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Cash Balance Management in Innovative Companies

Mariia Zarva
Financial Controller, Surgut Transshipment LLC, Moscow, Russia,
zarvamasa@yandex.ru, ORCID

Abstract

Since the 1980s, innovative companies all over the world have been holding a substantial cash balance on their books due to transactional, preventive, agency, tax-related and macroeconomic motives and by limitations in capital availability due to information asymmetry. Our research examines the determinants that influence the analysis of cash holdings of high-tech and non-high-tech companies.

Financial information for 38,386 unique companies was obtained from the 2009–2017 Compustat database. The final sample version comprised 12,083 companies, of which 2,909 were innovative. We used the panel regression method, selecting the appropriate calculation model and a number of proxy variables.

Our research confirmed the existence of innovative companies' significant cash holdings. Adding a macroeconomic factor variable (GDP growth) to the research model was justified for innovative companies only. In spite of the insignificant impact of GDP, increased GDP growth resulted in a decreased cash ratio for innovative companies. The authors also reveal the insignificance of R&D expenditures for innovative companies and prove that ranking companies by the amount of R&D expenditures and using this variable as innovation proxy was inexpedient. In addition, the authors confirm a positive relationship between growth opportunities, company size and cash ratio and a negative relationship between dividend payout and the amount of cash holdings.

An understanding of the reasons for cash accumulation facilitates prudential management of cash holdings in companies. This paper contributes new evidence to the study of corporate cash holding, focusing specifically on innovative companies, which have not been examined separately in the past.

Keywords: cash holding, high-tech companies, non-high-tech companies, R&D expenditures, patents

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Introduction

Over a prolonged period from the 1980s and to the present day, cash has been one of the principal items on the balance sheets of companies, in particular, American ones. According to Bates, Kahle and Stulz [1], the average ratio between cash and assets of the industrial US enterprises listed by the above authors increased from 10.5% in 1980 to 23.2% in 2006, while Sanchez and Yurdagul [2] noted a fourfold increase of cash funds held by American companies in 2011 in comparison to 1995. Moreover, a growth of cash holdings was observed in non-American companies. For instance, research by Daher [3] revealed that the ratio of cash to assets of private companies in Great Britain also almost doubled between 1994 and 2005, and a similar trend was observed in many research papers all over the world.

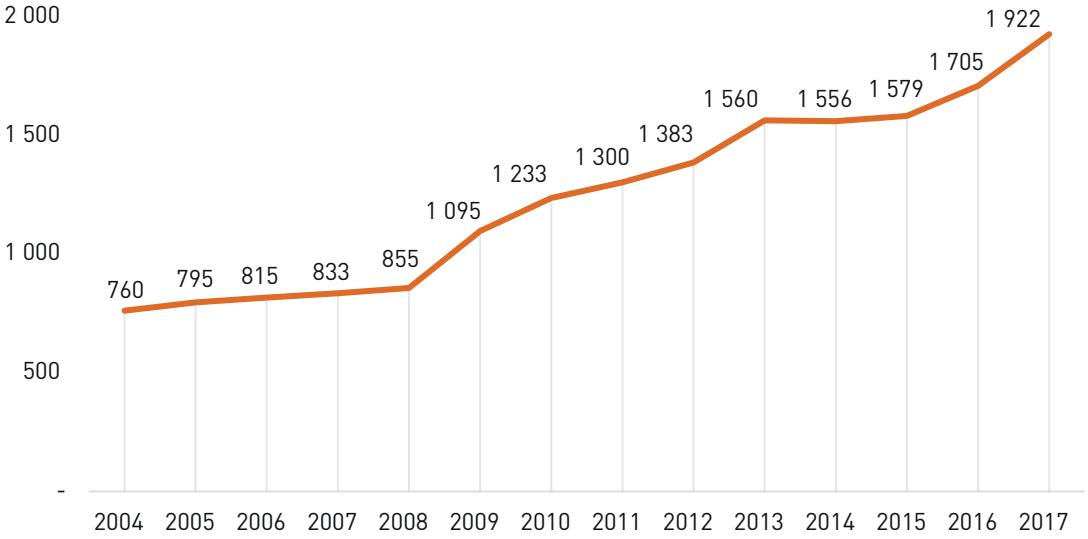
The amount of corporate cash continued growing between 2004 and 2017; cash holdings of non-financial companies across the globe increased almost fourfold from $2.8 trillion to $8.3 trillion.

As at the end of 2016, according to Standard & Poor's Global Ratings (S&P) [4], American non-financial companies held $1.9 trillion in cash, and in 2017, according to Bloomberg, this figure reached a record amount of $2,3 trillion. The first 25 companies (top 1) in S&P's rating of non-financial corporate borrowers, held more than a half of the total amount of cash in 2016.

Increase of the cash holdings level of American companies is confirmed by Compustat data for 1,797 American non-financial companies, although according to this database, cash holdings levels are slightly lower than the ones provided by information agencies (Figure 1). It may be related to incomplete data about public companies in Compustat and to the absence of data on private companies that also hold cash.

According to Compustat data, the share of American companies in global cash holdings as at the end of 2016 was 23%.

Figure 1. Amount of cash held by American public companies in 2004-2017, billion US dollars



Source: Compiled by the author based on Compustat data on 1,797 American companies.

In 1980–1990s an increase in cash holdings occurred partly due to the fact that many financially unstable companies went public [1]. After the crisis of 2008, the next IPO booms occurred (in 2010 and 2014) [2; 3]. They involved the soaring high-tech sector, which could have also partly caused an increase in the amount of cash [4], but obviously not to the present extent. What could trigger the sharp increase in the amount of cash holdings?

Studies demonstrate that there is a wide range in the amount of cash held by industry sector. In particular, a disproportionately large amount of cash is accumulated in high-tech sectors. As early as in 2009, research by Bates et al. [1] emphasized that high-tech companies had the biggest ratio of cash holdings to assets. According to Global Finance [5], in 2017 the largest American tech giants, such as Microsoft, Google and Apple accounted for just over $400 bln in cash, while the share of the top 10 companies holding the most cash in the world in the same year equaled approximately $750 bln. The top 10 companies were closest to the high-tech industry and electronics.

After a study of an international company sample, Stulz et al. [6] revealed that multinational corporations with a high R&D level held the largest cash balance. Lyandres et al. [7] assert that exceptionally innovative companies that invest significantly in R&D and patents increased the amount of cash in 1980s–2000s. Subsequently, Graham et al. [8] noted that in the 20th century cash holdings were approximately at the same level in all industries, in the 21st century there was a growth of cash holdings in high-tech and pharmaceutical sectors. The authors believe that the reason is the change in the companies' characteristics and their going public. These results suggest that industry-related characteristics are a key factor that defines the amount of cash holdings in corporations. This result is consistent with the conclusions

made by Booth et al. [9], who proved that cash-to-assets ratio grows due to the change in characteristics of high-tech companies.

The existing scientific literature defines companies' potential motives for cash accumulation. These include transactional, preventive, agency, tax-related and macroeconomic motives. One of the key reasons is limited capital availability due to information asymmetry, which leads high-tech companies to save more cash [10]. However, high-tech companies' motives have not been fully disclosed. Further we consider the determinants that influence the analysis of cash holdings of high-tech and non-high-tech companies.

Literature Review

Definition of an Innovative Company

Innovative companies (high-tech) is a term describing firms and industry sectors which manufacture or use advanced technologies in their business model.

The dominant feature of innovation is its use by a certain enterprise for the first time. This definition was provided by the US Bureau of Economic Analysis [11]; however, it describes the US digital economy, it is unique and does not replace the innovation concept.

The most popular definition of an innovative company is formulated in the OECD and EUROSTAT publication Oslo Manual. It points out that "an innovative firm is one that has implemented an innovation during the period under review" [12, p. 32]. Innovation is understood as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations" [12, c. 31]. Companies should receive the status of innovative using the criteria that distinguish high-tech companies from low-tech firms and reveal the key characteristics of the companies of the former type.

The first criterion for the selection of innovative companies used in literature is the absence or presence of R&D expenditures and their intensity. Some researchers define a company's innovativeness on the basis of presence/absence of R&D expenditures [13], intensity (amount) of research and development expenses [14; 15] and number of employees involved in research and development [16]. The biggest portion of these expenses is often comprised by salaries of highly educated engineers, scientists and researchers because companies prefer to retain the professionals who create the company's science and technology base, which, in its turn, generates income for the company [13].

R&D expenditures are fundamental for the survival and thriving of an innovative company. However, this approach is not entirely correct for two reasons: some companies do not disclose R&D expenditures or fail to mention them in their financial statements; studies may not be performed on an annual basis, thus, one (more innovative) company may have no R&D expenditures in the current period and, on the contrary, another (less innovative) company may incur significant expenses for research and development in the period under review.

The paper by Begenau et al. [17] proved the existence of a trend in American innovative companies towards developments that are less profitable, but have greater growth potential. According to PwC [21], the intensity of R&D expenditures does not guarantee financial success because there is no long-term correlation between the amount a company spends on innovation efforts and its overall financial performance. Only the way a company uses the money and other resources to create products and services for customers is of great importance.

The second criterion is based on the annual ratings of innovative companies [20]. One may use the available annual ratings of innovative companies published by such recognized resources as The Boston Consulting Group. "The most innovative companies 2018" – top 50 [19] and PricewaterhouseCoopers "The 2018 Global Innovation 1000 study" [18], Forbes "The World's Most Innovative Companies" – top 100. As per BCG [19], since 2014 the following four lines of innovation have gained significance: big data analysis, acceleration of new technology implementation, mobile applications and digital design. See the top 10 innovative companies according to the three abovementioned ratings in Table 1.

Table 1. Top 10 innovative companies in 2018

Number	BCG	PwC	Forbes
1	Apple	Amazon.com	ServiceNow
2	Alphabet (Google)	Alphabet (Google)	Workday
3	Microsoft	Volkswagen Aktiengesellschaft	Salesforce.com
4	Amazon.com	Samsung	Tesla
5	Samsung	Intel	Amazon.com
6	Tesla	Microsoft	Netflix
7	Facebook	Apple	Incyte

Number	BCG	PwC	Forbes
8	IBM	Roche Holding AG	Hindustan Unilever
9	Uber	Johnson & Johnson	Naver
10	Alibaba	Merck & Co.,	Facebook

Sources: BCG, PwC, Forbes.

One may note that while BCG and PwC ratings partially overlap (five out of ten companies are present in both ratings), the Forbes rating is in stark contrast with the above two, with Amazon.com being the only company included in all ratings. This is due to the use of different methodologies for creating the rating. Forbes corporate ratings rank companies by innovation premium: the difference between their market capitalization and the net present value of cash flows from existing businesses (on the basis of a patented Credit Suisse HOLT algorithm). The annual rating of the most innovative companies by BCG is based on a poll of senior executives by choice of respondents and evaluation of three financial indicators for three years: total shareholder returns (TSR), revenue growth and margin increase. The PwC [21] rating is comprises the companies that have spent the largest amounts on research and development within the last financial year, adjusted for the industry sector and amortization of capitalized costs. The use of annual ratings created by large agencies apparently limits the number of studied companies.

The third criterion is patents. Patents and their citation level are established in literature as reliable and significant indicators of innovation efficiency [23]. In early studies, research and development results were used as an approximate indicator of innovation efficiency. The variable represented the number of patents [24–26]. However, it was proven that the number of patents does not provide an accurate representation of innovative efficiency because it does not demonstrate the importance of patents. At the same time, a close relationship was discovered between the indicators based on patent citation and innovation costs [26]. Evaluation on the basis of the number of patent citations was one of popular ways to measure innovation efficiency [27–33].

Finally, the fourth criterion is the industry sector. It is a generic criterion for defining innovative companies. Its advantage lies in the fact that there are multiple industry classifiers among which one may specifically choose the ones with the presumably greatest number of high-tech companies. Usually, researchers choose Telecommunication, Health Care (Biotechnology and Pharmaceuticals, Medical Equipment) and companies engaged in the semiconductor industry, manufacturing of machinery, software, digital architecture and technology services.

Papers dedicated to corporate finance use the following international code classifiers:

- SIC [34–36];
- NAICS [37];
- GICS [38];
- Internal classifiers of systems Capital IQ [39], Reuters (RIC codes) and Bloomberg (BICS codes).

Research by Kile et al. [40] compares the quality of SIC, NAICS and GICS classifiers in regard to completeness and sufficiency and defines the codes containing a greater percentage of innovative companies recommended by the authors in order to create a sample of high-tech firms or intentionally selected high-tech industry sectors. Furthermore, the research is based on the sample by Kile et al. [40] of 3-digits SIC codes related to high-tech companies. At the same time, one has to bear in mind that the SIC-code sample is not free from shortcomings because affiliation with a high-tech industry does not guarantee that the company itself is really an innovative one, and vice versa, a low-tech industry may comprise high-tech companies [40; 41].

Being aware of all possible limitations of this approach, one has to take into consideration the intensity of R&D expenditures and companies' growth opportunities. This will help to draw a clearer line between company types [35].

Distinctive Features of Innovative Companies

High-tech companies have the following specific characteristics. First, initially high-tech companies have **larger cash holdings** than classic industrial companies [1; 42]. Second, it influences the **choice of the funding source**. Himmelberg et al. [43] presume that small high-tech companies, as a rule, use internal financing to maintain R&D and capital expenditures. Guiso [44] proves that it is more difficult for high-tech companies to obtain access to credits than for low-tech firms. This view is substantiated by the research conducted by Carpenter et al. [45] and Booth et al. [9]. They conclude that small high-tech companies prefer to raise equity capital instead of using debt instruments. This is due to the fact that the innovation development sphere is extremely unstable [7] from the effectiveness viewpoint, while external concerned parties cannot observe the situation and reasonably expect future results, thus aggravating *information asymmetry*. Besides, in view of their specific nature high-tech companies often have insufficient security for a loan [46]. This results in more expensive external financing for innovative companies [47] and their greater dependence on internal and equity financing than on debt financing. It is especially apparent in young innovative companies [9] and small high-tech companies [48]. Third, it has been proven that innovative companies have shifted to developments that are less profitable but have greater growth potential [17].

Financial literature defines companies' four main motives for holding cash. In this section we offer a literature review concerning these issues and analyze the motives that may influence corporate cash.

Transactional Motive

For the first time this motive was mentioned in the paper by Keynes [49]. Classic models assess the optimal levels of cash because companies face expenses related to the conversion of a non-monetary asset into cash [50; 51]. Due to economy of scale, larger companies have lower operating costs, which is why they also have a smaller amount of cash [1; 51]. Drobetz et al. [52] considered the cash holdings of 156 Swiss non-financial companies for 1995–2004. They revealed a strong negative relationship between the amount of tangible assets and cash correlation. This points out that companies are prone to accumulate smaller amounts of cash if they have large high liquidity assets that provide an easy way to obtain cash. Therefore, such companies minimize alternative liquidity costs. Besides, Drobetz et al. [52] also discover a substantiation of the fact that large companies experience economy of scale when issuing securities and, consequently, have less cash. These results correspond to the research results obtained by Mulligan [53]. High-tech companies are mainly smaller than traditional sector firms, they have less non-monetary current assets (which may be an analogue of cash). For this reason, in order to confirm the transactional motive, one has to expect less influence of the economy of scale on cash holdings in innovative companies [54].

The variables proposed for evaluating the motive are company size, non-monetary liquid assets. In order to assess liquidity, we used two variables: net working capital for the working capital requirement (WCR) and net liquidity balance (NLB). These indicators were developed by Shulman et al. [55], who used them to study working capital. WCR is measured in order to evaluate working capital management, and NLB – to evaluate capital distribution.

Preventive Motive

The second motive for a company to store cash is to hedge the risks related to possible future shocks. Therefore, we expect companies with more risky cash flows and less access to capital market to have more cash [56]. This theory also suggests that firms with higher growth rates and better investment opportunities will store more cash because their expenses in case of financial difficulties will be higher. Numerous studies confirm this positive relationship between investment opportunities and cash holdings [42; 54; 56–60]. Almeida et al. [61] revealed that companies without financial restrictions are less sensitive to cash flow changes and increase their cash holdings to a smaller extent than companies facing such restrictions. Han et al. [62] continue their research on a sample of companies traded in the USA in 1997–2002 and establish that a company with limited finances, unlike a company with unlimited funds, builds up its monetary holdings as a response to an increased cash flow volatility. Opler et al. [56] and Ferreira et al. [57] also substantiate the volatility of cash flows and cash holdings.

Due to the fact that innovative companies usually have more risky cash flows, debt financing is costlier for them, and investors demand a higher risk premium, high-tech companies in general are more financially restricted than low-tech companies, consequently, they accumulate more cash.

Biotechnology and medical equipment should be mentioned specially as an industry with extremely high investment opportunities and greatest risks. According to BCG, up to 90% of research expenses are wasted yielding no results because a medicines may have no effect and its development ceases, thus increasing the need for significant financing [63].

Ongoing development and high capital expenditures are characteristic of bio-industry and pharmaceutical industries, as well as in the manufacturing of medical equipment and devices because R&D expenditures and capital investments are the main preconditions for the viability of these companies. For this reason, companies from these industries in particular need access to capital market.

One of possible reasons for accumulation of cash is its investment into more promising projects, which is confirmed by papers by Opler et al. [56] and Bates et al. [1], or to even out R&D expenditures [13]. Apart from that, the importance of cash availability for increased probability of obtaining patents was proven [64].

The following variables are used to assess the preventive motive: cash flow volatility, size of tangible assets, dividend payouts, corporate financial leverage, R&D expenditures; selling, general and administrative expenditures (SG&A); capital expenditures (CapEx), Market-to-Book indicator, Springate Z-score – bankruptcy probability indicator: if $Z < 0.862$, an enterprise is classified as bankrupt (taken as an analogue of Altman Z-score used in the paper by García-Teruel et al. [59] because it is equal in accuracy to Altman Z-score and sometimes surpasses it [65; 66]); debt repayment structure.

Agency Motive

The third motive for cash holdings is an agency conflict between company owners and managers concerning distribution of internal capital caused by different aims of the concerned parties. The free cash flow theory states [67] that in the absence of good investment opportunities managers are more likely to create cash balance than increase dividend payments to shareholders because it provides them with an opportunity to get greater control over the company. Papers by Dittmar et al. [68] and Ferreira et al. [57] revealed that companies operating in the countries with minor agency conflicts (investors are well-protected) have less cash.

Apart from conflicts between company management and shareholders, there may be a clash of interests between a company's minority and majority shareholders. Major shareholders may take advantage of their position and gain more benefits than minority shareholders. As long as these

shareholders may obtain cash more easily, it is expected that these companies will have greater cash balance [69]. The paper by Bates et al. [1] also substantiated the agency theory.

Opposite results were obtained in the research conducted by Harford et al. [58] – higher cash holdings were observed in companies with a weaker corporate governance. The reasons for that were explained as follows: first, the management increased cash holdings to a smaller extent out of fear of disciplinary sanctions, which resulted in the re-assignment of money to capital expenditures (CapEx) and purchases. Second, a large cash balance could attract the attention of external investors.

Other studies also do not confirm the influence of the agency conflict on cash holdings [54; 56].

Tax-Related Motive

Another motive for the increase of cash holdings is tax expenses. Companies earning income in other countries may face negative tax consequences related to such income repatriation. Repatriation of income from branch offices in the countries with a lower tax rate results in higher tax expenses and, consequently, these branch offices have higher levels of cash than others. Falkeunder at al. [70], as well as Foley et al. [42] earlier, confirmed that US corporations threatened by a high repatriation tax have more cash.

This theory forecasts that multinational companies, especially innovative ones, will have a larger cash balance because it makes it easier to redistribute innovations, patents and R&D expenditures, while it is more difficult to trace the income gained from patents and innovations [42].

Macroeconomic motive

There are several papers dedicated to the study of the influence of macroeconomic factors on cash holdings. One of significant studies in this sphere is the paper by Graham at al. [8], where they prove that the use of only financial company characteristics is insufficient to study the influence of determinants on cash holdings. Therefore, they introduce proxy variables of macroeconomic factors: gross domestic product (GDP) growth rate and interest rate sensitivity. Research by Azar et al. [71] uses the T-bill rate as a variable for macroeconomic factors, which turned out to be an important factor in defining the level of corporate cash balance. Change of profitability influenced innovative companies to a smaller extent than classic industry companies because innovative companies had more saved cash as long as they preferred to save money for future investment opportunities and needed cash for immediate operations with customers and to a lesser extent – with suppliers. These companies had an opportunity to redistribute cash between interest-bearing and non-interest-bearing accounts in a better way. Research by Booth et al. [9] also confirms these conclusions.

On the basis of the literature review above, we may suggest the following hypotheses:

H1: *An increase in liquidity decreases cash holdings.*

H2: *As GDP grows, cash holdings decrease. The influence of this factor in innovative companies is less than in non-innovative ones.*

H3: *An increase in company size and R&D expenditures results in increased cash holdings.*

H4: *Innovative companies are sensitive to changes in cash flow, therefore, the higher the cash flow volatility, the more cash a company has.*

Data, Methodology and Descriptive Statistics

Data sample and formulars for indicators calculation

Financial information on companies was obtained from the Compustat database for the period of 2009–2017. We uploaded a total of 38,386 unique companies. Similarly to Castro et al. [35], we excluded companies with SIC code 4900–4999 (government-controlled ones) from the sample.

As in paper by García-Teruel at al. [59], we updated the sample, eliminating companies with data errors or lost values from the sample. In case of absence of data on R&D, CapEx or dividend payout, we assumed that the value for the company equals zero. In particular, it was necessary that variables such as total assets, fixed assets, proceeds and cash were positive [56; 59]. In order to calculate GDP growth rate, historical data was obtained from the online platform of the World Bank (https://www.worldbank.org/).

As a result of sample purging, 12,083 companies were left, 2,909 of them - innovative companies. Since we didn't have Compustat data concerning Market Capitalization, the data for this indicator was uploaded from Bloomberg only companies classified as high-tech in accordance with the BICS classifier: Telecommunication, Medical Industry and Technology. For this reason, the influence of the classic form of Market-to-Book ratio on cash holdings will be taken into consideration only for the complete sample and high-tech companies. As a result, the MtB_classic variable was calculated for 1,751 innovative companies and 300 non-innovative companies.

We calculated the required indicators on the basis of the uploaded financial information. See the indicator calculation formulas in Table 2.

Table 2. Variable calculation formulas

Item	Designation in the model	Variable calculation formula
Cash	Cash_ratio	$\frac{\text{Cash and marketable securities}}{\text{Total assets}}$
Company's growth opportunities	MtB_classic MtB_analogue	$\frac{BV_{assets} - BV_{equity} + MV_{equity}}{BV_{assets}}$ $\frac{Sales_{current\ year}}{Sales_{previous\ year}}$
Company size	FirmSize	$\ln(\text{Total Assets})$
Financial leverage	Lev	$\frac{\text{Long\_term debt} + \text{Short\_term debt}}{\text{Book value of assets}}$
Research and Development expenditures	RD	$\frac{R\ \&\ D_{expenditures}}{\text{Total Assets}}$
Selling, general and administrative expenditures	SGA	$\frac{SG\ \&\ A_{expenditures}}{\text{Total Assets}}$
Intangible assets	Intangibles	$\frac{\text{Intangible Assets}}{\text{Total Assets}}$
Capital expenditures	Capex	$\frac{\text{Capital expenditures}}{\text{Total Assets}}$
Cash flow amount	CashFlow	$\frac{\text{Pre}-\text{tax profits} + \text{Depreciation}}{\text{Sales}}$
Cash flow volatility	CF_volatility1 CF_volatility2	$\text{Stand.dev}\frac{Oper.CF_{-2nd\ year} + Oper.CF_{pr.year}}{2}$ Stand. dev of EBITDA for observed years
Debt repayment structure	Ldebt	$\text{Debt mat. structure} = \frac{\text{Long\_term debt}}{\text{Total debt}}$
Probability of bankruptcy	Springate_Score	$\text{Springate Z}-\text{Score}$
Liquidity	WCR_L1 NLB_L2	$\frac{WCR}{Sales}$ $\frac{NLB}{\text{Total Assets}}$
GDP growth rate	GDP_growth	$\frac{GDP_{current\ year} - GDP_{previous\ year}}{GDP_{previous\ year}}$

The following dummy variables were also added:

$$\text{DivPayout\_dummy} = \begin{cases} 1, \text{if a company pays dividends} \\ 0, \text{if a company doesn't pay dividends} \end{cases}.$$

$$\text{HightechbyKile\_dummy} = \begin{cases} 1, \text{if a compaby is innovative} \\ 0, \text{if a compaby is not innovative} \end{cases}$$

$$\text{R \& D\_dummy} = \begin{cases} 1, \text{if a company has RD expenditures} \\ 0, \text{if a company doesn't have RD expenditures.} \end{cases}$$

$$\text{Sector\_dum} = \begin{cases} 1, \text{if it is a pharmaceutical / biotech company} \\ 0, \text{if it is not a pharmaceutical company.} \end{cases}$$

$$\text{Country\_dum} = \begin{cases} 1, \text{if a company is in a developed country} \\ 0, \text{if a company is in an emerging country} \end{cases}$$

A company was considered a pharmaceutical one if it was classified under SIC codes 382, 384, 283, 873, 387.

Methodology Description

First, we started panel regression for the entire sample in order to see whether the selected determinants are significant or whether they make sense for the entire sample. Then we divided the sample into two parts: innovative and non-innovative companies and repeated the first step in order to define the correlation between cash and the chosen proxy variables for both types of companies. Then we assessed the pooled, random-effect and fixed-effect models. Then we chose the most appropriate calculation model on the basis of Breusch-Pagan, Haussman and Wald tests.

Let us consider the following model with regard to the restrictions of samples and variables described above:

$$\begin{aligned} \text{CASHratio} = {} & \beta_0 + \beta_1 \text{FirmSize} + \beta_2 \text{Lev} + \beta_3 \text{RD} + \\ & + \beta_4 \text{SGA} + \beta_5 \text{Intangibles} + \beta_6 \text{Capex} + \\ & + \beta_7 \text{CF\_volatility1} + \beta_8 \text{CF\_volatility2} + \\ & + \beta_9 \text{LDebt} + \beta_{10} \text{Springate\_Score} + \beta_{11} \text{WCR\_L1} + \\ & + \beta_{12} \text{NLB\_L2} + \beta_{13} \text{GDP\_growth} + \\ & + \beta_{14} \text{DivPayout\_dummy} + \\ & + \beta_{15} \text{HightechbyKile\_dummy} + \\ & + \beta_{16} \text{RD\_dummy} + \beta_{17} \text{Country\_dummy} + \\ & + \beta_{18} \text{Sector\_dummy} + \beta_{19} \text{MtB}_{\text{analogue}} + \\ & + \beta_{20} \text{MtB}_{\text{classic}} + \varepsilon. \end{aligned}$$

The dependent variable is the cash ratio; the other variables are grouped together in Table 3 according to the motives they explain.

Table 3. Motives explained by the variables:

Agency	Transactional	Preventive	Macroeconomic
Company size	Company size, liquidity	Company's growth opportunities, financial leverage, expenditures for R&D and SG&A, Capex, intangible assets, dividend payout, CF amount and volatility, debt repayment structure, probability of bankruptcy	GDP growth rate

Descriptive statistics

Descriptive statistics for all variables in the regression equation is presented in Table 4, while the descriptive statistics for the MtB_classic variable is provided only for high-tech companies.

Table 4. Descriptive statistics of all model variables except dummy variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Cash_ratio	108747	.150919	.1360805	2.68e-06	.9970662
GDP_growth	108747	.0415977	.0916111	−.348707	1.188959
CashFlow	108747	.0635924	28.21666	−1556	8581.092
CF_volatil~1	108747	33.4242	411.9104	0	102452.9
Lev	108738	1.405031	103.7957	0	28137.43
Ldebt	108747	.3683848	.3340301	0	1
FirmSize	108747	5.598556	1.937406	−2.864704	13.77684
MtB_analogue	108747	1.45825	84.76837	.0000166	27610.88
RD	108747	.0117841	.0353209	0	1.709541
Capex	108747	.0467223	.0870893	0	22.90815

Variable	Obs	Mean	Std. Dev.	Min	Max
Intangibles	108738	.0462	.0848139	0	.8955983
NLB_L2	108747	-.0655604	.204252	−1.932836	5.162755
WCR_L1	108747	.9130113	139.5594	−118.8889	45508.19
SGA	108747	.1661718	.1835545	0	3.713348
Springate_~e	108747	.9124516	19.86528	−1510.584	6302.671
CF_volatil~2	108747	78.57044	485.3962	.0053287	15581.01
MtB_classic	26181	557.8765	8248.482	0	952288.1

Further we present a cash ratio description table (Table 5) for the first sample, which demonstrates that on average innovative companies do, in fact, havetwice as much cash holdings as low-tech companies and as companies in general in the whole sample in 2009–2017. This is consistent with the findings of the previous studies of corporate cash.

However, unlike in previous studies such as Bates et al. [1] and Sanchez at al. [2], it is impossible to confirm observations of a steep growth of the cash ratio indicator (Figure 2). It is, however, possible to notice that innovative and non-innovative companies in general follow the common trends of decrease/growth of cash ratio, but at initially different levels.

One may observe that the mean value of cash ratio across the sample grows over time - although the growth is unstable and slow – from 0.1483 in 2009 to 0.1559 in 2017. The cash ratio indicator reaches the peak value for the entire sample and for the breakdown by types of companies in 2016 and amounts to an average of 0.1572 for the entire sample. The data allows to conclude that the cash holding phenomenon still exists and has been stable over a long time.

Table 5. The mean cash ratio value across the whole sample and in the breakdown by high-tech and non-high-tech companies for 2009–2017

	Total Sample		High-tech		Non-high-tech	
Year	N	Mean	N	Mean	N	Mean
2009	12083	.1482705	2909	.212071	9174	.1280399
2010	12083	.1551042	2909	.2196665	9174	.1346321
2011	12083	.1480538	2909	.2116815	9174	.127878
2012	12083	.1450895	2909	.2102078	9174	.124441
2013	12083	.1467378	2909	.2153591	9174	.1249786
2014	12083	.1481327	2909	.2164534	9174	.1264688
2015	12083	.1536616	2909	.2228572	9174	.1317203
2016	12083	.1572429	2909	.2244783	9174	.1359231
2017	12083	.155978	2909	.2244708	9174	.1342594

Table 6. Mean value of cash ratio in the breakdown by developed and developing countries for 2009–2017

	Total Sample		Developed		Developing	
Year	N	Mean	N	Mean	N	Mean
2009	12083	0.148271	4637	0.150098	7446	0.147132
2010	12083	0.155104	4637	0.154349	7446	0.155575
2011	12083	0.148054	4637	0.151232	7446	0.146075
2012	12083	0.145089	4637	0.151878	7446	0.140862
2013	12083	0.146738	4637	0.1548	7446	0.141717
2014	12083	0.148133	4637	0.156577	7446	0.142874
2015	12083	0.153662	4637	0.160484	7446	0.149413
2016	12083	0.157243	4637	0.164135	7446	0.152951
2017	12083	0.155978	4637	0.163693	7446	0.151173

Figure 2. Cash ratio dynamics for the entire sample, innovative companies and low-tech companies in 2009–2017

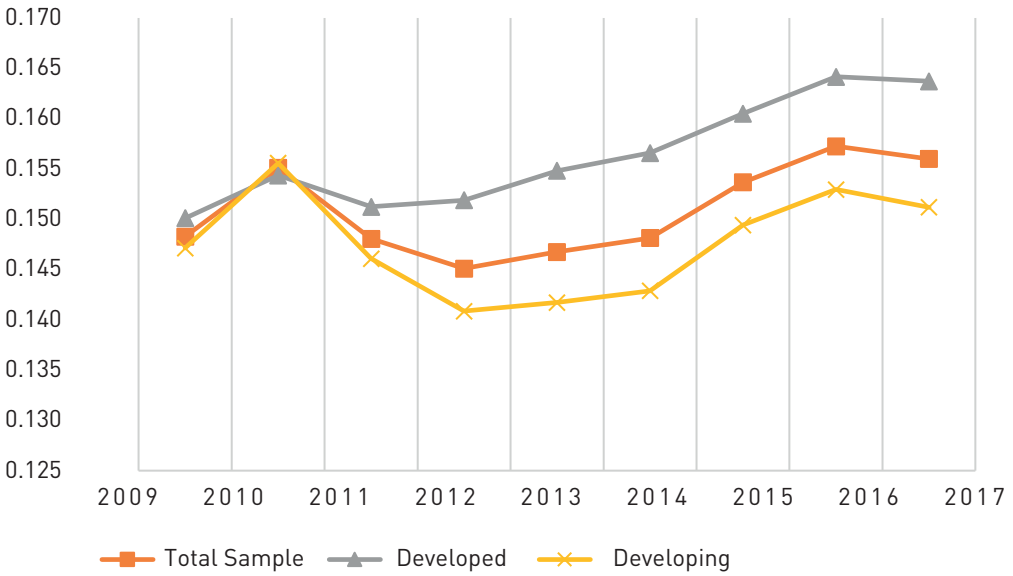


Table 6 presents mean values of cash ratio for emerging and developed countries. One may notice that the trend of cash ratio growth in the breakdown by developed/developing countries is preserved over nine years, at the same time, the difference of the mean value between cash ratio levels in developed and emerging countries in minimal. So, we can conclude that in general there isn't any relationship between the cash ratio mean level and the country type.

Table 7. Descriptive statistics of high-tech and non-high-tech companies

Indicator	Non-high-tech		High-tech	
Variable	Mean	Std. Dev.	Mean	Std. Dev.
Cash_ratio	.1298157	.118552	.2174717	.1635872
Sector_dummy	0	0	.2461327	.430765
Country_du~y	.3858731	.4868038	.3771055	.4846709
GDP_growth	.0424796	.0937058	.0388162	.0846078
CashFlow	–.0186727	10.53209	.3230287	54.38051
CF_volatil~1	34.47913	262.9168	30.0973	697.6782
Lev	1.27566	67.74268	1.813144	174.0222
Ldebt	.3776944	.3338205	.3390255	.3329962
FirmSize	5.729163	1.946793	5.186664	1.848034
Cash_ratio	.1298157	.118552	.2174717	.1635872
DivPayout_~y	.5471623	.4977738	.5596425	.4964395
RD	.0052734	.0152681	.0323167	.0623831
RD_dummy	.3703583	.4829036	.6895459	.4626884
Capex	.047791	.0534476	.0433522	.1499348
Intangibles	.0392533	.0742063	.068115	.1090082
NLB_L2	–.0878253	.191093	.0046554	.22723
WCR_L1	.5074767	23.34715	2.19193	281.3917
SGA	.1574245	.1774796	.193758	.1990179
Springate_~e	.9297205	22.71017	.8579914	3.556911
CF_volatil~2	84.443	515.1981	60.05037	375.6637
MtB_classic			557.8765	8248.482

Predictably, when analyzing mean values of variables in the breakdown by high-tech/non-high-tech companies, the mean level of R&D, SG&A and Intangibles was higher for innovative companies than for non-innovative ones. At the same time, for some reason the financial leverage of innovative companies was on average higher than for non-innovative ones, although the mean value of Ldebt was smaller (Table 7). The first explanation is that innovative companies have a greater deficiency of internal funds than low-tech companies and are forced to raise funds as the external market. But in this case, the obtained result contradicts the opinion that innovative companies will use borrowed funds to a lesser extent because they are expensive and difficult to obtain. The second explanation is more mathematical and is related to calculation of this variable: innovative companies simply have less assets than low-tech ones, consequently, the denominator is smaller. Therefore, with the same or even smaller amount of external financing, the mean variable for financial leverage records a higher level for innovative companies.

On average, the CashFlow variable has a negative value for low-tech companies. This means that companies from classic industries, unlike innovative ones, have problems with income. The sample was purged from companies with nonpositive proceeds, so we may see the influence of the numerator of this variable in the table.

Non-innovative companies showed a higher degree of cash flow volatility for both ways of calculation. A possible explanation is the sample bias towards low-tech companies in terms of quantity because there are over 9,000 non-innovative companies in the sample, while the number of high-tech companies is just over 2,000. Consequently, there is a greater variability of companies from classic industries in the sample.

Springate Z-score predictably shows that the mean value of bankruptcy probability for innovative companies is higher than for low-tech companies (an inverse relationship between the coefficient value and bankruptcy probability), which is due to a higher risk of failure of a company's operations.

We define the correlation level between regressors in order to eliminate the multicollinearity risk in the model to avoid an accidental omission of a potentially significant regressor. A strong relationship was revealed between the NLB_L2 variable and cash ratio – 0.762, between the MtB_analogue variable and WCR_L1 – 0.9941, between Sector_dummy and HightechbyKile – a dummy variable of an innovative company. It is hardly surprising because Sector_dummy tests the extent of influence of companys pertaining to the medical industry, which is one of the sectors comprising innovative companies. Thus, it is not advisable to use these two variables simultaneously. Then the sample is divided into subsamples consisting of only innovative companies or non-innovative companies and regressions are applied.

Results

The results of pooled regression testing for innovative and non-innovative companies separately, as well as for the entire sample are presented in Table 8.

Table 8. Pooled regression by innovative and non-innovative companies separately and for the entire sample

Variable	full_pool_1	full_pool_h~h	full_pool_n~h
Hightechby~e	.04144263***	(omitted)	(omitted)
Sector_dummy	–.02932382***	–.02799415***	(omitted)
Country_du~y	–.00995699***	.01305893***	–.0178002***
GDP_growth	.00477623	–.01778377**	.00833596**
CashFlow	–.00001665	–.00001497	–.0000423
CF_volatil~1	–1.709e-06**	–2.242e-07	–6.493e-06***
Lev	3.467e-06	1.421e-06	6.321e-06
Ldebt	–.07701833***	–.07015211***	–.07481558***
FirmSize	.00449972***	.00333379***	.00530312***
DivPayout_~y	–.00812249***	–.00787106***	–.00723117***
RD	.24297057***	.17434378***	.24365596***
RD_dummy	.00055358	–.00586204***	.00221221***
Capex	–.06561927***	–.01867492***	–.17079205***

Variable	full_pool_1	full_pool_h~h	full_pool_n~h
Intangibles	–.10774234***	–.13430975***	–.09921924***
NLB_L2	.50198908***	.59055881***	.4629501***
WCR_L1	8.347e-07	–7.042e-08	.00001517
SGA	.0673171***	.06720242***	.06874516***
Springate_~e	.00004409***	–.00007644	.00005208***
CF_volatil~2	–5.650e-06***	–7.823e-07	–4.555e-06***
MtB_classic	–2.610e-08	4.255e-08	5.486e-06***
_cons	.18106508***	.22372653***	.178417***
N	108736	26171	82565
r2	.65581589	.73670743	.58323074
r2_a	.65575257	.73651613	.58313986

Standard errors: *** p <0.01; ** p <0.05; * p <0.1.

As a result, we have formed the following models.

The final model for the whole sample:

CASH ratio = 0.181 - 0.004FirmSize +
3.467eLev+0.242RD+0.0006RD_{dummy} +
+ 0.067SGA – 0.108Intangibles - 0.066Capex –
–1.709e$CF_{volatility1}$ – 5.65e$CF_{volatility2}$ –0.077LDebt +
+ 0.00004$Springate_{Score}$ + 0.502NLB +
+8.347eWCR+0.0047GDP_{growth} – 0.008$DivPayout_{dummy}$ +
+0.414High $_{tech\ dummy}$ – 0.0099$Country_{dummy}$ +
+0.0006RD_{dummy} – 0.0293$Sector_{dummy}$ + ε

The final model for the high-tech companies sample:

CASH ratio = 0.022 + 0.003FirmSize + 1.421eLev +
+ 0.174RD + 0.067SGA – 0.134Intangibles –
– 0.0186Capex – 2.242e$CF_{volatility1}$ – 7.823e$CF_{volatility2}$ –
– 0.070LDebt – 0.00007$Springate^{Score}$ + 0.590NLB –
– 7.042eWCR – 0.0177GDP_{growth} –
– 0.007DivPayout_dummy – 0.005D_dummy +
+ 0.0130$Country_{dummy}$-0.027$Sector_{dummy}$ +
+4.255e$MtB_{classic}$ + ε

The final model for the non-high-tech companies sample:

CASH ratio = 0.178 + 0.005FirmSize + 6.321eLev +
+ 0.243RD + 0 .068SGA – 0.099Intangibles –
– 0.170Capex -6.493e$CF_{volatility1}$ – 4.555e$CF_{volatility2}$ –
– 0.074LDebt + 0.00005Springate_Score + 0.462NLB +
+ 0.00001WCR + 0.008GDP_growth –
– 0.007DivPayout_dummy + 0.002RD_dummy –
– 0.017Country_dummy + ε

One may observe that in general all three model variations have a rather high explanatory power; at the same time, the dependence of the cash ratio on the selected variables of non-innovative companies is not as easily explained. The highest explanatory power is observed in the model built using the sample that consists of only innovative companies and amounts to 73% (R-squared = 0.73 for the sample of innovative companies, R-squared = 0.58 for non-innovative companies and R-squared = 0.65 for the entire sample).

On the basis of the results of the pooled model for the entire sample one may conclude that a company's affiliation with the high-tech industry is a significant factor in the market and that model testing using different subsamples is justified.

It should be noted that GDP growth rate, which was absolutely insignificant for the entire sample, turned out to be significant for both subsamples; moreover, its influence on the cash ratio indicator for each subsample was diametrically opposed. For innovative companies, GDP growth rate produces a negative influence on the cash ratio, notably at the significance level of 0.001, while for non-innovative companies, on the contrary, increase of GDP growth rate results in an increased cash ratio at the significance level of 0.01. This is probably due to the fact that in case of GDP growth macroclimate in countries improves, making it easier for companies to survive, which, in its turn, results in rising competition in the high-tech industry, where the most important thing is to survive and be the first to introduce their product in the market.

The Cashflow variable turned out to be insignificant in the model on the whole. In addition, the WCR variable was insignificant in all models, which is surprising because, for example, the priority of high-tech companies is operating, rather than financial, activities, however, the testing

results of the pooled model regression prove otherwise: the NLB_L1 variable is significant, while the WCR variable is insignificant. Changes in the cash flow from operations (CF_volatility1) also show a significance level of 0.01 in the model across the entire sample and for low-tech companies, but are absolutely insignificant for high-tech companies. At the same time, the relationship between this variable and the cash ratio is negative. It is rather logical because a company has no reason to save cash against the possibility of shocks when cash flows increase. It should be noted that the second version of cash flow volatility calculation – CF_volatility2 – shows approximately the same result, but this variable has a higher significance level when used in the model for the entire sample and in the sample of non-innovative companies in comparison to the first version.

Financial leverage had no influence on the cash ratio variable in any of the samples, however, the debt structure of a company turned out to be significant in all samples and has an inverse relationship with the cash ratio. When the long-term debt level is increased with respect to the level of the whole debt financing, the cash holdings level decreases, thus partially substantiating the theory on the influence of financial restrictions on the amount of corporate cash holdings.

In all samples the following variables turned out to be significant to various degrees and showed the same trend of influence on the cash ratio: company size (in the model of innovative companies this variable has a smaller coefficient than the same variable in the low-tech company model), dividend payout, R&D expenditures, capital expenditures; selling, general and administrative expenditures; size of intangible assets in relation to all company assets, NLB coefficient.

Bankruptcy probability is significant for the model of the entire sample and for the low-tech company sample; at the same time, a decrease of bankruptcy probability in these samples results in the growth of the cash ratio level. Presumably, it is due to the fact that a company with a high bankruptcy probability has no opportunity to save cash because it is spent on company's operations, while companies with a low probability of bankruptcy prefer to save cash.

Further we consider pooled models with breakdown of the sample into pharmaceutical/biotech and non-pharmaceutical companies and across the entire sample (Table 9).

Table 9. Pooled regression for pharmaceutical and non- pharmaceutical company samples and across the entire sample

Variable	full_pool_1	full_pool_h~h	full_pool_n~h
Hightechby~e	(omitted)	.04307556***	.04144263***
Sector_dummy	(omitted)	(omitted)	−.02932382***
Country_du~y	.00255824	−.0114674***	−.00995699***
GDP_growth	−.00375661	.00426147	.00477623
CashFlow	−.0000144	−.00002682	−.00001665
CF_volatil~1	−3.978e-06	−1.668e-06**	−1.709e-06**
Lev	.00129077***	3.156e-06	3.467e-06
Ldebt	−.06569355***	−.07711462***	−.07701833***
FirmSize	.00807605***	.00434588***	.00449972***
DivPayout_~y	−.0239487***	−.0063829***	−.00812249***
RD	.18512009***	.18558128***	.24297057***
RD_dummy	−.0080702***	.00199835***	.00055358
Capex	−.16328455***	−.06280315***	−.06561927***
Intangibles	−.16262382***	−.10445286***	−.10774234***
NLB_L2	.62818606***	.49116173***	.50198908***
WCR_L1	−7.062e-07	.00001543	8.347e-07
SGA	.04153918***	.07139322***	.0673171***
Springate_~e	−.0053206***	.00004743***	.00004409***

Variable	full_pool_1	full_pool_h~h	full_pool_n~h
CF_volatil~2	4.471e-06	−5.504e-06***	−5.650e-06***
MtB_classic	5.916e-08	−7.253e-09	−2.610e-08
_cons	.20129678***	.17952257***	.18106508***
N	6436	102300	108736
r2	.81601751	.64028818	.65581589
r2_a	.81550143	.64022135	.65575257

Standard errors: *** p <0.01; ** p <0.05; * p <0.1.

Regression analysis shows that when companies are divided into subsamples in a different way, the explanatory power of the model is enhanced.

Unlike for the model of all innovative companies, financial leverage is significant for pharmaceutical/biotech companies, while the dummy variable designating developed and emerging countries is insignificant. Similar to high-tech companies, medical/pharmaceutical companies demonstrate an extremely high globalization level, therefore it generally makes no difference for them in which country to operate. As for all other variables, the line of influence and degree of significance are similar to previous models when the sample is divided into high-tech/non-high-tech companies.

We also studied and tested three types of models to choose the most accurate and appropriate one.

Studied models:

- Fixed effect model – a regression in deviation of indicators from the time average for each object. This model eliminates the influence of time-invariant characteristics in order to evaluate the net influence of variables on the dependent variable. In this case, each company in the sample adds its individual effect to the global constant;
- Random effect model resembles the FE model, but forms the individual effect as an error instead of a constant. Time-invariant variables are preserved in this model;

Pooled model.

The choice between the pooled and FE models

When making a choice between the pooled and FE models, one should pay attention to F-statistics. In all versions of the FE model the zero hypothesis stating that the elements responsible for the individual effect are insignificant is rejected. Therefore, out of the pooled and FE models, we chose the fixed effect model.

The choice between the pooled and RE models, the Breusch-Pagan test

When making a choice between the pooled and RE models, it is necessary to perform the Breusch-Pagan test, which verifies the hypothesis stating that the dispersion of individual effects equals 0.

As a result, we rejected the zero hypothesis and chose the RE model (Table 10).

Table 10. A complete RE model

Variable	Coef.	Z	P>z	Std. Err.
HightechbyKile	.0514289	32.21	0.000	.0015968
Sector_dummy	−.0244458	−8.62	0.000	.002835
Country_dummy	−.0052547	−4.06	0.000	.0012947
GDP_growth	−.0022927	−1.32	0.187	.0017393
CashFlow	−8.67e-06	−1.61	0.107	5.38e-06
CF_volatility_1	−1.63e-07	−0.41	0.683	3.99e-07
Lev	1.05e-06	0.73	0.465	1.44e-06
Ldebt	−.0469826	−76.62	0.000	.0006132

Variable	Coef.	Z	P>z	Std. Err.
FirmSize	.0030324	10.53	0.000	.0002881
DivPayout_dummy	–.0044481	–9.27	0.000	.00048
RD	.0362406	4.20	0.000	.008623
RD_dummy	–.0024362	–4.12	0.000	.000592
Capex	–.0275021	–14.85	0.000	.0018517
Intangibles	–.1772302	–49.88	0.000	.0035529
NLB_L2	.4922331	384.27	0.000	.001281
WCR_L1	2.12e-06	1.97	0.049	1.08e-06
SGA	.0303175	14.06	0.000	.0021561
Springate_score	.0000388	5.16	0.000	7.52e-06
CF_volatility_2	–7.15e-06	–5.52	0.000	1.29e-06
MtB_classic	1.16e-07	2.73	0.006	4.27e-08
_cons	.1827534	102.27	0.000	.001787
sigma_u	.06346205			
sigma_e	.04615585			
Rho	.65403801			

Standard errors: *** p <0,01, ** p <0,05, * p <0,1.

The Haussman Test

Now we need to choose between the FE and RE models. For this purpose, we conduct the Haussman test where the zero hypothesis states that the RE model is preferable to the alternative FE model. Mainly we verify whether unique errors are related to regressors. The zero hypothesis states that there is no relationship.

The Wald Test

The next stage is the testing of the selected FE model for heteroscedasticity. For this purpose, we verify the model by applying the modified Wald test. The testing results show that if there is heteroscedasticity in the model, robust standard errors are introduced to mitigate the heteroscedasticity effect.

You can see the result of testing the FE model with robust standard errors across the whole sample, in innovative companies and other companies in the sample (Table 11).

Table 11. FE model using robust standard errors across the entire sample of companies as well as in high-tech and non-high-tech companies

Variable	fe_non_high~t	fe_high_tec~t	fe_full_rob~t
Hightechby~e	(omitted)	(omitted)	(omitted)
Sector_dummy	(omitted)	(omitted)	(omitted)
Country_du~y	(omitted)	(omitted)	(omitted)
GDP_growth	.00017332	–.01304373**	–.00353664
CashFlow	–.00003203	–5.771e-06**	–8.209e-06*
CF_volatil~1	1.154e-06*	–2.194e-07	–1.981e-08

Variable	fe_non_high~t	fe_high_tec~t	fe_full_rob~t
Lev	−1.106e-06	2.145e-06***	9.766e-07
Ldebt	−.03823258***	−.05475872***	−.04334387***
FirmSize	.00184989	.00598256**	.00303322*
DivPayout_~y	−.00215961*	−.00512545***	−.00338009***
RD	−.0606296	.00324509	−.01462614
RD_dummy	−.00417975***	−.00181952	−.00330704**
Capex	−.10304346***	−.00380872	−.02418796
Intangibles	−.1831463***	−.19934908***	−.20036695***
NLB_L2	.45238543***	.56511748***	.48698371***
WCR_L1	.00002897***	1.247e-06***	2.224e-06**
SGA	.01886729*	.0110307	.00866056
Springate_~e	.00004585***	−.00001662	.00003912***
CF_volatil~2	(omitted)	(omitted)	(omitted)
MtB_classic	6.453e-07	1.424e-07***	1.331e-07***
N	82565	26171	108736
r2	.54267519	.69033815	.58829088
r2_a	.54258655	.69014871	.58823029
F	508.97997	1310.2036	376.37002

Standard errors: *** p <0.01; ** p <0.05; * p <0.1.

Analysis of Results

Company size

Company size is important for the complete sample and a sample comprised of only innovative companies. Thus, for the whole sample the size is significant at a 0.05 level, and for innovative companies – at a 0.01 level. The coefficient for innovative companies is also greater than for the whole sample, which is indicative of a greater impact on the cash ratio when this parameter is changed to 1. For non-innovative companies the size was insignificant.

In general, in all three samples company size is related positively to cash ratio: the bigger a company, the larger its cash holdings. Thus, hypothesis *H3* is partially validated. The FirmSize variable in this paper does not confirm the transactional motive of accumulating cash holdings, unlike in the paper by Drobetz et al. [52]. Moreover, in the model with only innovative companies the extent of influence of company size on cash holdings turned out to be the highest among the three samples. This also rejects the presence of the transactional motive of innovative companies proposed in the paper by Ozkan et al [54].

However, according to theory, a positive influence of company size is a sign of existence of the agency motive, but since for all companies the debt level is apparently significant and its relationship to the cash ratio is negative, one may presume, as does the research by Lee et al. [29], that during a crisis and postcrisis companies of any size face financial restrictions.

Liquidity Coefficients

The two variables WCR and NLB are used to evaluate liquidity. In all three regressions these indicators turned out to be significant and had a positive influence on the cash ratio, which contradicts the results of Ferreira et al. [57] and Opler et al. [56]. At the same time, the strongest influence of NLB is observed in high-tech companies (the variable coefficient is 0.565), which is unexpected because high-tech companies place greater focus on operations management instead of financial management.

Thus, hypothesis *H1* proposed at the beginning was rejected as a result of this research and the transactional motive was not confirmed.

Company's Growth Opportunities

In view of the incomplete data on the MtB_classic indicator, we cannot be sure that the result obtained for the whole sample and non-innovative companies is absolutely dependable, although for some non-high-tech companies the data was obtained due to a difference in classification of innovative companies in the BICS classifier and the sample of SIC code.

The results show that this proxy variable is significant in the model for companies from the entire sample, particularly for high-tech companies; at the same time, the model coefficient for high-tech companies is higher, which is not surprising. The obtained result of the positive influence of this variable on the innovative companies' cash holding level is aligned with the results of other researchers [1; 42; 58; 60; 61; 72].

Financial Leverage

The financial leverage variable turned out to be insignificant for all samples except for innovative companies, where influence of the leverage has a positive impact on cash holdings.

Debt Repayment Structure

All three samples demonstrate a negative relationship between the amount of the long-term debt and cash ratio, especially for innovative companies: in this model the coefficient is the biggest in modulus, which indicates that cash is probably used to repay corporate debt.

The research produced two exactly opposite effects for debt-related variables. On the one hand, the financial leverage variable has a positive impact on the cash ratio of innovative companies, however, at the same time the debt structure variable shows that cash holdings of any company that prefers long-term debt financing should decrease. This indicates that there is most probably an effect of preference of short-term debt operations financing in financial leverage. A similar observation was mentioned in paper by Bates et al. [1]. This presumption may explain the difference in the line of influence of the Ldebt and Lev variables on cash holdings.

Cash Flow Volatility

Fundamentally, this variable turned out to be insignificant in the first version of model calculation for the whole sample and for innovative companies; however, in low-tech companies this variable has a slight positive influence on cash holdings. The second variation of volatility may be assessed only by applying the RE model. In the RE model the second variable has an obvious negative relationship with the cash ratio. However, in spite of the fact that in the whole sample and in non-innovative companies CF_volatility2 turned out to be significant, cash flow volatility produces no significant influence on cash holdings for innovative companies. The coefficient of the model for high-tech companies only is significantly lower than of other models.

Generally, we may consider hypothesis H*4* rejected because this variable has no significance in the explanation of cash holdings of innovative companies and its influence is the exact opposite of the researchers' expectations.

R&D Expenditures

One of the most significant variables – R&D – turned out to be completely insignificant for the FE model as a whole. At the same time, the influence of this variable on cash ratio is negative, which contradicts hypothesis *H3* about a positive influence of RD on cash holdings. Thus, we tested variations of the model for RD and RD_dummy variables separately (Table 12 and 13). The results of these models showed that both RD and RD_dummy have a negative effect on cash holdings, but if the RD variable is still insignificant in all models, RD_dummy is significant for the sample as a whole and for low-tech companies. At the same time. in the latter sample the influence is greater than in the whole sample, which indicates that neither size nor the fact of incurring R&D expenditures are of any importance for innovative companies. Therefore, this confirms the result of the research performed by PWC [18] (concerning the amount of R&D expenditures).

Table 12. The FE model using robust standard errors for the whole sample of companies, as well as high-tech and non-high-tech companies without the RD_dummy variable

Variable	fe_non_high~h	fe_high_tech	fe_full_rob~t
Hightechby~e	(omitted)	(omitted)	(omitted)
Sector_dummy	(omitted)	(omitted)	(omitted)
Country_du~y	(omitted)	(omitted)	(omitted)
GDP_growth	.00084592	−.01251645**	−.00287144
CashFlow	−.00003178	−5.670e-06**	−8.024e-06
CF_volatil~1	1.176e-06*	−2.257e-07	−2.583e-08
Lev	−1.109e-06	2.158e-06***	9.918e-07

Variable	fe_non_high~h	fe_high_tech	fe_full_rob~t
Ldebt	−.0381406***	−.05474813***	−.04327181***
FirmSize	.00137565	.00567137**	.00258814*
DivPayout_~y	−.00262077**	−.00524879***	−.0037344***
RD	−.09593725	−.00058857	−.02518635
Capex	−.10201718***	−.00378516	−.02398725
Intangibles	−.18609835***	−.20040651***	−.20273037***
NLB_L2	.45242554***	.56517477***	.48701988***
WCR_L1	.00002925***	1.268e-06***	2.264e-06**
SGA	.01880381*	.01089707	.00847615
Springate_~e	.00004582***	−.00001689	.00003908***
CF_volatil~2	(omitted)	(omitted)	(omitted)
MtB_classic	6.760e-07	1.426e-07***	1.335e-07***
_cons	.18708942***	.21904228***	.195776***
N	82565	26171	108736
r2	.54247892	.69031169	.58817732
r2_a	.54239578	.69013408	.5881205
F	540.18016	1390.9392	395.40301

Standard errors: *** p <0.01; ** p <0.05; * p <0,1.

Table 13. The FE model using robust standard errors for the whole sample of companies, as well as high-tech and non-high-tech companies using only the RD_dummy variable

Variable	fe_non_high~h	fe_high_tech	fe_full_rob~t
Hightechby~e	(omitted)	(omitted)	(omitted)
Sector_dummy	(omitted)	(omitted)	(omitted)
Country_du~y	(omitted)	(omitted)	(omitted)
GDP_growth	.00024113	−.01303873**	−.00353174
CashFlow	−.00003202	−5.765e-06**	−8.212e-06*
CF_volatil~1	1.146e-06*	−2.199e-07	−1.876e-08
Lev	−1.105e-06	2.145e-06***	9.774e-07
Ldebt	−.0382285***	−.05475874***	−.04334457***
FirmSize	.00183039	.00596617**	.0030452*
DivPayout_~y	−.00221024*	−.00512125***	−.00339038***
RD_dummy	−.00477607***	−.00172924	−.00352567***

Variable	fe_non_high~h	fe_high_tech	fe_full_rob~t
Capex	−.10295384***	−.00381647	−.02416101
Intangibles	−.18325664***	−.19942601***	−.20023638***
NLB_L2	.4523531***	.5651113***	.48699214***
WCR_L1	.00002891***	1.249e-06***	2.221e-06**
SGA	.0175477*	.01128292	.00792359
Springate_~e	.00004589***	−.00001731	.00003915***
CF_volatil~2	(omitted)	(omitted)	(omitted)
MtB_classic	6.358e-07	1.425e-07***	1.329e-07***
_cons	.18570769***	.21849974***	.19434517***
N	82565	26171	108736
r2	.5426271	.69033704	.58828048
r2_a	.54254399	.69015945	.58822368
F	542.4207	1380.2093	400.56672

Standard errors: *** p <0.01; ** p <0.05; * p <0,1.

Capex

Capital expenditures have a negative relationship with cash holdings, however, at the same time this variable is significant only for low-tech companies.

Intangible assets

They have a significant negative influence on cash ratio in all subsamples, at the same time this variable has the most influence when used for the whole sample. The value for innovative companies is a little less than for the first sample. The negative relationship between cash ratio and intangibles may be due to the fact that it is easier/economically more advantageous for the company to purchase intangible assets for cash.

Dividend Payout

It has a predictably negative influence on cash ratio as was stated in the paper by Bates et al. [1]; at the same time this influence is greater for innovative companies, which may be indicative of the agency motive. Dividend payments are also a message for external investors that a company needs cash to protect itself from shocks to a lesser extent.

Probability of Bankruptcy

An increased Springate Z-score, i.e. a decreased probability of bankruptcy in the entire sample and in the sample of only non-innovative companies results in cash ratio growth, thus disconfirming the preventive motive. However, in spite of the absence of significance in the model of this variable for innovative companies, its negative relationship with the cash ratio should be noted.

GDP growth rate

It is of no significance for the whole sample and for its largest component – low-tech companies. However, the model with innovative companies shows a particularly significant negative relationship between the cash ratio and GDP growth rate. This, on the one hand, confirms the first part of hypothesis H2, which states that when GDP grows, the amount of cash holdings decreases, but disproves its second part. Here is a summary of results of hypotheses testing:

- H1: rejected.
- H2: confirmed partially.
- H3: confirmed partially.
- H4: rejected.

Conclusion

In this paper we examine the determinants of corporate cash holdings, including innovative companies in 2009–2014. We confirmed the existence of the phenomenon of innovative companies' large cash holdings. At the same time, however, there was no particularly significant growth of cash ratio in the period analyzed in this paper. An attempt to study cash ratio exclusively in terms of theoretically defined motives proved to be unsustainable because in the modern world, provided a viable company operates efficiently, there are other motives for accumulating cash. It is confirmed by the fact that no theory was vindicated completely or rejected by all proxy variables.

The validity of adding of a macroeconomic factor variable (GDP growth) to the research model for innovative

companies was demonstrated. In spite of an insignificant influence of GDP on the sample as a whole, for innovative companies an increased GDP growth rate results in a decreased cash ratio.

The revealed insignificance of R&D expenditures for innovative companies is in line with the conclusions of modern information and consulting agencies. Thus, the inexpediency of ranking companies by the amount of R&D expenditures and the use of this variable as proxy innovation is proven. Predictably, a positive relationship between growth opportunities, company size and cash ratio, as well as a negative relationship between dividend payments and the amount of cash holdings was confirmed.

It follows herefrom that an understanding of the reasons for cash accumulation may facilitate prudential management of cash holdings in companies.

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