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Money demand by non-financial corporations

Abstract

We document empirically the money demand by European non-financial corporations by exploiting a unique and brand-new survey on their cash usage in a stress period. We also assess: (i) the relation between cash held and firm size; and (ii) estimate point values of cash holdings and carry out statistical comparisons along the sectoral and country dimensions. First, we find that cash holdings are inversely related to firm size, providing additional evidence that Small and Medium Enterprises (SMEs) tend to store more cash relative to their larger peers. Second, we find that cash-intensive sectors and "cash-friendly" countries display right-shifted distributions of cash holdings with statistically-significant larger average holdings. We argue that in a low interest rate and low inflation environment cash holdings serve as a store of value for European firms, in particular for SMEs which are more likely to be financially constrained, especially in crisis times.

Keywords: Monetary economics; Cash demand; Store of value; Precautionary savings; Financial crisis

JEL classification: D22, D25, E41, G01, G32

Non-technical summary

Several articles and surveys document the store-of-value function of cash for consumers in crisis and non-crisis times, outlining the insurance role of cash against a credit supply shock and/or risk of bank defaults. Other papers document the store-of-value role of cash for firms in crisis times and that cash holdings give firms a competitive advantage over their peers even after a crisis is over. Our study contributes by assessing empirically the store-of-value function of cash, as narrowly defined by currency, for European firms during a crisis, like the COVID-19 pandemic.

We exploit a unique and brand-new survey on cash usage by European companies conducted by the European Central Bank (ECB) in a stress period to: 1) assess the relation between cash held and firm size; and 2) estimate point values of average cash holdings and carry out statistical comparisons along the sectoral and country dimensions. This paper contributes to the literature as follows. First, it provides additional evidence on the inverse relation between cash holdings and firm size, suggesting that SMEs tend to store more cash relative to their larger peers. Second, it provides an estimate of cash holdings of European firms for store-of-value purposes. Aggregating cash holdings along the country and sectoral dimensions, we find that firms in "cash-friendly" countries, e.g. Austria, or in cash-intensive sectors, e.g. hotels, hold more cash. Third, it offers insights on the design of Central Bank Digital Currency (CBDC), e.g. the calibration of holding limits for businesses. Fourth, it adds to the debate on monetary policy transmission and the zero lower bound.

Our findings point out that firms belonging to certain sectors, e.g. hotels, hold more cash, which, despite government support, suffered strongly the reduced income during the COVID-19 pandemic. We provide aggregate evidence that 1) cash in circulation accelerated at the onset of the pandemic; 2) this acceleration was driven by a precautionary demand. However, to confirm the latter finding, firms' cash holdings at the sectoral level are needed. Our hypothesis is that precautionary holdings grew even stronger for hotels, which try to protect themselves against income shocks due to uncertainty over lockdowns. Another, related, explanation on why SMEs tend to hold more cash is that they have restricted access to finance, especially in crisis times. The Survey on Access to Finance of Enterprises (SAFE) may be used to confirm this explanation.

1 Introduction

The functions of cash have been recently further investigated by the literature.[1] Several articles document the store-of-value function of cash for consumers in crisis times (see Faella & Zamora-Pérez (2025), Roesl & Seitz (2022), Jonker *et al.* (2022), Roesl & Seitz (2021), Zamora-Pérez (2021), Ashworth & Goodhart (2021), Ashworth & Goodhart (2020a), Stix (2013), Ramirez (2009)), outlining the insurance role of cash against a (potential) credit supply shock and/or risk of bank defaults.[2] Cusbert & Rohling (2013) show that part of higher cash demand can be attributed to reduced interest rates, i.e. the opportunity cost of holding cash, but the major part may be due to precautionary holdings. Similarly, Rainone (2022) reports that cash demand (as proxied by net withdrawals) increased substantially in Italy in 2010-2018 after interest rates approached the effective lower bound, however attributing this increase mostly to transactional demand, as cash holdings did not increase as much. Surveys document the store-of-value function of cash for consumers more generally (see ECB (2020) and Esselink & Hernandez (2017)). Assenmacher *et al.* (2019) provide evidence of Swiss cash held as a store of value in Switzerland and abroad in 1950-2017. Based on 70 economies over 2001-2014, Jobst & Stix (2017) conjecture that the level shift in cash demand is related to increased uncertainty. In contrast, Auer & Boehme (2021) argue that cash is of limited appeal as store of value but useful in transactions, as it carries no interest and is costly and risky to store in large quantities over long horizons.[3] Looking at a looser definition of "cash", i.e. not only banknotes but also overnight deposits[4], other papers document the store-of-value role of "cash" for firms in crisis times and, moreover, that "cash" holdings give firms a competitive advantage over their peers

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[1]Less recently, Keynes (1936) introduces the concept of liquidity preference and links it to a precautionary motive. Jevons (1876) and Menger (1892) elaborate on the classical functions of money conceptualized by Aristotle, including the precautionary or store-of-value motive. More recently, Hull & Sattah (2021) revisit the properties of money in the digital era, also from a computer science perspective.

[2]There are two necessary conditions for cash to act as store of value (assuming, for simplicity, a closed economy): interest rates are reasonably low and stable and inflation is bounded by nominal income growth.

[3]Using 2019 data, the authors report that cash in circulation (of which cash holdings are a subset) relative to bank deposits are low worldwide, but with some heterogeneity across currency areas. However, Tamele *et al.* (2021) show that cash in circulation increased abnormally in the euro area during the COVID-19 pandemic, despite the diminished use of cash for transactions and foreign demand for euro cash. Hence, Tamele *et al.* (2021) conclude that the surge in cash in circulation during the pandemic is likely due to store-of-value demand. In section 4 we repeat a similar analysis and arrive to the same conclusion.

[4]Overnight deposits are balances that can immediately be converted into currency or used for cashless payments. See https://www.ecb.europa.eu/pub/pdf/other/ecb.manualmfibalancesheetstatistics201901~d2e bf72987.en.pdf?7387f911ffbc48fa536a5e61bbd2ce49.

even after a crisis is over (boosting their investment capacity), see Joseph *et al.* (2020) and Duchin *et al.* (2010).[5]

In this paper, we add to this literature and assess empirically the money demand by European non-financial corporations, in particular their cash demand, i.e., currency (banknotes and coins) demand, to date the only available central bank money at the retail level, in a stress period, like the COVID-19 pandemic. We exploit a unique and brand-new survey on cash usage by European companies conducted by the ECB (ECB (2022)) to: 1) assess the relation between cash holdings and firm size, as measured by the number of employees; and 2) estimate point values of average cash holdings and carry out statistical comparisons along the sectoral and country dimensions.[6] The survey on cash usage by European companies is conducted for purposes that go beyond the scope of this article. It provides, for the first time in Europe, an overview on companies' strategic view on the current and future use and acceptance of cash. The main objectives of the survey are: 1) understanding acceptance of and satisfaction with cash (*versus* other means of payments); 2) understanding companies' views on the future of cash and their willingness to accept it going forward; and 3) estimating the cash received through payments and held by companies. In this paper we focus on 3). Assuming that the portion of cash useful for store-of-value purposes is not deposited in the first place, the average amount of cash holdings provides a reliable estimate of cash physically hoarded for store-of-value reasons.[7]

This paper contributes to the literature in several ways. First, it provides additional evidence on the inverse relation between cash holdings and firm size, suggesting that SMEs tend to store

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[5]Other important papers within the rich literature on money demand by non-financial firms are by Meltzer (1963), Miller & Orr (1966), Miller & Orr (1968), Marquis & Witte (1989), Bover & Watson (2005), Gao *et al.* (2021), Kiarsi (2024), Almeida *et al.* (2002), von Landesberger & Martínez-Carrascal (2010), von Landesberger (2007).

[6]The ECB conducted another similar survey in 2008, whose results are summarized at `https://www.ecb.europa.eu/pub/pdf/other/art2_mb201104en_pp79-90en.pdf`, however it concerns only a subset of European countries (in turn a subset of euro-area countries). In individual euro-area countries, another similar survey was run in Finland in 1996 and in the Netherlands in 1992, i.e. prior to the introduction of the euro (`https://helda.helsinki.fi/bof/bitstream/handle/123456789/10131/Bofbul_1996-03.pdf?sequence=1&isAllowed=y` and Boeschoten & Fase (1992)).

[7]In the survey, firms are asked the main transactional reasons why they withdraw their deposited cash, as we assume that withdrawal behaviour is due to a transactional motive only. This assumption rests on the fact that mostly high-denomination banknotes serve a store-of-value function (`https://www.bis.org/statistics/payment_stats/commentary2112.htm`), while there are usually withdrawal limits. See e.g. Amromin & Chakravorti (2009). There are only few firms not stating that they withdraw cash for transactional purposes (i.e. falling into the 'other' category), ca. 7%, confirming the validity of this assumption. Also, the reasons read out may not cover the entire transactional motive set, hence this percentage may be overestimated.

more cash relative to their larger peers.[8] Second, it provides an estimate of cash holdings of European firms for store-of-value purposes. Cash holdings may be seen as a prudential instrument providing firms with a protection against a (potential) credit supply shock. Third, it adds to the discussion on the design of a CBDC. Some features of cash make it unique until now, e.g. anonymity, real-time settlement and also physicality/offline property (see, e.g., Tarlin (2021), Nocciola & Zamora-Pérez (2024)). Firms are still holding physical cash for store-of-value purposes and this fact may be important for CBDC design, in particular with respect to holding limits for businesses and merchants. Finally, it adds to the literature on the monetary policy transmission and the effective lower bound (see e.g. Rogoff (2017), Assenmacher & Krogstrup (2021)). While cash constrains monetary policy, it acts as a store of value, too.

This article is structured as follows: section 2 describes the data, section 3 outlines the methodology, section 4 reports the results, section 5 discusses some anecdotal evidence about the precautionary motive for holding cash and section 6 concludes.

2   Data

We exploit a survey on cash usage by European firms conducted by the ECB (ECB (2022)). The survey is run for purposes that go beyond the scope of this article. It aims at getting an overview on companies' strategic view on the current and future use and acceptance of cash. In particular, it aims at: 1) understanding acceptance of and satisfaction with cash (*versus* other means of payments); 2) understanding companies' views on the future of cash and their willingness to accept it going forward; and 3) estimating cash received through payments and held by companies. The ECB interviewed 10,141 firms in the period October-December 2021, at the beginning of a COVID-19 pandemic wave in Europe due to the Omicron variant of SARS-CoV 2. The survey design, size, representativeness, non-response rate and weighting schemes are discussed and selected questions are reported in appendix A.

Our first key variable of interest is "cash holdings". Figure 1 (upper panel) reports the average amount of cash holdings by brackets both for cash-rich and cash-poor sectors.[9] There

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[8]Similarly, Amronin & Chakravorti (2009) find that the share of SMEs in 13 advanced economies in 1988-2003 is associated with stronger cash demand.

[9]Cash holdings and other variables are weighted by the employee size class to re-establish the proportions in

is no substantial difference in the percentage of firms stating that they hold less than €1000 or from €1000 to €4999 across the two sectoral categories. Firms are distributed differently across the bands €5000-€9999 and €10000-€49999, with cash-intensive firms having a larger share in the upper band. Figure 1 (lower panel) reports the average amount of cash holdings by brackets by country both for cash-rich and cash-poor sectors. We note that countries like Austria tend to have a lower share in the lowest bracket while larger shares in higher brackets, e.g. relative to France, although no clear pattern can be deduced from the chart. In sum, little can be drawn on the average amount of cash holdings when looking at (wide) bracket answers. We are interested in point values in order to rank holdings, calculate distributions and carry out inference.[10] The next section describes a methodology to do so.
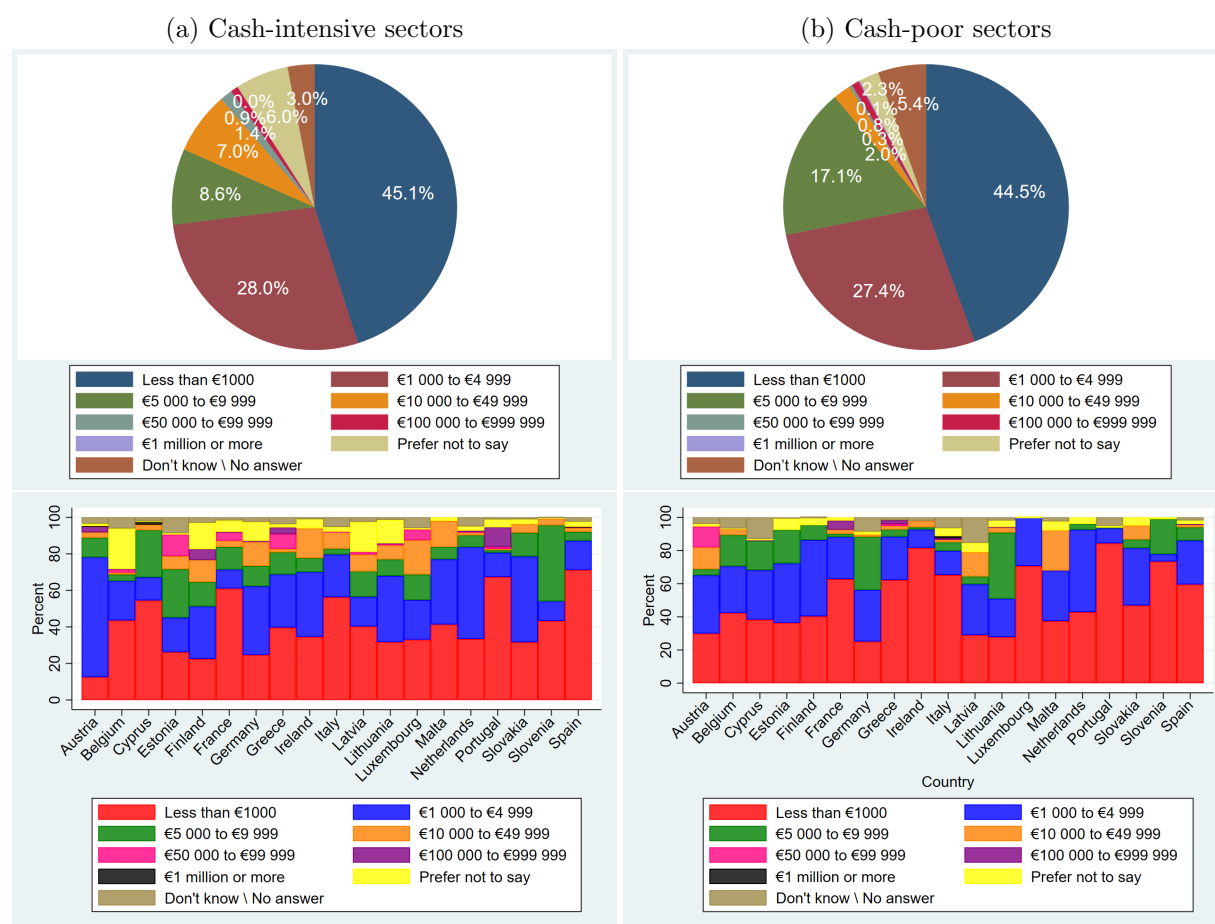

Figure 1: Average amount of cash holdings by sectors (upper panel) and country breakdown (lower panel). Source: author's elaboration based on ECB (2022).

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the population.

[10]For consistency, the question on the average amount of cash holdings is asked only to firms accepting cash.

The second key variable of interest is firm size, as measured by the number of employees. Figure 2 shows distributions of number of employees by sectors (LHS) and country breakdown (RHS). The number of employees is right-censored to 50 to improve visualisation of these extremely heavy-tailed distributions. It is striking to note the similarity of these distributions across sectors and countries. Nevertheless, the IT sector seem to have a steeper distribution with a longer tail relative to hotels, in which more mass is concentrated on lower sizes. Similarly, Slovenia appears to have a steeper distribution relative to France, where a larger share of bigger companies reside. The relation between cash holdings and firm size is investigated via a model described in the next section.

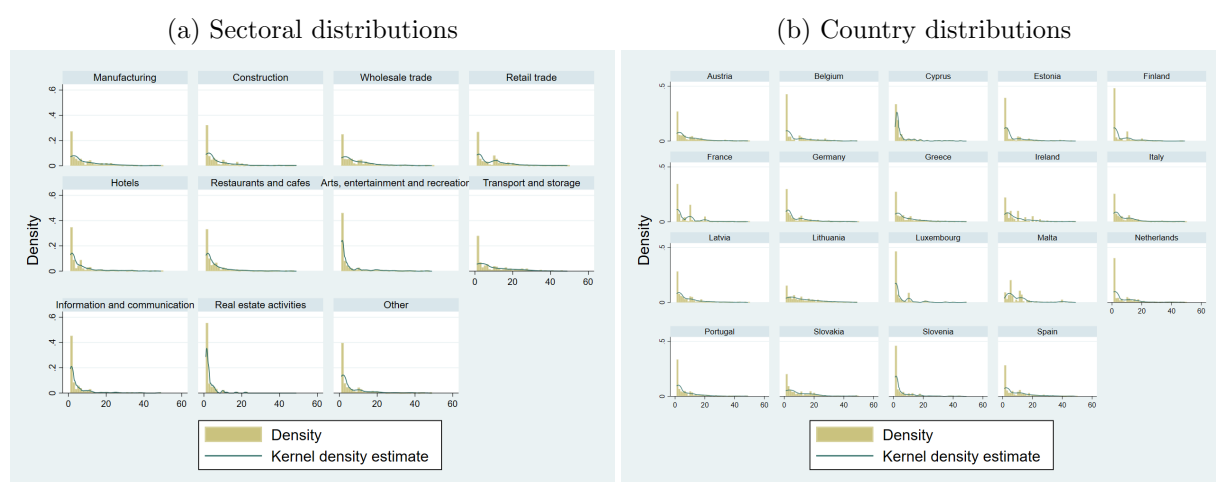(a) Sectoral distributions   (b) Country distributions

Figure 2: Distributions of number of employees by sectors (LHS) and country breakdown (RHS). The number of employees is right-censored to 50 to improve visualisation of these extremely heavy-tailed distributions. Source: author's elaboration based on ECB (2022).

3   Methodology

Firms are asked whether their average amount of cash held falls into certain brackets (figure 1), while point values are unobserved. The survey answers are interval-censored, i.e. the unobserved response falls within a bracket with fixed end-points. Exception is the largest bracket which is right-censored, i.e. the unobserved point value falls within an interval that has a fixed lower endpoint but an open-ended upper endpoint. To deal with censoring and estimate point values we use interval regression, which is a generalization of the tobit model for corner solutions (Tobin

([1958](#)) and is a particular type of censored regression model. Interval regression generalizes the tobit model as it extends censoring beyond left- or right-censoring. In what follows, we summarize the interval regression model.[11]

3.1   Interval regression

Let y_i be average cash holdings per firm i, x_i be firm size, as measured by the number of employees, $\mathbf{D}_k$ be categorical variables and $\mathbf{z}_i$ be firm-level controls. Consider the following model

$$y_i = \beta_0 + \beta_1 x_i + \mathbf{D}_k' \boldsymbol{\beta}_2 + \mathbf{z}_i' \boldsymbol{\beta}_3 + e_i \tag{1}$$

where $\beta_0, \beta_1, \boldsymbol{\beta}_2$ and $\boldsymbol{\beta}_3$ are parameters to be estimated. Notably, y_i is not observed and is therefore called a latent variable. If y_i was observed and randomly drawn from the population then the least square estimator would yield consistent estimation of the parameters. However, we observe only intervals of y_i. Let r_j, $j \in \{1, \ldots, J\}$, be known interval limits as specified in the survey design, with $r_0 = 0$, and define the observed quantity

$$w_i = \begin{cases} 1 & \text{if } 0 < y_i \leq r_1 \\ 2 & \text{if } r_1 < y_i \leq r_2 \\ \vdots \\ J & \text{if } y_i > r_J \end{cases} \tag{2}$$

Moreover, assume

$$e_i | x_i, \mathbf{D}_k, \mathbf{z}_i \overset{i.i.d.}{\sim} \mathcal{N}(0, \sigma^2) \tag{3}$$

Under the assumption in eq. ([3](#)) and calling $\beta_0 + \beta_1 x_i + \mathbf{D}_k' \boldsymbol{\beta}_2 + \mathbf{z}_i' \boldsymbol{\beta}_3 = \mathbf{x}' \boldsymbol{\beta}$ we can obtain the conditional probabilities for the observed quantity $\mathbb{P}(w_i = j | x_i, \mathbf{D}_k, \mathbf{z}_i)$ for $j \in \{1, \ldots, J\}$,

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[11]Censoring differs from truncation, as for the latter the sample is selected based on the response variable. Hence, truncating the sample generates non-random sampling based on the response. The control variables are themselves truncated. Instead, censoring is a problem of incomplete information about the response variable (i.e. it is a missing value problem), while the control variables are available and the sample can still be random, at least conditional on the controls. See e.g. Wooldridge (2010), Davidson & Mackinnon (2003).

i.e.

$$\mathbb{P}(w_i = j | x_i, \mathbf{D}_k, \mathbf{z}_i) = \begin{cases} \Phi[(r_1 - \mathbf{x}'\boldsymbol{\beta})/\sigma] - \Phi[(-\mathbf{x}'\boldsymbol{\beta})/\sigma] & \text{if } w_i = 1 \\ \Phi[(r_2 - \mathbf{x}'\boldsymbol{\beta})/\sigma] - \Phi[(r_1 - \mathbf{x}'\boldsymbol{\beta})/\sigma] & \text{if } w_i = 2 \\ \vdots \\ 1 - \Phi[(r_J - \mathbf{x}'\boldsymbol{\beta})/\sigma] & \text{if } w_i = J \end{cases} \tag{4}$$

where $\Phi[]$ is the standard normal cumulative distribution function.[12] The log-likelihood for a random draw i is

$$l_i(\beta, \sigma) = \sum_{j=1}^{J-1} \mathbb{1}_{[w_i=j]} log\left\{ \Phi\left[\left(\frac{r_j - \mathbf{x}'\boldsymbol{\beta}}{\sigma}\right)\right] - \Phi\left[\left(\frac{r_{j-1} - \mathbf{x}'\boldsymbol{\beta}}{\sigma}\right)\right] \right\} + \mathbb{1}_{[w_i=J]} log\left\{ 1 - \Phi\left[\left(\frac{r_J - \mathbf{x}'\boldsymbol{\beta}}{\sigma}\right]\right) \right\} \tag{5}$$

from which we can obtain the maximum likelihood estimators $\hat{\boldsymbol{\beta}}$, $\hat{\sigma}^2$.[13] We are particularly interested in the effect of firm size, as measured by the number of employees, on average cash holdings.[14] Given that eq. (1) is a linear model, we are especially interested in $\hat{\beta}_1$.[15] The next section clarifies this effect.

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[12] The proof behind eq. (4) is subsumed in Wooldridge (2010), but it is well-known in probability theory. We report it in the appendix for convenience.

[13] Our estimation procedure assumes normally-distributed errors in eq. (3) and, accordingly, average cash holdings. This is a fine assumption, as we are looking at average cash holdings and not cash holdings themselves. By the Lindeberg (1922)-Levy (1935) central limit theorem the average converges to a normal distribution with the only requirement being for cash holdings to be i.i.d. with finite first two moments, i.e. we do not require that they follow a Gaussian. This requirement is quite general and encompasses commonly known heavy-tailed distributions. For example, cash holdings may still follow a power law-type distribution such as the Pareto distribution. As long as the Pareto index is larger than two, i.e. the tail is sufficiently flat, i.e. the variance is finite, the Gnedenko & Kolmogorov (1954) central limit theorem assures that average cash holdings still converge to a normal distribution at a standard rate.

[14] The number of employees is imputed by the ECB based on the survey question D4, which asks firms to report a range for their number of employees. The point values are then compared with external data sources, like Eurostat's two sources of business statistics: the Structural Business Statistics (SBS) and the Business Demography (BD). Exceptionally (for sector A in all other sectors) the number of employees is compared against the Dun and Bradstreet business database. When the two sources diverge, the external data source was used.

[15] If eq. (1) followed a corner-solution tobit model, the (average) partial effect would not coincide with $\hat{\beta}_1$, but $\hat{\beta}_1$ would need to be adjusted by a scale factor between ranging from zero and one to deliver the partial effect. Even in that case, the sign of the effect would be unaffected. See e.g. Wooldridge (2010). As cash holdings, and even more so their average per firm, are likely to be non-zero for a non-trivial fraction of the population, we conclude that a linear model is a good model for average cash holdings (i.e. the scale factor or the estimated probability of observing positive average cash holdings approaches one) and hence $\hat{\beta}_1$ approximates well the average partial effect.

3.2 Point value estimation

Finally, using the estimated parameters of model (1), including all the confounding variables discussed in the next section, we predict the point value of average cash holdings (y_i^*) under the constraint that the point value should fall within the bracket limits (eq. (6)).

$$y_i^* = max\{a, min(\hat{y}_i, b)\} = \begin{cases} a & \text{if } \hat{y}_i \leq a \\ \mathbf{x}'\hat{\boldsymbol{\beta}} & \text{if } a < \hat{y}_i < b \\ b & \text{if } \hat{y}_i \geq b \end{cases} \qquad (6)$$

where $\hat{y}_i = \mathbf{x}'\hat{\boldsymbol{\beta}}$ and a and b, with $b > a$, are any of the interval limits r_j, $j \in \{1, \ldots, J\}$, specified in eq. (2). The point values cannot be compared with each other reliably, as they are estimated with error. However, they are useful to construct distributions over several dimensions to carry out statistical comparisons. In the following section, we report the estimated distribution of average cash held by bracket, sector and country and carry out inference per bracket for some countries and sectors.

4 Results

By design the sample surveyed is not a random sample from the firm population, as cash-intensive firms are over-sampled while cash-poor firms are under-sampled (see appendix A).[16] Hence, to apply the methodology described above and make valid inference we have to control for the sampling design by including the sampling categories in $\mathbf{D}_k$. We consider as relevant controls the sampling design categories, i.e. the sector of operation, the employee size class and the country of residence, and a firm-level variable, i.e. annual turnover.[17]

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[16] The description of the survey design is relegated to Appendix A. Essentially, the ECB employed quota sampling based on the firm sector, employee size class and country.

[17] Turnover is also imputed by the ECB based on the survey question Q16, which asks firms to report a range for their turnover. The point values are then compared with external data sources, like, as for the number of employees, the SBS and BD. For few sectors, among which arts, entertainment and recreation (and sector A, P, Q, S in all other sectors), turnover is compared against the Dun and Bradstreet (DB) business database or the Sales Rock (SR) business database. The choice of which source to use between DB and SR in each country is based on how closely their data match the SBS and BD data (for the sectors where SBS and BD data are available). Turnover is adjusted according to the ratio between average turnover per enterprise based on SBS/BD data and average turnover per enterprise based on the preferred data source (DB or SR). When the ECB does not have turnover from SBS/BD, the ECB calculated it as the number of enterprises per sector (counted from SBS or BD)

First, for the sector of operation quota sampling is based on specific target quotas per sector (see appendix A). The relation between average cash holdings and firm size may be affected by the sector of operation as follows: a firm belonging to a particular sector, e.g. retail trade or hotels, can be inherently more prone to hold cash. Contrarily, an IT firm may hold less cash. At the same time, a firm belonging to the food sector may be of a smaller size relative to a firm operating in the manufacturing sector. In sum, the sector is a confounding variable inducing an omitted variable bias in $\hat{\beta}_1$. Sectoral categories control for this issue and are included in model (1).

Second, we also have to consider the country of residence, as more firms are sampled for larger countries (see appendix A). For example, countries in which agents (including firms) have an intrinsic stronger preference for liquidity may hold more cash. For instance, in appendix A, figure 7, lower panel, shows that German companies are more prone to accept cash than Finnish companies. Also, countries may have heterogeneous populations of firms. Italy may host a relatively larger number of SMEs relative to France, which may host a relatively fewer number of larger firms (Nicoletti *et al.* (2022)). To clean our estimates from this confounding effect, we control for the country of residence.

Finally, we have to include the employee size class, as quota sampling for the retail trade sector is based on specific target quotas per employee size class within this sector (see appendix A). For example, firms belonging to a large size class may receive more payments and find more efficient to receive payments in electronic form to update their ledgers. Hence, relatively speaking, they may be less prone to store cash. A firm of a small size class may prefer cash payments and store more cash to avoid an inefficient frequent depositing.

4.1 Core result

We find that average cash holdings are inversely related to firm size as measured by the number of employees (see table 1), i.e. we find $\hat{\beta}_1$ to be negative. An increase of firm size by 1 employee leads to a reduction in average cash holdings by ca. 4.5 euro. By looking at 1 employee, this is a marginal effect. In reality, firms may vary by thousands of employees as order of magnitude.

times the average annual turnover per sector (scalar-adjusted from the preferred source, DB or SR). When the two sources (survey and external source) diverge, the external source was used.

VARIABLES	(1) Cash	(2) Cash	(3) Cash	(4) Cash	(5) Cash	(6) Cash
NR_EMPLOYEES	-4.515***	-4.617***	-4.659***	-4.642***	-4.468***	-4.471***
	(1.004)	(1.004)	(1.003)	(1.003)	(1.003)	(1.003)
Annual turnover	Yes	Yes	Yes	Yes	Yes	Yes
Sector	Yes	Yes	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes	Yes	Yes
Employee size class	Yes	Yes	Yes	Yes	Yes	Yes
Average # payments	No	Yes	Yes	Yes	Yes	Yes
% payments in cash	No	No	Yes	Yes	Yes	Yes
Respondent role	No	No	No	Yes	Yes	Yes
Legal type	No	No	No	No	Yes	Yes
Future cash acceptance	No	No	No	No	No	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes
N	7529	7529	7529	7529	7529	7529

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1: Average cash holdings as a function of number of employees. Controls: annual turnover, sector, country and size class. Column 2 includes the average number of payments. Column 3 includes the average number of payments and the percentage of payments in cash. Column 4 includes the average number of payments, the percentage of payments in cash and the respondent role. Column 5 includes the average number of payments, the percentage of payments in cash, the respondent role and the legal type. Finally, column 6 includes the average number of payments, the percentage of payments in cash, the respondent role, the legal type and information on future cash acceptance.

Hence, average cash holdings may vary by the same order of magnitude when comparing SMEs to large firms. For example, conditional on turnover, a firm increasing its size by 1,000 employees would have an average reduction in average cash holdings by ca. 4,500 euro. This result provides evidence that SMEs tend to store more cash relative to their larger peers and is in line with, e.g., Opler *et al.* (1999), who find that larger firms hold less cash, Bates *et al.* (2009), who find that smaller and riskier firms hold more cash, Almeida *et al.* (2004), who find that financially constrained firms hoard cash, Kakhbod *et al.* (2025), who show that cash levels decline as firms expand, although they document a U-shaped relationship between cash levels and firm size, and Amronin & Chakravorti (2009), who find that the share of SMEs in 13 advanced economies in 1988-2003 is associated with stronger cash demand.

The baseline model (column 1) is the simplest accounting for the sampling design and income.

Hence a causal statement on the relation between size and cash holdings may suffer from the criticism that several other confounding factors may be at play. In other words, our result may be biased, i.e. cannot be interpreted as causal and, at best, table 1 shows a negative correlation between cash holdings and firm size. For variation in firm size (treatment) to be as if it was randomly assigned across the firm sample, we have to compare firms that, apart from their size, are identical.[18] We add further relevant controls to mitigate this concern.

In addition to turnover, the average number of payments received by a company may be another relevant control. The average number of payments may affect cash holdings as follows. If a firm received many payments of low magnitude, it may be inefficient for it to deposit each time. Rather, a non-negligible fraction of these payments may be held in cash. Contrarily, if a firm received few payments of large amount, it may be convenient to deposit it as soon as possible to avoid security risks and do not incur in high storage costs. Also, the average number of payments may carry a different information compared to turnover. A firm with a given turnover may receive few payments of large amount or many payments of low amount, yielding the same turnover. Finally, the average number of payments may be related to the number of employees, thus resulting in a confounding factor. In the survey firms are asked to provide a point value to the question about the average number of payments. However, if the firm does not know or does not want to share this information, the firm is allowed to give bracket answers. We consider both point value answers as well as bracket answers. Column 2 shows that our result is still statistically significant with a similar magnitude and same sign.

In the survey firms are asked the proportion of payments in cash they receive monthly. The percentage of cash payments is another potentially relevant control, as it is supposedly related to both firm size and cash holdings. Small firms may be more prone to receive cash payments than large enterprises. A high percentage of cash payments may be associated with greater cash holdings. Column 3 shows that our finding is still statistically significant with a similar magnitude and same sign, too.

Also, the respondent may play role in identifying the causal effect, as the respondent role may

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[18]Having a cross-section and not panel data, we cannot control for unobserved time-invariant heterogeneity. Hence, causality is harder to identify. Nevertheless, this evidence can be validated with repeated surveys of the same firms in the future.

indicate the degree of measurement error in the response. For example, the financial director of a firm, due to her position, may know more precisely the level of cash holdings than the owner, who may delegate the bookkeeping to its management and, hence, respond less precisely to this question. To control for this measurement effect we add a covariate identifying the respondent role. Column 4 shows that the sign is identical, magnitude is similar and the result is again strongly statistically significant (at the 1% level).

In addition, the legal type of entity may be related to cash holdings and firm size and therefore bias the identification of the causal effect of interest. The headquarters of a large group may not store cash at all, but rather update the ledgers. Contrarily, a branch of the same large group may hold cash. Depending on the sector, the headquarters may host a larger number of employees in comparison to a local branch. A confounding effect from the legal type of entity cannot be excluded *a-priori*. Column 5 points out that the sign is identical, magnitude is similar and significance is again strong (at the 1% level).

Finally, the expectations on future acceptance of cash may be related to current cash holdings and firm size. Firms expecting not to accept cash in the future may be already divesting in cash storage infrastructure, e.g. a *caveau*, and, hence, already have lower cash holdings. Firms still planning to accept cash in the future may be of smaller size. Cash acceptance expectations may be considered a soft, forward-looking confounding factor that may proxy the firm cash management strategy. Column 6 highlights that the sign is identical, magnitude is similar and significance is again stark (at the 1% level).

The inclusion of these potentially confounding factors has not altered the sign, the magnitude nor the strong statistical significance of our result. Therefore, we conclude that our finding is robust, i.e. that firm size seems to negatively affect cash holding in a causal fashion.

4.2 Sectoral distribution

After estimating point values of cash holdings as in eq. (6), we report the estimated distribution of average cash held by sector and bracket. We start with the lowest bracket, 0-999 euro. Figure 3, panel (a), shows that the estimated distribution is fairly normal, slightly positively skewed, i.e. with a longer right tail. By comparing presumably cash-poor sectors against cash-intensive

sectors, it is visible that for the latter the distribution is shifted to the right. For example, this is evident if we compare the manufacturing sector against the hotels sector. For some sectors, e.g. real estate activities, the distribution is irregular due to the lower number of observations. When we move to the next bracket, 1000-4999 euro, we observe a similar pattern. Distributions are roughly normally-shaped and are right-shifted for certain sectors such as the hotels sector (panel (b)). For the bracket 5000-9999 euro, the distributions get more irregular as the number of observations decreases (panel (c)). Moreover, real estate activities and the information and communication sector, two supposedly cash-poor sectors, do not appear in this bracket of average cash holdings. Cash-intensive sectors, such as hotels, still display a smoothly-shaped distribution which is right-shifted. Similar remarks hold true for bracket 10000-49999 euro (panel (d)). Fewer and fewer firms report their average cash holdings to lie beyond this bracket, and they mostly belong to the cash-intensive sectors.

(a) Bracket: 0-999 euro.

(b) Bracket: 1000-4999 euro.

(c) Bracket: 5000-9999 euro.
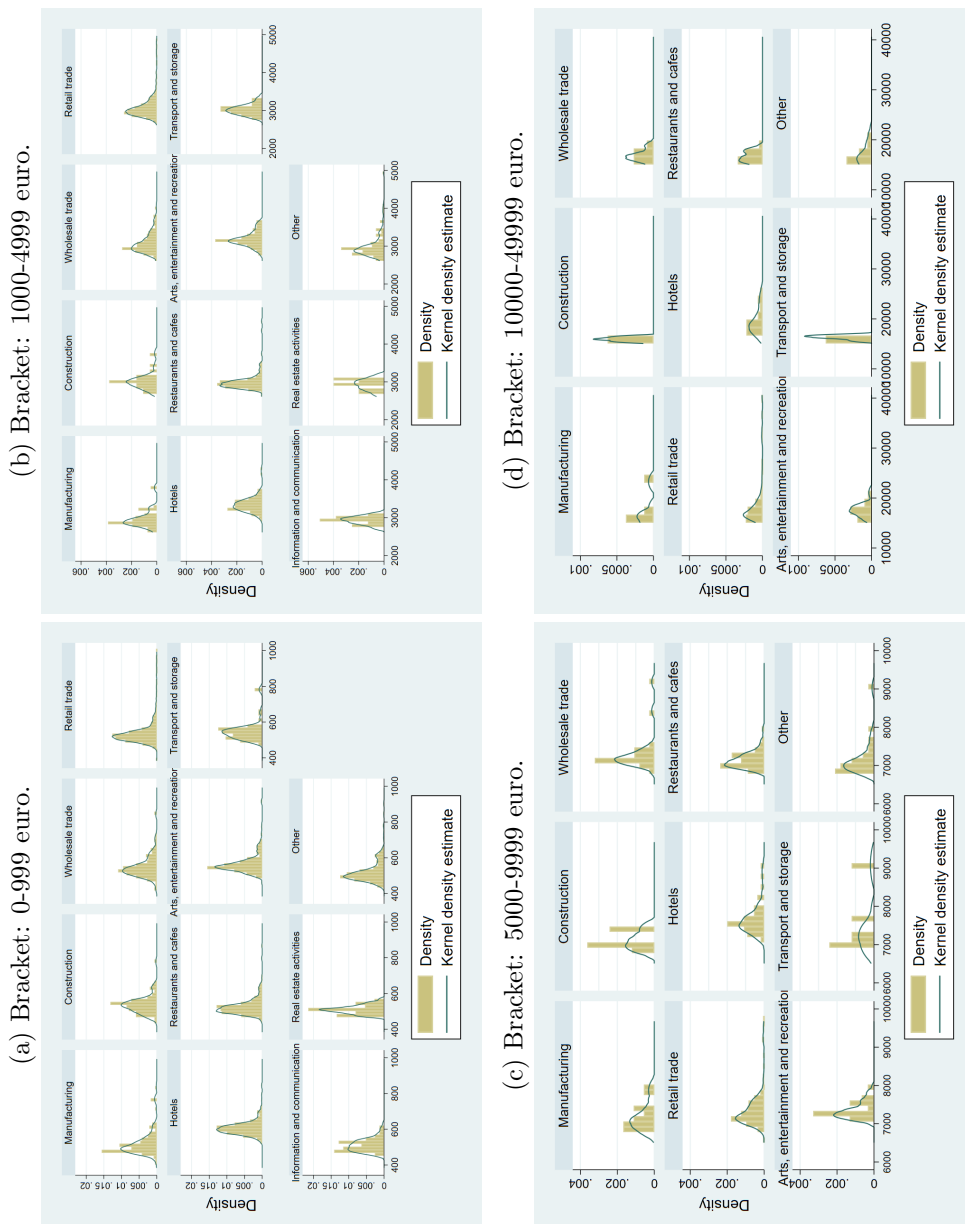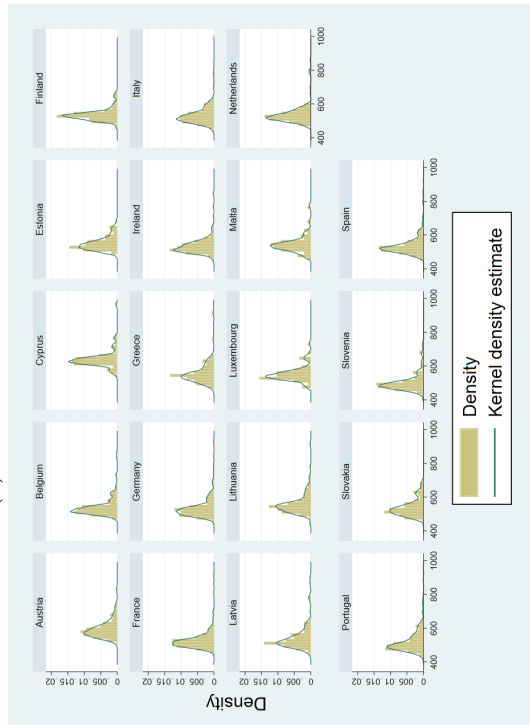
(d) Bracket: 10000-49999 euro.

Figure 3: Estimated distribution of average cash held by sector and brackets. Sample sizes are as follows. Manufacturing: 475, Construction: 325, Wholesale trade: 532, Retail trade: 5162, Hotels: 486, Restaurants and cafes: 933, Arts, entertainment and recreation: 690, Transport and storage: 174, Information and communication: 217, Real estate activities: 98, Other: 1049.
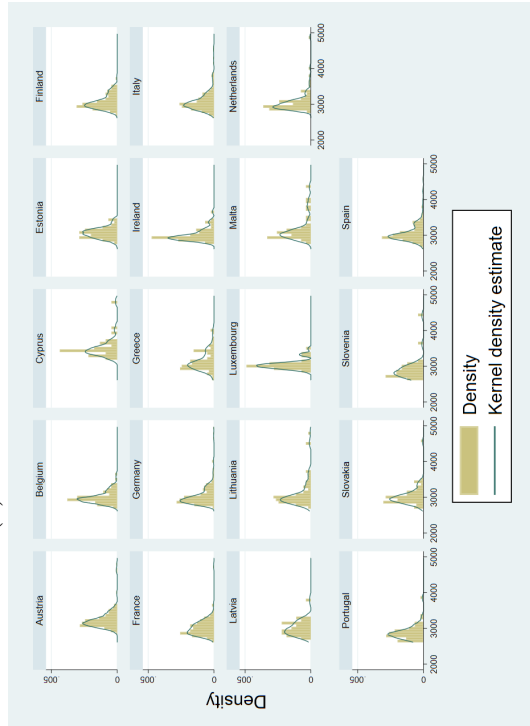
4.3 Country distribution

We also report the estimated distribution of average cash held by country and bracket. We start with the lowest bracket, 0-999 euro. Figure 4, panel (a), shows that the estimated distribution is fairly normal, slightly positively skewed. By comparing presumably less cash-friendly countries against cash-friendly countries, it is visible that for the latter the distribution is shifted to the right. For example, this is evident if we compare France to Austria. When we move to the next bracket, 1000-4999 euro, we observe a similar pattern. Distributions are roughly normally-shaped and are right-shifted for certain countries relative to other countries, such as Cyprus relative to Luxembourg or Austria relative to Portugal (panel (b)). For the bracket 5000-9999 euro (panel (c)), a similar conclusion can be drawn. For countries such as Cyprus or Italy we can note that the distribution of average cash holdings is still smoothly-shaped but regains *momentum* moving towards 10000 euro, while the distribution gets more irregular for other countries, such as Latvia, as fewer and fewer firms report cash holdings to fall within this band. Likewise for bracket 10000-49999 euro (panel (d)), Austria seems to have a right-shifted distributions, e.g. relative to Latvia. Beyond this bracket histograms become sparser for all countries and some countries do not appear any longer, as they do not host firms with such high cash holdings.
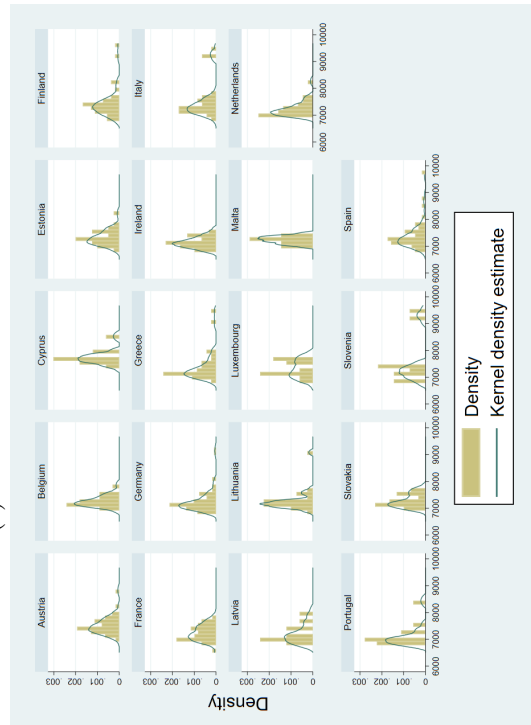
(a) Bracket: 0-999 euro.

(b) Bracket: 1000-4999 euro.

(c) Bracket: 5000-9999 euro.
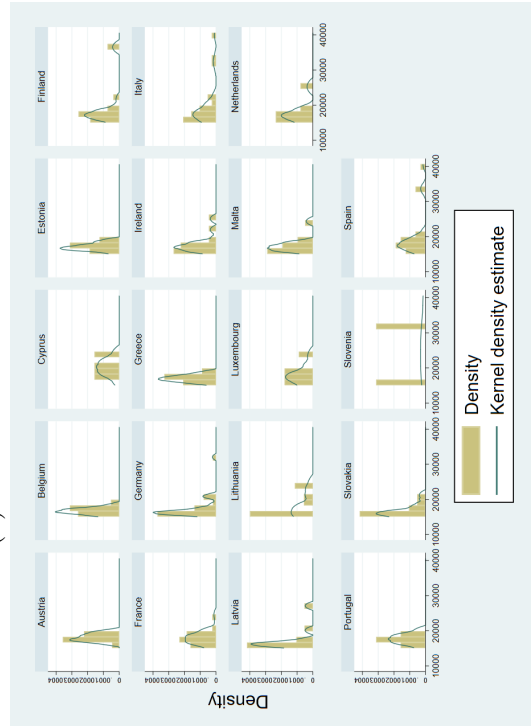
(d) Bracket: 10000-49999 euro.

Figure 4: Estimated distribution of average cash held by country and brackets. Sample sizes are reported in appendix A, table 5.

4.4   Statistical inference

In the last subsections we discussed visually the relative cash holdings of firms across sectors and countries. In this subsection we substantiate this discussion. We look at statistically significant differences in the distribution of average cash holdings per bracket by sector and country. For example, we test for equality of the mean of these distributions. We perform t-tests on selected combinations of pairs of sectors[19] with sufficient number of observations. We report selected pairs of interest based on the ex-ante categorization of cash-intensive against cash-poor sectors. Specifically, we look at the hotels sector against cash-poor sectors for each bracket, as its distribution is evidently right-shifted (table 2). In the bracket 0-999 euro, the hotels sector has statistically higher average cash holdings compared to cash-poor sectors, with no exception. The strongest differences are against the IT and communication or real estate companies. The lowest gap is recorded against the arts and entertainment sector. In the bracket 1000-4999 euro, for the hotels sector we can conclude similarly as for the lower bracket. In the bracket 5000-9999 euro, the hotels sector still display statistically higher average cash holdings relative to (almost) all other cash-poor sectors, however when compared to the transport and storage sector this time the difference in average cash holdings is statistically insignificant. In sum, the hotels sector seem to be an industry in which average cash holdings are higher compared to cash-poor sectors.

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[19]In combinatorics, the binomial coefficient provides the number of all possible combinations of pairs, e.g. in our case 11!/(2!*9!)=55.

	Hotels		
	Bracket: 0-999 euro	Bracket: 1000-4999 euro	Bracket: 5000-9999 euro
Sector	€ 607.423	€ 3340.258	€ 7678.196
Manufacturing	-87.468***	-385.884***	-491.648***
	(-13.77)	(-11.14)	(-4.25)
Construction	-70.035***	-315.893***	-572.346***
	(-11.99)	(-6.72)	(-5.20)
Wholesale trade	-58.599***	-251.870***	-376.868***
	(-11.02)	(-8.17)	(-3.39)
Arts, entertainment	-41.751***	-158.079***	-325.155***
	(-10.29)	(-5.94)	(-4.13)
Transport, storage	-57.938***	-320.756***	-125.773***
	(-7.32)	(-8.79)	(-0.46)
IT, communication	-95.810***	-411.753***	-
	(-16.35)	(-11.48)	-
Real estate	-97.542***	-422.899***	-
	(-17.62)	(-7.47)	-

Table 2: *T*-test on the equality of means. The mean difference of average cash holdings for cash-poor sectors *versus* hotels (rows) by bracket (columns) is reported from the fourth row onwards. The third row reports the mean of average cash holdings for the hotels sector by bracket (columns). *T*-statistics in parenthesis.

Similarly, we test for equality of means of the distributions of average cash holdings across countries. We perform *t*-tests on selected combinations of pairs of countries[20] with sufficient number of observations. Again, we report selected pairs by focusing on a country whose distribution appears right-shifted: Austria. We compare average cash holdings of this country against the five largest economies in the euro area, i.e. Germany, France, Italy, Spain and the Netherlands and countries with tech-savvy firms, e.g. Finland (table 3).[21] In the bracket 0-999 euro, average cash holdings in Austria are statistically larger than average cash holdings in Finland, France, Germany, Italy, the Netherlands and Spain. Likewise, in the bracket 1000-4999 euro Austria displays statistically significant higher average cash holdings than the other selected countries. In the bracket 5000-9999 euro, Austrian average cash holdings are still higher than

[20]The number of all possible combinations of pairs in this case is higher, as there are nineteen countries in the euro area. The exact number is 19!/(2!*17!)=171.

[21]The percentage of firms stating that they prefer cash payments is the lowest in Finland (4%), while contactless card payments rank highest (40%).

German, Dutch and French ones, however the difference with Italian, Spanish and Finnish ones are statistically insignificant. In sum, across bands cash holdings in Austria seem to be on average higher than elsewhere.

		Austria	
	Bracket: 0-999 euro	Bracket: 1000-4999 euro	Bracket: 5000-9999 euro
Country	€ 592.567	€ 3236.728	€ 7512.101
Finland	-57.022***	-175.155***	-62.627
	(-11.22)	(-11.14)	(-0.62)
France	-68.067***	-221.073***	-273.814***
	(-14.75)	(-8.65)	(-4.19)
Germany	-56.314***	-192.919***	-265.752***
	(-11.27)	(-7.56)	(-4.09)
Italy	-61.869***	-160.412***	11.638
	(-13.19)	(-5.92)	(0.09)
Netherlands	-56.927***	-177.494***	-281.104***
	(-9.68)	(-4.99)	(-4.07)
Spain	-55.357***	-163.555***	-104.154
	(-11.53)	(-6.01)	(-1.14)

Table 3: *T*-test on the equality of means. The mean difference of average cash holdings for other selected countries *versus* Austria (rows) by bracket (columns) is reported from the fourth row onwards. The third row reports the mean of average cash holdings for Austria by bracket (columns). *T*-statistics in parenthesis.

5 Evidence of precautionary motive?

Particularly noteworthy, our findings point to the fact that firms belonging to certain categories, such as SMEs, to certain sectors or countries hold more cash. For instance, firms operating in the hotels sector have statistically significant higher cash holdings. This finding is particularly intuitive bearing in mind the special period hotels were surveyed, as, despite government support measures, high-contact service sectors and, in particular, hotels suffered tremendously the reduced influx of clients during the COVID-19 pandemic. A possible explanation for higher cash holdings in the hotels sector is that hotels try to protect themselves against income shocks due to uncertainty over lockdowns by holding more cash to ensure that they have sufficient liquidity

to survive for a sufficient period. This is a possible explanation that would need to be confirmed by 1) repeated surveys to identify the causal effect of firm size and to claim that the prediction for hotels is unique to the pandemic; 2) analyzing the dynamics of cash holdings and deposits of hotels to exclude a substitution effect in favour of deposits during the pandemic; and 3) distilling the components of cash demand of hotels (transactional, precautionary and foreign) to identify its precautionary part. In absence of such a disaggregated evidence, aggregate time series as well as model-based evidence of cash demand may shed initial light on this explanation, in particular clarifying on 2) and 3).

A natural question is why firms would hold cash rather than deposit it at banks. Firms may behave in a precautionary manner by maximising their deposits and reducing cash holdings. In other words, we may observe a substitution effect between cash holdings and deposits, in favour of deposits. First, aggregate cash in circulation in the euro area, sourced from the ECB Statistical Data Warehouse, increased starkly at the beginning of the pandemic (figure 5, panel (a)). While this is already evidence against a reduction in cash holdings at the onset of the pandemic, we provide further evidence on the dynamics of overnight deposits. Figure 5, panel (a), shows that deposits accelerated as well at the beginning of the pandemic.[22] The correlation during the COVID-19 period between acceleration rates of the two forms of money is positive and rather stark, ca. 0.7, way stronger than the same correlation over the full sample, ca. 0.2. Hence, there has been no substitution effect, neither in favour of deposits nor in favour of cash, rather both forms of money expanded, clarifying on point 2).[23] Moreover, the Quarterly Sectoral Accounts from the ECB Statistical Data Warehouse offer further indications on the dynamics of cash and deposit holdings for NFC. Figure 5, panel (b), shows that both increased starkly in aggregate for NFC, even when separating the dynamics of cash[24] and deposits distinctly.

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[22]Deposits of non-financial corporations accelerated even faster than households' deposits, see e.g. https://oecdecoscope.blog/2020/12/10/the-increase-in-bank-deposits-during-the-covid-19-crisis-possible-drivers-and-implications/?print=pdf.

[23]This feature of the COVID-19 pandemic period contrasts what happened during the most intense period of the global financial crisis (September 2007 - September 2008), when the correlation between cash and deposit acceleration rates was negative, ca. -0.25. Within this period, at the onset of Lehman's bankruptcy, deposits actually diminished (bank runs) while cash continued to grow (see e.g. Ashworth & Goodhart (2020b)), i.e. there was a substitution effect. At a smaller geographical scale, a similar substitution effect has been observed in Finland during the financial crisis the country experienced in the early 1990s (https://helda.helsinki.fi/bof/bitstream/handle/123456789/10131/Bofbul_1996-03.pdf?sequence=1&isAllowed=y). The effect of financial crises on depositor behaviour is discussed in e.g. Osili & Paulson (2014).

[24]A back of the envelope calculation shows that the total amount of average cash holdings of NFC as estimated

However, this is aggregate evidence and, at present, we are not able to distinguish between cash holdings and deposits of firms along the sectoral dimension.

As said, aggregate cash in circulation in the euro area increased strongly at the onset of the pandemic. This stark increase may be due to euro-area transactional, precautionary or foreign demand. While a consequence of the pandemic and lockdowns has been reduced physical transactions, we provide evidence of precautionary demand by comparing the data with the prediction from a cash demand model (Rua (2021)), where transactional and foreign demand fundamentals are taken into account, clarifying on point 3).[25] Figure 5, panel (c), shows that the residual spikes at the beginning of the pandemic, providing evidence that the prediction based on fundamentals does not suffice to match the actual value, which is way higher.[26] The residual can be attributed to the precautionary role played by the additional cash in circulation in the euro area. However, again, this is aggregate evidence and, at present, we are not able to distinguish cash demanded by firms along the sectoral dimension.

Another related and plausible explanation on why SMEs tend to store more cash is that they have restricted access to finance, especially in crisis times, when it is more needed.[27] The need of funding of non-financial corporations during the pandemic is reflected in the stark increase in indebtedness in the euro area (de Bondt et al. (2021)). Accordingly, firms with high leverage find it harder to obtain new funds from external sources due to their higher default risk. Sectoral

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via the survey results in circa 94 billion euro. This is the result of a multiplication of the mean of the estimated point value of average cash holdings across the sampled firms by the total number of firms in the EU as sourced from the SBS, which is 32 millions in 2022. This figure is a lower-bound estimate for two reasons, as it can be seen when comparing it with figure 5, panel (b), which shows circa 140 billion euro in 2022. First, the information about cash holdings is sensitive and companies tend to under-report or not report it. Second, when considering the standard deviation around the micro-level mean, the upper-bound estimate of the total amount of average cash holdings of NFC results in 335 billion euro, which signals a large variation around the mean.

[25]Evidence that foreign demand did not play a role in the surge in cash in circulation comes also from net shipments data, which, although cannot be equated with foreign demand, offers a proxy of it. Extending the data by Lalouette et al. (2021) (Chart 14 on p. 29), it is visible that net shipments did not increase during the COVID-19 pandemic, providing support to the hypothesis that foreign demand did not matter for the surge in cash in circulation (appendix D, figure 10). As in Tamele et al. (2021), although net shipments are just a component of foreign demand, we rule out that tourism played any additional role for foreign demand due to lockdowns. Moreover, by plotting also banks' vault cash demand (appendix D, figure 10) we can see, by contrast, that banks' vault cash increased sharply at the onset of the COVID-19 pandemic. This comparison is also highlighted in Faella & Zamora-Pérez (2025).

[26]I thank António Rua for kindly providing the residuals of his model.

[27]Access to finance includes not only access to credit but also to capital markets. SMEs are less likely to access capital markets due to relatively high costs and concerns over excessive influence of new investors. See e.g. Goel & Serena (2020). Other important work on firms' financing constraints, their size and/or their cash management are by Ferrando & Pal (2010), Coluzzi et al. (2015), Bongini et al. (2017), and, for crisis times, by Bankowska et al. (2020), Ferrando & Ganoulis (2020).

(a) Growth rate of cash in circulation and overnight deposits - euro area.

(b) NFC deposits and cash holdings (volume) - euro area.
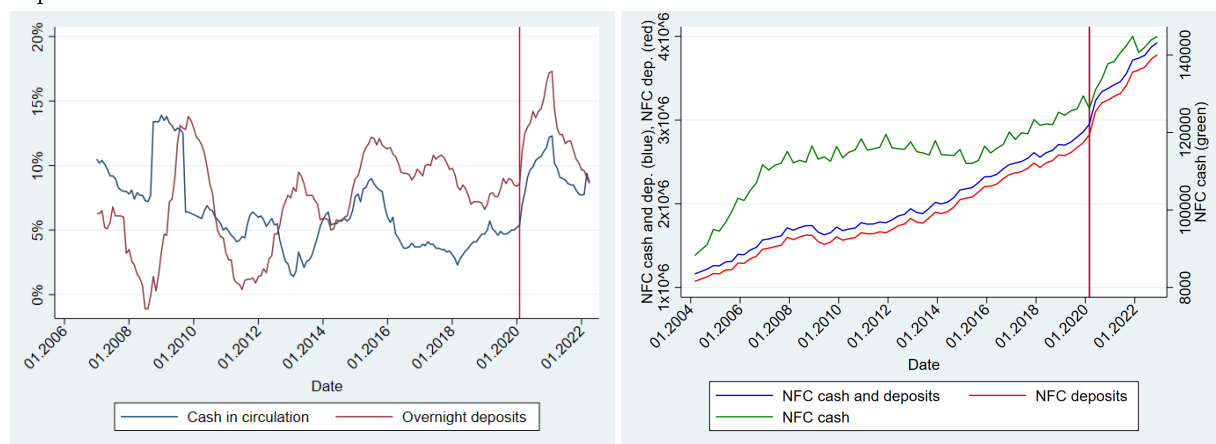
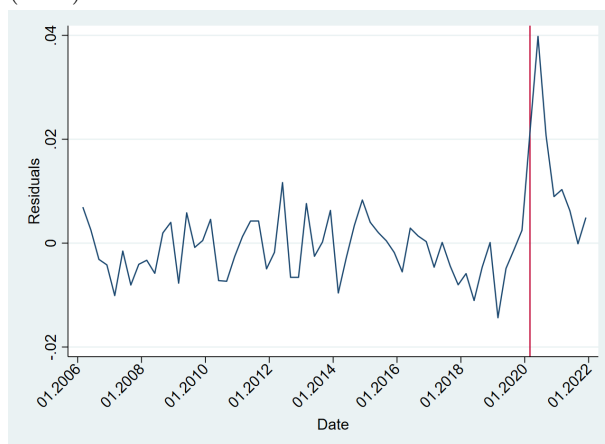(c) Residuals from a cash demand model by Rua (2021) - euro area.

Figure 5: The red vertical lines coincide with the beginning of the COVID-19 pandemic in Europe, i.e. March 2020. Panel (a) shows growth rates. Panel (b) shows volumes in million euros, where the y axis of NFC deposit plus cash holdings and NFC deposit holdings (the dominant component) is on the LHS, while the y axis of NFC cash holdings is on the RHS. In panel (c), the response variable is log-variation in cash in circulation, while (selected) predictors are real GDP (transactional component) and foreign demand indicator and exchange rate (foreign demand component). The resulting residuals are expressed in percentage points. Source panel (a): ECB Statistical Data Warehouse, series keys BSI.M.U2.Y.V.L10.X.I.U2.2300.Z01.A, BSI.M.U2.Y.V.L21.A.I.U2.2300.Z01.A. Source panel (b): ECB Statistical Data Warehouse, series keys QSA.Q.N.I8.W0.S11.S1.N.A.LE.F2.T._Z.XDC._T.S.V.N._T, QSA.Q.N.I8.W0.S11.S1.N.A.LE.F2M.T._Z.XDC._T.S.V.N._T, QSA.Q.N.I8.W0.S11.S1.N.A.LE.F21.T._Z.XDC._T.S.V.N._T. Source panel (c): Rua (2021).

shocks due to lockdowns contributes to weaker corporate asset quality. In particular, firms operating in the services sectors are more likely to see their loans reclassified in higher credit-

risk stages (Nicoletti *et al.* (2022)). Another survey carried out by the ECB and the European Commission, the SAFE survey, may be used to confirm this explanation, at least at the sectoral level.[28] Future research may highlight an inverse relation between access to finance and cash holdings, shedding light on this explanation.[29]

6 Conclusion

This paper documents empirically the money demand by European non-financial corporations by exploiting a unique and brand-new survey on their cash usage in a stress period, like the COVID-19 pandemic, and contributes to the literature in multiple ways. First, it provides additional evidence on the inverse relation between cash holdings and firm size, suggesting that SMEs tend to store more cash relative to their larger peers (see e.g. Amronin & Chakravorti (2009)). Second, this article provides an estimate of cash holdings of European firms for store-of-value purposes. Cash holdings may be seen as a prudential instrument providing firms with a protection against a (potential) credit supply shock. Third, it adds to the discussion on the design of a CBDC. Some features of cash make it unique until now, e.g. anonymity, real-time settlement and also physicality/offline property (see, e.g., Tarlin (2021), Nocciola & Zamora-Pérez (2024)). Firms are still holding physical cash for store-of-value purposes and this fact may be important for CBDC design, in particular with respect to holding limits for businesses and merchants. For instance, one reason for firms to store cash is its real-time settlement property. By holding cash, firms rely on its ability to settle future transactions instantly, overcoming distrust in counterparties and without any transaction risk except counterfeiting[30]. Finally, it adds to the literature on the monetary policy transmission and the effective lower bound (see e.g. Rogoff (2017), Assenmacher & Krogstrup (2021)). While cash constrains monetary policy,

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[28] Due to privacy we do not have company IDs to match the survey on cash usage by European companies with other data at the firm level.

[29] A counter-argument to the inverse relation between access to finance and cash holdings is that firms with troubles in obtaining loans would try to show to their banks their creditworthiness by maximising their deposits, thus reducing cash holdings. In other words, this counter-argument suggests the same substitution effect between cash holdings and deposits, in favour of deposits. We have already shown that in aggregate terms this was not the case.

[30] In the euro area the number of counterfeits relative to cash in circulation is decreasing, i.e. the risk of encountering a counterfeit is decreasing. See https://www.ecb.europa.eu/press/pr/date/2021/html/ecb.pr 210122~5b82ddc7b9.en.html

it acts as a store of value, too.

Particularly noteworthy, our findings point out that firms belonging to certain sectors, e.g. hotels, hold more cash, which, despite government support, suffered strongly the reduced income during the COVID-19 pandemic. In section 4 we provide aggregate evidence that the increase in cash in circulation was driven by a precautionary demand. To confirm this explanation for higher cash holdings of firms in the hotels sector the next step would be to collect data on firms' cash holdings at the sectoral level. Our plausible hypothesis is that precautionary holdings grew even stronger for hotels, which try to protect themselves against income shocks due to uncertainty over lockdowns. Another, related and plausible explanation on why SMEs tend to store more cash is that they have restricted access to finance, especially in crisis times. Another survey carried out by the ECB and the European Commission, the SAFE survey, may be used to confirm this explanation. Future research may highlight an inverse relation between access to finance and cash holdings, shedding light on this explanation.

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Appendix

A. Survey data

The statistical unit is the firm. A firm is considered as a company having at least one employee, including those where the owner is the sole employee. The answers from different establishments or different respondents within the same firm are considered as being part of the same unit. The eligibility of firms in different economic sectors is described below. The respondent is the owner, the chief financial officer, the head accountant or another employee of the firm with decision-making power related to the acceptance of payments.

Design

The main survey method is telephone interviews (CATI). All companies are supposed to answer the survey screener or socio-demographic questions (D1 to D6) by CATI. The respondents are offered the option of answering any of the remaining questions by web interviews (CAWI). To improve response rates, an official letter is provided by the ECB to respondents to reassure

them about the purpose of the survey. The survey is conducted in one round, but, to ensure its feasibility, a pilot phase is included. The pilot phase prior to the fieldwork is conducted in three countries (one "small", "medium" and "big" country).

Sample size and representativeness

All nineteen euro-area countries are included and interviews are conducted in each respective national languages (table 4).[31] The target and achieved sample sizes per country are reported in table 5.

Country	Language
Austria	German
Belgium	Dutch, French
Estonia	Estonian, Russian
Finland	Finnish, Swedish
France	French
Germany	German
Greece	Greek
Ireland	English
Italy	Italian
Latvia	Latvian, Russian
Lithuania	Lithuanian
Netherlands	Dutch
Portugal	Portuguese
Slovakia	Slovak
Slovenia	Slovene
Spain	Spanish
Malta	Maltese, English
Cyprus	Greek
Luxembourg	French, German, Luxembourgish

Table 4: Survey languages.

Country codes	Target nr. interviews	Achieved nr. interviews
CY, LU, MT	200	207; 203; 174
SI, EE, LV, LT, IE, SK	300	294; 276; 284; 359; 301; 294
GR, AT, BE, FI, NL, PT	500	500; 492; 468; 503; 455; 504
FR, DE, IT, ES	1200	1202; 1218; 1222; 1185

Table 5: Target and achieved sample sizes per country.

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[31]Translations to Russian in Estonia and Latvia and Luxembourgish in Luxembourg are provided.

The sample is a quota sample, stratified in each country by sector (as classified in the list of NACE codes by Eurostat[32]) and, additionally, by the size of the enterprise for the retail sector. The exact target quotas of each sector and size category are defined in each country. In general, enterprises in the retail trade sector (NACE G45+G47) have a minimum quota of 50%. The sample in the retail trade sector is stratified by the following size classes: micro (1-9 employees), small (10-49), medium (50-249) and big (250+). The minimum quota for micro and small enterprises in the retail trade sector is 35% of the sample, for medium-sized enterprises 8% and for large enterprises around 1-2%. The requirement to sample large firms does not apply to countries where the number of large firms in the retail trade sector is less than 50.[33] Enterprises in the accommodation and food service activities (NACE I) have a minimum quota of 10%. Enterprises in arts, entertainment and recreation (NACE R) have a minimum quota of 5%. Enterprises in all size classes mentioned above are covered. The coverage of large enterprises is a requirement only in countries in which the total sample size is 500 or more. Financial sector enterprises (banks, insurances, etc.) and companies working within the cash cycle (cash in transit, providers of lodgement services, etc.) are excluded from the survey. Enterprises in all other sectors cover the remaining quota. The maximum size of the remaining quota is no higher than 35% in any country covered by the survey. The survey also covers enterprises in all NUTS 1 regions of each country.

The achieved quotas are roughly coincident with the target quotas specified above (figure 6). Retail trade covers circa 51%, hotels and restaurants covers 14%, arts and entertainment about 7% and other sectors roughly 28%. In the retail trade sector, micro (1-9 employees) and small (10-49) enterprises covers circa 90%, medium (50-249) enterprises cover about 8% and big (250+) enterprises cover roughly 2%.

Non-responses and weighting

Item non-response is addressed *ex-ante* by designing bracket answers to confidential numerical questions and by sharing an official letter from the ECB on the scope of the survey. *Ex-post*, the remaining item non-response is corrected if needed with imputation methods for selected

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[32] https://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF.

[33] These countries include Estonia, Cyprus, Latvia, Luxembourg, Malta and Slovenia (https://ec.europa.eu/eurostat/databrowser/view/sbs_sc_dt_r2/default/table).
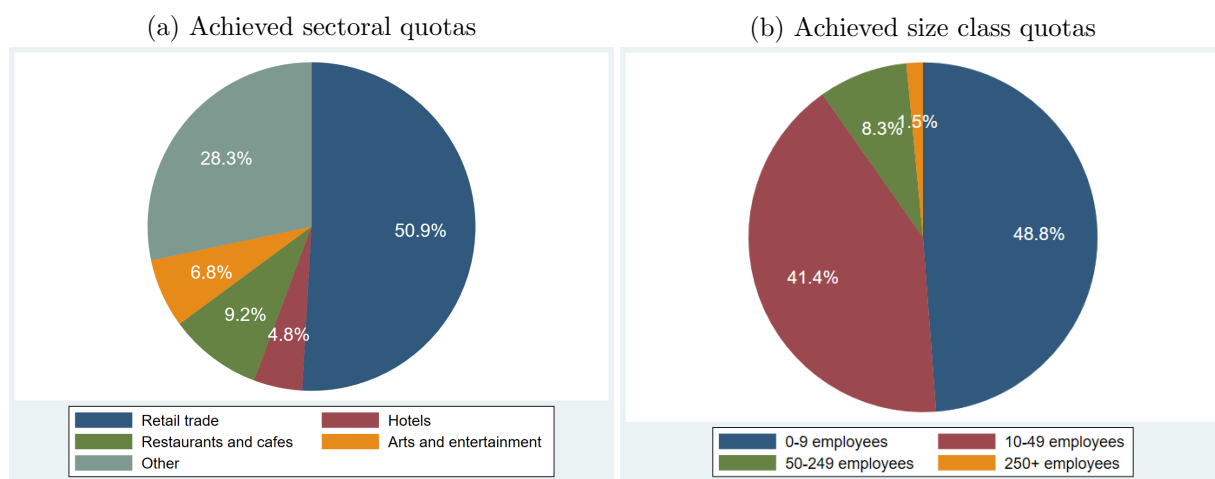
Figure 6: Achieved sectoral and size class quotas. Source: author's elaboration based on ECB (2022).

variables, in particular of those indicating amounts or percentages.

The data is weighted to minimise the observable bias of survey estimates and enable valid inference. Two sets of weights are calculated: i) weights that restore the proportions of the number of employees of each size class, economic sector and country and, if possible, ii) weights that restore the proportions of turnover of each size class, economic sector and country. For the summary statistics above and below reported, the first set of weights are used, i.e. the employment weights.

Selected questions

- D1. In which sector does your company carry out its main activities? (ONE ANSWER ONLY)

    1. Manufacturing

    2. Construction

    3. Wholesale trade

    4. Retail trade

    5. Hotels

    6. Restaurants and cafes

7. Arts, entertainment and recreation

8. Transport and storage

9. Information and communication

10. Real estate activities

11. Banks, insurances and cash in transit

12. Other (DO NOT READ OUT)

999998. Do not know/no answer

- D2. What exactly is your position in the company? (ONE ANSWER ONLY)

    1. CEO/Managing director

    2. Financial director/manager

    3. Senior accountant

    4. Owner

    5. Other (DO NOT READ OUT)

    999998. Do not know/no answer

- D3. Is your company...? (ONE ANSWER ONLY)

    1. Independent

    2. Franchise undertaking

    3. A branch of a national group

    4. A branch of an international group

    5. The headquarters of a national group

    6. The headquarters of an international group

    999998. Do not know/no answer

- D4. How many employees (full-time equivalent), including yourself, does your company currently have? (ONE ANSWER ONLY)

1. 1 to 9 employees

2. 10 to 49 employees

3. 50 to 249 employees

4. 250 to 999 employees

5. 1000 employees or more

999998. Do not know/no answer

- D5. On average, how many payments from your customers, both private and business, does your company receive per month? (ONE ANSWER ONLY)

    [](NUMERICAL, OPEN-ENDED)

    If does not know exactly (ONE ANSWER ONLY)

    1. Less than 100

    2. 100 to 999

    3. 1000 to 9999

    4. 10000 to 49999

    5. 50000 to 99999

    6. 100000 to 999999

    7. 1 million or over

    999998. Do not know/no answer

- D6. What proportion of the payments from customers, both private and business, does your company receive each month in cash? (ONE ANSWER ONLY)

    1. None

    2. 1 to 10%

    3. 11 to 25%

    4. 26 to 50%

5. 51 to 75%

6. 76 to 99%

7. 100%

999998. Do not know/no answer

- Q1. Which means of payment does your company accept? (RANDOMISE ITEMS 1 to 11 (item 10 always follows item 9) - MULTIPLE ANSWERS POSSIBLE)

    1. Cash

    2. Debit card

    3. Credit card

    4. Contactless card payments

    5. Bank cheque [only in countries that have bank cheques]

    6. Credit transfer

    7. Direct debit

    8. Gift cards or vouchers / loyalty points

    9. PayPal

    10. Other online or mobile payment methods (e.g. Klarna Sofort, iDEAL, Afterpay)

    11. Crypto-assets (e.g. virtual currencies, such as Bitcoin, Ethereum)

    12. Other (DO NOT READ OUT)

    999998. Do not know/no answer

- Q3. Do you think you will continue accepting cash in the future? (ask if company accepts cash, ONE ANSWER ONLY)

    1. Yes

    2. No

    999998. Do not know/no answer

- Q16. What would you say is your company's approximate annual turnover?

    1. Less than €10000

    2. €10000 to €99999

    3. €100000 to €999999

    4. €1 million to €4999999

    5. €5 million or more

    6. Do not know/no answer

- Q17. Thinking of your annual turnover, what proportion of your income from customers is in cash? (Ask if Q1=1, i.e. if company accepts cash, others end the interview)

    1. None

    2. 1-10%

    3. 11-25%

    4. 26-50%

    5. 51-75%

    6. 76-99%

    7. 100%

    8. Do not know/no answer

- Q18. What is the average amount of cash that you hold (e.g. in the till, in a vault or safe)? (ONE ANSWER ONLY)

    1. Less than €1000

    2. €1000 to €4999

    3. €5000 to €9999

    4. €10000 to €49999

    5. €50000 to €99999

    6. €100000 to €999999

7. €1 million or more

8. Prefer not to say (DO NOT READ OUT)

999998. Do not know/no answer

Further summary statistics

Figure 7 reports cash acceptance rates, i.e. the percentage of companies accepting cash, by supposedly "cash-intensive" and "cash-poor" sectors separately at the euro-area and country level. Cash-intensive sectors include sectors with a larger quota of private customers such as the retail trade, hotels and restaurant and cafes sectors, while cash-poor sectors include the manufacturing, construction, wholesale trade, arts, entertainment and recreation, transport and storage, information and communication and real estate activities sectors.[34] Visibly, the upper panel of figure 7 shows that cash acceptance varies dramatically between cash-intensive (97%) and cash-poor sectors (54%). At the country-level (figure 7, lower panel) cash acceptance is relatively low in Finland (92% in cash-intensive sectors, 30% in cash-poor sectors) while it is relatively high in Germany (99% in cash-intensive sectors, 72% in cash-poor sectors). Cash acceptance reaches 100% in the cash-intensive sectors of Cyprus.

Then, we display the proportion of payments from customers, both private and business, that companies receive each month in cash. The breakdown for cash-intensive *versus* cash-poor sectors is shown in figure 8. In the upper panel, there is a large difference in the percentage of firms declaring not to receive payments in cash (4% only in cash-intensive sectors, 51% in cash-poor sectors). This large difference is then redistributed across the bracket percentages. For example, the percentage of firms stating that they receive 11-25% of payments in cash is way larger for cash-intensive sectors (27%) than cash-poor sectors (7%). Similar remarks hold true for higher brackets, while for the lowest bracket percentages are similar.[35] The lower panel of figure 8 shows the country breakdown along the two sectoral categories. The "None" response is much larger for cash-poor sectors relative to cash-intensive sectors. Germany, Austria and

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[34]The sector nomenclature is drawn from NACE. Financial sector enterprises (banks, insurances, etc.) and companies working within the cash cycle (cash-in-transit, providers of lodgment services, etc.) are excluded from the survey.

[35]For consistency, all firms responding that they receive a non-zero fraction of payments in cash (figure 8) are automatically assumed to accept cash (figure 7).
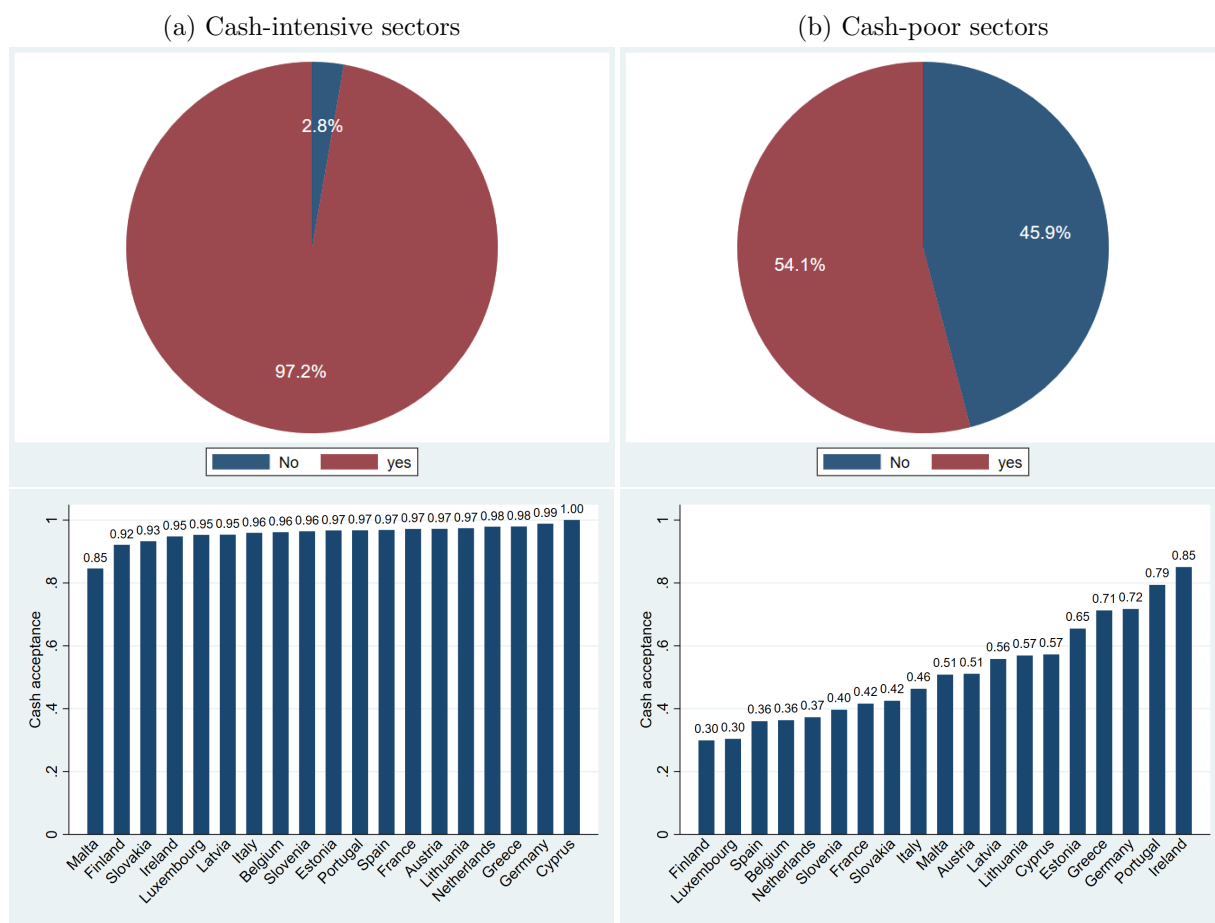
Figure 7: Cash acceptance by sectors: euro-area level (upper panel) and country breakdown (lower panel). Source: author's elaboration based on ECB (2022).

Cyprus seem to host firms that received more cash payments, at least in the cash-intensive sectoral group.

Finally, we show the proportion of annual turnover from customers that is in cash. The cash-intensive *versus* cash-poor sectors comparison is depicted in figure 9. Notably, in the upper panel, cash-poor firms state that they do not have annual turnover in cash more frequently than cash-intensive firms (9% *versus* 1%, respectively). Also, cash-poor firms state that they have 1-10% annual turnover in cash more frequently than cash-intensive firms (49% *versus* 29%, respectively). However, the trend reverts starting from bracket 11-25%, i.e. cash-intensive firms report a larger turnover in cash more often than their cash-poor counterparts.[36] The lower panel of figure 9 points out the country breakdown. Large fractions of annual turnover in cash

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[36] For consistency, the question on the quota of turnover in cash is asked only to firms accepting cash.
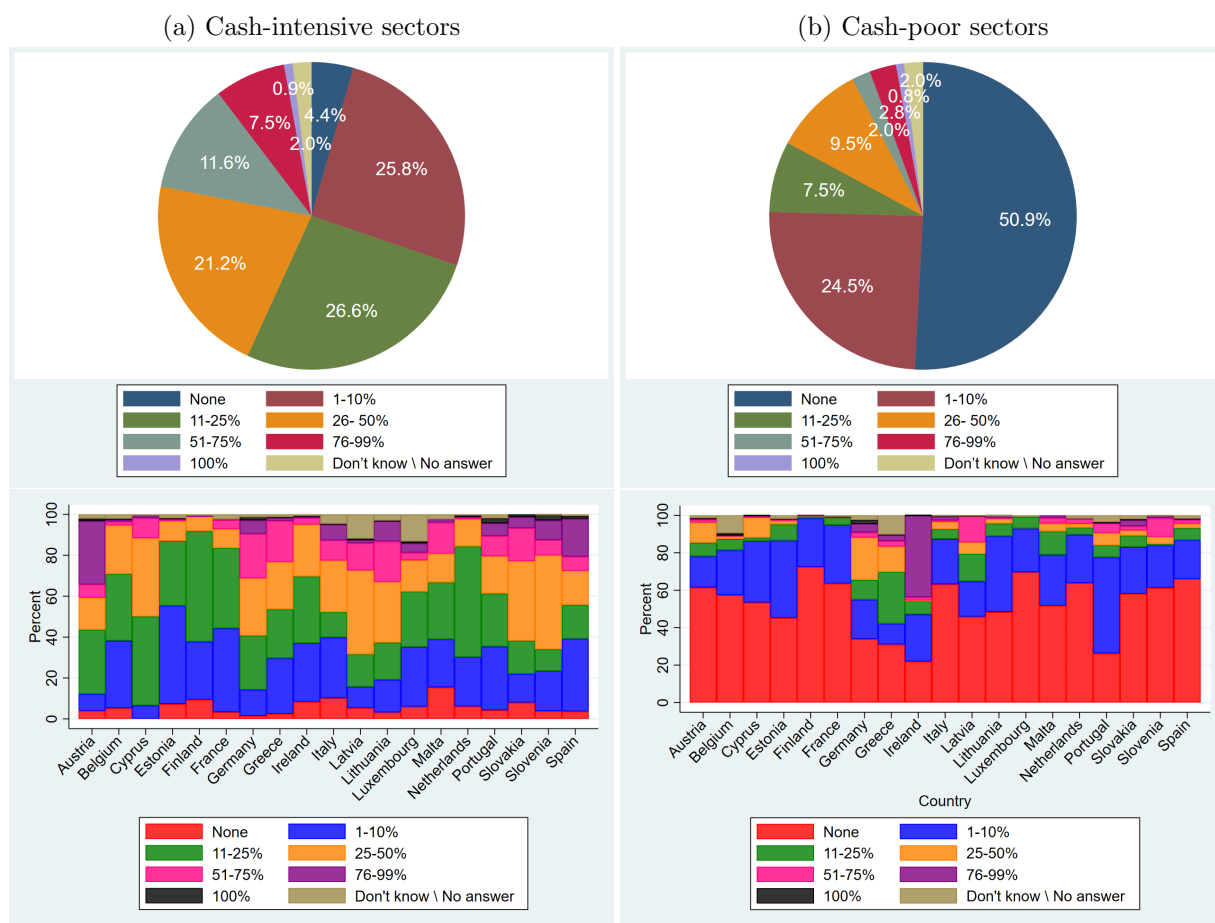
Figure 8: % payments received from customers in cash monthly by sectors (upper panel) and country breakdown (lower panel). Source: author's elaboration based on ECB (2022).

are reported in Cyprus, Germany and Greece along the two sectoral groups, while France seems to have a relatively low percentage of annual turnover in cash.
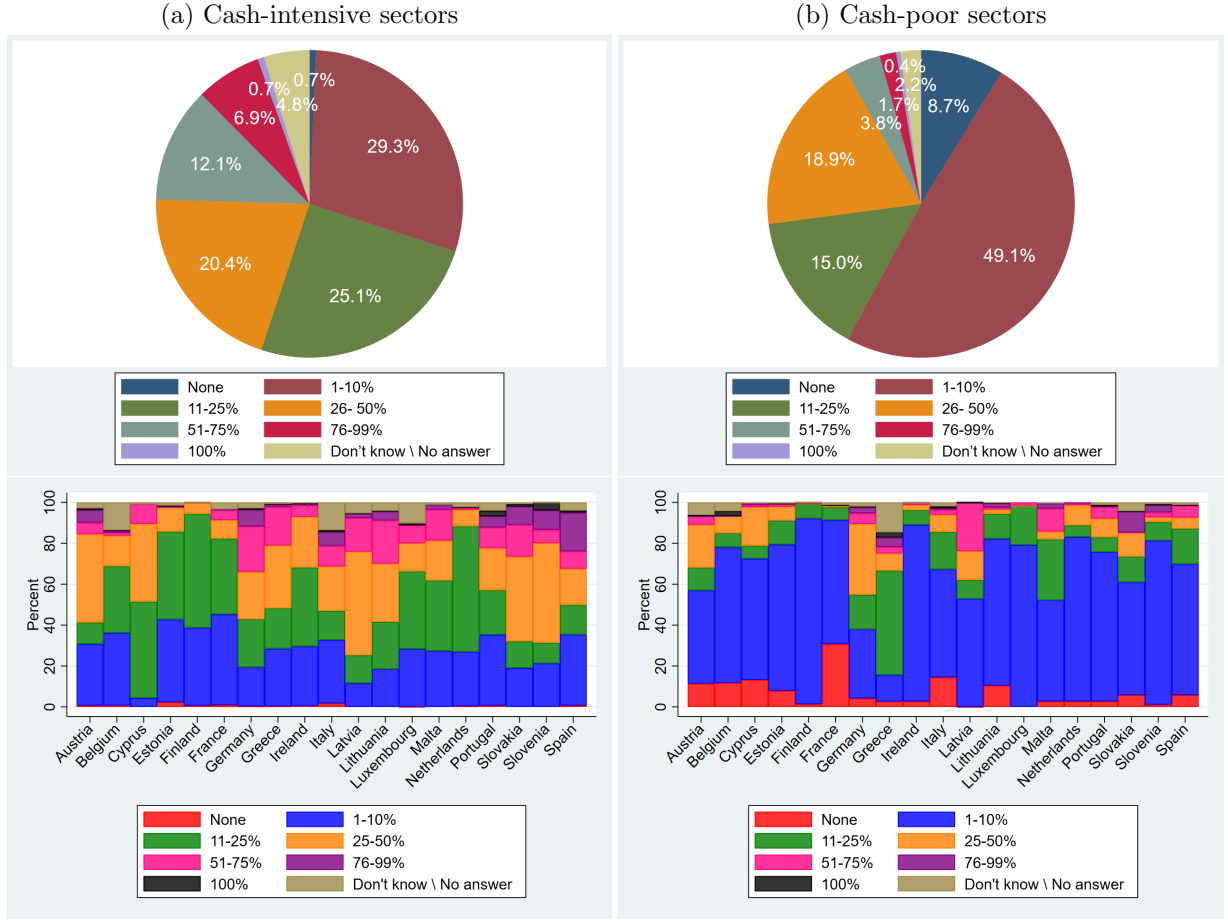
Figure 9: % annual turnover from customers in cash by sectors (upper panel) and country breakdown (lower panel). Source: author's elaboration based on ECB (2022).

B. Conditional probabilities

Suppose $w_i = 1$. Substituting y_i, rearranging and dividing by σ we get

$$\mathbb{P}(w_i = 1 | x_i, \mathbf{D}_k, \mathbf{z}_i) = \mathbb{P}(0 < y_i \le r_1 | x_i, \mathbf{D}_k, \mathbf{z}_i) =$$

$$= \mathbb{P}(0 < \mathbf{x}'\boldsymbol{\beta} + e_i \le r_1 | x_i, \mathbf{D}_k, \mathbf{z}_i) =$$

$$= \mathbb{P}(-\mathbf{x}'\boldsymbol{\beta} < e_i \le r_1 - \mathbf{x}'\boldsymbol{\beta} | x_i, \mathbf{D}_k, \mathbf{z}_i) =$$

$$= \mathbb{P}\left(-\frac{\mathbf{x}'\boldsymbol{\beta}}{\sigma} < \frac{e_i}{\sigma} \le \frac{r_1 - \mathbf{x}'\boldsymbol{\beta}}{\sigma} \bigg| x_i, \mathbf{D}_k, \mathbf{z}_i \right)$$

noting that $\frac{e_i}{\sigma} | x_i, \mathbf{D}_k, \mathbf{z}_i \overset{i.i.d.}{\sim} \mathcal{N}(0, 1)$, we can rewrite the conditional probability for the observed variable as follows

$$\mathbb{P}(w_i = 1 | x_i, \mathbf{D}_k, \mathbf{z}_i) = \Phi\left(\frac{r_1 - \mathbf{x}'\boldsymbol{\beta}}{\sigma}\right) - \Phi\left(-\frac{\mathbf{x}'\boldsymbol{\beta}}{\sigma}\right)$$

Now suppose $w_i = 2$. Similarly, substituting y_i, rearranging and dividing by σ we get

$$\mathbb{P}(w_i = 2 | x_i, \mathbf{D}_k, \mathbf{z}_i) = \mathbb{P}(r_1 < y_i \le r_2 | x_i, \mathbf{D}_k, \mathbf{z}_i) =$$

$$= \mathbb{P}(r_1 < \mathbf{x}'\boldsymbol{\beta} + e_i \le r_2 | x_i, \mathbf{D}_k, \mathbf{z}_i) =$$

$$= \mathbb{P}(r_1 - \mathbf{x}'\boldsymbol{\beta} < e_i \le r_2 - \mathbf{x}'\boldsymbol{\beta} | x_i, \mathbf{D}_k, \mathbf{z}_i) =$$

$$= \mathbb{P}\left(\frac{r_1 - \mathbf{x}'\boldsymbol{\beta}}{\sigma} < \frac{e_i}{\sigma} \le \frac{r_2 - \mathbf{x}'\boldsymbol{\beta}}{\sigma} \middle| x_i, \mathbf{D}_k, \mathbf{z}_i\right)$$

noting again that $\frac{e_i}{\sigma} | x_i, \mathbf{D}_k, \mathbf{z}_i \overset{i.i.d.}{\sim} \mathcal{N}(0,1)$, we can rewrite the conditional probability as

$$\mathbb{P}(w_i = 2 | x_i, \mathbf{D}_k, \mathbf{z}_i) = \Phi\left(\frac{r_2 - \mathbf{x}'\boldsymbol{\beta}}{\sigma}\right) - \Phi\left(\frac{r_1 - \mathbf{x}'\boldsymbol{\beta}}{\sigma}\right)$$

Finally, suppose $W_i = J$. Again, substituting y_i, rearranging and dividing by σ we get

$$\mathbb{P}(w_i = J | x_i, \mathbf{D}_k, \mathbf{z}_i) = \mathbb{P}(y_i > r_J | x_i, \mathbf{D}_k, \mathbf{z}_i) =$$

$$= \mathbb{P}(\mathbf{x}'\boldsymbol{\beta} + e_i > r_J | x_i, \mathbf{D}_k, \mathbf{z}_i) =$$

$$= \mathbb{P}(e_i > r_J - \mathbf{x}'\boldsymbol{\beta} | x_i, \mathbf{D}_k, \mathbf{z}_i) =$$

$$= \mathbb{P}\left(\frac{e_i}{\sigma} > \frac{r_J - \mathbf{x}'\boldsymbol{\beta}}{\sigma} \middle| x_i, \mathbf{D}_k, \mathbf{z}_i\right)$$

noting once again that $\frac{e_i}{\sigma} | x_i, \mathbf{D}_k, \mathbf{z}_i \overset{i.i.d.}{\sim} \mathcal{N}(0,1)$, the conditional probability is as follows

$$\mathbb{P}(w_i = J | x_i, \mathbf{D}_k, \mathbf{z}_i) = 1 - \Phi\left(\frac{r_J - \mathbf{x}'\boldsymbol{\beta}}{\sigma}\right)$$

called also complementary cumulative distribution function, tail distribution or exceedance.

C. T-test for the equality of means

Let μ_k, $\mu_{\tilde{k}}$ and σ_k, $\sigma_{\tilde{k}}$ be the population means and standard deviations of average cash holdings for category k and $\tilde{k}$, where the two categories can be two sectors or two countries. The null hypothesis is as follows

$$\mathbb{H}_0 : \mu_k = \mu_{\tilde{k}}$$

The t-test statistic (Gosset (1908)) when the standard deviations are relaxed to be potentially different across categories ($\sigma_k \neq \sigma_{\tilde{k}}$) is given by

$$t = \frac{\hat{\mu}_k - \hat{\mu}_{\tilde{k}}}{(\hat{\sigma}_k^2/n_k + \hat{\sigma}_{\tilde{k}}^2/n_{\tilde{k}})^{1/2}}$$

where $\hat{\mu}_k$, $\hat{\mu}_{\tilde{k}}$, $\hat{\sigma}_k^2$ and $\hat{\sigma}_{\tilde{k}}^2$ are estimators and n_k and $n_{\tilde{k}}$ are the sample sizes of the two groups. The t-statistic follows a Student's t-distribution

$$t \sim \mathcal{T}(v)$$

where v are degrees of freedom whose expression is given by Satterthwaite (1946). The decision is taken by comparing the value of the t-statistic with the critical value from the Student's t-distribution. If the t-statistic exceeds (in absolute value) the critical value then we can reject the null hypothesis of mean equality.

D. Net shipments of euro cash and banks' vault cash holdings
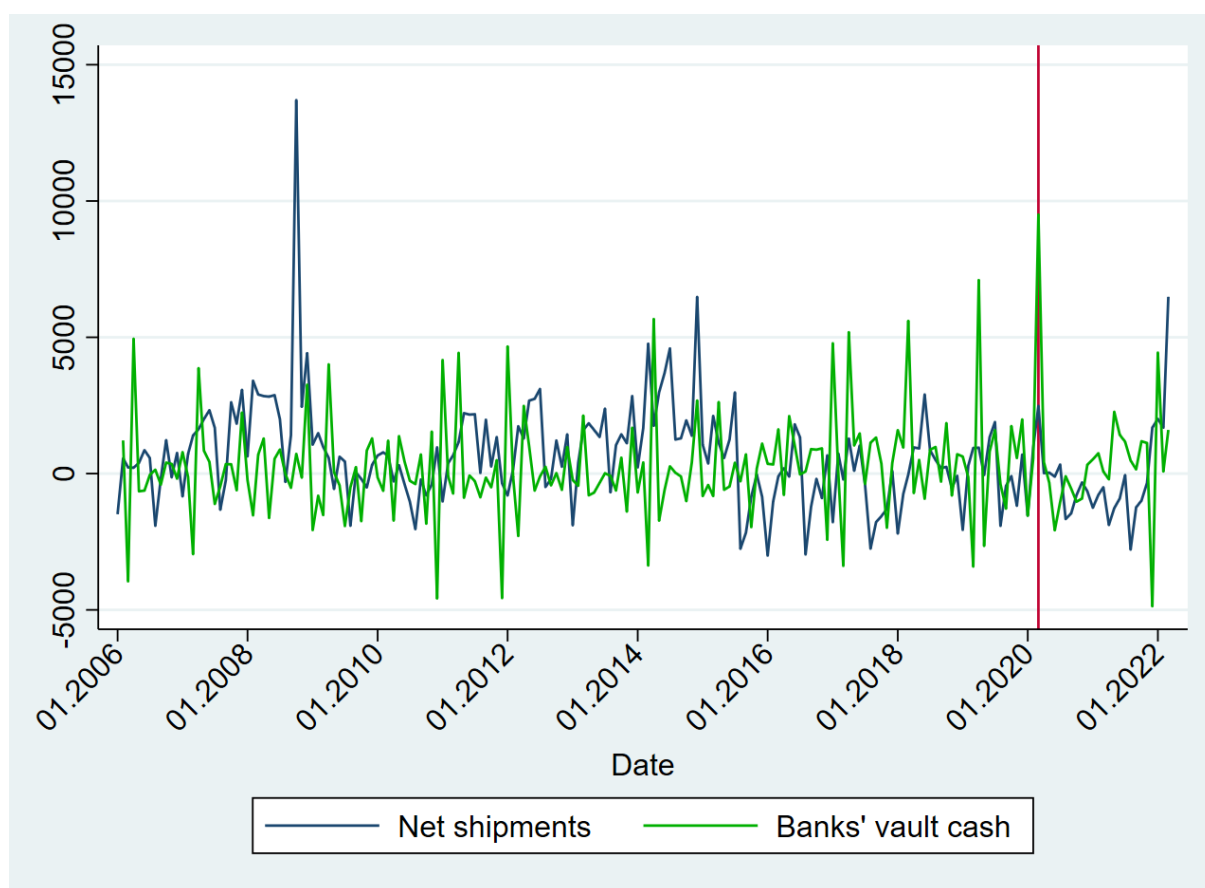
Figure 10: Net shipments of euro cash, i.e. exports minus imports, and banks' vault cash from registered/wholesale bank channels. The unit of measure is in € million. The red vertical line coincides with the beginning of the COVID-19 pandemic in Europe, i.e. March 2020. Source: ECB Statistical Data Warehouse, series keys BNT.M.U2.N.4.ALLD.W1.E and BSI.M.U2.N.A.A10.X.1.Z5.0000.EUR.E (the latter seasonally adjusted and first-differenced). See also Faella & Zamora-Pérez (2025).

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