. Such a company is unlikely to experience any difficulties with raising capital, thus the coefficient is significant and negative (which corresponds to the results achieved by Whited and Wu (2006) and Kaplan and Zingales (1997)).

Figures 1, 2 present the estimates of the density of the distribution of the constructed indexes  $\lambda_1$ ,  $\lambda_2$ . The index of financial constraints possesses positive values since the variable  $\lambda_{it}$  – the shadow costs – is greater than zero.

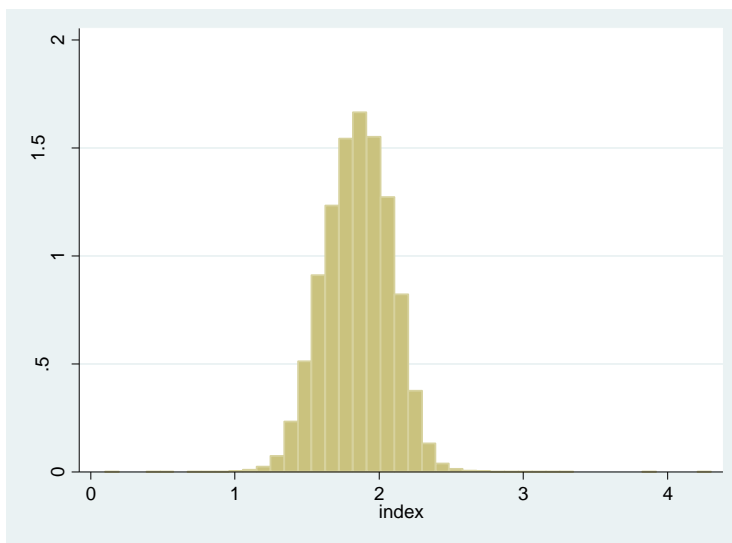


Fig. 1. The estimates of the density of index  $\lambda_1$  distribution

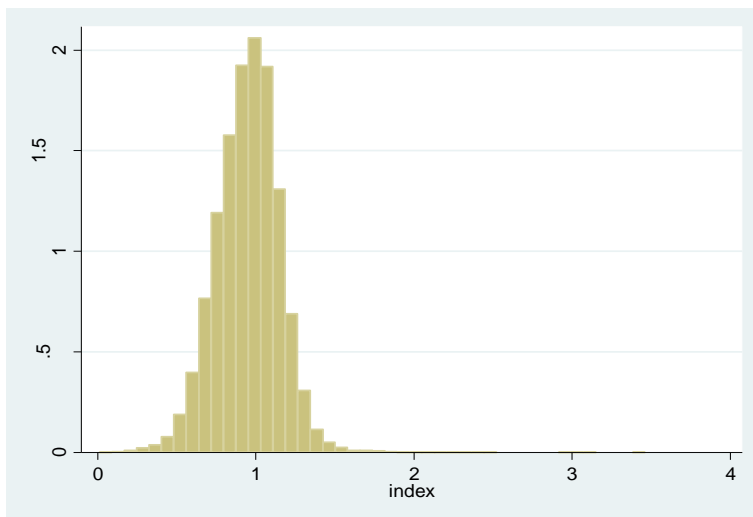


Fig. 2. The estimates of the density of index  $\lambda_2$  distribution

## 6. Constructing the empirical proxy for the real options effect

A real option might be interpreted as a manager's ability to use the built-in flexibility of an investment project, under uncertainty. As far as real options to delay are concerned, the option is exercised if the information available at the moment is ambiguous. The firm 'buys' some time for investment hoping that the market will develop in a favorable direction, so that when uncertainty is resolved, the final decision can be made.

Let us consider a project to be launched immediately. The value created might be presented as the sum of discounted profit streams generated by the capital employed. If the firm decides to postpone investment, it retains the value of the investment opportunity. At the optimum point: 1) it does not matter for the firm whether to invest now or later, thus the value of the firm with the option taken into account must be equal to the firm's value if it invests right away less the investment cost; 2) increments of the firm's value (the first derivatives of the value with respect to profit) are equal in both cases.

In accordance with the NPV criterion, guided by the logic of 'now or never' an investor launches a project if the present value generated by investment ( $V$ ) exceeds the investment cost ( $I$ ):  $V > I$ . Since the real option multiple is included in the analysis the given inequality takes on the form of  $V > Multiple * I$ , reducing the number of projects accepted. The multiple is defined by the average and the variance of the profits generated by the project and the discount rate (Dixit and Pyndyck (1994), Bo et al (2006)):

$$Multiple = \frac{k}{k-1} > 1 \quad (9)$$

$$k = \frac{1}{2} - \frac{\mu_{\pi}}{\sigma_{\pi}^2} + \left[ \left( \frac{\mu_{\pi}}{\sigma_{\pi}^2} - \frac{1}{2} \right)^2 + \frac{2r}{\sigma_{\pi}^2} \right]^{1/2} \quad (10)$$

where  $\mu_{\pi}$  is the average growth rate of profits,  $\sigma_{\pi}^2$  is the variance of the profit stream,  $r$  is the discount rate,  $I$  is the investment cost.

## 7. An empirical evaluation of the influence of real options and financial constraints 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  $ROA$  and current liquidity coefficient ( $Liq$ ).

$$Investment_{it} = f_i + f_t + a_1 \times Index_{it} + a_2 \times ROA_{it} + a_3 \times Liq_{it} + \xi_{it} \quad (11)$$

where  $f_i, f_t$  are fixed and time effects respectively;  $Investment_{it}$  is calculated as the ratio of capital expenditure to total assets;  $\xi_{it}$  is the regression error. We use the Fixed Effects Model to estimate the parameters of (11). The choice of the method is based on Hausman's test results.

Because of heterogeneity of the countries included in the sample we estimate the regression (11) separately for country subsamples. We therefore form four blocs: Europe, America, Japan and Australia. The relevance of the division has been proved by Chow's test. The figure 3 describes the sample in accordance with the geographical profile.

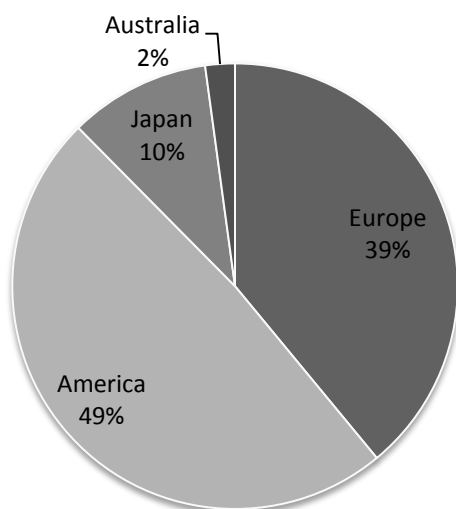


Fig. 3. The geographical distribution of the sample analyzed

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 subperiods are separated out: from 1993 to 2008 inclusive and from 2009. 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 for the first index specification (7) are presented in Table 3. We do not show the estimates for the second specification (8) to save space, since the findings are comparable.

**Tab.3. Empirical estimates of financial constraints effect 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
<b>Index</b>	-7.753*** (1.757)	-0.959 (0.831)	-9.681*** (1.045)	-2.486*** (0.758)	0.622 (1.285)	0.793 (0.702)	2.230** (1.034)	-4.914*** (1.567)	12.823** (6.482)
<b>ROA</b>	0.062*** (0.017)	0.011 (0.010)	0.038*** (0.014)	0.022*** (0.008)	0.230*** (0.066)	0.118*** (0.024)	-0.093*** (0.031)	0.083** (0.034)	-0.002 (0.086)
<b>Current liquidity</b>	-0.702 (0.445)	-2.007** (0.902)	-1.208** (0.573)	-0.971* (0.531)	-2.254** (1.060)	-1.738* (0.902)	-3.282* (1.869)	0.079 (1.240)	-1.622 (2.900)
<b>Const</b>	8.020*** (1.237)	2.995*** (0.752)	12.641*** (1.008)	5.145*** (0.738)	0.561* (0.287)	0.456** (0.181)	0.283 (0.306)	0.348*** (0.058)	-0.336 (0.252)
<b>R-sq within</b>	0.057	0.011	0.087	0.039	0.038	0.039	0.167	0.039	0.201
<b>R-sq between</b>	0.595	0.434	0.503	0.372	0.046	0.297	0.390	0.800	0.725
<b>R-sq overall</b>	0.348	0.367	0.320	0.334	0.022	0.219	0.370	0.613	0.660
<b>F-statistic</b>	21.94	2.50	37.84	12.56	6.04	7.73	8.99	8.66	1.69
<b>Obs.</b>	21470	4019	21470	4019	8051	13419	4019	21470	4019

Notes: 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, an empirical evaluation proves 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. Alternatively, it could be necessary to deepen the analysis, adding both fundamental and behavioral factors forming investor behavior. Thus, we expand the investment model (11) by including real options to delay. We would like to investigate the effect of real options on the relationship between investment and financial constraints. We treat the constructed proxy for the real option multiple as the threshold, a parameter that switches the regimes, which qualitatively alters the relation between financial constraints and investment as the uncertainty level changes. The extended model takes the following form:

$$Investment_{it} = f_i + f_t + b_1 \times Index_{it} \times I(Multiple \leq \theta) + b_2 \times Index_{it} \times I(Multiple > \theta) + b_3 \times ROA_{it} + b_4 \times Liq + \vartheta_{it} \quad (12)$$

where  $I$  is the indicator function taking the value of 1 if the argument is true and zero otherwise;  $\theta$  is the threshold value for the real option multiple to be estimated;  $\vartheta$  is the regression error.

According to Bo et.al (2006) the real option component *Multiple* contains information on both uncertainty surrounding the firm and its attitude towards risk. Assuming that investor

attitude to risk remains unchanged for some time, then uncertainty might be considered as a key source of the *Multiple* change. Thus, the threshold variable determines two regimes:

- 1) Uncertainty exceeds the threshold value:  $Multiple > \theta$ . The option price grows, and the firm is inclined to exercise the option, that is, the firm postpones investment. In this case, we expect a stronger negative effect of financial constraints on investment activity.
- 2) Uncertainty is less than or equal to the threshold value:  $Multiple \leq \theta$ . The firm has no need to wait until uncertainty is resolved. The option is unlikely to be exercised, thus the investment project is undertaken. In this connection, the real option should have a more limited impact on the negative effect of financial constraints.

We expect the coefficients  $b_1$  and  $b_2$  in the model (12) to differ. To find the threshold value, 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  $\theta$  value (Hansen (1996), Bo et al. (2006)). Taking into consideration the  $\theta$  value, we estimate the regression coefficients (12), applying the Fixed Effects Model. To check the robustness of the results, we estimate the model (12) for both index specifications. To save space, we present the results for the index built in accordance with (7), with the same conclusions for (7) and (8) (see Table 4).

*Comments on Table 4.*

A) All the coefficients estimated in the regression (12) for Europe from 2009 turned out to be insignificant. Excluding the explanatory variables *ROA* and *Current Liquidity* from the model enabled us to achieve significant indexes coefficients (10% significance level). However, the hypothesis of coefficient equality is not rejected. In this connection, included in Table 4 are the estimates for Europe for the whole observation period, plus the control for the years 2009-2011 as corresponding dummy variables.

B) The situation is the same for the countries in the American bloc.

C) For Australia, the problem of the small number of observations and, consequently, insignificant coefficients for both periods, 1993-2008 and 2009-2011, is not solved by estimating the regression (12) for the whole period (1993-2011). Thus, Australia is excluded from the analysis of the combined effect of financial constraints and real options on investment.

D) For Japan in 1999-2008, the list of regressors is limited to indexes only.

E) For all country blocs and for each time period we control the equality of the index coefficients.



**Tab.4. Empirical estimates of financial constraints and real options to delay on corporate investment**

Variable	Europe, 1993-2008	Europe, 1993-2011	America, 1993-2008	America, 1993-2011	Japan, 1993-1998	Japan, 1999-2008	Japan, 2009-2011
<b>Index (Multiple&lt;0)</b>	-0.492*** (0.192)	-0.700*** (0.194)	-1.205*** (0.159)	-1.390*** (0.176)	-0.365*** (0.109)	-1.068 (0.762)	2.294** (1.028)
<b>Index (Multiple&gt;0)</b>	-1.375*** (0.235)	-1.596*** (0.222)	-1.661*** (0.218)	-1.790*** (0.201)	-0.597*** (0.181)	-1.377* (0.797)	2.458** (1.041)
<b>ROA</b>	0.098*** (0.022)	0.093*** (0.020)	0.068*** (0.021)	0.068*** (0.018)	0.227*** (0.071)	-	-.093*** (0.032)
<b>Current liquidity</b>	-0.977** (0.449)	-0.745** (0.364)	-1.649*** (0.607)	-1.566*** (0.476)	-2.581** (1.079)	-	-3.311* (1.855)
<b>Const</b>	3.039*** (0.233)	3.101*** (0.210)	5.157*** (0.329)	5.232*** (0.276)	0.788*** (0.108)	0.710*** (0.156)	0.274 (0.303)
<b>Year 2009</b>	-	-0.695*** (0.069)	-	-0.781*** (0.083)	-	-	-
<b>Year 2010</b>	-	-0.922*** (0.063)	-	-0.967*** (0.076)	-	-	-
<b>Year 2010</b>	-	-0.811*** (0.067)	-	-0.680*** (0.071)	-	-	-
<b>R-sq within</b>	0.030	0.044	0.044	0.060	0.064	0.007	0.172
<b>R-sq between</b>	0.353	0.423	0.445	0.457	0.657	0.777	0.391
<b>R-sq overall</b>	0.090	0.091	0.224	0.207	0.544	0.678	0.372
<b>F-statistic</b>	16.22	44.10	18.63	34.24	6.73	3.56	8.00
<b>Obs.</b>	21503	25540	21503	25540	8051	13452	4037

Notes: standard errors are given in parentheses; the significance level is marked with asterisks:

\*p<0.1, \*\*p<0.05, \*\*\*p<0.01.

The results prove the proposition that under high uncertainty (above the threshold value) the negative influence of financial constraints on investment is reinforced by the effect of real options to delay: the coefficients  $b_1$  and  $b_2$  of the regression (12) are significant and negative,  $|b_1| < |b_2|$ . An exception to this tendency is found in Japan starting from 2009. For Japan, the extension of the model (11) by adding real options effect does not change the positive sign of the variable *Index*. The behavioral change in Japanese firms after the 2008 crisis (the change of the sign from negative to positive) requires further investigation. The situation is likely to be clarified if we take into consideration the attitude towards risk of Japanese investors. On the whole, under growing uncertainty the factors of financial constraints and real options are codirectional and cause a decline in corporate investment activity. Under high uncertainty, regardless of the ability to attract external funds for investments, companies are more likely to use options to delay and do not take risks, waiting for the situation to become clearer. Theoretical conclusions made in Boyle and Guthrie (2003) are partly corroborated: in comparison with a less constrained firm, a company facing difficulties in raising capital is

compelled to stop an investment project exercising the option to delay. However, we do not find the opposite effect: when the option is undervalued, the project is launched by the financially constrained firm because of the high risk of not being able to attract the resources in the future.

As far as other explanatory variables in (12) are concerned, companies with a high ROA intensify capital investment. If the return on capital exceeds its cost 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.

## 8. Conclusion

In this study we confirm the proposition that under growing uncertainty conditions the real options effect reinforces the negative influence of financial constraints on investment made by public nonfinancial companies operating in developed countries in 1991-2011. 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 two specifications of indexes. 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 proxy for the real options effect is built on the basis of the approach used by Dixit and Pindyck (1994) and Bo et al. (2006). The real option multiple is treated as the threshold parameter switching the uncertainty regimes from relatively high to relatively low. With respect to the optimum threshold value found (the estimation procedure of Hansen (1999) was used) we prove that: 1) under high uncertainty a firm is inclined to exercise an option to delay, thus the real options effect magnifies the negative influence of financial constraints on investment activity; 2) under low uncertainty an investment project is more likely to be launched immediately, with real options having a minimal effect on the relation between financial constraints and investment.

## References

Akerlof G.A. (1970). The market for "lemons": Quality and the market mechanism // Quarterly Journal of Economics – Vol. 84, P. 488-500.

- Bo H., Jacobs J., Sterken E. (2006). A threshold uncertainty investment model for the Netherlands // *Applied Financial Economics* – Vol. 16, P.665–673.
- Bo H., Sterken E. (2007). Attitude towards risk, uncertainty, and fixed investment// *The North American Journal of Economics and Finance* – Vol.18, No. 1, P. 59–75.
- Boyle G.W., Guthrie G.A. (2003). Investment, uncertainty, and liquidity // *Journal of Finance* – Vol. 58, P. 2143-2166.
- Caballero R. and Pindyck R. (1996). Uncertainty, investment, and industry evolution // *International Economic Review* – Vol. 37, P. 641–62.
- Dixit A. and Pindyck R. (1994) *Investment under Uncertainty* // Princeton University Press, Princeton, NJ.
- Eisner R., Strotz R.J. (1963). Determinants of business investment. Commission on Money and Credit // *Impacts of monetary policy*: Prentice-Hall: Englewood Cliffs, N.J.
- Fama, E. F., French, K. R. (2000). Forecasting Profitability and Earnings// *Journal of Business* – Vol. 73, P. 161-175.
- Fazzari S. M, Hubbard R. G., Petersen B. C. (1988). Financing Constraints and Corporate Investment // *Brookings Papers on Economic Activity* – Vol. 1, P. 141-195.
- Greenwald B., Stiglitz J. E., Weiss A. (1984). Information imperfections in the capital market and macroeconomic fluctuations // *American Economic Review* – Vol. 74, P. 391-414.
- Hansen B. E. (1996). Inference when a nuisance parameter is not identified under the null hypothesis // *Econometrica* – Vol. 64, 413–30.
- Jensen M., Meckling W. (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure // *Journal of Financial Economics* – Vol. 3, P.305-360.
- Kaplan S., Zingales L. (1997). Do financing constraints explain why investment is correlated with cash flow? // *Quarterly Journal of Economics* – Vol. 112, P. 169-216.
- Modigliani F., Miller M.H. (1958). The Cost of Capital, Corporation Finance and the Theory of Investment // *The American Economic Review* – Vol., No. 3, P. 261-297.
- Myers S. C. (1977). Determinants of Corporate Borrowing // *Journal of Financial Economics* – Vol. 5, P. 147-175.
- Myers S. C. (1984). The capital structure puzzle // *Journal of Finance* – Vol. 39, 575-592.
- Myers S. C., Majluf N.S. (1984). Corporate financing decisions when firms have investment information that investors do not // *Journal of Financial Economics* – Vol.13, P. 187-220.
- Pindyck R., Solimano A. (1993). Economic instability and aggregate investment // *NBER Macroeconomics Annual*,1993, P. 259–303.
- Ross S. A., Westerfield R.W., Jordan, B. D. (1993). *Fundamentals of corporate finance*. 2nd Ed // Homewood, IL: Irwin Press.

Whited T. M. (1992). Debt, liquidity constraints, and corporate investment: evidence from panel data // *Journal of Finance* – Vol. 47, P. 1425-1460.

Whited T. M. (1998). Why do Investment Euler Equations Fail? // *Journal of Business and Economic Statistics* – Vol. 16, P. 469-478.

Whited T. M., Wu, G. (2006). Financial Constraints Risk // *The Review of Financial Studies* – Vol. 19, No. 2, P. 531-559.

Xie, F. (2009). Managerial flexibility, uncertainty, and corporate investment: The real options effect // *International Review of Economics & Finance* – Vol. 18, No. 4, P. 643-655.

Ekaterina E. Kuzmicheva  
National Research University Higher School of Economics (Nizhny Novgorod, Russia).  
Financial Management Department. Teacher;  
E-mail: ekuzmicheva@hse.ru, Tel. +7 (920) 033-27-01

**Any opinions or claims contained in this Working Paper do not necessarily reflect the views of HSE.**

© Ekaterina E. Kuzmicheva, Kirill E. Kuzmichev, 2013