FINANCIAL CONSTRAINTS, ASSET TANGIBILITY AND FIRM INVESTMENT: A CASE STUDY FOR RUSSIAN MANUFACTURING FIRMS

by

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Abstract

The purpose of this study is to identify the channels through which financial constraints affect corporate investment. For this purpose, I use a unique firm-level sample of Russian manufacturing firms for the period 2008–2016. Unlike other studies focusing on publicly listed large companies, this highly heterogeneous sample enables me to investigate the role of collateral (as proxied by asset tangibility) on investment decisions by exploiting the bank-dominant nature of Russian credit markets. I find that the risk premium of individual firms which can be interpreted as an indirect measure of degree of firms' collateral constraints is negatively related to asset tangibility, and positively related to firm leverage. To capture this finding, I firstly formulate a model of optimal firm investment with costly debt finance, and secondly I test the implications of this model by estimating the structural Euler equation. The results are consistent with the pioneering paper by Almeida and Campello (2007) who, in contrast with earlier findings of Fazzari, Hubbard and Petersen (1988) with respect to excess sensitivity of investment to cash flow, argue that firm investment should be less sensitive to cash flow after controlling for asset tangibility.

Keywords: corporate investment, financial constraints, asset tangibility, investment-cash flow sensitivity, collateral constraints, debt finance, emerging market economy, Russia, SME

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In memory of my father...

Contents

1 Introduction

Real investment expenditure of firms has been extensively studied in corporate finance and macroeconomics. Since the most volatile component of GDP is aggregate investment expenditures, special importance has been attached to firms' real investment decisions.[1] Modigliani-Miller theorem (1958) occupies an important place in investment literature. According to this theorem, if capital markets are perfect, then firm's value cannot be altered by firm's financial decisions. Hence, firm's investment and financial decisions are separable in value optimization. However, in an economy with capital market frictions, a firm's optimal financial and real decisions would be dependent on each other. The role of financial constraints on firms' optimal investment has been stressed as a key propagation mechanism through which aggregate shocks affect real economy (Kiyotaki & Moore, 1997; Bernanke, Gertler, & Gilchrist, 1999).

Frictions in financial markets can be considered in several ways. If external finance is assumed to be costlier than internal finance, investment expenditures might be sensitive to the availability of cash flow. If a firm is financially constrained in a period, it is expected to cease its investment expenditure before reaching its optimal level, since marginal revenue of an additional capital could not exceed additional cost of external finance. Thus, a windfall increase in cash flow is expected to increase firm's investment. This line of reasoning induces positive sensitivity of investment to cash flow as the firm is considered as more financially constrained.

The seminal paper by Fazzari, Hubbard and Petersen (1988) and many subsequent studies document significant evidence supporting this view. Most of the studies in this literature use panels of publicly listed firms to analyze the impact of financial constraints. For this purpose, they divide their sample as financially constrained or not according to some prespecified criteria such as dividend payout ratios. Such exercises assume that firms have access to equity financing, which is prevalent in financial markets for developed countries. In this study, I investigate the role of financial frictions on firms' investment decisions in an emerging country, namely, the Russian Federation.

[1]See Bond and Reenen (2007) for an extensive survey.

It is widely known that Russian firms use banks loans to finance their investment decisions.[2] In bank-dominant credit markets, banks typically prefer debt contracts with collateral especially for loans made to SMEs who are more likely to be subject to asymmetric information between agents and to suffer from deadweight losses in case of defaults. For studying the impact of financial frictions on firm investment behaviour, this structure of external financing suggests an alternative channel which works through the prevalence of collateral in debt contracts.

The pioneering paper by Almeida and Campello (2007) suggests that pledgeable assets loosen firms' borrowing constraints that in turn allow for further investment in pledgeable assets. This creates a different mechanism for testing excess sensitivity of investment to cash flow. Using a panel of US publicly listed firms, they exploit this mechanism to show that investment-cash flow sensitivity (hereafter ICFS) increases with different measures of asset tangibility. In this study, I rather use a unique firm-level data set of Russian manufacturing firms which is characterized by a high degree of heterogeneity in terms of firm size, age, asset tangibility rate, and other firm characteristics. This highly heterogeneous sample enables me to investigate the role of collateral (as proxied by asset tangibility) on investment decisions by exploiting the bank-dominant nature of Russian credit markets.

Before presenting my model, I investigate the relationship between a measure of risk premium (proxied by firm-specific interest rates) and leverage and asset tangibility. I find that the risk premium of individual firms which can be interpreted as an indirect measure of degree of firms' collateral constraints is negatively related to asset tangibility, and positively related to firm leverage. In the light of these findings, I firstly formulate a model of optimal firm investment. According to the model, only debt finance is available, and firms pay firm-specific interest rates on their debt stock in every period. Collateral constraints are embedded into the model by risk premium payments which is assumed to be a decreasing function of

[2]According to the report Survey on Access to Finance of small and medium-sized enterprises (SAFE) on financing patterns in European countries including Russia, SMEs are more likely to view access to finance as one of their most important constraints. The same report shows that Russian SMEs who seek to finance their investment expenditure rely on: bank loans, leasing, factoring, micro-finance, private equity. The most widely used source of SME financing is bank loans (27%) followed by borrowing from relatives and friends (19%) and trade credit (17%), whereas leasing, factoring and others are not widely used. This report is conducted by European Central Bank in 2013. It is published twice a year. All issues can be reached on https://www.ecb.europa.eu/stats/ecb_surveys/safe/html/index.en.html

tangibility. I then test the implications of this model by estimating the structural Euler equation. The results are consistent with the pioneering paper by Almeida and Campello (2007) who, in contrast with earlier findings of Fazzari, Hubbard and Petersen (1988) with respect to excess sensitivity of investment to cash flow, argue that firm investment should be less sensitive to cash flow after controlling for asset tangibility.

The outline of the paper is as follows. Section 2 describes the related literature while Section 3 presents the unique firm-level Russian data set used in this study. This section also presents initial estimates of a Q-type investment equation and a structural investment equation from a model without financial constraints following Almeida and Campello (2007). Section 4 proposes the model of investment with costly debt finance, and provides estimates from the Euler equation implied by this model. Section 5 concludes.

2 The Related Literature

Q-model of investment is the primary theoretical standing point of most of studies analyzing firm investment and investment-cash flow sensitivities (ICFS). Main difference of Q-model from Jorgenson (1963)'s neoclassical counterpart is the inclusion of adjustment costs of investment which is the main source of dynamics of investment. Four main assumptions of Q-model of investment can be stated as follows:

(A1) Firms employ linearly homogeneous technology in capital and take prices as given,

(A2) Installed capital is subject to quadratic, symmetric and strictly convex adjustment costs,

(A3) Stock prices reflect the fundamental value of the firm, i.e. there is no measurement error,

(A4) Capital markets are perfect, i.e. firms are not constrained by any form of finance, internal or external, whenever they wish to undertake any investment project. In other words, Modigliani - Miller theorem holds.

Hayashi (1982) first formulated that marginal Q and average Q, which is the measure proposed by Tobin (1969) to explain investment decisions of firms, are equal each other under the assumptions (A1) and (A3). Assumption of quadratic adjustment cost of capital, (A2), further induced researchers to obtain a linear specification for investment rate having Tobin's average Q as the only sufficient explanatory variable. Although Q-model is intuitively appealing in theory, it underperformed empirically in many studies.[3] Very low estimates of adjustment speed of capital casted doubt on the validity of underlying assumptions of the standard model, mostly the assumption of perfect capital markets.

In their seminal work, Fazzari, Hubbard and Petersen (1988) (hereafter FHP (1988)) add cash flow to the regression equation of Q investment model to measure investment-cash flow sensitivity (ICFS) of firms. A simple hierarchy of finance model in which external funds are more expensive than internal funds can theoretically be proposed in order to explain the positive impact of windfall increase in cash flow on investment expenditure of financially constrained firms (S. Bond & Meghir, 1994). FHP (1988) reach significant coefficient estimates of cash flow which raised questions about the presence of financial constraints among their sample of publicly listed US firms. Furthermore, it employs sample splitting tests on their panel of firms by which firms are grouped as a priori constrained or unconstrained with respect to their dividend payout ratios, and ICFSs are estimated separately for each group of firms. While cash flow coefficient is estimated positive and significant for the group of financially constrained firms when investment rate is regressed on cash flow along with average Q as a control for firm's capital stock's profitability, it becomes insignificant for the group of unconstrained firms. This evidence suggests that some firms are subject to financial constraints while others are not, and a monotone and increasing ICFS is expected as the degree of financial constraints increases. This phenomenon is named as excess sensitivity of investment to cash flow after this seminal work of FHP (1988). This finding is exploited by a large body of the subsequent investment literature as a measure of financing constraints. Similar monotone excess sensitivity results are further obtained by several studies.[4]

[3]See Hayashi and Inoue (1991); Blundell et al. (1992) among others. These papers require special importance, as they clearly formulated how to estimate structural equations obtained from Q-model by using panel datasets. Similar improbable results can be found in Summers et al. (1981). It examines aggregate US data and particularly concentrates on effects of tax changes on investment.

[4]See Hayashi and Inoue (1991); Blundell et al. (1992); Hoshi, Kashyap and Scharfstein (1991) for further estimates and similar sample splitting exercises using panel data.

Alternatively, some studies were cautionary on excess ICFS results by arguing that share prices, hence average Q might be subject to measurement error. Even in the presence of weak and semi-strong forms of efficient markets hypothesis, rational bubbles in share prices can be observed. This motivation has left excess sensitivity literature open to criticism by showing that excess sensitivity results could be merely due to measurement errors in average Q of firms.[5] Opposing the results of FHP (1988), some other studies with numerical findings worth noting. Gomes (2001) shows that, in his quantitative model without external funding costs, optimal investment is sensitive to both Tobin's average Q and cash flow. Cooper and Ejarque (2003) also examines a quantitative model without financial constraints but market power and they show similarly that optimal investment is sensitive to cash flow. Similar analytical results are present in Abel and Eberly (2011), even they exclude adjustment costs of investment from their model. Alti (2003) utilizes cash flow in his model without financial constraints as a predictor by which younger firms resolve the uncertainty about their future productivity as cash flow realizations provide new information through time. After calibration, similar excess ICFS results are obtained. These findings provide unignorable evidence that researchers must be very cautious when they perform ICFS sample splitting tests within Q setting.

As an alternative explanation for why cash flow is observed as a positive and significant explanatory variable of firm investment along with Q, some studies have drawn attention on the possibility that cash flow could proxy for future profitability of capital. To refute this idea, Gilchrist and Himmelberg (1995) follow the strategy proposed by Abel and Blanchard (1986), which propose direct estimation of unobservable marginal Q using firm's observable characteristics.[6] When they construct their "fundamental Q" to control for future profitability of firm's capital stock completely, they take cash flow into account. After controlling for this effect of cash flow via their fundamental Q, they report positive and significant ICFS.[7]

[5]See Erickson and Whited (2000) for a measurement-error-consistent GMM estimator. Bond and Cummins (2001) use securities analysts' earnings forecasts instead of Q. Furthermore, recent work of Abel (2015) explains theoretically how ICFS sample splitting tests can be misleading when average Q is measured with error.

[6]Several problems can be realized when equating both Qs. Measurement error is just one of them. Deviation from the assumption of perfect competition when firms have market power yields similar results, since a linearly homogeneous production function cannot be assumed any more in such a context.

[7]Carpenter and Guariglia (2008) also reports similar results. However, additional contradictory results

These contradictory results on ICFS provoked the use of Euler equations instead of Q specification of optimal investment. Euler equations can also be obtained from the same model with Q. Straightforward advantage of this approach is the flexibility provided for the researcher to avoid measurement problems in share prices. Whited (1992) presents one of the earliest examples of this approach. He proposes a model of firm with costly debt finance and predicts that optimal invetment of financially more constrained firms must respond changes in cash flow more in a positive way. It is a novel study, since it recognizes possible endogeneity problems that are very likely to emerge when the full sample is splitted into financially constrained and unconstrained groups. Hence, Whited (1992) emphasizes the importance of using appropriate indicators of firms' financial distress in order to measure better the sensitivity of investment to financial variables such as cash flow. He finds evidence in accordance with FHP (1988)'s excess ICFS result, but with some caveats.

Additionally, Bond and Meghir (1994) introduces a hierarchy of finance model with both equity and debt finance. They define financial regimes which firms may face. In the unconstrained regime, for example, firms pay positive dividends to their shareholders, while they do not issue new shares. In the constrained regime, firms do not pay dividend and issue share, implying that cost of external finance is higher than the marginal revenue of investment. Presence of debt finance induces leverage squared as an explanatory variable for the investment rate. Their model predicts significantly different coefficient estimates of lagged investment, cash flow and leverage squared for financially constrained and unconstrained firms. When they firstly estimate resulting equation for the full sample, positive coefficient for cash flow is obtained, even though the model predicts it to be negative. This finding is interpreted by the authors stating that cash flow term may reflect liquidity constraints as well as marginal profitability. When the same equation is estimated across two subsamples of firms, only cash flow coefficient is estimated significantly different for two groups, as it is higher for constrained firms.[8]

are reported by Bond et al. (2004) and Cummins et al. (2006) using similar methods. Differently, both studies use securities analysts' earnings forecasts to control for firms' future expected profitability and report insensitive firm investment against cash flow.

[8]Bond et al. (2003) provides cross-country comparisons in terms of financial frictions. Mizen and Vermeulen (2005) argues that different ICFS results across firms or countries are mainly the consequence of firms' creditworthiness rather than the nature of financial system or industrial composition.

2.1 FHP (1988) vs Kaplan and Zingales (1997) and Almeida and Campello (2007)

Whited (1992), Bond and Meghir (1994) and Bond et al. (2003) find evidence and propose explanations supporting the findings of FHP (1988) about excess sensitivity of investment to cash flow. There are influential studies that provide alternative explanations why FHP (1988) might not be right in its conclusions both theoretically and empirically. Kaplan and Zingales (1997) is the main paper in this vein. They contradict the proposition of FHP (1988) that ICFS increases with the degree of financial constraints facing firms. The most important contribution of Kaplan and Zingales (1997) can be stated as it discourses the need for a well-established theoretical explanation for the proposed monotone relationship between ICFS and financial constraints. Even if they introduce a simple static model of firm investment which is actually weak and challenged by some of ensuing papers,[9] a financial constraints index is proposed in the paper and used to show that as the degree of financial constraints increases, ICFS does not increase for the sample of firms which was originally used by FHP (1988) as their financially constrained subsample.[10] They create financial constraints scores ranging 1 to 5 using qualitative data on FHP (1988)'s original sample for the firms such information is available. Then, they construct financial constraints index (hereafter KZ index) by estimating a logit model in which cash flow, Q, leverage, dividend-to-capital and cash-to-capital are used as explanatory variables. This study influenced construction of other indices aimed at measuring gradual changes at financial constraints facing firms, and the use of these indices in order to investigate ICFS in more depth.[11]

Following Kaplan and Zingales (1997), Almeida and Campello (2007) (hereafter AC (2007)) initiated a discussion by presenting evidence that cash flow sensitivity of investment (ICFS) is an increasing function of asset tangibility. Asset tangibility amounts to how much a firm can pledge its assets in order to be able to get loans from its creditors, mostly banks, in debt markets. They propose a simple model of firm with two periods. This model

[9]Fazzari, Hubbard and Petersen (2000) is one of them. However, FHP (2000) agrees with Kaplan and Zingales (1997) on the necessity of theoretical explanations for excess ICFS.

[10]There are studies supporting Kaplan and Zingales (1997)'s findings. See, Cleary (1999), Guariglia (2008), and Lyanders (2007).

[11]See Section 4.1 for further treatment of such indices.

predicts that, under a threshold of tangibility, firm gets financially constrained and its ICFS increases as the firm's tangibility increases. The model further predicts that, above the same threshold, the firm gets financially unconstrained and its ICFS becomes independent of the level of the firm's tangibility. These findings are contradictory to the common intuition on ICFS. Common intuition following FHP (1988) states that, all else being equal, higher tangibility induces lower borrowing costs, as the firm can pledge more assets as collaterals, when collateral constraints are present. As a firm gets more constrained in reaching loans in debt markets, its investment expenditure must become positively more sensitive to increases in its cash flow. However, another line of reasoning can be proposed as in AC (2007). Consider a positive cash flow shock to two firms with the same tangibility rates. Suppose these firms are both financially constrained. Positive cash flow shock would certainly increase both firms' investment spending at the same amount. However, the more tangible firm can increase its borrowing capacity more, since the same amount of investment would create higher amount of marginal capital that can be collateralized for the firm with higher tangibility rate. This higher relaxation in borrowing constraint of the more tangible firm induces higher optimal investment spending in the current period.

These contradictory predictions about the effect of tangibility on ICFS need to be analyzed. This topic is at the center of the discussion between FHP (1988) and KZ (1997), since there exist two valid, but opposing explanations about it.

3 Data and Empirical Motivation

Data set used in this study is obtained from ORBIS database which is an umbrella product that provides firm-level data for many countries worldwide. This database is compiled by the Bureau van Dijk Electronic Publishing (BvD). Several subsets of ORBIS database are available such as ORIANA for Asia-Pacific region, FAME for UK and Ireland among many others. AMADEUS is the one which covers Europe from which we receive firm-level Russian data between the periods. Administrative data at the firm-level in ORBIS, that is financial and balance sheet data, come from business registers collected by the local chambers of commerce to fulfill legal and administrative requirements and are relayed to BvD via over

40 different information providers.[12]

ORBIS and AMADEUS cover financial accounting information from detailed harmonized balance sheets, income statements and statements of cash flow. These financial statements cover firms in all sectors of the Russian economy. Firms are classified with respect to NACE Revision 2 in four-digit level. Another novel feature of this dataset is that all firms are privately held, contrary to commonly used datasets in investment literature such as Compustat, Compustat Global and Worldscope. With this distinctive feature, I aim to exploit firm heterogeneity in the highest extent possible in order to be able to examine effects of financial constraints on investment much better.

ORBIS and AMADEUS are independent products of BvD and operated by different sets of rules. For example, AMADEUS provides data for at most 10 recent years for the same firm, while ORBIS only reports data for up to 5 recent years. In addition, AMADEUS drops firms from the database if they did not report any information during the last five years, while ORBIS keeps the information for these firms as long as they are active. These differences in nuance of both ORBIS and AMADEUS are so vital for a researcher who wants to construct a dataset of firms as representative as possible. Kalemli-Ozcan et al. (2015) lists very basic cleaning and download strategies for ORBIS and AMADEUS databases so that researchers can clean and construct a dataset without losing any necessary information keeping the coverage of the dataset as high as possible at the same time. Hence, I also followed those strategies provided by Kalemli-Ozcan et al. (2015) to construct my final sample of the Russian economy for the period of 2008-2016.

In addition to basic cleaning filters documented by Kalemli-Ozcan et al. (2015), I cleaned the dataset by dropping problematic firms and problematic observations in the sense of consistency which must hold according to some very basic accounting criteria. I firstly dropped the firms which report negative total assets, negative employment, negative sales or negative tangible fixed assets in any year. Secondly, I cleaned dataset from firm-year observations which does not satisfy basic accounting rules. In particular, I dropped firm-years having negative values for nonnegative balance sheet variables and zero value for nonzero variables such as total assets or shareholders funds, etc. I also deleted missing observations

[12] See Kalemli-Ozcan et al. (2015) for further details.

for total assets and liabilities, and shareholder funds. Lastly, further accounting identities are checked and observations without NACE sectoral information are dropped.[13]

Final sample used in estimations contains firm-year observations only in manufacturing sector according to NACE Rev. 2 classification between the years 2008 - 2016. Since production functions of manufacturing firms are mostly examined in economics literature, and a general consensus is reached on the issue, I focus on this sector. Moreover, manufacturing sector is the third largest sector composing 10.39% of all observations among all sectors. According to balance sheet measures, manufacturing sector comprises 18.83% of total assets in the Russian economy. Finally, Russian manufacturing sector generates 15.96% of total operational turnover in all years.

In the final sample, there are 812,898 firm-year observations with 218,291 unique firms. Average number of years for a firm is 3.72. According to the size classification of ORBIS AMADEUS, percentage of small, medium, large and very large firms are 15.4%, 36.3%, 29.3% and 19.1%, respectively.

3.1 Variable Definitions

Main variables used in this study are investment rate, cash flow rate, firm tangibility, leverage, interest payment, size and age. Definitions and constructions of variables are explained in Data Appendix in its full detail. Investment rates are calculated by perpetual inventory method with the help of aggregate price indices obtained from OECD - Domestic Produced Prices Manufacturing for final goods produced by manufacturing sector, and Russian Federation Federal Statistics Service for investment goods. Price of final goods are normalized to one in every year by reflecting annual changes in its price to the price of investment goods. Depreciation expenses are not available in the data set. However, 8% is assumed in calculations. Main variable in constructing ratios is tangible fixed capital stock. This variable is not decomposed further, but it contains machinery, equipment, building and lands by definition. Cash flow is measured by two different ways. The first one is earning before interest and taxes (EBIT) divided by tangible fixed assets. This measure is implied by both

[13]See Data Appendix on cleaning and construction of variables in more detail.

models in the paper. Second measure is, on the other hand, the one used more than the other one in the literature. It is calculated as sum of net income and depreciation expenses divided by tangible fixed assets. The first measure is the measure preferred more, since it does not contain depreciation which is not available in the data, and the structural models offer its use. It is shown in estimations that the first measure indeed provides better and more reasonable parameter estimates.

Firm tangibility is calculated as the ratio of tangible fixed assets to total assets. There are several measures for asset tangibility. Since main balance sheet variables of Russian data is not decomposed into sub items, other measures cannot be used.[14] Leverage, on the other hand, is defined as the ratio of long term debt stock to tangible fixed assets in real terms. This definition of leverage is also suggested by the model given in Section 4. The reason why long term debt stock is taken into account instead of other liabilities is that short term liabilities are generally used to cover operational expenses such as wage payments, inventory building and purchase of inputs and raw materials to be used in production process. There exist interest expenses in cash flow statements of firms to be used to calculate an "aggregate" interest rate for each firm. This rate is defined as interest payments divided by firm's long term debt stock. Since the term structure of firm's debt cannot be known, this variable is named as aggregate interest rate and used as a proxy for risk premium paid by firms in return of debt they take. Size is defined as the natural logarithm of tangible fixed assets as is proposed in Hadlock and Pierce (2010). Lastly, firm age is calculated by subtracting the current year from firm's year of incorporation as they are reported as in the data set. All variables except tangibility, size and age are trimmed 2% from upper and lower limits, because outliers are present and very effective on the results due to the very comprehensive nature of the data set.[15]

[14] See Almeida and Campello (2007) for an extensive treatment on different tangibility measures and robustness checks.

[15] When rates are constructed, tangible fixed assets is deflated by the relative price of capital calculated from aggregate price indices. Nominal variables on the other hand are assumed to have a price of one. See Data Appendix for further details on variable constructions.

3.2 Empirical Motivation

I firstly check the findings of AC (2007) in my sample of firms. AC (2007) originally uses a regression equation for firm investment of the form

$$\gamma_{i,t} = \alpha_1 Q_{i,t-1} + \alpha_2 c_{i,t} + \alpha_3 t_{i,t} + \alpha_4 (c_{i,t} t_{i,t}) + \sum_i \mu_i + \sum_t year_t + \epsilon_{i,t} \tag{1}$$

where $\gamma_{i,t}$ is the investment rate of the firm i at period t, $Q_{i,t-1}$ is average Q (market value of the firm in the stock market divided by the replacement cost of the firm's capital stock), $c_{i,t}$ is cash flow rate, $t_{i,t}$ is the tangibility measure, μ_i and $year_t$ stand for firm and time dummies, respectively. This equation is an augmented version of Q regression of investment. The presence of Q can be interpreted as a control for firm's future profitability. Hence α_1 is expected to be estimated positive.

Since all the firms are privately held in Russian data, I proxy future growth prospects of the firm using its gross operating revenue (turnover).[16] I have two options as is standard in the literature. Firstly, I proxy average Q with natural logarithm of firm's turnover-to-capital ratio. This strategy is followed by Gilchrist, Sim and Zakrajsek (2014) in their empirical investigation of how credit spreads affect investment rates along with firm specific uncertainty. Second possibility is, on the other hand, to use sales growth. As it is explained in the footnote 16, I proxy this rate with the growth rate of operating turnover. Hence, specification with turnover growth rate is used as a robustness check.

Table 1 represents estimation results of equation (1). While the first four columns present results with natural logarithm of turnover as a proxy for average Q, the last four columns make use of turnover growth. All results are in favor of prediction of AC (2007) that investment cash flow sensitivity is an increasing function of firm tangibility. This finding is robust to the choice of firm's future growth prospects. Columns 2, 4, 6 and 8 controls for firm size and age, since these are the variables that are reported as the most parsimonious among several in determining financial constraints by Hadlock and Pierce (2010). As it will be clear

[16] Actually a better measure would be sales data. Since I do not have it, I proxy sales data with turnover. A clear definition of turnover is not presented by BvD. It is highly possible that sales data is recorded under operational turnover variable, since sales data is completely missing for all firms in ORBIS Russian data set.

Table 1:

$\gamma_{i,t}$	(1) FE	(2) FE	(3) GMM	(4) GMM	(5) FE	(6) FE	(7) GMM	(8) GMM
$ln(o_{i,t})$	0.184***	0.0692***	0.180***	0.0759***				
	(0.002)	(0.002)	(0.01)	(0.005)				
$go_{i,t}$					0.179***	0.107***	0.275***	0.458***
					(0.002)	(0.002)	(0.017)	(0.061)
$c_{i,t}$	-0.0210***	-0.0239***	-0.0928***	-0.0611***	-0.0187***	-0.0248***	0.00842**	-0.0275***
	(0.001)	(0.001)	(0.009)	(0.004)	(0.000)	(0.001)	(0.003)	(0.006)
$t_{i,t}$	1.546***	1.692***	0.444***	-0.161**	1.184***	1.648***	0.0701	-0.343***
	(0.014)	(0.014)	(0.088)	(0.050)	(0.012)	(0.014)	(0.042)	(0.059)
$c_{i,t}t_{i,t}$	0.185***	0.201***	2.044***	3.593***	0.115***	0.174***	0.836***	1.933***
	(0.019)	(0.021)	(0.137)	(0.102)	(0.013)	(0.019)	(0.115)	(0.153)
$size_{i,t-1}$		-0.218***		0.0216***		-0.263***		0.0154**
		(0.002)		(0.004)		(0.002)		(0.006)
$age_{i,t-1}$		0.0277***		0.000649**		0.0319***		0.00197***
		(0.003)		(0.000)		(0.003)		(0.000)
N	334497	334497	334497	334497	354542	334497	354542	334497
R^2	0.206	0.266			0.138	0.269		
m_1			-22.73 (0.000)	-17.58 (0.000)			-39.51 (0.000)	-30.11 (0.000)
m_2			-4.682 (0.000)	-3.132 (0.002)			-1.458 (0.145)	-2.157 (0.031)
m_3			-1.892 (0.058)	-1.160 (0.246)			1.288 (0.198)	-0.589 (0.055)
Hansen's J			548.1 (56)	1915.2 (87)			1299.3 (65)	543.2 (69)
(p-value)			0.000	0.000			0.000	0.000

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

in Section 4, tangibility rate of the firm is also a very significant explanatory variable for the risk premium that is paid by the firms in order to reach debt finance. Inclusion of such controls do not affect the main conclusion. However, significant changes in coefficients of ln(turnover) and tangibility rates are observed.

System GMM is used in these estimations due to a highly possible endogeneity problems. When within estimators are obtained, variables are demeaned in order to cancel unobserved firm fixed effects out from the level equations. Such a transformation can yield correlated transformed regressors with the transformed error terms, since especially cash flow variables can be subject to same shocks that affect investment simultaneously. This problem could yield inconsistent parameter estimates. When GMMs are performed, optimal MA structure for the level error terms are considered in accordance with Arellano-Bond AR test statistics where m_i stands for the test statistics of the null hypothesis that first differenced error terms do not have i^{th} order serial autocorrelation. Because of the dynamic specification, maximum two lags are used as instruments for all explanatory variables considering proposed MA structure of level error terms.[17]

As it is stated above, these findings supporting AC (2007) seem contradictory to the evidence defended by FHP (1988) and its subsequent literature. Another interesting result is the finding that coefficient of cash flow is estimated negatively in almost all specifications. Table 2 represents another set of results the only difference than Table 1 being that measure of cash flow is changed as it is explained in Section 3.1 of variable definitions. As it will be clear from the next subsection, the benchmark model offers EBIT-to-capital ratio as the measure of cash flow. Besides the evidence supporting AC (2007), intuitively better parameter estimates are obtained in this case, that is tangibility itself positively affects investment rate, as it might be expected due to financial constraints channel.

3.3 A Benchmark Model of Investment and ICFS

In this subsection, I analyze a model of optimal firm investment with symmetric and quadratic adjustment costs in a partial equilibrium setting in order to test the positive relationship be-

[17]Selection of instruments and other econometric issues are examined in much more detail in Section 3.3.1.

Table 2:

$\gamma_{i,t}$	(1) FE	(2) FE	(3) GMM	(4) GMM	(5) FE	(6) FE	(7) GMM	(8) GMM
$ln(o_{i,t})$	0.188***	0.0710***	0.180***	0.0708***				
	(0.002)	(0.002)	(0.012)	(0.005)				
$go_{i,t}$					0.0668***	0.0621***	0.0645***	0.243***
					(0.003)	(0.002)	(0.005)	(0.021)
$c_{i,t}$	-0.0181***	-0.0206***	-0.0510***	-0.0374***	-0.0150***	-0.0216***	-0.0160***	-0.0212***
	(0.000)	(0.000)	(0.003)	(0.002)	(0.001)	(0.001)	(0.002)	(0.003)
$t_{i,t}$	1.516***	1.662***	0.675***	0.280***	1.231***	1.725***	0.00769	-0.0301
	(0.014)	(0.014)	(0.080)	(0.038)	(0.017)	(0.018)	(0.036)	(0.045)
$c_{i,t}t_{i,t}$	0.133***	0.139***	1.508***	2.146***	0.176***	0.216***	1.432***	1.656***
	(0.017)	(0.018)	(0.123)	(0.182)	(0.024)	(0.029)	(0.184)	(0.174)
$size_{i,t-1}$		-0.223***		0.0195***		-0.302***		0.00205
		(0.002)		(0.003)		(0.002)		(0.006)
$age_{i,t-1}$		0.0265***		0.000139		0.0256***		0.00250***
		(0.003)		(0.000)		(0.003)		(0.000)
N	334582	334582	334582	334582	255957	246985	255957	246985
R^2	0.214	0.277			0.112	0.280		
m_1			-19.91 (0.000)	-14.25 (0.000)			-12.41 (0.000)	-28.75 (0.000)
m_2			-2.529 (0.011)	-1.089 (0.276)			-2.850 (0.004)	-3.976 (0.000)
m_3			-1.916 (0.055)	-1.130 (0.259)			0.817 (0.414)	0.235 (0.814)
Hansen's J			855.6 (62)	4407.7 (93)			997.5 (65)	903.9 (74)
(p-value)			0.000	0.000			0.000	0.000

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

tween ICFS and tangibility proposed by AC (2007) with a structural investment equation in addition to the previous exercise. This specification of symmetric and quadratic adjustment costs is consistent with a large body of investment literature. It results in a linear Euler equation for optimal investment rate which can be estimated by appropriate econometric strategies. Contrary to adjustment costs, several studies are concentrated on the real option value of investment which can be theoretically explained by the presence of investment irreversibility. In this view, investment is assumed to be partially or completely irreversible in the sense that a positive wedge between the resale price of capital and its purchase price induces a cost on reversing the installed investment (disinvestment). This wedge mainly stems from the fact that used capital is subject to *lemons problem.* Hence, a wait-and-see channel is present, when an uncertainty shock hits the economy. Due to irreversibility of investment, it can be optimal to wait for the new information in the future without taking any action of investing or disinvesting in the current period. Thus investment (disinvestment) projects can be considered as call (put) options values of which can be calculated by standard asset pricing techniques.[18] However, Cooper and Haltiwanger (2006) shows in their simulations that assumption of quadratic adjustment costs of capital cannot be completely rejected along with irreversibility, fixed and asymmetric costs of investment. Hence, I stick to this assumption due to mainly its analytical convenience and I am more focused on financing constraints rather than effects of uncertainty on investment.

More importantly, perfect capital markets are assumed in this benchmark model. In other words, any firm can raise external or internal finance where the risk-free rate stands for the discount rate and the opportunity cost of both types of funds. Euler equation characterizing the optimal investment rate consists of cash flow as an explanatory. This result is different that of Q-equation, since average Q is predicted to be the only explanatory variable for optimal investment.

For timing convenience, and a better correspondence with the data and the notation, I assume that firms begin the period with its capital stock, k_{t-1} and a realized technology parameter which has an exogenous motion, θ_t. This exogenous motion does not need to be specified explicitly. In period t, firm decides on how much to invest. Since the production

[18] See Altug et al. (2003) for a comprehensive treatment on the subject.

takes place at the end of the period, invested capital becomes productive in the same period. Firm solves the following Bellman equation

$$V(k_{t-1}, \theta_t) = \max_{i_t, k_t} \left\{ \pi(k_t, i_t) + \frac{1}{1+r} \mathbb{E}_t \left[V(k_t, \theta_{t+1}) \right] \right\} \tag{2}$$

s.t.

$$k_t = (1-\delta)k_{t-1} + i_t \tag{3}$$

where $V(k_{t-1}, \theta_t)$ is the value function, $\pi(k_t, i_t)$ is net cash flow which is going to specified later, r is risk free interest rate which is assumed to be constant over time, and $\mathbb{E}_t(\cdot)$ is the expectation operator with respect to the information available at the beginning of the period t. In fact, this information only contains productivity parameter as a random variable that follows Markov process so that all expectations can be formed only using the latest realization.

Standard optimization yields the following first order conditions, where λ_t is Lagrange multiplier for the motion of capital,

$$\lambda_t = -\pi_2(k_t, i_t) \tag{4}$$

$$\pi_1(k_t, i_t) + \frac{1}{1+r} \mathbb{E}_t \left[V_1(k_t, \theta_{t+1}) \right] = \lambda_t \tag{5}$$

where $f_n(\cdot)$ denotes the partial derivative of a general function f with respect to its n^{th} argument.

We can define q as the change in value function due to a marginal change in current capital stock, k_{t-1}, i.e. marginal revenue product of capital. Therefore, $V_1(k_{t-1}, \theta_t) = q_t$. Envelope condition yields

$$q_t = V_1(k_{t-1}, \theta_t) = (1-\delta)\lambda_t \tag{6}$$

If (5) is substituted into (3), it can be obtained that q-regression equation of investment under the assumption of quadratic adjustment costs. When both first order conditions are exploited using the envelope condition, we can get Euler equation of investment as follows

$$-\frac{1-\delta}{1+r}\mathbb{E}_t\left[\pi_2(k_{t+1}, i_{t+1})\right] = -\pi_2(k_t, i_t) - \pi_1(k_t, i_t) \tag{7}$$

Immediate advantages of using Euler equation is to avoid highly possible mismeasurement errors in Q and to overcome lack of data as average Q is not present for any firm in my data set. Another important implication of Euler equation is that we can trace effects of expectations about future productivity of invested capital on current investment via one-step-ahead investment forecast. This feature yields a dynamic empirical specification for optimal firm investment.

The net cash flow at t can be specified as follows

$$\pi(k_t, i_t) = \max_{l_t}\left[a_t^{(1-\alpha)\chi} f(k_t, l_t)^{\chi} - w_t l_t\right] - g(i_t, k_t) - p_t i_t \tag{8}$$

$$f(k_t, l_t) = k_t^{\alpha} l_t^{1-\alpha} \tag{9}$$

$$g(i_t, k_t) = \frac{1}{2} b k_t \left(\frac{i_t}{k_t} - c\right)^2 \tag{10}$$

$$y_t = \max_{l_t}\left[a_t^{(1-\alpha)\chi} f(k_t, l_t)^{\chi} - w_t l_t\right] \tag{11}$$

where $f(k_t, l_t)$ is a function which is linearly homogeneous in its both arguments, $g(i_t, k_t)$ is the quadratic cost of adjustment.

In this specification, c can be interpreted as *normal rate of investment* which does not cause the firm any adjustment cost. In the literature, it is assumed to be equal to either zero or the depreciation rate of capital, δ. y_t stands for gross revenue after the wage bill is subtracted. The parameter χ captures the degree of decreasing returns to scale which can also be regarded as a consequence of market power the firm has. Actually, it can be shown that the above functional form for y_t can be the result of two different views. One possibility is that firms produce output with a constant returns to scale production function $f(k_t, l_t)$, but have market power on the price of the good which they sell. In this case, a_t can represent demand shocks to the market price, and χ captures the market power via price elasticity of demand. On the other hand, the second possibility is that firms produce their products by a decreasing returns to scale production function, $a_t^{(1-\alpha)\chi} f(k_t, l_t)^{\chi}$, which is subject to technology shocks, a_t, and sell them with a price which is normalized to one. Both views are complementary and more realistic than the assumption of perfect competition, because this specification induces firms to be able to earn strictly positive or negative profits in equilibrium.

It is assumed that firm has two optimization problems in every period. In the first one, firm chooses its labor demand statically. This choice does not induce any dynamics. On the other hand, the second choice of the firm is optimal investment which has a dynamic nature. After the gross revenue function is maximized out with respect to labor, we have the following functional form

$$y(k_t, \theta_t) = \max_{l_t} \left[a_t^{(1-\alpha)\chi} f(k_t, l_t)^{\chi} - w_t l_t \right] = \theta_t k_t^{\beta} \tag{12}$$

where

$$\beta = \frac{\alpha\chi}{1-(1-\alpha)\chi}$$

$$\theta_t = a_t \left[1-(1-\alpha)\chi\right] \left[\frac{(1-\alpha)\chi}{w_t}\right]^{\frac{(1-\alpha)}{1-(1-\alpha)\chi}}$$

As it is seen, θ_t captures all the random variables faced by the firm, both wage and technology (or demand) shock. Further notice that, if $\chi = 1$ under perfect competition, then $\beta = 1$. Henceforth, the Euler equation can be derived easily. Let the subscript i denote the firm i, $\gamma_{i,t} = i_{i,t}/k_{i,t}$ denote the investment rate, and $c_{i,t} = y_{i,t}/k_{i,t}$ denote the cash flow per physical capital as in equation (1), then

$$\mathbb{E}_t[\gamma_{i,t+1}] = \beta_0 + \frac{1+r}{1-\delta}\gamma_{i,t} - \frac{1}{2}\frac{1+r}{1-\delta}\gamma_{i,t}^2 - \frac{\beta}{b}\frac{1+r}{1-\delta}c_{i,t} \tag{13}$$

which relates the expected future rate of investment to current investment rate by a quadratic form, and to cash flow rate via the gross revenue parameter β.

3.3.1 Empirical Specification

If the error term is defined as $\gamma_{i,t+1} = \mathbb{E}_t[\gamma_{i,t+1}] + \epsilon_{i,t+1}$, and it is replaced by further components of firm-effect and time-effects as $\epsilon_{i,t+1} = \mu_i + \eta_{t+1} + \vartheta_{i,t+1}$, then equation (13) induces a benchmark regression equation as follows

$$\gamma_{i,t} = \beta_0 + \beta_1\gamma_{i,t-1} + \beta_2\gamma_{i,t-1}^2 + \beta_3 c_{i,t-1} + \mu_i + \eta_t + \vartheta_{i,t} \tag{14}$$

with expected parameter estimates of $\hat{\beta}_1 > 1$, $\hat{\beta}_2 < 0$ and $\hat{\beta}_3 < 0$. Because of the dynamic specification of the model, I am constrained to using GMM to estimate the parameters. First of all, pooled OLS will give inconsistent parameter estimates, since unobserved error term $\mu_i + \eta_t + \vartheta_{i,t}$ is necessarily correlated with $\gamma_{i,t-1}$ through firm-fixed effect, μ_i, that does not change over time. Similarly, fixed effects estimation methods such as the within estimator or first differencing will yield inconsistent estimators. To see this, consider the within estimator and demeaned transformation of the original model, which is obtained by subtracting equation in means from the original levels equation (14)

$$(\gamma_{i,t} - \bar{\gamma}_i) = \beta_1(\gamma_{i,t-1} - \bar{\gamma}_i) + \beta_2(\gamma_{i,t-1}^2 - \bar{\gamma_i^2}) + \beta_3(c_{i,t-1} - \bar{c_i}) + (\eta_t - \bar{\eta}) + (\vartheta_{i,t} - \bar{\vartheta}_i) \tag{15}$$

Means are represented by a bar on the corresponding variable in (14). They are firm-specific and calculated over the periods in which that firm has reported.

When OLS is attempted for (15) to get the within estimators, it is easily seen that parameter estimates will be biased due to the correlation between the explanatory variable $(\gamma_{i,t-1} - \bar{\gamma}_i)$ and the error term $(\vartheta_{i,t} - \bar{\vartheta}_i)$. This correlation stems from the fact that $\gamma_{i,t-1}$ is positively correlated with $\vartheta_{i,t-1}$ which is inside $\bar{\vartheta}_i$, hence inside the error term. Similarly, method of first differencing to eliminate fixed effects from the levels equation (14) yields inconsistent estimators. To see this, take the first difference of (14)

$$\Delta\gamma_{i,t} = \beta_1\Delta\gamma_{i,t-1} + \beta_2\Delta\gamma_{i,t-1}^2 + \beta_3\Delta c_{i,t-1} + \Delta\eta_t + \Delta\vartheta_{i,t} \tag{16}$$

where $\Delta x_t = x_t - x_{t-1}$. When OLS is applied for (16), inconsistent parameter estimates are obtained, since the explanatory variable $\Delta\gamma_{i,t-1}$ and the error term $\Delta\vartheta_{i,t}$ are necessarily correlated due to the correlation between $\gamma_{i,t-1}$ and $\vartheta_{i,t-1}$.

Although the estimation of first-differenced transformation (16) by OLS yields inconsistent estimates, we have to exploit this transformation to eliminate unobserved firm fixed-effects. Note that dummies for each firm cannot be used due to "large N, small T" property of our panel. First-differenced equation (16) remains some problems for the consistent estimation of parameters. These are that explanatory variables are endogenous as shown above,[19] and autocorrelation structure of error terms are disturbed.[20] These observations force us to employ GMM methods for the consistent estimation of parameters in (16).

There exist two different kinds of GMM which can be employed *together* in this case that is summarized by two equations; (14) is untransformed in levels, and (16) is transformed in first-differences. The first kind is called *difference GMM* which is proposed by Arellano and Bond (1991). This method offers to exploit moment conditions which can be derived from levels equation in (14). In particular, if it is assumed that regressors in (14) are predetermined, as it is in this case, then lagged values in levels at dates $t-s$ for $s \geq 2$ can be used as instruments for their own first differences in the transformed equation (16).[21] Since the more remote lags do not provide additional information as being valid instruments, I use two appropriate lags as the instruments in the estimations in accordance with the MA structure of errors in levels equation (14).[22]

Arellano and Bover (1995) suggests an additional set of moment conditions which can increase efficiency of difference GMM estimators. This strategy is called *system GMM*. It makes use of the fact that predetermined variables in levels equation can be instrumented

[19]Notice that all three explanatory variables are predetermined with respect to the innovation $\vartheta_{i,t}$. This is obvious for lagged investment rate $\gamma_{i,t-1}$ as explained in previous paragraphs. Similarly, $\vartheta_{i,t-1}$ and $(y/k)_{i,t-1}$ are correlated, because $(y/k)_{i,t-1} = \theta_{i,t-1}k_{i,t-1}^{\beta-1}$ and $\vartheta_{i,t-1}$ can easily be assumed to be correlated with $\theta_{i,t-1}$, since it is considered as the state variable of the period $t-1$. Thus, first differences of these predetermined explanatory variables have to be correlated with transformed error terms in (16) due to the correlation of lagged explanatory variables with $\vartheta_{i,t-1}$.

[20]Even if it is assumed initially that $\mathbb{E}(\vartheta_{i,t}\vartheta_{j,s}) = 0$, $\forall i, j, t, s$; i.e. error terms are serially uncorrelated after subtracting firm and time fixed-effects, it is clear that $\mathbb{E}(\Delta\vartheta_{i,t}\Delta\vartheta_{i,t-1}) \neq 0$. So, transformed error terms in (16) cannot be serially uncorrelated.

[21]This is the case if $\{\Delta\vartheta_{i,t}\}$ follows AR(0) process. In particular, if AR(p) process can be validated for the series $\{\Delta\vartheta_{i,t}\}$, then our instruments would suffer from weak instruments problem. For example, $\gamma_{i,t-s}$ for $1 \leq s \leq p+1$ would be correlated with $\vartheta_{i,t-s}$, thus with $\Delta\vartheta_{i,t-s+1}$ and $\Delta\vartheta_{i,t}$, due to the presence of AR(p) process.

[22]See footnote 24.

by suitable lags of their own first differences, as long as first differences can be assumed to be uncorrelated with firm-fixed effects. For example, if $\{\vartheta_{i,t}\}$ is assumed to be serially uncorrelated, then $\mathbb{E}[\Delta x_{i,t-1}(\mu_i+\vartheta_{i,t})] = 0$ where $x_{i,t-1}$ is one of regressors in (14).[23] [24] Bond and Van Reenen (2007) states that these additional moment conditions are over-identifying restrictions that can be tested, and once they are valid, they can significantly improve on both the asymptotic and small sample properties of difference GMM estimators.

In all GMM estimations, two-step procedure is applied. It must be noted that even though two-step is asymptotically more efficient, reported standard errors tend to be extremely downward biased (Arellano & Bond, 1991; Blundell & Bond, 1998). Therefore, to correct this bias, the correction to two-step covariance matrix that is proposed by Windmeijer (2005) is performed during estimations. This strategy makes two-step estimations more efficient than first-step robust estimation.

To check the validity of instruments, I use Hansen's J test of overidentifying restrictions, since it is robust to heteroskedasticity. In order to verify that error terms are not serially correlated, m_1, m_2 and m_3 statistics are included as tests for first, second and third order serial correlation in residuals from differenced equation, respectively. Year dummies are always included in regressions.

3.3.2 Estimation Results

Before moving on the results, I would like to compare equations (1) and (14). In equation (14), future expectations are captured by the lagged investment rate, while lagged (beginning-of-period) average Q proxies for the marginal productivity of invested capital.

[23]Notice that the unobserved error term in levels equation is the sum $\mu_i + \vartheta_{i,t}$. We already know that, the correlation between firm fixed-effects μ_i and other predetermined variables is the main cause of the bias in parameter estimates when OLS and the within estimators are used.

[24]As an example, if MA(0) is assumed for the level errors, then lags dated $t-2$ and $t-3$ are used as instruments for the transformed equation. In this case, the first lag of differenced variables dated $t-1$ are used as instruments in levels equation as well. If MA(q) is detected in level errors, then lags dated $t-(q+2)$ and $t-(q+3)$ are used as instruments for the variables subscribed $t-1$. Similarly, the first differenced variables dated $t-(q+1)$ are used as instruments for regressors dated $t-1$ in levels equation for this case. Please note that, when an endogenous variable is present in levels equation, then date of instruments would not change. Date of instruments are completely determined by the MA structure of the errors in levels equation.

Equation (14) consists of square of lagged investment rate due to quadratic adjustment costs specification. Moreover, cash flow terms are common in both equations with a slight difference. Structural equation (14) employs lagged cash flow variable (realized at the beginning of period t), not the current cash flow which is actually assumed to be realized at the end of the period t. This specification is more intuitive in the sense that choice variables in a given period are determined by the state variables which are actually realized at the end of the previous period. However, tangibility rate at t is utilized in both equations, since end-of-period tangibility matters more for creditworthiness of the firm. This view is consistent with that of Caggese (2007) in the sense that creditors might consider their loans as a part of collateral which is going to be saved in case of a default. In other words, what matters for the creditors is the realized tangible capital stock at the beginning of the next period. Endogeneity issues possibly arising due to the presence of presumably endogenous tangibility rate $t_{i,t}$ are overcome during the estimations by specifying appropriate lags as instruments as explained in the footnote 24.

In Table 3 column 1, no additional variable is added to equation (14). MA(1) is allowed for this equation in accordance with Arellano-Bond autocorrelation test. β_1 is estimated as expected in direction, whilst its point estimate is less than 1. Square of lagged investment rate is estimated statistically insignificantly. As opposed to Bond and Meghir (1994) and Bond et al. (2003), coefficient of cash flow is estimated negatively compatible with the expectation of the model. Both papers reach positive coefficient estimates of cash flow, and they both interpret positive and higher cash flow coefficients as a sign of higher levels of financing constraints in the economy. Since this model does not predict the absolute value of β_3, it is not determinate how much higher this coefficient is estimated. The main problem with this estimation is high values of Hansen's J statistics. Overidentifying restrictions are not jointly valid, i.e. instruments are not jointly valid instruments for this specification. This finding questions the validity of the model with its all aspects.

This problem of high Hansen's J statistics comes to exist as a common problem when other investment equations are also estimated. Same equations with all possible definitions of the variables do not fix this problem, whereas same equations are estimated in other papers as in Bond and Meghir (1994) and Bond et al. (2003) with normal values of Hansen's J statistics.

Table 3:

$\gamma_{i,t}$	(1) GMM	(2) GMM	(3) GMM	(4) GMM
$\gamma_{i,t-1}$	0.733***	0.566***	0.348***	0.449***
	(0.032)	(0.024)	(0.030)	(0.029)
$\gamma^2_{i,t-1}$	0.0559	-0.0724*	-0.0897**	-0.138***
	(0.031)	(0.030)	(0.030)	(0.037)
$c_{i,t-1}$	-0.00864***	-0.00165	-0.0153***	-0.0207***
	(0.002)	(0.002)	(0.003)	(0.003)
$t_{i,t}$		0.146***	0.126**	0.0509
		(0.040)	(0.042)	(0.042)
$c_{i,t-1}t_{i,t}$			0.674***	0.931***
			(0.066)	(0.091)
$size_{i,t-1}$				0.0145*
				(0.006)
$age_{i,t-1}$				0.00174***
				(0.000)
N	268242	268242	268242	268242
R^2				
m_1	-23.70 (0.000)	-20.68 (0.000)	-17.50 (0.000)	-18.72 (0.000)
m_2	11.82 (0.000)	10.85 (0.000)	6.970 (0.000)	7.810 (0.000)
m_3	0.632 (0.527)	0.580 (0.562)	-1.007 (0.314)	-1.259 (0.208)
Hansen's J	248.0 (46)	418.9 (62)	232.2 (75)	327.2 (91)
(p-value)	0.000	0.000	0.000	0.000

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The model with costly debt finance introduced in Section 4 proposes an explanation for this puzzle.

Column 2 of Table 3 adds tangibility rate as a control which proxies financing constraints firms face. Coefficient of tangibility is estimated correctly. All else being equal, a positive and highly significant relationship between asset tangibility and investment rate might reflect the importance of financing constraints on the optimal rate of investment. It is worth noting that cash flow is estimated insignificantly when tangibility is added to the equation.

Column 3 and 4 of the same table test the proposition of AC (2007). Point estimates of the interaction term between cash flow and tangibility are 0.674 and 0.931, respectively. As stated earlier, this finding contradicts with the standard view of excess sensitivity literature. AC (2007)'s findings are also mitigated by a structural equation for the firm investment, as well as Q-type of equations of Section 3.1.

AC (2007)'s findings are replicated in the Russian panel of firms all of which are privately held and subject to serious financial constraints. Equation (1) is constructed as in AC (2007) and estimated with some proxy variables such as turnover instead of sales and average Q. Combinations on the measures of future growth prospects and cash flow variables are sperately considered. In all 16 columns of both Tables 1 and 2, positive and significant coefficient estimates of cash flow-tangibility interaction term are reached. Due to possible misspecification and mismeasurement problems, a structural model is developed and estimated by system GMM which is the appropriate method for dynamic panel models. AC (2007)'s findings are also replicated by this structural equation. In the next sections, a model of investment with costly debt finance is proposed in order to analytically show the positive relationship between tangibility and ICFS, then Euler equation derived from this model is estimated and tests for AC (2007)'s propositions are conducted. Moreover, a possible reason for high Hansen's J statistics is also alleged.

4 A Model of Investment with Costly Debt Finance

In this section, I extend the benchmark model with costly debt finance. In this setup, firms pay the debt stock inherited from the previous period, and borrow to finance its investment and operational expenses. Interest payment on the debt stock is determined by the firm characteristics. Bond and Meghir (1994) assume that this interest payment is only an increasing function of firm leverage, and linearly homogenous in it. It is differently assumed in this model that firm's interest payment in return of loans it gets is a function of its leverage, tangibility rate and other unobservable factors affecting borrowing costs confronted in debt markets. Leverage is defined as the long term debt of the firm divided by its real tangible fixed capital stock.[25] Tangibility rate is defined as the ratio of tangible fixed assets to firm's total assets as it is defined as earlier. Unobservable firm characteristics are usually measured by financial constraint indices.

This flexible specification is sufficient to derive analytical expressions to test AC (2007)'s proposition, as well as it is intuitively appealing. The intuition behind this specification is as follows. Asymmetric information is the key factor in determining the cost of borrowing which essentially can be considered as highly positively correlated with the risk premium a firm pays when it borrows. Risk premium can be defined as the spread between the interest rate that the firm pays and the risk-free rate in the economy. If asymmetric information and deadweight losses in case of default are present, then the bank must be compensated against the default risk of its loan with a premium on the risk-free rate. Hence, the more risky the firm is, the higher the risk premium it pays.

Riskiness, on the other hand, might be determined by many factors either firm specific or sector specific. Among the firm specific factors, leverage is the one which is considered most in the literature. Consider two identical firms which only differ from each other in leverage. Highly levered firm is expected not to generate sufficient cash flow in the future to clear its debt comparing to the other, as the amount of capital per unit of debt, which is the main factor of production and sales, is less than the other firm. Secondly, tangibility rate can be declared another determinant of interest payment in return of firm's loans. If

[25] While all prices are normalized to one, price of capital is allowed to vary in both models. Hence, debt and capital stock have different prices.

two firms are the same in leverage and size, then the one with higher rate of tangible assets is expected to be affected less by collateral constraints, since it has higher level of capital which can be collateralized. Thus, expected loss of creditors are diminished in case of a default on debt, implying low levels of risk premium that the firm must pay. Lastly, other factors might consist of many factors as will be explained in next subsection. In short, as leverage increases, interest payment is expected to increase, and as tangibility increases, it is expected to decrease, when other controls are hold constant.

Analytically, let $r(l_{i,t-1},\ t_{i,t};\ controls_{i,t-1})$ denote the interest rate which the firm i is subject to in period t. Note that firms observe beginning-of-period variables excluding tangibility as it is explained earlier. Following features are assumed for the function $r(\cdot)$

Assumption 1. *Let $r_i(\cdot,\cdot)$ denotes the partial derivative with respect to i^{th} argument of the function, for $i = 1, 2$, and hold other $controls_{i,t-1}$ constant;*

- $r_1(l_{i,t-1}, t_{i,t}) > 0$
- $r_2(l_{i,t-1}, t_{i,t}) < 0$
- $r_{12}(l_{i,t-1}, t_{i,t}) < 0$

4.1 Risk Premium and Its Determinants

In this subsection, determinants of risk premium are investigated, and empirical evidence supporting Assumption 1 is presented. Whited (1992) emphasizes the importance of a comprehensive treatment of borrowing constraints in order to understand investment-financial constraints linkages better. In this vein, several indices are developed. Kaplan and Zingales (1997) create financial constraints scores ranging 1 to 5 using qualitative data on FHP's original sample for the firms such information is available. Then, they construct financial constraints index (hereafter KZ index) by estimating a logit model by which cash flow, Tobin's Q, leverage, dividend-to-capital and cash-to-capital are used as explanatory variables. This study influenced construction of other indices aimed at measuring gradual changes at financial constraints facing firms.

Whited and Wu (2006) estimated a different index (hereafter WW index) using observable variables of cash flow, dividend dummy, leverage, firm size, industry and firm sales growths. Both leverage and cash flows are common explanatory variables in KZ and WW indices, and they affect degree of financing constraints positively and negatively, respectively. Also, Lamont et al. (2001) follows a similar strategy that of KZ. However, both Whited and Wu (2006) and Lamont et al. (2001) are mainly focused on an investigation of presence of a common factor behind the stock returns of financially constrained firms instead of their investment decisions.

On the other hand, Hadlock and Pierce (2010) is more focused on the fundamental determinants of financial constraints. They comprehensively analyse KZ and WW indices with their sample of firms. By adding exogenous variables of firm size and age into the specifications offered by KZ and WW, they try to reach more parsimonious specifications for their ordered logit model. As a result, they propose an index of financing constraints with cash flow, leverage as endogenous explanatory variables and size, age as exogenous explanatory variables. Hadlock and Pierce (2010) warns researchers not solely rely on this index due to endogeneity problems in investment studies. Instead, they recommend a slightly modified index which is only constructed by firm size, its square and age, and they name it SA (size-age) index. Firm size is defined as the natural logarithm of real tangible capital stock the firm. Following specification and parameter estimates are proposed to construct the SA index.

$$sa_{i,t} = -0.737size_{i,t} + 0.043size_{i,t}^2 - 0.040age_{i,t} \tag{17}$$

Equation (17) is used to construct the index for the Russian sample. But, some caveats are in order. Parameter estimates of (17) are obtained from Compustat US data which consists of large and publicly traded firms. Therefore, these estimates are open to criticism of sample selection bias. For example, squared size is present in (17) to control for a convex or concave specification, whereas there might exist a threshold in our data set for such a relationship to be present. Very small firms might be completely rationed out from credit markets, or they might use only trade credits just to maintain their operations. Hence, a significant size squared variable might not be consistent for the very small firms.

Another index proposed by Hadlock and Pierce (2010) along with SA index is given by

$$fc_{i,t} = -0.592c_{i,t} + 1.747l_{i,t} - 0.357size_{i,t} - 0.025age_{i,t} \tag{18}$$

where $c_{i,t}$ is cash flow measured as net income plus depreciation, $l_{i,t}$ is firm leverage. This index will not be used in my analysis, since it already contains leverage linearly.

Finally, risk premiums are not observable in balance sheet data I have. In cash flow statements, the amount paid as interest on the debt stock of each firm in every period is present. However, because the term structure of firms' debt differs from each other significantly, it is almost impossible to identify variation in the amount of debt which is due in current period. Hence, I cannot calculate the exact risk premium firms pay from the balance sheet and cash flow data. But, this premium can be proxied by the ratio of interest paid to the long term debt stock. This ratio actually captures the "aggregate" interest rate on the current debt stock of firms. As the unobservable risk premium increases for a firm, this interest payment ratio of the firm is expected to increase due to the monotonic relationship between them. The correlation between two variables are actually dependent on how the risk free rate in the market is determined. There are two options. Firstly, it is quite common to take the rate of return on government bonds as the risk free rate. Since, this rate is the same for all firms in the economy in a given year, the correlation would not be affected by this choice. Second option is to take the interest rate paid by the biggest firm for a given sector. In this case, the correlation is affected by the sector-fixed effects. However, when sector-fixed effects are controlled for in the regressions, they are estimated to be insignificant.

Proposed partial derivatives given by Assumption 1 are estimated considering "aggregate" interest rate being strongly correlated with risk premium. Hence, this measure is regressed on lagged leverage, current tangibility and lagged SA index by using appropriate methods. Since SA index contains firm size as natural logarithm of firm's capital stock, and lagged capital stock is a linear function of lagged investment; firm size, hence the SA index, is considered predetermined in columns 6 and 8 of Table 4. Thus, GMM is also applied due to this consideration. In these specifications, leverage and tangibility variables are considered as strictly exogenous to the error terms.

Table 4 presents estimation results. Low R^2s for fixed effects estimations are common in the results. Coefficients are correctly estimated with respect to expected signs in all specifications. However, coefficients of leverage and the interaction term are estimated very low. In columns 7 and 8, size and age are linearly controlled for instead of inclusion of the SA index. As it is expected, same coefficient signs for asset tangibility, leverage and their interaction are obtained. Also, significant improvement in the coefficient of tangibility is observed in column 8. This result might be due to exclusion of size squared variable from the regression.[26] If columns 4 and 5 are compared, exclusion of SA index weakens the magnitudes of point estimates of other regressors. This finding can be explained by the need for inclusion of firm specific controls while investigating effects of tangibility and leverage on the borrowing costs. To sum up, evidence presented in Table 4 supports the postulation in Assumption 1.

4.2 Model Solution and Euler Equation

The model is solved and Euler equations characterizing the optimal investment are derived by assuming Assumption 1. Because all the firms are privately held in the panel, they do not make dividend payments. However, dividend payments of publicly listed companies can be considered as a payment to the owner of the firm in the case of privately held companies. Thus, the same assumption of nonnegativity of dividends can be maintained in our case. Let me suppress the firm notation i temporarily, and $d(k_t, i_t, b_t, b_{t-1})$ denote such payments to the owner of the firm as explained above. Hence,

$$d(k_t, i_t, b_t, b_{t-1}) = \pi(k_t, i_t) + b_t - (1 + r(l_{t-1}, t_t))b_{t-1} \tag{19}$$

$$d(k_t, i_t, b_t, b_{t-1}) \geq 0 \tag{20}$$

hold $\forall t = 0, 1, 2, ...$, where b_t denotes the debt stock at the end of period t, $l_{t-1} = b_{t-1}/k_{t-1}$ denotes leverage and t_t denotes tangibility rate as earlier, $r(\cdot)$ denotes firm specific interest rate on firm's debt repayments. Let $r(b_{t-1}/k_{t-1})$ stand for the whole function $r(l_{t-1}, t_t; sa_{t-1})$

[26] Exclusion of SA index merely amounts to exclusion of size squared when size and age remain as controls.

Table 4:

$r_{i,t}$	(1) FE	(2) FE	(3) FE	(4) FE	(5) FE	(6) GMM	(7) FE	(8) GMM
$sa_{i,t-1}$	0.0406***	0.0426***	0.0524***	0.0520***		0.0949***		
	(0.003)	(0.003)	(0.004)	(0.004)		(0.008)		
$t_{i,t}$		-0.0143**	-0.0177***	-0.0161**	0.00623	-0.0637***	-0.0152**	-0.147***
		(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
$l_{i,t-1}$			0.00152***	0.00166***	0.000762*	0.00142***	0.00191***	0.00403***
			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$l_{i,t-1}t_{i,t}$				-0.00127	-0.00666***	-0.00611***	-0.00385**	-0.00338**
				(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$size_{i,t-1}$							0.0146***	0.0446***
							(0.000)	(0.002)
$age_{i,t-1}$							-0.00151	-0.000713***
							(0.001)	(0.000)
N	93239	93239	87343	87343	94596	87343	94596	94596
R^2	0.015	0.015	0.016	0.016	0.012		0.017	
m_1						-17.82 (0.000)		-19.27 (0.000)
m_2						-3.255 (0.001)		-4.364 (0.000)
m_3						-0.263 (0.793)		-0.582 (0.561)
Hansen's J						631.2 (14)		268.7 (14)
(p-value)						0.000		0.000

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

and satisfy the Assumption 1. In other words, the firm operates and generates the revenue $\pi(k_t, i_t)$, makes its debt payments inherited from the previous period $(1 + r(l_{t-1}, t_t))b_{t-1}$ and lastly take loans in order to sustain its operational activities b_t.

Nonnegativity constraint (20) can be justified by two main reasons. Firstly, this condition actually captures the fact that the firm maintains its operations and stays active in period t. Because our data set completely consists of actively operating firms in every year, this condition can be accepted as a valid one. Secondly, the constraint (20) is a consequence of the postulation that the firm and its owner are different entities legally,i.e. separation of the budgets of the firm and its owner as a household.

The firm maximizes its value by solving the following Bellman equation,

$$V(k_{t-1}, b_{t-1}, \theta_t) = \max_{i_t, k_t, b_t} \left\{ d(k_t, i_t, b_t, b_{t-1}) + \frac{1}{1+r} \mathbb{E}_t \left[V(k_t, b_t, \theta_{t+1}) \right] \right\} \tag{21}$$

subject to the constraints (3), law of motion for capital stock, and (20). First order conditions yield

$$\lambda_t = -(1 + \mu_t)\pi_2(k_t, i_t) \tag{22}$$

$$(1 + \mu_t)\pi_1(k_t, i_t) + \frac{1}{1+r} \mathbb{E}_t \left[V_1(k_t, b_t, \theta_{t+1}) \right] = \lambda_t \tag{23}$$

$$1 + \mu_t + \frac{1}{1+r} \mathbb{E}_t \left[V_2(k_t, b_t, \theta_{t+1}) \right] = 0 \tag{24}$$

where λ_t is the lagrange multiplier of the constraint (3) as before, and μ_t is that of the constraint (20). Equations (22) and (23) are correspondents of (4) and (5) from the previous model, respectively. The only difference between (4)-(5) and (22)-(23) is the inclusion of $(1 + \mu_t)$ multiplicatively. Equation (24) is due to optimal choice of b_t. Complementary and slackness conditions derived from Kuhn-Tucker theorem are

$$\mu_t \geq 0 \tag{25}$$

$$\pi(k_t, i_t) + b_t - (1 + r(b_{t-1}/k_{t-1}))b_{t-1} \geq 0 \tag{26}$$

$$\mu_t \left[\pi(k_t, i_t) + b_t - (1 + r(b_{t-1}/k_{t-1}))b_{t-1} \right] = 0 \tag{27}$$

When the optimally derived policy functions are substituted in the Bellman equation (21) and appropriate derivatives of the value function are taken, following equations are obtained as Envelope conditions [27]

$$V_1(k_{t-1}, b_{t-1}, \theta_t) = \lambda_t(1-\delta) + (1+\mu_t)r'(l_{t-1})l_{t-1}^2 \tag{28}$$

$$V_2(k_{t-1}, b_{t-1}, \theta_t) = -(1+\mu_t)[1 + r'(l_{t-1})l_{t-1} + r(l_{t-1})] \tag{29}$$

where $r'(l_{t-1}) = r_1(l_{t-1}, t_t)$. Equation (28) is the correspondent of (6) which is an expression for firm's Q. When equations (24) and (29) are solved simultaneously,

$$1 + \mu_t = \frac{1}{1+r}\left[1 + r'(l_{t-1})l_{t-1} + r(l_{t-1})\right]\mathbb{E}_t\left(1 + \mu_{t+1}\right) \tag{30}$$

is obtained as an Euler equation for the shadow value of the nonnegativity constraint (20). This equation determines the optimal path of the unobserved sequence μ_t. When equations (22), (23) and (28) are solved together, Euler equation for the optimal investment rate is obtained as follows

$$(1+\mu_t)\pi_1(k_t, i_t) + \frac{1}{1+r}\mathbb{E}_t\left[-(1+\mu_{t+1})\pi_2(k_{t+1}, i_{t+1})(1-\delta) + (1+\mu_{t+1})r'(l_t)l_t^2\right] = -(1+\mu_t)\pi_2(k_t, i_t) \tag{31}$$

Finally, when (31) is rearranged and (30) is substituted into, the following equation is obtained corresponding to (7)

$$-\frac{1-\delta}{1+r}\mathbb{E}_t\left[\frac{1+\mu_{t+1}}{1+\mu_t}\pi_2(k_{t+1}, i_{t+1})\right] = -\pi_1(k_t, i_t) - \pi_2(k_t, i_t) - R_t l_t^2 \tag{32}$$

where

$$R_t = \frac{r'(l_t)}{h_t}, \text{ and } h_t = 1 + r'(l_t)l_t + r(l_t) \tag{33}$$

and when the profit function π_t is specified by equations (8)-(11) as before, the following equation is obtained characterizing the optimal path of firm investment rate as

$$\mathbb{E}_t\left[\frac{1+\mu_{t+1}}{1+\mu_t}\gamma_{t+1}\right] = \beta_0 + \frac{1+r}{1-\delta}\gamma_t - \frac{1}{2}\frac{1+r}{1-\delta}\gamma_t^2 - \frac{\beta}{b}\frac{1+r}{1-\delta}c_t - \frac{R_t}{b}\frac{1+r}{1-\delta}l_t^2 \tag{34}$$

[27]See Appendix for the derivation.

Equation (34) holds for all firms whether the nonnegativity constraint binds or not. Bond and Meghir (1994) analyze a model of hierarchy of finance with costly equity and debt finance, and they also obtain leverage squared as an explanatory variable as it is the case in (34). Indeed, the only difference of right hand side of (34) and their Euler equation is that they add output term as a control for imperfect competition.

In this study, I do not split the sample into two groups as financially constrained and unconstrained, and analyze (34) for two distinct groups separately. Instead, I exploit one of two optimality conditions (30) in order to eliminate the expectations term in (34). Rearrange (30) and define u_{t+1} as the error term between the realization and the expectation of $(1 + \mu_{t+1})/(1 + \mu_t)$ as follows

$$\frac{1 + \mu_{t+1}}{1 + \mu_t} = \frac{1 + r}{h_t} + u_{t+1} \tag{35}$$

where h_t is defined as in (33). When the same method is applied for (34), it is obtained that

$$\frac{1 + \mu_{t+1}}{1 + \mu_t}\gamma_{t+1} = r.h.s_t + \epsilon_{t+1} \tag{36}$$

where $r.h.s_t$ stands for the right hand side of (34). When the left hand side of (35) is replaced in (36), the following equation is obtained after $r.h.s_t$ is replaced and the resulting equation is backdated for one period,

$$\gamma_t = \beta_0 + \frac{h_{t-1}}{1-\delta}\gamma_{t-1} - \frac{1}{2}\frac{h_{t-1}}{1-\delta}\gamma_{t-1}^2 - \frac{\beta}{b}\frac{h_{t-1}}{1-\delta}c_{t-1} - \frac{r'(l_{t-1})}{b(1-\delta)}l_{t-1}^2 + \frac{h_{t-1}}{1+r}(\epsilon_t - u_t\gamma_t) \tag{37}$$

where

$h_{t-1} = 1 + r_1(l_{t-1}, t_t)l_{t-1} + r(l_{t-1}, t_t) > 0$, and

$r'(l_{t-1}) = r_1(l_{t-1}, t_t) > 0$

Equation (37) is very interesting in the sense that $(h_{t-1}/(1+r))(\epsilon_t - u_t\gamma_t)$ is the error term of the regression equation, and it contains the explanatory variable γ_t. However, because γ_t is a function of explanatory variables of (37) intrinsically, correlation between explanatory variables and the error term cannot be equal to zero. This implies that right hand side variables of (37) cannot be accepted as predetermined as is standard in the literature, hence lagged variables cannot be used as valid instruments in estimations. The only solution to overcome this problem is to find different instruments other than regressors' own lags. This finding can be regarded as an explanation to the observation that Hansen's J statistics always rejects the null hypothesis that instruments are jointly valid in almost all specifications and different trials.

4.3 Sensitivity of ICFS to Tangibility

Equation (37) implies that regressors' coefficients depend on the level of risk premium that the firm pays. When the expression for h_{t-1} is replaced in (37), presence of interactions between tangibility rate and the regressors in the regression equation can be seen. It is observed at this point that not only the coefficient of cash flow (ICFS) should vary with tangibility, but also those of all regressors. After substitution, the following equation is obtained

$$\begin{aligned}\gamma_t = \beta_0 + \frac{1}{1-\delta}\gamma_{t-1} + \frac{\bar{r}(l_{t-1},t_t)}{1-\delta}\gamma_{t-1} + \frac{1}{2}\frac{1}{1-\delta}\gamma_{t-1}^2 - \frac{1}{2}\frac{\bar{r}(l_{t-1},t_t)}{1-\delta}\gamma_{t-1}^2 \\ - \frac{\beta}{b}\frac{1}{1-\delta}c_{t-1} - \frac{\beta}{b}\frac{\bar{r}(l_{t-1},t_t)}{1-\delta}c_{t-1} - \frac{r_1(l_{t-1},t_t)}{b(1-\delta)}l_{t-1}^2 + \frac{h_{t-1}}{1+r}(\epsilon_t - u_t\gamma_t) \qquad (38)\end{aligned}$$

where

$$\begin{aligned}\bar{r}(l_{t-1},t_t) = r_1(l_{t-1},t_t)l_{t-1} + r(l_{t-1},t_t) \\ \bar{r}_2(l_{t-1},t_t) = r_{12}(l_{t-1},t_t)l_{t-1} + r_2(l_{t-1},t_t) < 0 \qquad (39)\end{aligned}$$

due to empirically verified Assumption 1. Hence, the following specification can be formed

$$\gamma_{i,t} = \beta_0+\beta_1\gamma_{i,t-1}+\alpha_1\gamma_{i,t-1}t_{i,t}+\beta_2\gamma_{i,t-1}^2+\alpha_2\gamma_{i,t-1}^2t_{i,t}+\beta_3c_{i,t-1}+\alpha_3c_{i,t-1}t_{i,t}+\alpha_4l_{i,t-1}^2t_{i,t}+\mu_i+\eta_t+\vartheta_{i,t} \qquad (40)$$

with expected parameter estimates of $\beta_1 > 0$, $\alpha_1 < 0$; $\beta_2 < 0$, $\alpha_2 > 0$; $\beta_3 < 0$, $\alpha_3 > 0$; and $\alpha_4 > 0$. Among all parameters, AC (2007) is focused on α_3; and the expected sign of this parameter, which is completely derived from a dynamic model of optimal firm investment with costly debt finance, is consistent with the findings of AC (2007). Moreover, this model also predicts estimated signs of other interaction parameters as well. These expected signs can be used as a test of the model along with Hansen's J statistics. As stated earlier, Hansen's

J statistics cannot be solely used in this framework, due to the proposed endogeneity of all regressors in both (37) and (40).

4.4 Estimation Results

In this subsection, equations (37), (40) and its extensions are estimated. Econometric issues explained in Section 3.2.1 are taken into account during estimations and instrument choices. In the last section, it is shown why lagged explanatory variables are not valid instruments due to the structure of the error term. However, I do not propose valid instruments outside of the model at this point. Rather, equations are estimated by system GMMs as done earlier, and signs of estimations are checked as a test of the validity of the model with costly debt finance. Appropriate lags are chosen as instruments, as if regressors are assumed to be predetermined with respect to the error term.

All four columns of Table 5 are estimated for the full sample. Usual practice of the literature is to obtain different specifications for financially constrained and unconstrained firms, and to test the proposed differences by parameter estimations. Such sample splitting tests are performed generally according to dividend payout policies of firms or whether firms have bond ratings or not. Because all the firms are privately held, and I can reach an equation which is valid for all firm-year observations, i.e. equation (37), it is preferred to exploit all observations in estimations. Lastly, system GMMs are preferred to difference GMMs, since significant improvements on both efficiency and estimates in terms of magnitudes are observed. Results are not changed qualitatively when difference GMMs are applied. Appropriate MA processes are considered for the level errors following Arellano-Bond autocorrelation test in order to determine valid instruments suitably.

First column of Table 5 presents parameter estimates for the equation (37). Only the coefficient to square of lagged investment rate is estimated insignificantly. Other estimates are both correct in predicted signs, and highly significant. Cash flow coefficient is estimated negatively, contrary to Bond and Meghir (1994), and Bond et al. (2003). Because the value of $h_{i,t-1}$ is not postulated by the model a priori, and it is also firm specific; exact inference on the magnitudes of the parameters cannot be made. Parameter estimates other than lagged

Table 5:

$\gamma_{i,t}$	(1) GMM	(2) GMM	(3) GMM	(4) GMM
$\gamma_{i,t-1}$ (β_1)	0.737***	0.374***	0.615***	0.469***
	(0.030)	(0.029)	(0.067)	(0.043)
$\gamma^2_{i,t-1}$ (β_2)	0.0530	-0.0909**	-0.108*	-0.0529
	(0.031)	(0.029)	(0.047)	(0.043)
$c_{i,t-1}$ (β_3)	-0.00954***	-0.0158***	-0.0157***	-0.0177***
	(0.002)	(0.003)	(0.003)	(0.003)
$l^2_{i,t-1}$	-0.00253***	-0.00144**		-0.00326***
	(0.001)	(0.001)		(0.001)
$t_{i,t}$		0.119**		0.161***
		(0.042)		(0.040)
$c_{i,t-1}t_{i,t}$ (α_3)		0.647***	0.433***	0.606***
		(0.067)	(0.081)	(0.066)
$\gamma_{i,t-1}t_{i,t}$ (α_1)			-0.953***	-0.320**
			(0.230)	(0.106)
$\gamma^2_{i,t-1}t_{i,t}$ (α_2)			0.281	-0.313
			(0.276)	(0.189)
$l^2_{i,t-1}t_{i,t}$ (α_4)			0.00681	0.0270**
			(0.008)	(0.009)
N	265042	265042	265042	265042
R^2				
m_1	-24.23 (0.000)	-18.31 (0.000)	-19.27 (0.000)	-19.81 (0.000)
m_2	11.84 (0.000)	7.493 (0.000)	8.031 (0.000)	8.562 (0.000)
m_3	1.041 (0.298)	-0.603 (0.546)	-0.448 (0.654)	-0.556 (0.578)
Hansen's J	236.5 (62)	246.1 (91)	271.6 (98)	304.9 (130)
(p-value)	0.000	0.000	0.000	0.000

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

investment rate are too low and very close to zero, even though they are significant. The last but not least result in this estimation is the very high Hansen's J test statistics which might lead to rejection of joint validity of the instruments, and the entire model. However, this result is already predicted by the model as stated in the previous subsection. ,Hence, another prediction of the model is verified. Hansen's J statistics for this specification is obtained as 236.5 with 62 degrees of freedom. First column of Table 3, on the other hand, gives parameter estimations of the model without financial frictions. In this case, Hansen's J statistics is obtained as 248.0 with 46 degrees of freedom. When more instruments are used in a GMM setting, or degrees of freedom are increased in other words, Hansen's J is expected to increase, all else being equal. In this sense, both models are comparable. Although the model with debt has more instruments and higher degrees of freedom, its estimation results in lower Hansen's J statistics. This finding supports the model with costly debt over the model without financial frictions, as expected.

Second column of Table 5 tests AC (2007)'s findings with the Russian data for the third time, by adding tangibility and its interaction term with cash flow to the main equation. As the model and AC (2007) predicts, coefficient of the interaction term is estimated positively and highly significantly. Positive effect of tangibility on ICFS is verified one more time with a more structural model of investment. Differently from column 1, square of lagged investment coefficient is significantly estimated in correct direction. Moreover, improvement on the absolute value of cash flow parameter is also noticed, from -0.00954 to -0.0158. Tangibility term is estimated positively in accordance with the expectations due to the direct financial constraints channel as explained earlier. When tangibility and the interaction term are added, Hansen's J increases from 236.5 to 246.1, while degrees of freedom increase from 62 to 91. Increase in Hansen's J is proportionately lower than the increase in degrees of freedom. This observation suggests that tangibility is an important determinant of investment. This fact further suggests the inclusion collateral constraints to the model along with the risk premium approach.

Third and fourth columns of Table 5 test the predictions of Section 4.3 by estimating equation (40) with two nested settings. Columns (3) presents direct estimation of equation (40). Signs of estimated parameters are completely correct with respect to model predictions.

Except coefficients of interaction terms $\gamma^2_{i,t-1}t_{i,t}$ and $l^2_{i,t-1}t_{i,t}$, all coefficients are estimated significantly. This finding is a strong evidence in favor of the model presented in Section 4. AC (2007)'s proposition is again verified with a significant point estimate of 0.433 for the cash flow-tangibility interaction. Moreover, if coefficients varying with firm tangibility are allowed as proposed by the model, Hansen's J statistics increases from 236.5 to 271.6, while degrees of freedom increase from 62 to 98. Again, since the increase in Hansen's J statistics is proportionately lower than the increase in degrees of freedom, it can be concluded that the inclusion of tangibility-varying-coefficients causes more reliable parameter estimates.

The last column includes tangibility and square of leverage to the equation (40), since these variables form the interactions in the equation. Balli and Sørensen (2013) warns researchers to include the sole terms which form the interaction terms in order to minimize the risk of estimated interaction terms spuriously capturing other effects. Main findings must be robust to possible functional forms. Hence, tangibility and square of leverage are added into the original equation. Coefficient of leverage squared is estimated negatively, and that of tangibility is estimated positively compatible with collateral constraints channel. Other parameter estimates still satisfy sign predictions of Section 4.3 consistent with column 3. AC (2007)'s proposition is also valid for this case. Main conclusions are not changed.

5 Conclusion

In this study, bank dominant nature of Russian credit markets is exploited to identify through which channels financial constraints affect corporate investment. Contradictory views of FHP (1988) and KZ (1997) - AC (2007) on investment-cash flow sensitivity are tested using a highly heterogeneous firm-level data on Russian manufacturing firms in terms of degree of financial constraints.

Firstly, findings of AC (2007) are verified by estimating their original Q-type of investment equation, and an Euler equation derived from a benchmark model of investment with ORBIS data. AC (2007) originally proposes that investment-cash flow sensitivities should be increasing in the tangibility of firm's assets, which is contradictory to FHP (1988)'s excess sensitivity findings. I also verify this finding by employing more comprehensive data set on Russian manufacturing firms which are all privately held and considered as subject to collateral constraints due to bank dominant nature of Russian credit markets.

These findings need to be explained with a more structural model of corporate investment. In this direction, bank dominant nature of Russian credit markets is exploited to identify the channels that are effective in reaching this conclusion. I offer a model with debt finance as the only source of external funds. Firms are assumed to face with collateral constraints in reaching bank loans. Collateral constraints are embedded into the model by risk premium payments which is assumed to be a decreasing function of tangibility, and increasing function of leverage.

This postulation is also tested in the data using total interest payments as a proxy for the risk premia. Hadlock and Pierce (2010)'s SA (size-age) index is used as a control for other firm characteristics in determining firm-specific interest payments. Robust results to different functional forms supporting my assumptions are reached. Interest payments are estimated as they increase with leverage, while they decrease with tangibility.

Novel features of my model can be listed as follows. Firstly, it only considers debt finance, excluding equity financing, so that it becomes more relevant for SMEs facing collateral constraints in bank dominated credit markets. Secondly, collateral constraints are embedded into the model via inclusion of risk premium. This strategy allows me to reach an estimable and analytically tractable Euler equation of investment. Thirdly, the model analytically predicts the sign of the interaction term between cash flow and tangibility directly. This prediction of the model forms a theoretical basis for the findings of Almeida and Campello (2007), and extends their simple two-period model of investment. Fourthly, the model also produces testable implications on the all other parameters in the Euler equation as well. Almeida and Campello (2007)'s finding appears one of them. Hence, while I nest ICFS-tangibility relationship in the model, testing the model implies testing the presence of collateral constraints in Russian credit markets at the same time. Finally, it also provides a possible explanation for higher values of Hansen's J test statistics which tend to reject the null hypothesis that instruments are jointly valid in all system GMM estimations.

The Euler equation derived from the model is estimated by system GMM to test the sign implications. Almost all these implications are validated including that of Almeida and

Campello (2007). Robustness checks are done in the spirit of Balli and Sørensen (2013), and I confirm that results are robust to functional changes in case of existence of interaction terms. High Hansen's J values are detected as the model predicts. However, they are quite smaller than that of the first model without financial frictions. Investigation on more valid instruments other than lagged explanatory variables as the model suggests is left for future research.

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A Data Appendix

Data set used in this study is obtained from ORBIS database which is an umbrella product that provides firm-level data for many countries worldwide. This database is compiled by the Bureau van Dijk Electronic Publishing (BvD). My unbalanced sample covers Russian manufacturing firms between the periods 2008-2016.

ORBIS and AMADEUS are independent products of BvD and operated by different sets of rules. For example, AMADEUS provides data for at most 10 recent years for the same firm, while ORBIS only reports data for up to 5 recent years. In addition, AMADEUS drops firms from the database if they did not report any information during the last five years, while ORBIS keeps the information for these firms as long as they are active. These differences in nuance of both ORBIS and AMADEUS are so vital for a researcher who wants to construct a dataset of firms as representative as possible. Kalemli-Ozcan et al. (2015) lists very basic cleaning and download strategies for ORBIS and AMADEUS databases so that researchers can clean and construct a dataset without losing any necessary information keeping the coverage of the dataset as high as possible at the same time. Hence, I also followed those strategies provided by Kalemli-Ozcan et al. (2015) to construct my final sample.

All cleaning filters including the ones stated in Kalemli-Ozcan et al. (2015) are listed as below.

- Nine parts of the data which are all wide type are merged.
- Data is reshaped as long, after duplicates in terms of id numbers are dropped.

- YEAR variable is constructed with respect to close date of accounts.
- Unconsolidated accounts are separated from unconsolidated ones, and unconsolidated accounts are dropped.
- Duplicates in terms of YEAR are dropped. Latest accounts in months of the same year are kept.
- Firm-year observations having all missing financial accounts, sector information, currency and units are dropped.
- Country codes given by BvD are checked.
- All accounts in terms of Russian Ruble are converted to Dollars.
- Firm-year observations having negative total assets, employment, sales, tangible fixed assets items are dropped.
- Firm-year observations having zero total assets, shareholders' funds and equity are removed, since this means that the firm is about to go bankruptcy.
- Accounts which do not satisfy basic accounting rules are dropped from the latest sample. These accounting identities cover the following equities
  - Current assets must be equal to sum of current assets stock, current assets debtors and other current assets.
  - Fixed assets must be equal to sum of tangible fixed assets, intangible fixed assets and other fixed assets.
  - Total assets must be equal to sum of current assets and fixed assets.
  - Current liabilities must be equal to sum of current liabilities loans, current liabilities to creditors and other current liabilities.
  - Noncurrent liabilities must be equal to sum of long term debts and other long term liabilities.
  - Shareholders' funds must be equal to sum of equity and other shareholders' funds.

- Lastly, only firm-years in manufacturing sector according to NACE Rev. 2 sector classification are kept.

These filters lead a final sample of Russian firm-years between the periods 2008-2016 consisting of 812,898 firm-year observations with 218,291 unique firms. Average number of years for a firm is 3.72. All items in the final sample are in nominal terms. However, in estimations, real terms are used. Therefore, aggregate price data for both final and investment goods are needed. In models presented in the paper, price of final goods is normalized to one in all time periods by reflecting annual changes in the price of final goods to the price of investment goods.

Aggregate price index for manufacturing final goods is obtained from OECD - Domestic Manufacturing Produced Prices item. Also, aggregate price index for investment goods is obtained from Russian Federation Federal State Statistics Service (http://www.gks.ru/). This index is named as "The index of prices for machinery and equipment for investment purpose" by the source. It was monthly percentage change with respect to previous month. I calculated monthly levels by fixing a base month which was 2005 December. Then I took December data as the price for that year. Also, the data for the last year 2016 was not available. I fitted an ARIMA model for annual data. This is the model: $p_t = 12.67 + p_{t-1} + \epsilon_t$. Then price for 2016 is estimated accordingly.

Because the price of the final good is normalized to one in our model, I have divided price of investment goods by price of final goods to calculate the relative price. Also note that in the perpetual inventory method, p_t/p_{t-1} is needed. Because this ratio is used along the calculations, there is no need to select a basis year for both price series. Lastly, 8% is assumed as depreciation rate in the calculations, since depreciation expenses are not available in the data.

Main variables used in the paper are real tangible capital stock, investment rate, cash flow rate, firm tangibility, leverage, aggregate interest rate, firm size and two proxies for firm sales. All variables except tangibility and size are trimmed at the top and bottom 2 and 98 percentiles, since first moments are excessively driven by extreme outliers. Firm tangibility is not trimmed, since it has natural bounds as 0 and 1. On the other hand, trimming is not needed for firm size, when first moments are checked.

Real tangible capital stock, $k_{i,t}$: Tangible fixed assets item in balance sheet is divided by the relative price of investment goods to final goods.

Investment rate $\gamma_{i,t}$: Difference between end-of-year tangible fixed assets and beginning-of-year tangible fixed assets is divided by end-of-year tangible fixed assets. Since, both the numerator and the denominator are in nominal terms, price data is not used to obtain real terms. This method of calculation is inferred from the models in the paper.

Cash flow rates, $c_{i,t}$: Two different cash flow measures are used for robustness checks. The one implied from the models is constructed as the ratio of earning before interest and taxes (EBIT) to real tangible capital stock. Second measure of cash flow rate is constructed as the ratio of the sum of net income and depreciation expenses to real tangible capital stock. Since net income item in the dataset is obtained by subtracting interest, tax and depreciation payments from EBIT, depreciation expenses are added to net income.

Tangibility rate, $t_{i,t}$: This rate is obtained by dividing firm's tangible capital stock to firm's total assets. Since total assets include current assets of the firm, price index for investment goods is taken into account.

Leverage, $l_{i,t}$: This variable is obtained by dividing firm's long term debt stock to its real tangible capital stock as is standard in the literature.

Aggregate interest rate, $r_{i,t}$: This rate is defined as interest payments item divided by firm's long term debt stock.

Firm size, $size_{i,t}$: This measure of size for each firm is defined as the natural logarithm of tangible capital stock as is proposed by Hadlock and Pierce (2010).

Proxies for firm sales, $ln(o_{i,t})$ and $go_{i,t}$: Since sales item is not directly available in the data, I use two different proxies for sales. The first one is natural logarithm of operating turnover of the firm, $ln(o_{i,t})$. The second measure is the growth rate of firm's operating turnover, $go_{i,t}$, that is defined as the difference between end-of-year turnover and beginning-of-year turnover divided by their average.