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Foreign Currency Debt and Exchange Rate Pass-Through

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Foreign Currency Debt and Exchange Rate Pass-Through*

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Abstract

This paper studies both theoretically and empirically the firm's choice of currency for its debt. We use a parsimonious model with financial frictions to derive an intuitive sufficient statistic for the share of foreign-currency debt in firm's liabilities and demonstrate its robustness in several extensions. Due to the risk management considerations, firms are more likely to borrow in dollars when the pass-through of the exchange rate into their profits is higher. We leverage this insight empirically using the micro-level data on loans issued by Russian banks to local firms as well as the data on firms' balance sheets and cash flows. The data strongly supports the predictions of the model indicating that firms with profits more stable in dollars are more likely to borrow in foreign currency than firms with profits stable in local currency. These results extend to a choice between the euro and the dollar and survive after controlling for firms' size and export status. Note that our results describe efficiency at the firm level, and they do not have direct implications for macroprudential policy as foreign currency debt may also affect exchange rate volatility, inflation and output.

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1 Introduction

One of the key features of the international monetary system is the dominant status of the dollar, which is widely used as a currency of invoicing in international trade (Gopinath 2015), the central bank reserve currency (Gopinath and Stein 2018), the anchor currency in monetary policy (Ilzetzki, Reinhart, and Rogoff 2019), and the currency of borrowing (Maggiori, Neiman, and Schreger 2020). These facts have important normative implications: the dominance of the dollar leads to asymmetric spillovers of U.S. monetary policy on other economies (Gopinath, Boz, Casas, Díez, Gourinchas, and Plagborg-Møller 2020), makes other countries vulnerable to currency mismatch (Rey 2015), and substantially limits the effectiveness of local policies (Egorov and Mukhin 2020). This raises several policy-relevant questions (Gourinchas 2021): What makes private agents prefer to sign contracts in dollars? Is this currency choice efficient from social perspective? Can the government propel the de-dollarization of the economy? Using novel data and theory, this paper aims to enhance our understanding of how firms choose the currency of borrowing.

We start with a simple, yet fairly general model to guide our empirical analysis. To depart from the classical Modigliani and Miller (1958) benchmark with an undetermined balance sheet, we introduce financial frictions that put a limit on how much risk a firm can take (*cf.* Froot, Scharfstein, and Stein 1993). As a result, rather than using the household stochastic discount factor when making investment and financial decisions, a firm is also concerned with the volatility of its cash flow and chooses the debt structure that is better aligned with the future profits. In particular, the model predicts that firms with a higher pass-through of the dollar exchange rate into their profits are more likely to borrow in foreign currency, while firms with a low pass-through prefer to borrow in local currency. Intuitively, to lower the probability of a mismatch between future income and debt payments, it is optimal to borrow in a currency, in which firm's profits are more stable. Thus, the currency choice can be predicted with a simple "sufficient statistic" that can be directly estimated in the data and does not require any exogenous variation. We also provide several extensions of the baseline model — discussing the case of discrete currency choice, the presence of other types of liabilities on firm's balance sheet, the choice between two foreign currencies, and endogenous investment — all showing the robustness of the derived statistic. Interestingly, our model and empirical strategy show a remarkable analogy to the choice of invoicing currency in international trade from the previous literature Engel (2006), Gopinath, Itskhoki, and Rigobon (2010).

We then implement empirically this approach using the data on Russian firms. The information comes from two main sources. First, we use the loan-level data from the Bank of Russia credit register that covers all loans issued by local banks to domestic firms. The dataset includes the size of each loan, its maturity, the interest rate, and most importantly for our analysis, the currency of the loan. According to the aggregate statistics, domestic loans included in the credit register account for about 75% of all local-currency debt and 30% of all foreign-currency debt. Second, we use the accounting data, including revenues, expenditures and profits, reported to the Federal State Statistics Service and provided by SPARK/Interfax. The merged dataset covers about 130,000 firms from 2017–2019.

Using a subsample of firms borrowing only in one currency as a benchmark, we find the pass-through of -0.02 for firms borrowing in local currency and 3.26 for firms with dollar loans. The difference between the two estimates is large and statistically significant. This confirms the central prediction of the model that firms borrow in dollars whenever their cash flows are more stable in that currency. Despite a smaller number of observations, the same result holds when we compare firms that borrow in two foreign currencies: the pass-through of the bilateral exchange rate between the dollar and the euro is higher for firms borrowing in dollars relative to firms with euro loans. Moreover, the main result also extends to the intensive margin: dividing the sample into five bins based on the dollar share in observed total loans, we find that the pass-through of the exchange rate into profits is monotonically increasing.

We try alternative specifications and confirm the robustness of these findings. First, the sample is winsorized below and above based on firms' profits. Second, we include differential time trends and macroeconomic variables as controls. Third, we use a larger sample that includes firms with missing data in consecutive years. In all these cases, the estimates of the pass-through coefficients barely change. Finally, we run a horserace between our theory and the alternative models that emphasize firm's size and export status as a proxy for better access to asset markets, and find that the results survive.

In sum, the paper proposes and implements a novel method to evaluate the currency mismatch in the economy. This new approach has several advantages over the methods used by the previous literature. First, it does not require strong theoretical assumptions or a fully specified general equilibrium model with a large number of unknown parameters. Instead, our framework nests a large class of models with financial frictions and is parameter-free. Second, the procedure can be easily implemented empirically and does not require any exogenous variation. Third, the data requirements are relatively weak and the proposed sufficient statistic can be estimated for any country with an available credit register. Moreover, the application of the method is not limited to private firms and can potentially be extended to banks and households. Finally, our approach provides a clear guidance to policymakers allowing to evaluate the degree of currency mismatch in the economy and – given sufficiently long series for individual firms – to identify companies and sectors that are especially prone to exchange rate risk.

Related literature This paper contributes to the vast literature on firms' currency choice. This includes the theoretical models by Engel (2006) and Mukhin (2021) studying the invoicing decisions of firms as well as empirical evidence from Gopinath, Itskhoki, and Rigobon (2010). Despite the fact we focus on a different type of frictions — financial rather than nominal — there is a clear analogy between our results and this literature as we explain below. Our focus on financial frictions follows the recent literature on the optimal currency in contracts (Doepke and Schneider 2017, Drenik, Kirpalani, and Perez 2018). In contrast to these models, the purpose of our analysis is to provide an empirical test of the theory. The choice between local and foreign currency debt has also been extensively discussed in a large "original sin" literature, which however, focuses on government rather than private debt (Eichengreen, Hausmann, and Panizza 2005).

Two approaches to evaluate the currency composition of corporate debt have been used in the previous literature. First, there are empirical papers, including the work done by central banks and financial agencies, that estimate correlations between currency shares and other firms' characteristics. The main issue with this literature is the ad-hoc nature of the chosen empirical moments and no connection to the theory. Second, there are a few papers that implement a fully structural approach developing a general equilibrium model of currency choice and then calibrating it using empirical moments (see e.g. Salomao and Varela 2020, Eren and Malamud 2021, Gopinath and Stein 2021). The weakness of this approach is that it usually relies on strong theoretical assumptions about the structure of the economy and involves a large number of parameters. In contrast, this paper develops a novel methodology that combines the advantages of the two existing approaches. On the one hand, our method has explicit theoretical foundation. On the other hand, it nests several models of currency choice and is largely parameter-free.

2 Theoretical Framework

This section describes a theoretical framework that guides our empirical analysis. The model provides a simple, yet fairly general way to think about the currency composition of corporate debt under financial frictions, which break the Modigliani-Miller indifference result.

2.1 Currency choice

Setup is static and focuses on the partial equilibrium financial decisions of firms. There are two currencies, home and foreign, and if not noted otherwise, all variables are expressed in units of local currency. A firm undertakes an investment project with ex-ante investment B and stochastic ex-post cash flow (profits) Π. The loan required to finance the project can be taken from bank either in local currency or in foreign one, i.e. $B_h + \mathcal{E}B_f = B$, where $\mathcal{E}$ is the ex-ante nominal exchange rate in units of home currency per one unit of foreign currency. Given the corresponding gross interest rates of R_h and R_f, the firm has to pay back $R_h B_h + \mathcal{E}' R_f B_f$ after the project is completed. We introduce financial frictions in a tractable way by assuming that firms have mean-variance preferences over the net returns and solve the following optimization problem:

$$\begin{aligned} \max_{W, B_h, B_f} \quad & \mathbb{E}[W] - \frac{\bar{\gamma}}{2}\mathbb{V}[W] \\ \text{s.t.} \quad & W = \Pi - R_h B_h - \mathcal{E}' R_f B_f \\ & B = B_h + \mathcal{E} B_f, \end{aligned}$$

where $\mathbb{E}[\cdot]$ and $\mathbb{V}[\cdot]$ are expectation and variance operators and $\bar{\gamma}$ is the risk-aversion parameter. The model nests the frictionless benchmark that features $\bar{\gamma} = 0$ and the expectation taken with respect to the risk-neutral measure determined by the household stochastic discount factor (see e.g. Cochrane 2009). The Modigliani-Miller theorem applies in this special case and implies that the

firm is indifferent between the alternative currency compositions of its debt. On the other hand, the debt structure is well determined away from this knife-edge parametrization.

Debt currency composition is then determine from the optimal portfolio problem. It is convenient to normalize variables by the size of the project and to rewrite the firm's problem as

$$\begin{aligned} \max_{w,x} \ & \mathbb{E}[w] - \frac{\gamma}{2}\mathbb{V}[w] \\ \text{s.t.} \ & w = (\pi - R_h) + \left(R_h - R_f \frac{\mathcal{E}'}{\mathcal{E}}\right) b_f, \end{aligned}$$

where $w \equiv \frac{W}{B}$, $\pi \equiv \frac{\Pi}{B}$, $\gamma \equiv \bar{\gamma} B$, and $b_f \equiv \frac{\mathcal{E} B_f}{B}$ is the share of loans in foreign currency.[1] Denote the ex-post currency premium with $\Psi \equiv \left(R_h - R_f \frac{\mathcal{E}'}{\mathcal{E}}\right)$ and substitute expression for w from the constraint into the objective function. Using the definition of variance and taking the first-order condition, we get

$$\mathbb{E}[\Psi] - \gamma \text{cov}[\Psi, \pi + \Psi b_f] = 0.$$

It follows that the optimal share of foreign currency loans is given by

$$b_f = \frac{\mathbb{E}[\Psi]}{\gamma \mathbb{V}[\Psi]} - \frac{\text{cov}[\Psi, \pi]}{\mathbb{V}[\Psi]}$$

and can be simplified using the approximation $\Psi = e^{r_h} - e^{r_f + \Delta e} \approx r_h - r_f - \Delta e$:

$$b_f = \frac{\mathbb{E}[r_h - r_f - \Delta e]}{\gamma \mathbb{V}[\Delta e]} + \frac{\text{cov}[\Delta e, \pi]}{\mathbb{V}[\Delta e]}. \tag{1}$$

The economic intuition for this expression is straightforward: the first term reflects the differences in *average returns* on two types of loans, while the second term accounts for differences in *riskiness* of borrowing in home and foreign currencies. In the frictionless limit of $\gamma = 0$, the former motive dominates and firms borrow in a currency with a lower UIP premium. In contrast, the risk management is important under financial frictions: other things equal, a firm prefers to take loans with higher payments in "good" states of the world when returns on its project are high and with lower payments in "bad" states of the world when returns on its project are low. In our setting, this principle implies that the share of foreign currency is higher if local currency depreciates increasing the debt burden when the firms has higher profits (in local currency). Vice versa, if the depreciation of the exchange rate is associated with lower profits, the firm takes less risk by borrowing in home currency.

Remarkably, the risk term is independent of any parameters and in particular, does not depend on the strength of financial frictions γ. Intuitively, while the risk does not matter in the Modigliani-Miller case with $\gamma = 0$, the currency choice is well determined and depends on the risk for any

[1] While parameter γ depends on the size of the project if we take $\bar{\gamma}$ as a primitive, an arguably more realistic assumption is that the larger projects are undertaken by larger firms with a better diversification of risk making γ similar across firms. This argument can be formalized using the preferences with a constant relative risk aversion.

value of γ arbitrary close to zero. The important implication of this observation is that although our empirical analysis allows testing the theory of currency choice, it is silent about the magnitude of financial frictions. This is similar to the sticky-price models of invoicing with the optimal currency choice well determined even in the limit when probability of price adjustment converging to one (see Mukhin 2021).

2.2 Extensions

Discrete choice Given that the vast majority of firms in our sample take loans only in one currency, the discrete currency choice with $b_f \in \{0, 1\}$ deserves special attention. Comparing the values of the objective function under the two alternative values of b_f, it is straightforward to show that a firm chooses foreign currency debt $b_f = 1$ if and only if

$$\frac{\text{cov}[\pi, \Delta e]}{\mathbb{V}[\Delta e]} \geq \frac{1}{2} - \frac{\mathbb{E}[r_h - r_f - \Delta e]}{\gamma \mathbb{V}[\Delta e]}.$$

Note that under the same average returns $\mathbb{E}[r_h - r_f - \Delta e] = 0$, this condition is equivalent to

$$\mathbb{V}[\pi - e'] \leq \mathbb{V}[\pi],$$

which means that firms choose foreign currency debt when their profits are more stable in foreign currency than in home one. This result again mirrors the optimal discrete choice of invoicing currency under sticky prices (see Gopinath, Itskhoki, and Rigobon 2010, Mukhin 2021). While the optimal threshold for the pass-through is likely to deviate from 0.5 because of the UIP deviations, the main implication of the model that β is lower for firms with local currency debt remains unchanged.

Other liabilities Another potential concern is that the data is often available only for some balance sheet positions of firms, but not all of them. In particular, our data covers the loans from local banks, but does not include foreign loans or any bond issues. To what extent does this invalidate the results from above? To answer the question, we extend the model allowing firms to borrow using multiple assets $k = 1, ..N$ and focusing on the optimal choice of assets h and f. Let b_k denote that share of project B financed via asset k and denote the gross returns on assets with R_k. The latter are allowed to have an arbitrary joint distribution – the only restriction that we impose to ensure the uniqueness of optimal debt is that there are no collinearities between assets' returns. Given that $\sum_k b_k = 1$, the net returns on the project can be expressed as

$$w = \pi - \sum_k R_k b_k = (\pi - R_h) + \sum_{k \neq h} (R_h - R_k) b_k.$$

Substitute w into the objective function and take the first-order condition with respect to b_f to obtain

$$\mathbb{E}[R_h - R_f] - \gamma \text{cov}\Big[(\pi - R_h) + \sum_{k \neq h,f} (R_h - R_k)b_k + (R_h - R_f)b_f, R_h - R_f\Big] = 0.$$

Rearranging terms, the optimal share of debt f is equal

$$b_f = \frac{\mathbb{E}[R_h - R_f]}{\gamma \mathbb{V}[R_f]} + \frac{\text{cov}\Big[\pi - \sum_{k \neq h,f} R_k b_k, R_f\Big]}{\mathbb{V}[R_f]}.$$

In particular, applying this result to foreign currency loans, we get

$$b_f = \frac{\mathbb{E}[r_h - r_f - \Delta e]}{\gamma \mathbb{V}[\Delta e]} + \frac{\text{cov}\Big[\pi - \sum_{k \neq h,f} R_k b_k, \Delta e\Big]}{\mathbb{V}[\Delta e]}.$$

This expression resembles closely the optimal solution from the baseline model (1) with two important differences. First, the relevant exchange rate pass-through is now computed into cash flows net of payments on all liabilities other than $k = h, f$.[2] Second, the optimal choice variable b_f reflects the share of foreign currency loans in *total liabilities* rather than in home and foreign currency loans. Thus, although testing the model with multiple liabilities requires some extra data, there is no need to have complete information about all positions and their returns.

Other currencies While the benchmark model focuses on the choice between home and foreign currency debt, the same approach works equally well for loans in any other currencies. In particular, consider the choice between debt issued in dollars and euros. The firm's problem is then

$$\begin{aligned} \max_{w, b_\$, b_€} \quad & \mathbb{E}[w] - \frac{\gamma}{2}\mathbb{V}[W] \\ \text{s.t.} \quad & w = \left(\pi - \frac{\mathcal{E}'_\$}{\mathcal{E}_\$} R_\$\right) + \left(\frac{\mathcal{E}'_\$}{\mathcal{E}_\$} R_\$ - \frac{\mathcal{E}'_€}{\mathcal{E}_€} R_€\right) b_€. \end{aligned}$$

Following the same steps as before, we get that the optimal share of dollar debt is

$$b_\$ = \frac{\mathbb{E}\left[r_€ - r_\$ - e_{€/\$}\right]}{\gamma \mathbb{V}\left[\Delta e_{€/\$}\right]} + \frac{\text{cov}\left[\pi - \Delta e_€, \Delta e_{€/\$}\right]}{\mathbb{V}\left[\Delta e_{€/\$}\right]}.$$

The expression mirrors the optimal choice (1) in the baseline model: the foreign exchange rate is replaced with the bilateral exchange rate between the euro and the dollar $e_{€/\$}$ and the profits are expressed in euros. Thus, the model predicts that firms with a higher pass-through coefficient β_i

[2] A symmetric argument also applies to the asset side of firm's balance sheet: when computing the pass-through coefficient β, one needs to include the income on all financial assets in π.

estimated from the following regression

$$\pi_{it} - \Delta e_{€t} = \alpha_t + \beta_i \Delta e_{€/\$t} + \varepsilon_{it}$$

are expected to have a larger share of dollar debt relative to the euro debt. Of course, the results about the discrete choice between the two currencies apply here as well.

Endogenous investment Another thing to notice is that although the assumption that the scale of the project B is fixed simplifies the analysis, it does not affect the results. To see this, go back to the original problem and allow the firm to choose optimally investment B assuming that $\Pi(B)$ is concave to ensure an interior solution. As before, the net returns can be expressed in terms size of the project B and the share of foreign currency borrowing

$$W = \Pi(B) - R_h B + \left(R_h - R_f \frac{\mathcal{E}'}{\mathcal{E}} \right) b_f B.$$

Taking the optimality condition for b_f and using the definitions $\pi(b) \equiv \frac{\Pi(B)}{B}$ and $\gamma \equiv \bar{\gamma} B$, we get exactly the same expression (1) for foreign currency share. Thus, once expressed in terms of the sufficient statistics, the currency composition of debt does not depend on the endogenous choice of investment. Note that the reverse is not necessarily true: the size of the project depends on the composition of debt and is implicitly defined by the optimality condition:

$$\mathbb{E}[\Pi'(B) - r_h(1 - b_f) - (r_f + \Delta e) b_f] = \gamma \text{cov}\left[\pi(B) - b_f \Delta e, \Pi'(B) - b_f \Delta e\right].$$

With these results at hand, we next proceed to the empirical analysis.

3 Empirical Evidence

3.1 Data

This section describes the data we use in the empirical analysis and presents the key stylized facts about foreign currency debt. We combine two major datasets to perform our analysis. First and foremost, we use loan-level data from the credit register[3] from the Bank of Russia. It contains information about all loans extended by domestic banks to domestic firms in Russia. For each loan, we observe the firm's taxpayer's identification number, the size of the loan, its maturity, the interest rate, and, crucially, the currency of the loan. This data is available for 3 years, 2017-19, and we observe around 130-171 thousand firms each year in this dataset. Using the aggregate statistics from the Bank of Russia, we have verified that this dataset covers about 90-92% of all domestic loans taken by Russian firms.

[3]Referred to as the credit registry is reporting form 0409303, "Information on Granted Funds to Legal Entities", submitted by the Russian credit institutions to the Bank of Russia on a monthly basis. Description of the form see at https://www.cbr.ru/eng/statistics/pdko/sors/summary_methodology/#highlight=0409303

Table 1: Number of firms and size of bank loans by currency

	Single currency				Multiple currencies
	Ruble	Dollar	Euro	Other	
		Year 2017			
Average size of all loans	164	4,112	2,694	0.11	11,194
# of firms	107,283	549	210	16,503	680
		Year 2018			
Average size of all loans	168	5,415	3,640	0.14	14,216
# of firms	117,550	418	229	19,715	546
		Year 2019			
Average size of all loans	168	5,163	3,710	0.03	15,398
# of firms	128,107	307	220	29,219	445

Notes: the table reports the number of firms and the average size of all bank loans by currency for each year in our sample. The first three columns represent firms that borrow only in rubles, dollars, and euros. The next column groups together all firms that borrow in all other currencies. The last column shows the firms that have loans in multiple currencies. The size of bank loans are reported in millions of rubles.

Second, we merge the credit register's data with the data from SPARK/Interfax, which is a database similar to ORBIS/AMADEUS. It contains accounting data for all domestic firms in Russia, and it comes from two government agencies. First, all Russian firms are required to provide their basic accounting data to the government statistical agency (Federal State Statistics Service) each year. This data includes the some balance sheet data and information on revenue, expenditures, and profits. In addition to that, each firm is also required to provide a subset of the same data (namely, revenues, expenditures, and pre-tax profits) each year to the government tax agency (Federal Taxation Service). Although we do not get any new information from the tax data, but we use it to verify the accuracy of the rest of our data. Overall, this database contains information on all firms registered in Russia, and we observe about 2 million firms each year. We match observations from the credit register with the accounting data at the level of a firm (by taxpayer's id) and a year. We successfully match observations for about 79.7% of all firms from the credit register that account for about 89.5% of all debt from the credit register.

Our theoretical results indicate that we do not need data on all firm's liabilities and their currency composition. Still, our data covers a large share of all debt. According to the aggregate statistics from the Bank of Russia, domestic loans cover about 75% of all debt in domestic currency (ruble). This is the part of the debt that we observe in the credit register. The rest of the ruble debt comes in the form of securities (17%) and loans from foreign banks (8%). Out of all debt in foreign currency, around 30% is taken from domestic banks and thus is covered in the credit register. Securities account only for about 1.7%, and 69% of all foreign-currency debt is due to loans from foreigners. In our sample, all bank loans represent about 20% of total liabilities (the size of the balance sheet minus equity) for a median firm. The long-term bank loans (loans with maturity over a year) account for 96% of total long-term debt for a median firm.

The following facts about foreign currency debt in the credit register are important for our

Table 2: Summary statistics by currency of bank loans

	Currency of bank loans		
	No dollar loans	Dollar and other loans	Only dollar loans
Average revenue	993	74,588	15,275
Average size of dollar loans	0	6,272	4,870
Average size of all loans	156	16,174	4,870
# of observations	339,333	1,198	1,287

Notes: the table reports summary statistics for three groups of firms based on the currency of their bank loans. Each observation is at the firm-year level. The data is based on 3 years of observations, 2017-19. Revenue and size of bank loans are reported in millions of rubles.

analysis:

1. Foreign currency debt is large. It accounts for about 20% of all bank loans.

2. Foreign currency debt is heavily dominated by the dollar. About 76% of all non-ruble loans are in dollars.

3. Foreign currency debt is highly concentrated. In particular, only 0.7% of all firms in our sample have any loans denominated in dollars.

4. Most firms borrow only in one currency. As shown in Table 1, only 0.4% of firms borrow in multiple currencies.

5. The currency of debt is sticky. Table 3 shows that 99.8% of firms that do not have dollar loans in the current year also did not have any dollar loans in the previous year. Similarly, 90.7% of firms that borrow only in dollars in the current year also borrowed in dollars in the previous year.

6. Firms that borrow in dollars are large. As shown in Table 2, their revenue is on average 15 times higher than the revenue of firms that do not have dollar loans. The size of their bank loans is 31 times larger. Firms that borrow in multiple currencies are even larger.

7. The interest rate differential exists (the average interest rate for ruble-denominated loans is 14-15%, while the average interest rate in dollars is 6-7%). Potentially it could be exploited, if firms perceive the cost of borrowing in one currency as being inconsistent with its respective exchange rate developments, and expect the correction over time.

8. Foreign currency debt is long-term. The average maturity for ruble-denominated loans is 2.95 years, and the average maturity for loans in dollars is 4.8 years. For a small subset of firms that borrow in both currencies, the average maturity of dollar loans is longer by 195 days.

3.2 Empirical specification

Our empirical approach is based on two key properties of the optimal debt composition. First, the deviations from the UIP are the same for all firms and therefore, the first term in equation (1) can be taken as constant in the cross-sectional analysis. In contrast, the risk term depends crucially on the stochastic properties of profits π_i and varies across firms indexed by i. Second, the risk term involves only unconditional moments and can be directly estimated from the data using a simple OLS regression

$$\pi_{it} = \alpha + \beta_i \Delta e_t + \varepsilon_{it}. \tag{2}$$

Thus, the pass-through of exchange rate shocks into firm's profits is a "sufficient statistic" for the currency composition of debt independently from the general equilibrium forces that describe how π_i and Δe are determined. This central prediction of the model echoes the insights of Engel (2006) and Gopinath, Itskhoki, and Rigobon (2010) that the pass-through into optimal price is the key determinant of exporters' choice of invoicing currency.

While conceptually specification (2) can be estimated at the firm level, the available panel data is unlikely to be long enough to get precise estimates of β_i. Even if one had a high-frequency data on firms' cash flows to estimate the pass-through coefficient, it might be a low-frequency comovement between profits and exchange rates that determines the medium and long term borrowing of firms. Therefore, we take a different route and split the sample based on the distribution of foreign currency debt and estimate an average pass-through coefficient for each bin. We then test whether the pass-through is higher for firms with a larger share of foreign currency loans.

3.3 Results

According to Fact 4 from Section 3.1, most variation in our data is driven by firms that borrow in one currency only. We label all results based on comparison of these firms as the "extensive margin" and present them in Section 3.3.1. We then use the observations on firms that borrow in several currencies and present the results on the "intensive margin" in Section 3.3.2.

3.3.1 Extensive margin

For our baseline specification, we focus on long-term bank loans only, i.e. the loans with a maturity longer than 1 year. This choice helps us to be consistent with the annual frequency of profits that we observe. This is also in line with our theoretical framework that allows us to focus on any subset of the liabilities in the main specification. At the same time, we capture most of the variation in our data since 82% of all debt in the credit register is long-term. In Section 3.3.2 we extend our analysis to include short-term loans as well.

Because most firms in our sample borrow in one currency only (Fact 4 from Section 3.1), in our baseline specification we focus on firms that borrow in rubles only or in dollars only. Conservatively, we put a firm in one of these groups only if the firm borrows in the same currency in all years that we observe. In Section 3.3.2, we extend our analysis to allow one firm to switch groups from year

Table 3: Transition matrix for the currency of bank loans

Status in year $t-1$	Status in year t		
	No dollar loans	Dollar and other loans	Only dollar loans
No dollar loans	208,799	128	30
Dollar and other loans	315	706	59
Only dollar loans	176	90	870

Notes: the table shows the number of firm-year observations based on the current and previous status of the currency of firms' bank loans. The data is based on 3 years of observations, 2017-19.

to year. We use the fact that the currency choice is sticky over time (Fact 5 above) and use the same assignment of firms into two groups for years 2015-16, for which we only observe profits, but not loans.

We use equation (2) as our main specification, where $\triangle e_t \equiv \triangle \log \mathcal{E}_t$, and $\mathcal{E}_t$ is the average daily ruble-to-dollar exchange rate in year t. We use the measure of profits before taxes but after all interest payments. We do not correct profits for interest payments from ruble and dollar bank loans because that would considerably lower the size of the sample: this measure of profits requires data from credit register and thus is limited only to 2017-19. However, note that the presence of interest payments on dollar loans is likely to underestimate our pass-through coefficients for firms that borrow only in dollars as the exchange rate depreciation is likely to increase the size of interest payments on dollar debt, and thus to decrease our measure of profits. In Table 4 below, we show that the pass-through coefficient for these firms is robustly positive despite this downward bias. We also take $\log$ of profits to convert them into units comparable with e_t and interpret our main pass-through coefficient β as an elasticity. Finally, we take a time difference in profits to remove any firm-level fixed effects and focus only on the time-series variation.

The results of our baseline specification are presented in column (1) of Table 4. We find that the pass-through of the exchange rate $\triangle e_t$ into profits $\triangle \log \pi_{it}$ is positive and significant for firms with loans in dollars and close to zero and insignificant for firms with loans in rubles. The difference between the two coefficients is large and statistically significant. Thus, firms with dollar debt are the ones that have higher profits when exchange rate depreciates, which confirms the main prediction of our theoretical framework in Section 2.

Since there is vast heterogeneity in firm size, we next explore whether our results are driven by a large number of small firms. To do that, we weight each observation by the average revenues of each firm (in logs). Column (2) shows that the results barely change. To check whether our results are driven by the opposite force — a few very large firms — we exclude from our sample the top and bottom 1% of all observations based on the value of the dependent variable, $\triangle \log \pi_{it}$. Results presented in column (3) confirm robustness of our main finding.

We also allow for firm-level trends by including firm-level fixed effects in specification with changes across time. This is our most conservative specification as it allows firms with dollar loans to be different not only in terms average level of profits, but also have different trends in their profits. While the pass-through coefficient is slightly lower for dollar-currency firms in this case,

Table 4: Exchange rate pass-through and the currency of debt

Dep. var.:	$\triangle \log \pi_{it}$					$\log \pi_{it}$	$\triangle \log \pi^{€}_{it}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Firms with no dollar loans							
$\triangle e_t$	-0.02	0.05*	-0.02	-0.01	-0.96***		
	(0.03)	(0.03)	(0.02)	(0.03)	(0.04)		
e_t						0.24***	
						(0.03)	
$\triangle e_{€/\$t}$							1.28
							(1.41)
N	386,169	383,014	378,696	386,169	386,169	569,504	1,135
R^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Panel B: Firms with only dollar loans							
$\triangle e_t$	3.26***	3.43***	3.25***	2.04**	4.11***		
	(0.71)	(0.70)	(0.51)	(0.83)	(1.12)		
e_t						3.95***	
						(0.70)	
$\triangle e_{€/\$t}$							5.32***
							(1.14)
N	810	808	774	810	810	1,418	1,836
R^2	0.03	0.04	0.06	0.03	0.05	0.00	0.01
Weighted by revenue		✓					
Without outliers			✓				
Firm-level fixed effects				✓		✓	
Aggregate controls					✓		

Notes: panel A shows results for a sample of firms that do not have any dollar-denominated bank loans. Panel B contrasts it with the results for a sample of firms that have only dollar-denominated bank loans. To construct both samples, we select firms that have loans in just one currency in all the years available from the credit register, 2017-19. Then we use the fact that firms' currency choice is sticky (Fact 5 from Section 3.1) and include time series for profits and exchange rates for all 5 years with the available information on profits, 2015-19. The unit of observation is the combination of a firm i and a year t. π_{it} is the measure of profits before taxes but after all interest payments expressed in rubles for year t. $\triangle \log \pi^{€}_{it}$ is the same measure, but expressed in euros using the average daily exchange rate. $e_t \equiv \log \mathcal{E}_t$, where $\mathcal{E}_t$ is the average daily ruble-to-dollar exchange rate in year t, and $e_{€/\$t}$ is the log of the average daily euro-to-dollar exchange rate. Specification (2) weights each observation with the log of average revenues of a given firm. Specification (3) limits the overall sample of firms by removing top and bottom 1% of observations based on the values of $\triangle \log \pi_{it}$. Aggregate controls in specification (5) include the growth rates of GDP and CPI in Russia. The growth rate of CPI in the US is excluded because we can include only 3 time series in a regression with 4 time periods (once we convert the period of 2015-19 to 4 periods of year-to-year changes). Robust standard errors in parentheses for all specifications except for (4) and (6) are clustered at the firm level. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

column (4) shows that it remains positive and statistically different from the pass-through estimate for local-currency firms.

Specification in column (5) includes aggregate time series as additional controls — the growth rate of GDP and CPI in Russia — and shows that if anything, the differences between the two groups of firms become larger. Next, we extend our sample and include firms that we do not necessarily

Table 5: Exchange rate pass-through by firm size and the currency of debt

	Low revenue	High revenue
No dollar loans	-0.04	0.29***
# of observations	*364,872*	*22,041*
Average revenue	*110*	*10,867*
Average size of all loans	*47*	*2,569*
Only dollar loans	2.40*	3.93***
# of observations	*357*	*453*
Average revenue	*367*	*17,962*
Average size of all loans	*498*	*7,874*

Notes: firms are sorted by their average revenue. The cutoff level of the average revenue of 1,060 million rubles is chosen so that roughly the same number of firms with only dollar loans are below and above this cutoff. The table shows the pass-through coefficients from regressions of $\triangle \log \pi_{it}$ on $\triangle e_t$ for each subsample. Revenue and size of all long-term bank loans are averaged across time and reported in millions of rubles. Robust standard errors are clustered at the firm level. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

observe in two consecutive years. In column (6), we regress the level of profits on the level of exchange rate allowing for the firm-level fixed effects. The number of observations increases substantially without affecting the main results.

The last column of Table 4 tests predictions of our theoretical framework for other currencies (see Section 2.2). As shown in Table 1, the third largest currency in our sample after the ruble and the dollar is the euro. Thus, we compare firms that in all years of our sample borrow exclusively in euros with the firms that borrow exclusively in dollars. We find that firms that borrow in euros are precisely the firms that have higher profits (expressed in euros) when the euro is depreciated against the dollar. Thus, we again confirm the main prediction of our theoretical framework.

As Table 2 shows, firms that borrow in dollars are significantly larger than firms that do not borrow in dollars (recall Fact 6 from Section 3.1). For this reason, one might be concerned that all our results are driven by firm's size, while the pass-through of exchange rates is just an imperfect proxy for this variable. To check this hypothesis, we divide all firms into two groups based on their average revenues and choose this cutoff level so that roughly half of the firms that borrow in dollars are classified as "large", and half is classified as "small". We then apply the same cutoff level of revenue to firms that do not have loans in dollars, and present the pass-through estimates for all four groups in Table 5. Indeed, we find that the larger is the firm, the higher is the pass-through of exchange rate into its profits. However, even conditional on firm size, firms that borrow in dollars always have a higher pass-through than firms that do not have dollar loans. Thus, the main prediction of our framework is consistent with the data even after controlling for firm's size.

Finally, it is possible that our results on firms' currency choice is driven exclusively by exporters. The fact that they export in dollars and thus their profits are correlated with the exchange rate is captured by our framework, and therefore it does not present a threat to our analysis. However, bank regulation in Russia treats differently loans to exporters and to non-exporters. Therefore, firms

Table 6: Exchange rate pass-through by exporter status and the currency of debt

	Non-exporters	Exporters
No dollar loans	-0.06**	0.45***
# of observations	*357,719*	*29,194*
Average revenue	*476*	*3,742*
Average size of all loans	*161*	*975*
Only dollar loans	3.46***	2.79***
# of observations	*556*	*254*
Average revenue	*5,524*	*20,457*
Average size of all loans	*6,071*	*2,615*

Notes: the table shows the pass-through coefficients from regressions of $\triangle \log \pi_{it}$ on $\triangle e_t$ separately for the subsamples of firms who did and did not export during the period of 2014-19. Revenue and size of all long-term bank loans are averaged across time and reported in millions of rubles. Robust standard errors are clustered at the firm level. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

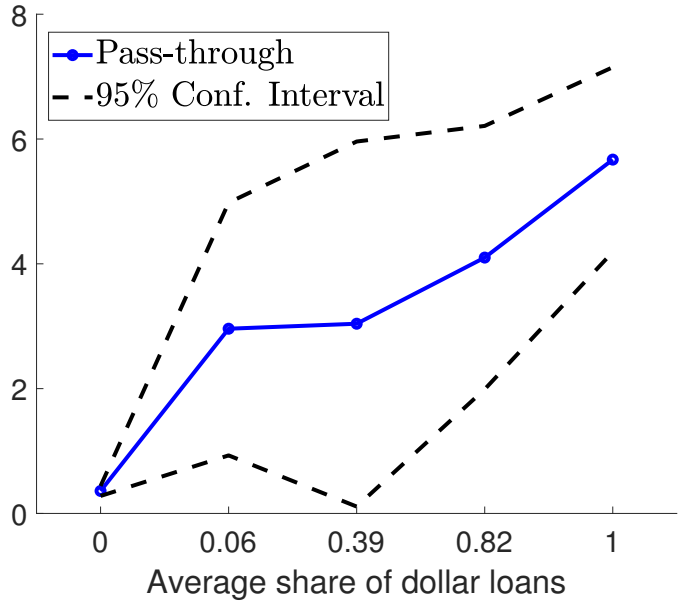
whose profits are correlated with exchange rate may borrow in dollars not in order to minimize the variance of their cash flows, but just because banks may offer them better terms for dollar loans. To check this hypothesis, we complement our data with the list of taxpayer's identification numbers for all exporters during 2014-19 from the customs data. We then repeat our analysis while controlling for the export status and report results in Table 6. Consistent with the fact that profits of exporters would be more correlated with exchange rate, we find a higher pass-through for exporters among firms that do not have dollar loans. However, we still find a higher pass-through for firms with dollar debt even after we control for exporter status, and thus we confirm robustness of our main finding.

3.3.2 Intensive margin

So far, we have leveraged implications of our theoretical framework to explain firms' decisions on whether or not to borrow in dollars. Now we go further and apply the same methodology to explain the currency composition of firms that borrow in multiple currencies. Due to the fact that most firms borrow in one currency only (recall fact 4 from Section 3.1), we are severely limited in our sample size. Thus, we increase the number of observations by changing our approach in several directions. First, in this section, we extend our analysis to all bank loans, and not just the long-term loans. Second, we do not limit our focus only to firms that borrow in dollars in all years available to us. Instead, we also include firms that borrow only in dollars in one year, but borrow in multiple currencies in other years.

Specifically, we group all firm-year observations into 5 bins. The first and the last contain observations with no dollar loans and only dollar loans. Next, we take all observations with dollar and other loans and divide them into three equally-sized groups based on the average share of dollar loans. We then estimate the pass-through coefficient separately for each bin and present the results

Figure 1: Exchange rate pass-through and the share of dollar debt



Notes: the figure shows the pass-through coefficients from regressions of $\log \pi_{it}$ on e_t with firm-level fixed effects separately for five subsamples based on firms' share of dollar loans. The first and the last subsamples include observations where firms take only ruble and only dollar loans. The rest of the observations include firms with loans both in rubles and in dollars. We separate them into 3 subsamples with roughly the same number of observations based on the average share of dollar loans. Black dashed line shows the 95% confidence interval for each pass-through estimate based on robust standard errors. Labels on the x axis show the average share of dollar loans in all bank loans for each subsample. The number of observations in these five groups from left to right are: 298624, 360, 344, 345, and 1072.

in Figure 1.

As before, we find that firms with only dollar loans have a higher pass-through of exchange rate into profits than firms with no dollar loans. Recall that Section 3.3.1 showed this finding for long-term loans only and for separate groups of firms. Now we extend our main finding to all bank loans. More importantly, we also show that the same firm may have a higher pass-through in years when it borrows in dollars than in years when it does not. Lastly, Figure 1 shows that the pass-through is monotonically increasing in the average dollar share indicating that predictions of the model hold not only on the extensive margin of firms' currency choice, but on their intensive margin as well.

4 Conclusion

This paper studies both theoretically and empirically the firm's choice of currency for its debt. Our main methodological contribution is the derivation of a simple sufficient statistic that pins down the currency choice of an individual firm and can be directly measured in the data. The application of this methodology to a universe of Russian firms can be viewed as a proof of concept. We find significant differences in the pass-through of exchange rates into firms' profits depending on the currency of borrowing validating predictions of the model. Our hope is that this methodology and empirical evidence will prove useful in future research about the dominant status of the dollar in

global economy.

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