// NO.23-060 | 12/2023

DISCUSSION PAPER

// ALBRECHT BOHNE, ANTONIOS M. KOUMPIAS,
AND ANNALISA TASSI

Cashless Payments and Tax Evasion: Evidence From VAT Gaps in the EU

Leibniz Association

ZEW

Cashless Payments and Tax Evasion: Evidence from VAT Gaps in the EU

Albrecht Bohne[*], Antonios M. Koumpias[†], Annalisa Tassi[‡]

December 4 2023

Abstract

This paper explores the connection between the proliferation of cashless, or e-money, payments and value-added tax (VAT) compliance. We present both visual and descriptive evidence that illustrates a negative correlation between e-money use and VAT evasion, proxied by the VAT compliance gap for countries in the European Union, from 2001 until 2021. We find that increased e-money usage by 100 percentage points (pp) is associated with a reduction in the VAT gap of 0.3pp or 1.92% of the aggregate VAT compliance gap over time. Moreover, we contribute a novel estimate of the causal impact of cashless payments on VAT evasion during the COVID-19 public health emergency. We identify a link between mobility restrictions in the European Union and reductions in VAT compliance gaps, facilitated by changes in payment norms. An estimated rise of 1pp or 5.51% in e-money use results in an 11.9% reduction in the VAT compliance gap. Our findings suggest that changes in transaction payment behavior such as the adoption of cashless payments may yield significantly more tax revenues by curbing non-compliance. Policies aimed at promoting e-money usage and limiting cash circulation are relevant steps forward in this direction.

Keywords: Tax evasion, VAT gap, cashless payments, e-money, mobility restrictions, COVID-19 pandemic
JEL Codes: H26, K42

[*]ZEW - Leibniz-Centre for European Economic Research, Corporate Tax and Public Finance Research Unit, Mannheim, Germany. Albrecht.Bohne@zew.de, ORCID iD: 0000-0002-6592-6221

[†]University of Michigan-Dearborn, Department of Social Sciences, Dearborn, MI, USA. koumpias@umich.edu , ORCiD: 0000-0001-9792-5103

[‡]Friedrich-Alexander-Universität Erlangen-Nürnberg, Chair of Public Economics, Nürnberg, Germany. annalisa.tassi@fau.de.

Acknowledgments: Albrecht Bohne acknowledges funding from the German Research Foundation for a research stay at the University of Michigan (Walter Benjamin Program grant BO 5782/1). Antonios M. Koumpias recognizes support from the Undergraduate Research Opportunity Program at the University of Michigan under project #204. We thank Amir Alinaghi, David Chagoyen-Neumann and Emily Wang for excellent research assistance. We thank Johannes Kasinger, Jorge Martinez-Vazquez, Irina Simankova, Mazhar Waseem, and conference participants at the 2023 EEA-ESEM Congress for helpful comments.

Corresponding Author: Koumpias, A.M. koumpias@umich.edu

1 Introduction

It is widely accepted that third-party reporting of income operates as one of the primary drivers of tax compliance by individuals and firms (Kopczuk and Slemrod, 2006; Kleven et al., 2011). Its importance is exemplified in the design of the value-added tax (VAT) that generates a paper trail of business-to-business transactions known to facilitate tax compliance, but not sufficient to fully deter evasion downstream (Pomeranz, 2015; Waseem, 2023). The rise of cashless transactions has expanded opportunities to curb consumption tax evasion by establishing an electronic trail of individual consumption expenditures and firm income (Artavanis et al., 2016; Slemrod et al., 2017). The aims of this paper are to investigate the interplay between the expansion of cashless payments and VAT compliance, to explore potential mechanisms driving the underlying relationship, and to derive a credible estimate of the effect of cashless payments on VAT compliance following exogenous changes in cashless payments.

This analysis is particularly important as tax administrations around the world are investing heavily in modernizing IT infrastructure and are implementing reforms that will enable them to harness increasingly-available transaction data from financial institutions and reduce the tax gap (Treasury, 2021; Bellon et al., 2022; Waseem, 2023). This policy development is also gaining ground in the European Union (EU), where 18 of the 27 member states have adopted tax information reporting systems of varying sophistication that range from standardized accounting standards to real time e-invoicing (Holá et al., 2022).

Early evidence in the literature identifies a positive impact of cashless payments on VAT compliance (Hondroyiannis and Papaoikonomou, 2020; Madzharova, 2020). Studies exploiting exogenous variation in the use of cashless payments find large improvements in VAT compliance but are either relying on instruments based on regional banking infrastructure differences or focusing on a single country (Hondroyiannis and Papaoikonomou, 2017; Immordino and Russo, 2018; Danchev et al., 2020; Alognon et al., 2021). However, there is no evidence to this day of the EU-wide effect of cashless payments on VAT compliance driven by external behavioral shifts in population-level e-money usage norms.

This study fills this gap in the tax compliance literature by providing a comprehensive evaluation of the association between e-money usage and VAT compliance gaps from 2001 through 2019, and contributing a novel estimate of the causal effect of cashless payments on the VAT compliance gap during the COVID-19 public health emergency (PHE) in the years 2020 and 2021. In addition, we provide evidence of an unintended effect of the PHE mobility restrictions in reducing consumption tax evasion that was not previously documented in the literature. Thus, a third contribution of this study is the examination, for the first time to the best of our knowledge, of the interplay between the PHE and tax compliance.

Initially, we provide comprehensive visual and descriptive evidence on the trends and the correlational association between cashless payments via debit or credit cards (hereafter, e-money) and the VAT compliance gap, measured as the difference between realized and expected VAT revenue. The negative relationship between these two factors suggests that VAT tax compliance gains may be realized in periods of rapid e-money usage growth. Leveraging the ubiquitous e-money use growth during the COVID-19 public health emergency (PHE), we employ an instrumental variables approach based on the stringency of national mobility restrictions. The results provide a causal relationship

between increased e-money use as a a share of the GDP and improved VAT compliance in EU member states.

We begin in Section 2 with a description of the variables we employ in the exploratory data analysis and empirical investigations. Section 3 provides visual evidence of e-money and VAT compliance gap developments in EU countries over time. This section shows a distinctly negative correlation between VAT compliance gaps and e-money use. The exploratory data analysis is supplemented by empirical evidence in Section 3 drawing from an extended time-series data confirming the negative association between e-money and VAT compliance. Finally, the descriptive evidence based on historical data is supported by the quasi-experimental analysis in Section 4 of a more recent natural experiment, the PHE, that shifted behavioral norms surrounding e-money use. Section 5 concludes.

2 Data

Before diving into the analysis, we provide a description of the information we employ, which includes variable definition and data sources. We proxy our study outcome, population-level VAT non-compliance, by the VAT compliance gap. This measurement of non-compliance is defined as the difference between expected and realized VAT revenues, representing the overall loss of VAT revenue due to non-compliance, and is expressed in percentage terms as a share of the expected revenues, the so-called VAT Total Tax Liability (VTTL). The VAT compliance gaps and the VTTL are produced by the Center for Economic and Social Research (CASE) on behalf of the European Commission and obtained from its latest report in November 2023 (Poniatowski et al., 2023).

Information on payment statistics comes from the European Central Bank (2022). We approximate e-money use based on the value of transactions with credit and debit cards, issued by resident payment service providers (PSPs).[1] E-money information is not available for Cyprus, Latvia, and Malta for all years. Even though the focus of our study is e-money adoption, it is necessary to examine cash developments over the same period. Cash use is proxied by the value of cash withdrawals with cards issued by resident PSPs, which is not available for the full sample period for Bulgaria, Cyprus, Estonia, Luxembourg, and Malta.

For the instrumental-variables (IV) analysis, we use three proxies of COVID-19 related social distancing policy to isolate exogenous variation in e-money usage. Our measure of intensity of the PHE social distancing policies comes from the Oxford Covid-19 Government Response Tracker (OxCGRC) and, specifically, its government stringency index, a composite measure that includes information on nine distinct response metrics: school closures, workplace closures, cancellation of public events, restrictions on public gatherings, closures of public transport, stay-at-home requirements, public information campaigns, restrictions on internal movements, and international travel controls (Hale et al., 2021). Data on individual mobility based on mobile ping geo-location data are obtained from the Google COVID-19 Community Mobility Reports and reflect percentage changes in mobility across different categories of places relative to a pre-PHE baseline (January 3 to February 6, 2020). To capture the intensity of mobility restrictions that

[1]We focus on resident PSPs to minimize confounding variation in the volume of payments with cards issued by nonresident PSPs which are affected by PHE-related disruptions in international travel.

may affect cashless payments, we focus on percentage changes in retail and recreational mobility. To represent differences in social distancing policy at the country level, we also use an indicator of mobility restrictions that were enforced in all member states but Sweden during 2020 and 2021.

Finally, we use a collection of explanatory variables to account for changes in economic and tax policy indicators in member states over time. Information on economic indicators includes GDP, government expenditures, government debt, and unemployment rate sourced from the Eurostat (Eurostat, 2023). Data on socio-demographic indicators such as population, percentage of urban and rural population, the industry and trade sectors' value added as a share of GDP, the share of population that is self-employed, public sector corrupt exchanges, the number of mobile cellular subscriptions per 100k individuals, and fixed broadband subscriptions per 100k individuals are obtained from the Quality of Government Institute (Teorell et al., 2022). Data related to COVID-19 caseload is retrieved from the World Health Organization (WHO) COVID-19 Dashboard. Survey measures of tax morale are based on the Eurobarometer. Policy changes that introduce more sophisticated tax reporting systems are accounted for by an indicator of "VAT listings" from Holá et al. (2022). These publicly-accessible data sources are reported in detail in Table 5.

3 Trends in Payment Methods and VAT Gaps

This section provides an overview and discussion of major trends in the evolution of payment methods and estimated VAT gaps in the EU. The first subsection focuses on a descriptive overview of these trends including a brief discussion of the recent COVID-19 period. A second subsection presents correlations between payment methods and VAT gaps, and investigates the evolution of VAT gaps of countries depending on their levels and growth rates of e-money usage. This subsection also includes a discussion of VAT gaps during the PHE and an illustration of their differential trends by the stringency of PHE-related mobility restrictions.

3.1 Descriptive Analysis

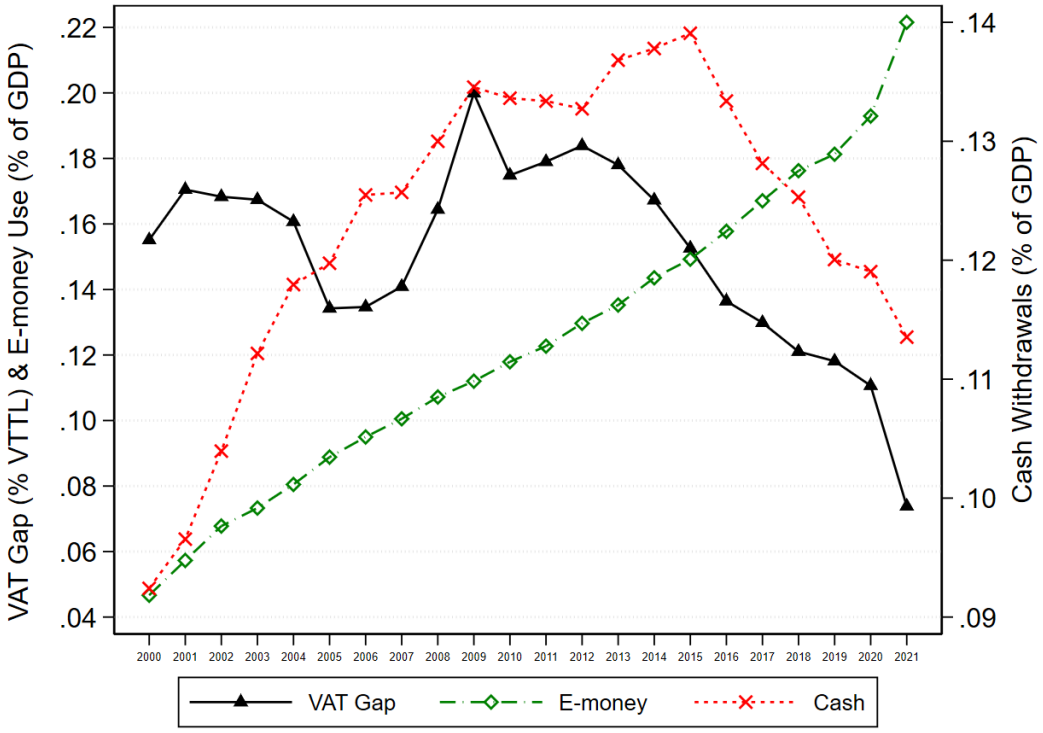
Technological innovations and changes in consumer preferences in recent years have led to the proliferation of cashless payments. The share of payments using credit and debit cards issued by domestic financial institutions among all payment transactions in the EU nearly doubled from 25.8% in 2000 to 50.3% by 2020 (European Central Bank, 2022).

The VAT gap, measured as the difference between expected and realized VAT revenue (refer to Section 2 for details), has also undergone profound changes in recent years, as documented in Figure 1. Since 2012, the estimated VAT gap has been steadily decreasing within EU countries, from about 18% in 2012 down to 8% of expected revenue in 2021. Moreover, this downward trends seems to evolve in parallel to the decrease in cash usage.

The PHE has accelerated these developments in payment norms. In 2021, the pre-existing trends of increasing e-money usage, decreasing cash usage, and decreasing VAT gaps all experienced a strong increase in their respective steepness. These PHE-induced changes in the trends of payment methods constitute a unique natural experiment.

The just-discussed visual evidence of EU-wide trends is likely to mask important cross-country differences in usage of e-money as a share of GDP and in VAT non-compliance as a share of the VAT total tax liability (VTTL). Figure 7 in the Appendix provides an overview of how these variables evolve over time for each country along with cash withdrawals as a share of GDP. We can see that the Nordic countries have been early adopters of e-money, while also displaying low levels of VAT compliance gaps. On the opposite side of the spectrum, Central and Eastern European countries display higher levels of the VAT compliance gap while also being late adopters of e-money usage.

Figure 1: 2000-2021 trends in VAT compliance gaps, e-money use, and cash withdrawals

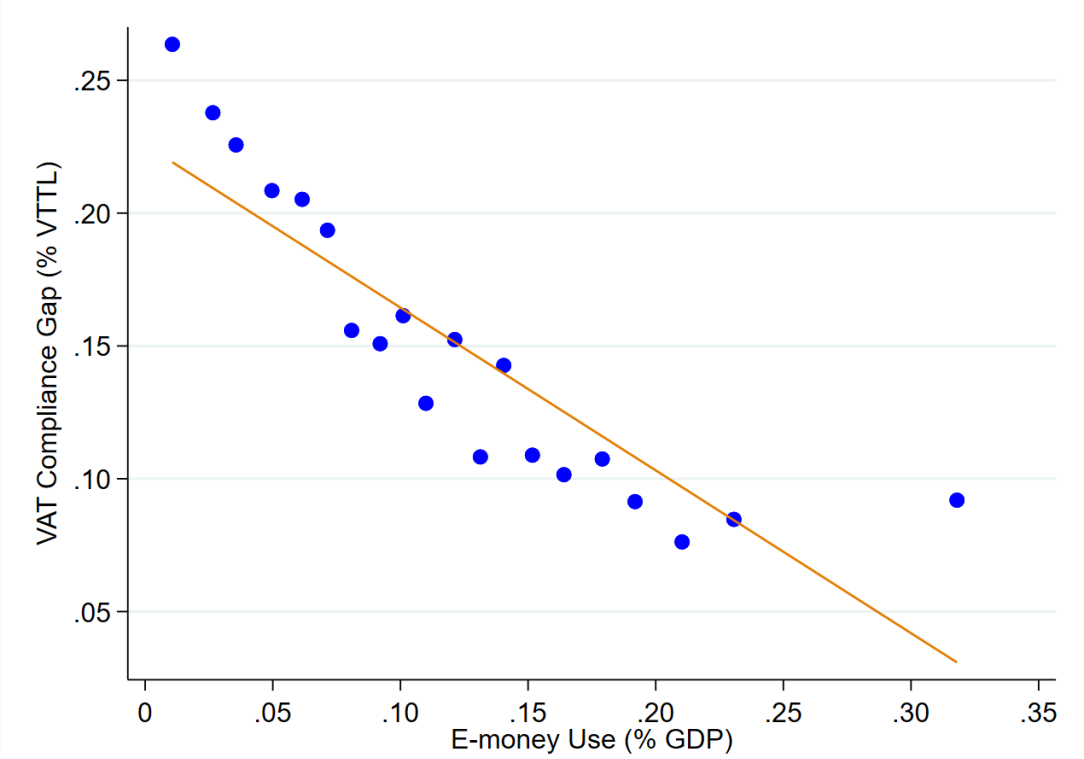


Notes: For each year, we calculate the average e-money use and cash withdrawals as a share of the GDP in the EU by dividing the value of credit and debit card transactions and the value of cash withdrawals with nominal GDP. The solid black series plots EU-average VAT compliance gap levels as a share of the VTTL from 2000 till 2021 in annual frequency. The dashed green series plots e-money use as a share of the GDP from 2000 till 2021 in annual frequency. The dashed red series plots cash withdrawals as a share of the GDP from 2000 till 2021 in annual frequency.

3.2 Correlations between Payment Methods and VAT Gaps

In particular since the 2010s, there seems to be a strong correlation between the prevalence of payment methods and estimated VAT gaps. While cash usage and VAT gaps evolve almost in parallel, e-money usage is clearly negatively correlated with the VAT gap (see Figure 1). This corresponds to the time period after which tax authorities rely increasingly more on third-party information and implement tax administration reforms such as VAT listings to combat VAT evasion (Holá et al., 2022).

Figure 2: Binned scatterplot of VAT compliance gaps and e-money use



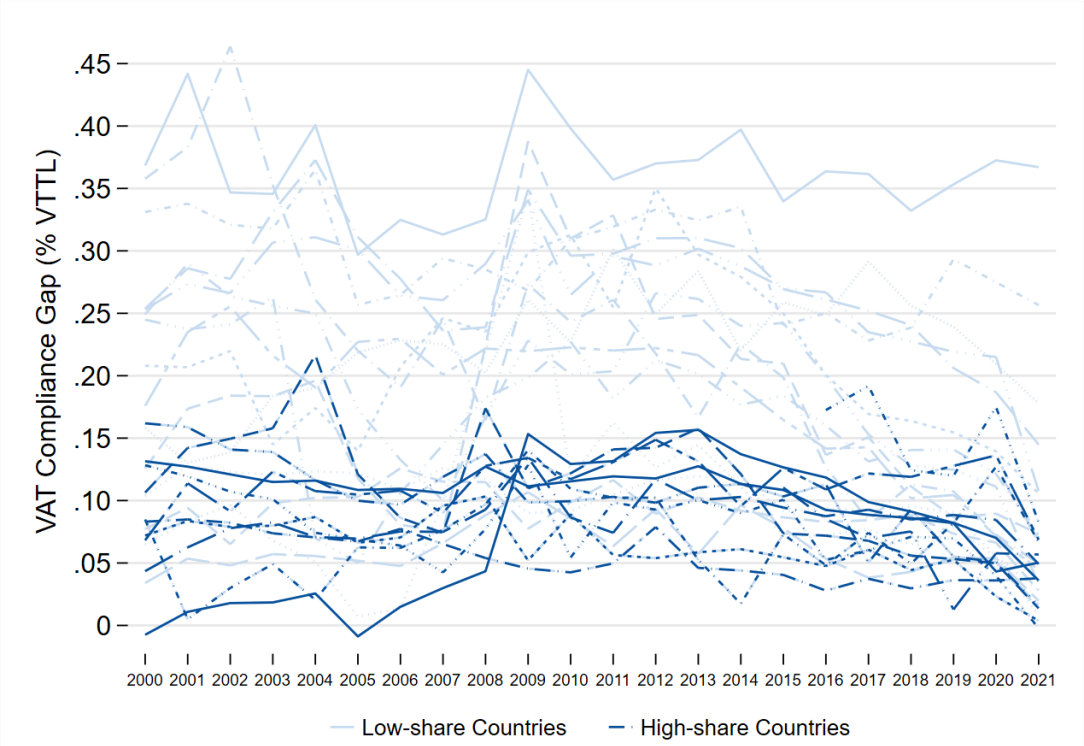
Notes: The binscatter procedure groups e-money use into equal-sized bins, then computes the average value of e-money use as a share of GDP and VAT compliance gap as a share of VTTL within each bin, and finally generates a scatterplot of these average values. The 20 blue circles are the binned scatterpoints and the solid orange series plots the best linear fit based on an OLS regression of e-money on the VAT compliance gap.

The focus of this study is the relationship between VAT compliance and e-money usage. We visualize the univariate relationship between VAT gap estimates and e-money use employing a binned scatterplot shown in Figure 2.

A clear image of a negative correlation between VAT compliance gaps and e-money use emerges. The negative pattern is robust to a different specification (see Figure 8, based on Cattaneo et al. (2019)). The negative relationship between VAT non-compliance and e-money usage we report is in-line with prior evidence in the literature (Hondroyiannis and Papaoikonomou, 2020; Madzharova, 2020; Alognon et al., 2021).

While a negative correlation between e-money use and VAT gaps holds for aggregate cross-country averages, it is unclear whether VAT gaps and the prevalence of specific payment methods are also correlated at the individual country level. By distinguishing EU countries by their average e-money adoption over time in Figure 3, we can see that countries with above-average e-money adoption as share of the GDP display consistently low VAT compliance gaps. These VAT gaps mostly range between 5%-15% of the expected VAT revenue (VTTL) and do not exhibit significant within-country variation over time. At the same time, countries with below-average e-money usage as a share of GDP are also those with relatively greater VAT compliance gaps. For the majority of countries in this group, VAT compliance gaps typically take values between 20%-35% of the VTTL. There

Figure 3: 2000-2021 trends in member-state VAT compliance gaps by high, low share of e-money use



Notes: We group countries into high or low e-money use as a share of the GDP if they, respectively, record above or below average EU e-money use levels in 2000 to 2021. The collection of navy blue series plot country-specific VAT compliance gap levels as a share of the VTTL of the high e-money use group of countries from 2000 till 2021 in annual frequency. The collection of light blue series plot country-specific VAT compliance gap levels as a share of the VTTL of the low e-money use group of countries from 2000 till 2021 in annual frequency.

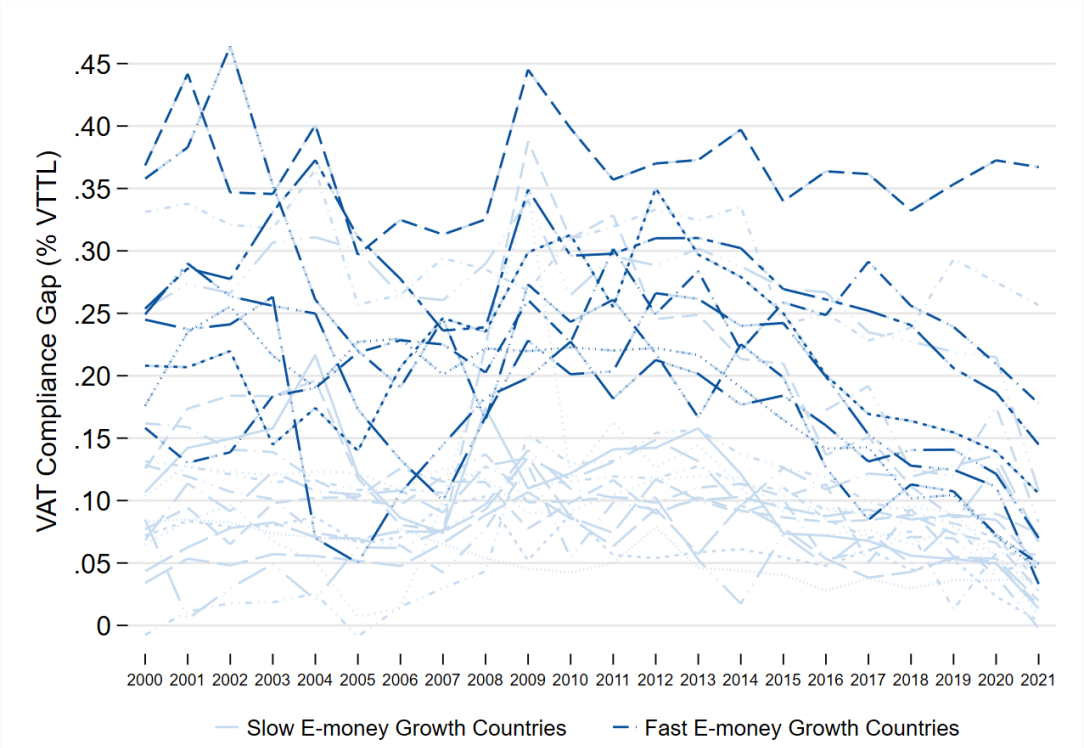
is a notable reduction in the variance of VAT compliance gaps among below-average e-money usage countries in later years, especially starting from 2013. This suggests that even countries with low e-money adoption as a share of GDP were able to achieve VAT gap reductions and moderate VAT gaps to levels comparable to high share of e-money adoption countries. Therefore, high levels of e-money adoption as a share of GDP alone may not be a necessary condition for countries to achieve VAT gap reductions.

However, to better understand the dynamics behind VAT gap reductions, it is equally important to look at how changes in e-money levels are related to observed VAT gaps. To this end, we provide a second sample split along the growth rates of e-money adoption. Figure 4 differentiates countries based on their speed of e-money growth, defined as the average year-on-year percentage change of e-money usage for the period 2000-2019.[2] Following this graphic, countries that experience larger long-term increases in e-money adoption are also those in which the VAT compliance gap declines faster.

Specifically, in the majority of countries with above-average growth in e-money use,

[2]The PHE years are excluded from these calculations given the peculiarity of that period.

Figure 4: 2000-2021 trends in member-state VAT compliance gaps by fast, slow growth of e-money use



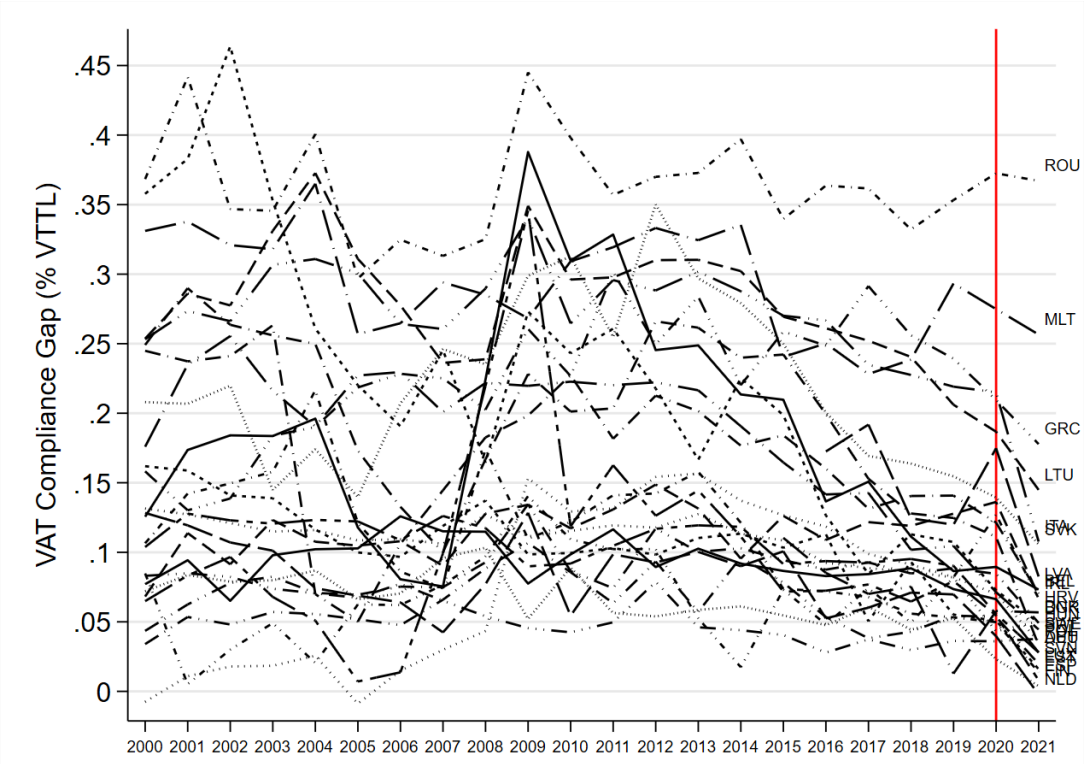
Notes: We group countries into fast or slow e-money growth groups if they, respectively, record above or below average EU e-money growth rates in 2000 to 2021. The collection of navy blue series plot country-specific VAT compliance gap levels as a share of the VTTL of the fast e-money growth group of countries from 2000 till 2021 in annual frequency. The collection of light blue series plot country-specific VAT compliance gap levels as a share of the VTTL of the slow e-money growth group of countries from 2000 till 2021 in annual frequency.

VAT gaps trend non-monotonically, fluctuating widely around 25% in early years before steadily declining in later years. On the contrary, VAT gaps in countries with below-average growth in e-money use persist around 10% before reducing further to 5% after 2019. This provides support to the notion that faster penetration of e-money may be relatively more effective in reducing VAT gaps.

These country-level descriptive analyses allow for two additional observations. First, the strong reductions in observed VAT gaps initiated around 2011 and happened almost universally across all countries. This puts a spotlight on the effectiveness of combining third-party information with information technology, which experienced a strong increase in that time period.

Second, during the PHE all countries experienced strong increases in the usage of e-money along with further decreases in the observed VAT gaps, see Figure 5. These changes took place irrespective of the baseline levels or growth rates of e-money adoption. Moreover, these PHE-related developments may be associated with the COVID-19 mitigation strategies chosen by each country. Figure 6 splits the sample of countries by the stringency of their mobility restrictions (a compound measure, see Section 2 for

Figure 5: 2000-2021 trends in member-state VAT compliance gaps

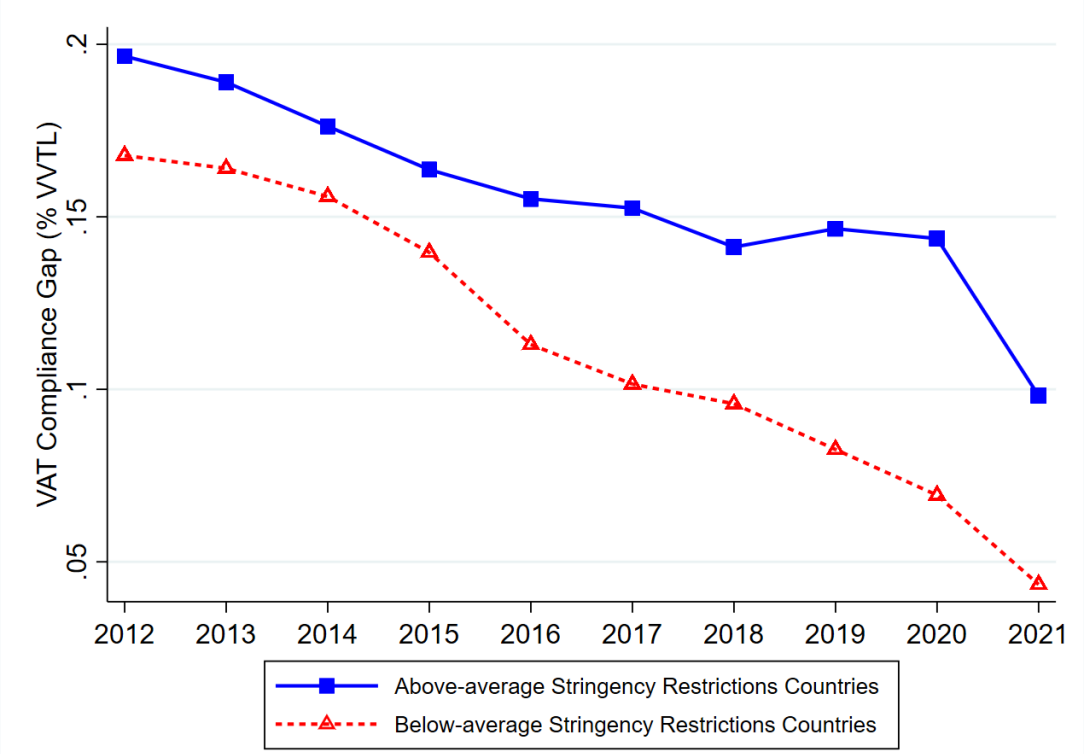


Notes: The black lines plot VAT compliance gap levels as a share of the VTTL from 2000 till 2021 in annual frequency of 27 EU countries labeled with name tags. The red vertical line denotes the first year of the COVID-19 public health emergency in 2020.

details), demonstrating that countries with above average stringency restrictions experienced a notably stronger reduction in their estimated VAT gaps than countries with below-average stringency reductions.

To summarize, this section has documented how technological innovations and changes in consumer payment preferences have led to the proliferation of cashless payments during the time period 2000-2021. Concurrently, observed VAT gaps have reduced substantially and in accordance with reductions in cash since about 2011. Moreover, we have documented a clear and strong negative correlation between e-money usage and estimated VAT gaps. These observations point to the fact that changes in payment norms seem to have provided authorities with improved possibilities to enforce VAT and deter non-compliance. While these correlations cannot be interpreted as causal evidence, they provide a strong indication that e-money usage seems to support VAT gap reductions. The subsequent section will provide an empirical analysis, drawing on both the length of the observed panel data as well as a natural experiment arising due to the influence of the PHE on population-level payment behavior.

Figure 6: Trends in VAT compliance gaps by country stringency groups



Notes: We group countries into above- or below-average stringency of mobility restrictions groups if they, respectively, record above or below average EU stringency levels in 2020 and 2021. The solid blue series plots mean VAT compliance gap levels as a share of the VTTL of the above-average stringency group of countries from 2000 till 2021 in annual frequency. The dashed red series plots meean VAT compliance gap levels as a share of the VTTL of the above-average stringency group of countries from 2000 till 2021 in annual frequency.

4 Regression Analysis

4.1 Panel OLS Regressions

Descriptive statistics for the EU countries over the period 2000-19 are provided in Table 1. They show an average VAT compliance gap of about 15.6%, the evolution of which has been examined in more detail over time and by country groups in the earlier paragraphs. E-money usage as a percentage of GDP has a value of about 11.6% on average and, notably, this has been expanding very quickly at an average rate of 11.3%. We can note an average share of cash withdrawals of 12.5% of GDP, which has varied only marginally during the overall period. It should be noted, however, that this low growth rate masks an increase followed by a decrease of cash withdrawals as seen in Figure 1. Another relevant aspect to be mentioned at this stage is that about 23% of country-year observations display the use of VAT listings, showing that the adoption of VAT listings is also non-negligible in our setting.

For the long-run, descriptive part of the regression analysis, we estimate the following two-way fixed effects model.

$$VAT\ gap_{ct} = \alpha_c + \theta_t + \beta_1 E - money\ growth_{ct} + \mathbf{X}'_{ct}\Gamma + u_{ct}, \tag{1}$$

Table 1: Summary Statistics, All countries – 2000-2019

	Mean	SD	Min	Max	N
VAT Gap	0.156	0.095	-0.009	0.464	509
E-money (% GDP)	0.116	0.070	0	0.425	524
E-money Growth Rate	0.113	0.421	-0.626	8.834	492
Cash Withdrawals (% GDP)	0.125	0.057	0.009	0.302	489
Cash Growth Rate	0.025	0.159	-0.469	1.634	462
VAT Listings	0.228	0.419	0	1	540
Self-employed (% of total employment)	16.183	7.187	6.71	46.11	540
Unemployment (% of total labor force)	8.739	4.429	1.716	27.47	520
% Urban Population	69.239	18.829	-0.526	98.041	520
Industry Value-added Share (% of GDP)	4.045	4.512	2.344	26.804	520
Trade (% of GDP)	113.941	65.75	17.249	377.843	520
Population	15.354	2.86	2.654	18.235	520
% Rural population	27.129	13.634	-0.314	49.246	540
Public Sector Corrupt Exchanges	2.778	0.727	0.239	3.926	520
Mobile Cellular Subscriptions (per 100k people)	104.876	30.433	9.114	172.151	540
Fixed Broadband Subscriptions (per 100k people)	20.488	12.600	0.0119	46.211	513

Notes: Column 2 presents the standard deviation of each variable. The natural logarithm of member state population is used in regression analysis but shown above in levels. See Table 5 for data sources.

where $VAT\ gap_{ct}$ is the VAT compliance gap of country c in year t and $E{-}money\ growth_{ct}$ represents the growth rate of e-money for the same observation. Our coefficient of interest is β_1 which represents the relationship between a one percentage point (pp) increase in e-money usage and the percentage-point change in VAT gaps. Based on our theoretical priors of improved third-party information and on the earlier graphical evidence, our hypothesis is that β_1 is negative. Regression 1 also includes country fixed effects α_c and year fixed effects θ_t. $\mathbf{X}_{ct}$ is a vector of time-varying control variables, including an indicator of VAT listings, the unemployment rate, the share of self-employed among all employed individuals, the shares of urban and rural population, the value added by the industry and trade sectors as a share of the GDP, the natural logarithm of population and public sector corrupt exchanges, the number of mobile cellular subscriptions per 100k individuals, and the number of fixed broadband subscriptions per 100k individuals. Standard errors are clustered at the country level.

The results from Equation 1 are shown in Table 2. The first column shows the results for all the countries in the period 2001-19. The empirical estimates confirm the negative association between the two variables. Specifically, a one pp increase in the e-money growth rate relates to a VAT gap decline by about 0.003 pps. We further conduct a heterogeneity analysis to explore this relationship by splitting the sample for countries with slow and fast adoption of e-money, as we did in Figure 4. The estimates for countries with slow e-money adoption are non statistically different from zero (column 2), while in

Table 2: Correlations, E-money Growth Rates, 2001-2019

	(1) All	(2) Slow	(3) Fast
E-money growth	-0.003*	0.014	-0.006**
	(0.002)	(0.042)	(0.002)
Observations	463	322	141

Notes: All regressions include control variables, omitted for brevity. Standard errors clustered at country level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

countries with fast e-money adoption the baseline effect doubles in magnitude and is also more precisely estimated (column 3). This highlights the importance of quick adoption of e-money in the fight against VAT non-compliance.

Although these results are in line with graphical evidence and support our hypothesis, they represent correlational evidence. Despite our efforts in curbing omitted variable bias by including important covariates related to both e-money adoption and VAT compliance, the observed e-money growth rates are plausibly not exogenous. To go beyond correlational evidence, we exploit the policy-induced changes in e-money (and cash) usage during the PHE and present this analysis in the next subsection.

4.2 Instrumental-variables Analysis

The COVID-19 public health emergency (PHE) intensified the use of cashless payments in Europe as consumer behavior adapted to PHE-related stay-at-home orders (Kotkowski and Polasik, 2021). Even though all EU member states (except for Sweden) adopted mobility restrictions during the initial stages of the PHE, the stringency of such measures varied greatly, ranging from low-stringency information campaigns to high-stringency containment and closure policies. We exploit this source of national-level, exogenous variation in mobility restrictions and, in turn, in cashless transactions to identify the causal effect of e-money use on VAT compliance in EU member states during the PHE using an instrumental-variables approach. Specifically, we isolate population-level, exogenous variation in e-money use generated by the imposition of mobility restrictions in response to the undoubtedly unanticipated PHE.

4.2.1 Descriptive Statistics and Methods

Figure 6 illustrates the evolution of the VAT compliance gap (2012-2021) for EU member states with below- and above-average mobility restrictions. This figure plots the VAT compliance gap levels of 27 EU member states from 2012 to 2021. It distinguishes between 15 member states (Austria, Belgium, Cyprus, Czechia, France, Germany, Greece, Ireland, Italy, Malta, Portugal, Romania, Slovakia, Slovenia and Spain) with above- and 12 member states with below-average stringency of mobility restrictions (Bulgaria, Croatia, Denmark, Estonia, Finland, Hungary, Latvia, Lithuania, Luxembourg, the Netherlands, Poland and Sweden). This figure demonstrates an overall decline in VAT gaps in both sets of countries during the past decade which was particularly pronounced in 2020

among below-average stringency countries and in 2021 among above-average stringency countries.

Although data on changes in mobility are available for 2020-2022, the VAT gap information is only available for the full panel of countries through 2021 and, thus, the empirical analysis is restricted to a 2019-2021 panel of 26 EU countries in annual frequency, excluding Cyprus due to no e-money information availability. Table 3 shows summary statistics for countries with above- (Panel A) and below-average (Panel B) stringency mobility restrictions for 2019, the pre-PHE year used in regression analysis.

The two groups are quite comparable with respect to several characteristics and economic indicators. Notably, countries adopting more stringent restrictions have, on average, higher VAT gaps, and use more cash and less e-money as a share of GDP, in line with theoretical predictions of the economics of deterrence (Becker, 1968).

The identification strategy in this part of the paper is based on an instrumental variables approach exploiting various measures of PHE mobility restrictions and their effect on the prevalence of two classes of payment methods: cash versus e-money. We employ a combination of three different instrumental variables gauging the intensity of the PHE restriction policies of a given country. First, we use an intensity measure of the stringency summarizing all PHE-related mobility restrictive policies. Second, we use an indicator function for whether a country enacted any mobility restrictions in 2020 and 2021, with Sweden being the only country that never enacted restrictions. Third, we use the intensity of the observed change in retail and recreational mobility, as provided by Google mobility data (refer to Section 2 for more details on the variables). The stringency of the PHE restrictions and the reductions of retail and recreational mobility may be considered instruments capturing the intensive margin of restrictions whereas the mobility restrictions indicator reflects their extensive margin. It should be noted that our analysis does not rely on a parallel trends assumption for identification but on exogenous variation in e-money adoption levels.

In the first stage of our estimation we regress a given measure of payment method {e-money to GDP, cash to GDP} on our instruments. Specifically, we estimate the following regression:

$$Payment\ method_{ct} = \eta_c + \mathbf{Z}'_{ct}\Theta + \mathbf{X}'_{ct}\Delta + \epsilon_{ct}, \tag{2}$$

with the vector of first stage instruments $\mathbf{Z}_{ct}$ including various combinations of the three aforementioned instrumental variables for country c in year t. The first stage regression includes $\mathbf{X}_{ct}$, a vector of time-varying control variables such an indicator of VAT listings, the unemployment rate, the share of urban population, the value added by the industry and trade sectors as a share of the GDP, the natural logarithm of population and public sector corrupt exchanges, and country fixed effects η_c.

In the second stage of the two-stage least squares estimation setup, we regress our main outcome of interest, the observed VAT gap, on the predicted change in payment method from the first stage:

$$VAT\ gap_{ct} = \alpha_c + \beta_1 \widehat{Payment\ method}_{ct} + \mathbf{X}'_{ct}\Gamma + u_{ct}. \tag{3}$$

The above regression includes the same time-varying control variables used in the first stage regression ($\mathbf{X}_{ct}$), country fixed effects α_c, and standard errors u_{ct} are clustered at

Table 3: Summary Statistics – Year 2019

	Mean	SD	Min	Max	N
Panel A – Countries with high restrictions					
VAT Gap	0.147	0.089	0.055	0.353	15
E-money (% GDP)	0.172	0.078	0.101	0.389	13
Cash (% GDP)	0.124	0.051	0.047	0.226	13
Vat Listings	0.533	0.516	0	1	15
Unemployment (% of total labor force)	6.687	4.397	1.716	17.31	14
Urban population (% of total population)	66.599	23.802	0.568	98.041	14
Population	15.327	3.883	2.764	18.235	14
Industry Value-added Share (% of GDP)	24.324	8.591	12.497	43.744	14
Trade (% of GDP)	121.120	75.040	22.272	275.290	14
Public Sector Corrupt Exchanges	2.721	0.748	0.408	3.55	14
Total Government Expenditure	42.78	7.601	24.3	55.4	15
General Government Debt	81.438	41.216	30.049	180.607	15
Tax Morale	0.267	0.458	0	1	15
Panel B – Countries with low restrictions					
VAT Gap	0.083	0.050	0.013	0.206	12
E-money (% GDP)	0.193	0.046	0.105	0.263	11
Cash (% GDP)	0.115	0.072	0.019	0.207	10
Vat Listings	0.667	0.492	0	1	12
Unemployment (% of total labor force)	5.173	1.385	3.28	6.83	12
Urban population (% of total population)	76.137	12.266	57.242	91.876	12
Population	15.432	1.136	13.337	17.452	12
Industry Value-added Share (% of GDP)	21.482	4.316	11.703	28.637	12
Trade (% of GDP)	143.122	78.394	79.605	377.843	12
Public Sector Corrupt Exchanges	2.921	0.634	1.83	3.926	12
Total Government Expenditure	43.358	5.705	34.7	53.3	12
General Government Debt	40.664	19.339	8.548	71.040	12
Tax Morale	0.5	0.522	0	1	12

Notes: Panel A refers to countries with mean stringency restrictions in 2020 and 2021 above the EU average, while panel B refers to countries with stringency restrictions below the EU average. Sources: See Table 5.

the country level.

The validity of this research design is based on the exogeneity of our instruments. We argue that PHE mobility restrictions did not have a direct effect on the level of VAT compliance in the economy, and that their only effect went through the change in payment behavior by the population. This is particularly credible for VAT evasion operating primarily through unreported cash payments received by businesses. Moreover, we do not expect the decisions of policymakers regarding optimal PHE mobility restriction

policies to be influenced by tax administration performance. While this assumption is not directly testable, we corroborate that the effect remains similar in direction and magnitude when using different instruments and different first-stage outcome variables.

To test the strength of our instruments, we employ various tests of first-stage significance, including standard F-statistics on the strength of the first stage instruments, but also Anderson-Rubin (AR) F-tests for weak-instrument robust inference. We exploit the fact that we have several instruments to conduct an overidentification test, i.e., we report the Hansen J statistic.

4.2.2 Instrumental Variables Results

This section summarizes our results from the instrumental variables estimation based on PHE mobility restrictions affecting the usage of payment methods in the population, and subsequent changes in comparable measures of VAT compliance. We begin by documenting descriptive evidence on the VAT gap, mobility restrictions, and usage of different payment methods. The section then describes the empirical estimates of the first stage, second stage, and reduced form.

When comparing countries based on the stringency of their mobility restrictions (above versus below average stringency mobility restrictions) in figure 6, we report a general downward trend in the VAT compliance gap, corresponding to an increase in VAT compliance, in line with findings in earlier sections. Moreover, we observe that countries with relatively stronger mobility restrictions also experienced a stronger drop in the VAT compliance gap, particularly in 2021.[3] This provides first descriptive evidence for the reduced form connection between PHE restrictions and VAT compliance. Moreover, it appears that the two groups of countries, while exhibiting different levels of VAT compliance, evolved relatively in parallel before the onset of the PHE. Even though the validity of our research design is not based on parallel trends, this lends credibility to the exogeneity of the variation behind the intensity of the PHE mobility restrictions.

Our main estimates are presented in Table 4. In the first stage (Panel B), we observe that in particular our measure for mobility restrictions has a strong effect on the usage of payment options. In column (1) more stringent restrictions are related to an increase in the usage of e-money, and in column (4) they are associated with a decrease in the usage of cash in the economy. When employing the first stage outcome of cash versus GDP (columns 4-6), the first stage F statistics are continuously above 15 and we can therefore consider our instruments to be "strong". However, the regular F-statistics range between 10 and 20 for the first stage outcome of e-money/GDP (columns 1-3). We therefore additionally employ the AR F-test, which tests for the statistical significance of the second stage estimates in the face of potentially weak instruments. These AR F-statistics and the corresponding p-values indicate that despite the relatively low values of the first-stage F-statistics and potentially weak instruments, the causal effect of e-money-to-GDP on the VAT gap is statistically significant. The Hansen J test for overidentification (weakly) rejects the validity of the second instrument in columns 3, 5, and 6. This is in line with our prior that the stringency intended by policymakers is the strongest instrument among the three, and that both the observed behavioral change and the indicator for any

[3]This trend reversal was not present in 2020, although in this year the mobility restrictions were already in place. We rationalize this with the delayed effect of changes in compliance behavior on VAT gaps, because of the retrospective nature of the tax collection process [p. 137, Poniatowski et al. (2023)].

mobility restrictions do not provide sufficient additional variation. We therefore consider the results in columns (1) and (4) to be our baseline estimates.

Table 4: Effects on VAT compliance gap, 2019-2021

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: 2SLS						
E-money (% GDP)	-1.4083***	-1.3746***	-0.8561**			
	(0.383)	(0.392)	(0.428)			
Cash (% GDP)				3.6628***	2.5392***	2.6073***
				(0.922)	(0.831)	(0.975)
Panel B: First Stage						
Stringency	0.0005***	0.0004	0.0002	-0.0002***	0.0001	-0.0001
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
$\boldsymbol{I}$[Mobil. Res.]		0.0074			-0.0159**	
		(0.033)			(0.007)	
Δ(Retail Mobil.)%			0.0008			-0.0002
			(0.001)			(0.000)
Panel C: Reduced Form						
Stringency	−.0007***					
	(0.0001)					
Observations	72	72	72	68	68	68
$F-1^{st}$ *stage*	19.179	10.896	13.575	28.979	20.215	15.393
AR F-test	25.966	17.215	15.922	25.104	15.373	13.795
AR F-test p-value	0.000	0.000	0.000	0.000	0.000	0.000
Hansen J statistic	0.000	0.796	5.665	0.000	4.311	6.458
Hansen J statistic p-value		0.372	0.017		0.038	0.011

Notes: Mean VAT gap in 2019 is 11.81pp. Inverse retail change denotes retail and recreational mobility changes relative to 2019 in percent terms multiplied by -1 to express mobility reductions. All regressions include control variables, estimated coefficients of industry/trade value-added, VAT listings, unemployment rate, % urban population, the natural logarithm of population, and public sector corrupt exchanges omitted for brevity. Standard errors clustered at country level in parentheses. AR F-Test refers to the Anderson-Rubin (AR) F-test for weak-instrument robust inference (Baum et al., 2007), the Hansen J statistic is a test for over-identification. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Panel A of Table 4 reports second stage results of the two stage least squares (2SLS) estimation procedure laid out in equation (3). By leveraging arguably exogenous variation in e-money and cash usage arising from different intensities of PHE mobility restrictions across EU member states, the IV regression estimates shed light on the causal relationship between payment method and tax compliance. Our preferred estimates in columns (1) and (4) indicate a substantial negative relationship between e-money usage and gaps in VAT compliance, while cash usage is positively related to gaps in VAT compliance. Besides being statistically significant, the effects are sizeable: A one pp increase in e-money/GDP usage is related to a decrease in the VAT gap by 1.4pp, while a similar increase in the cash/GDP ratio is related to an increase in the VAT gap by 3.7pp. While these effects may seem small, they appear significantly larger when set in relation to the 2019 baseline values of the quantities. First, a one pp increase of e-money/GDP and

cash/GDP corresponds to increased e-money usage by 5.51% (baseline e-money/GDP of 18.13pp) and cash withdrawals by 8.33% (baseline cash/GDP of 12.01pp). These large changes in payment methods employed by the population are associated with substantial differences in the observed VAT gap, which was 11.81pp on average in 2019. Based on this pre-treatment average, an estimated 5.51% increase in e-money use is causing an 11.9% reduction in the VAT compliance gap whereas an 8.33% increase in cash withdrawals is leading to a 31% increase in the VAT compliance gap.

When interpreting these coefficients it should be noted that their different magnitudes may be explained from the different nature of payment methods. One potential explanation why the effect of cash is stronger than that of e-money is the fact that while e-money is recorded for each individual transaction, the data on cash/GDP measures how much cash is withdrawn from bank accounts. This cash then enters the economy and remains in circulation where it is used repeatedly. Therefore, any amount of cash pushed into economic activities is subject to a certain "magnifying effect".

Panel C of Table 4 also reports results on the reduced form estimation, where we estimate the direct effect of the stringency of PHE policies on the observed VAT gap. When evaluated at a hypothetical country with the average level of stringency (value of 54.5), the introduction of the mobility restrictions are associated to a modest decrease of 0.038 percentage points in the VAT gap. While this is undoubtedly a small effect, this cannot be interpreted as evidence that tax compliance did not improve with the onset of the PHE. As we have shown in our previous results, the PHE is associated with a strong change in payment behavior of the population and also a strong change in tax compliance behavior. This reduced-form estimate only picks up that part of the variation in both payment behavior and tax compliance which can be explained by cross-country differences in the stringency of mobility restrictions. While this provides a good setup to estimate the causal effects of payment behavior on VAT evasion, this procedure is less suited for assessing the overall influence of the PHE on tax compliance.

4.2.3 Robustness

Table 6 presents further results from robustness tests, which are conducted for both e-money and cash usage. Columns 1 and 6 include an additional instrument for the severity of the PHE via the share of COVID-19 infections per 100k individuals. Since the spread of COVID-19 infection might affect VAT compliance via social interactions and policy, we include it as an additional instrument in the first stage and the results remain comparable to the baseline ones. The other tests include only the average stringency instrument, following our preferred specification. Columns 2 and 7 include a control for government expenditure, while columns 3 and 8 include a control for public debt. Here the rationale is to account for budget-related developments that might be related to stringency but would not be captured by e-money or cash usage (Ufier, 2017). Elevated public expenditures during the PHE driven by preferences for redistribution, representing VAT compliant purchases with certainty, may also be contributing to VAT gap reductions (Klemm and Mauro, 2022). The negative (positive) effect of e-money usage (cash withdrawals) on VAT gap reported in our baseline estimates is robust to the consideration of these measures of PHE severity and government fiscal health in Columns 1-3 (6-8). Tax morale might also be an an important determinant of VAT compliance and is measured by the share of the population that is open to performing paid work that goes undeclared to tax

authorities. Tax morale cannot be used as a control due to the availability of a single data point for 2019 from Eurobarometer. Instead, we present results for e-money use (cash withdrawals) in Columns 4-5 (9-10) separately for countries with below- and above-average tax morale. Columns 4 and 9 show the results for countries with tax morale above the mean, columns 5 and 10 for those below the mean. These findings suggest that in high tax morale environments, the e-money coefficient becomes negative and very large, though insignificant. Column 10 shows that particularly in countries with below-average tax morale, cash withdrawals are significantly associated with VAT gap increases.

5 Conclusion

This paper identifies the long-run association and short-run effects of e-money use on a population-level measure of VAT non-compliance, the VAT gap. We provide visual illustrations, descriptive results using panel data methods, and causal evidence based on an instrumental variables approach of a negative relationship between e-money and the VAT gap.

Our findings support the view that increased e-money usage and decreased cash circulation can be linked to higher levels of VAT compliance. The results from the instrumental-variables analysis indicate that the PHE mobility restrictions had a measurable impact reducing the usage of cash and increasing the prevalence of e-money in economies of the EU. We document changes in the payment behavior of the population, which in turn had an effect on the observed VAT gap. Our preferred instrumental-variables estimates indicate a strong underlying relationship between the prevalence of payment methods and measured VAT gaps. An 8% reduction in cash usage is associated with a 31% decrease in the VAT gap, while a 5.5% increase in e-money usage can be linked to a decrease in the VAT gap by 11.9%. Due to the universality of these mobility restrictions, our findings are both credible and generalizable to other high- or middle-income countries.

This study is subject to a number of limitations. First, our IV setup with one baseline year and two PHE periods does not allow us to use sophisticated methods for panel data sets, as the data only provide yearly cross-country variation. Using a single pre-PHE year is done to ensure that our measures of pre-PHE mobility are as comparable to PHE mobility changes as possible and refrain from extrapolations to additional pre-PHE years. Furthermore, the arguably underpowered analysis lends to conservative regression estimates. Despite the limited sample size of the IV analysis, it is nonetheless reassuring that e-money and cash have effects that go in the opposite direction, as expected. Second, we do not consider changes in interchange fees in the presence of cashless stores that may also influence cashless payment adoption rates during the PHE (Shy, 2022). Third, trends in VAT compliance gaps may be influenced by underlying social capital that has impacted the incidence of the PHE and resulting mobility restrictions in Austria, Germany, Italy, the Netherlands and Sweden (Bartscher et al., 2021). Although we do not directly account for trust in government, to minimize these concerns we control for public sector corruption, which is known to erode social capital, and further analyze countries by their level of tax morale (Bjørnskov, 2003).

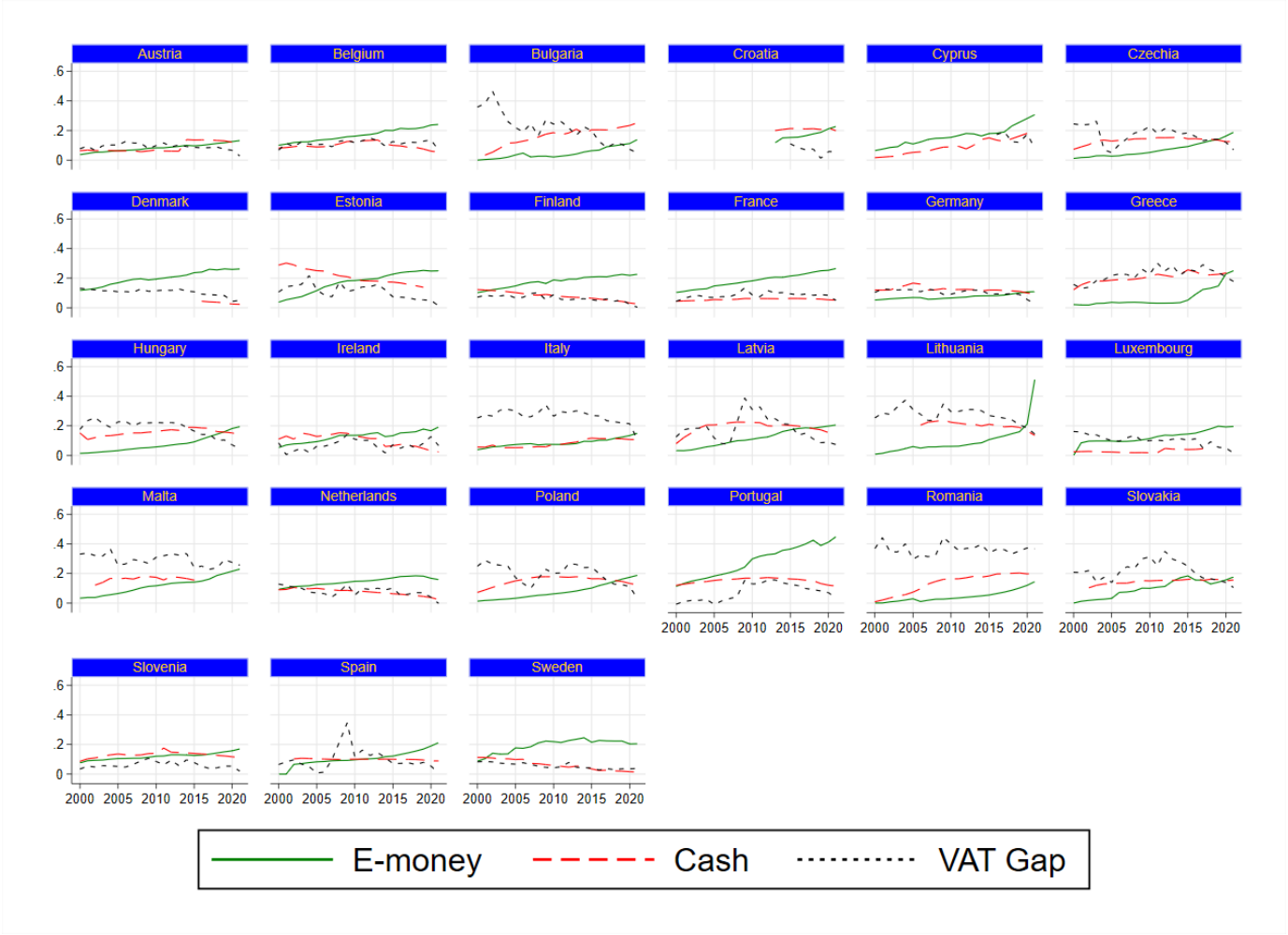
The study findings have important policy implications. Although the estimates that

can be causally interpreted stem from a time of unprecedented crisis, they highlight the significance of the link between payment methods and tax compliance. This important takeaway underscores the benefits of increased use of e-money during the PHE to curb VAT evasion. Still, the shift towards increased e-money usage to promote VAT compliance should not be achieved through higher stringency environments or mandates. In fact, enhanced tax administration e-capacity through the adoption of VAT listings may have been conducive to increased tax compliance by improving adopters' ability to process third-party information and capitalize on the rise in e-money usage during the PHE. Although our study does not focus on whether these investments may lead to population-level, VAT compliance gap reductions detectable at conventional levels of statistical significance, our findings indicate that nearly costless behavioral changes in transaction payment norms such as the adoption of cashless payments may also yield significantly more tax revenues at a, presumably, significantly lower tax price to traditional tax enforcement strategies such as audits. Policies designed to increase e-money usage and decrease cash circulation such as those adopted in Italy, Greece or India are relevant steps into this direction (Hondroyiannis and Papaoikonomou, 2017; Sands et al., 2017; Danchev et al., 2020; Russo, 2022; Das et al., 2023).

Future research could investigate more deeply whether a policy increasing e-money usage with the explicit aim to improve tax compliance has the same effects as the PHE policies studied in this paper. Moreover, additional work is needed to understand how far incentivizing businesses to accept (more) e-money could lead to similar improvements in outcomes by exploiting country-specific instances of mandatory usage of e-money implemented by various member states in recent years. Another research question reserved for a potential follow-up analysis relates to the interactive impacts of VAT listings and e-money usage on VAT evasion.

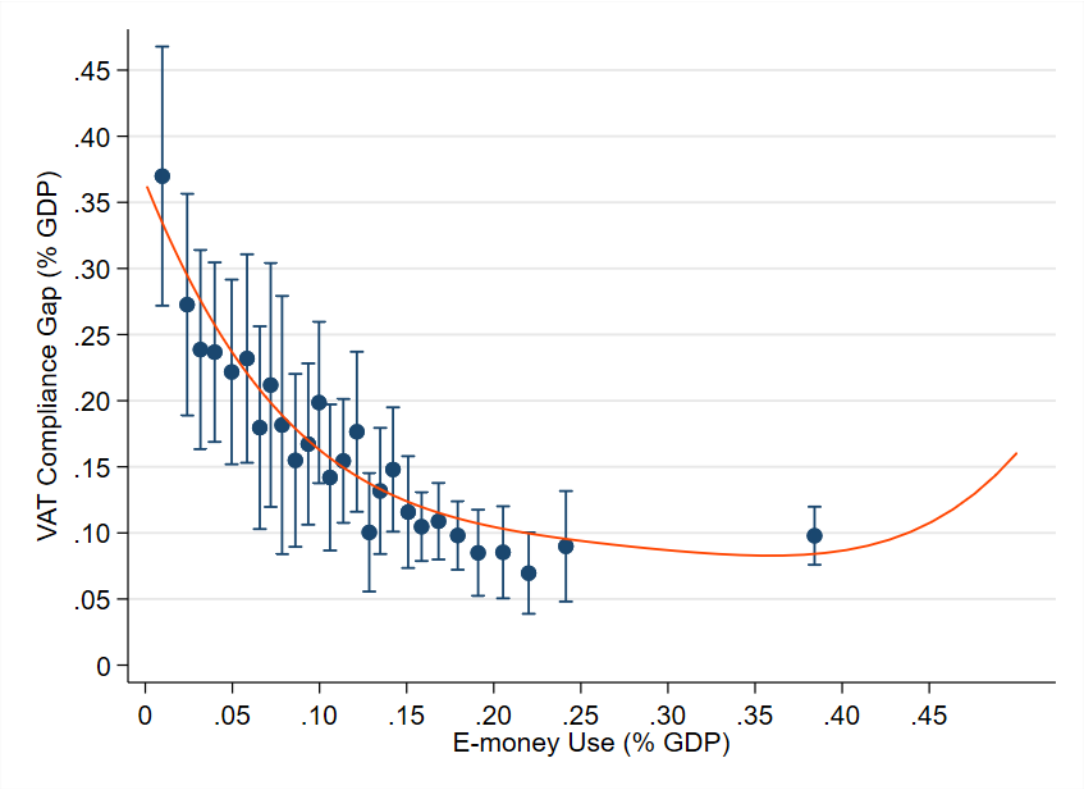
A Figures

Figure 7: 2000-2021 member state-specific trends in VAT compliance gaps, e-money use and cash withdrawals



Notes:

Figure 8: Binned regression plot of VAT compliance gaps and e-money use using Cattaneo et al. (2019)



Notes:

B Tables

Table 5: Data sources

Variables	**Source**	**Link**
VAT Compliance Gap	Poniatowski et al. (2023)	accessed 11.02.2023
Cash and E-money (% GDP)	European Central Bank	accessed 12.15.2022
Unemployment rate	Eurostat	accessed 11.28.2023
Government expenditures	Eurostat	accessed 10.23.2023
Government deficit/surplus, debt	Eurostat	accessed 10.23.2023
Retail Mobility Changes	Google Community Mobility Reports	accessed 01.23.2023
Government Stringency Index	Hale et al. (2021)	accessed 02.23.2023
VAT listings	Holá et al. (2022)	accessed 10.15.2022
Industry sector value added	Teorell et al. (2022)	accessed 10.15.2022
Trade sector value added	Teorell et al. (2022)	accessed 10.15.2022
Population	Teorell et al. (2022)	accessed 10.15.2022
% Urban population	Teorell et al. (2022)	accessed 10.15.2022
% Rural population	Teorell et al. (2022)	accessed 10.15.2022
Public sector corrupt exchanges	Teorell et al. (2022)	accessed 10.15.2022
% Self-employed population	Teorell et al. (2022)	accessed 10.15.2022
Fixed broadband subscriptions	Teorell et al. (2022)	accessed 10.15.2022
Mobile cellular subscriptions	Teorell et al. (2022)	accessed 10.15.2022
COVID-19 Infection Count	World Health Organization	accessed 10.23.2023
Tax Morale	Eurobarometer	accessed 10.23.2023

Table 6: Effect on VAT gap – Robustness tests

	Covid Cases	Gvt Exp.	Public Debt	Tax Morale		Covid Cases	Gvt Exp.	Public Debt	Tax Morale	
				High	Low				High	Low
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
E-money (% GDP)	-1.2915***	-1.1817***	-1.8775***	-10.6995	-0.5881					
	(0.3719)	(0.4451)	(0.7040)	(35.2513)	(0.4663)					
Cash (% GDP)						3.5806***	3.2333***	2.9369***	1.0665	2.7230**
						(0.7927)	(0.6050)	(0.6755)	(1.0230)	(1.3637)
First Stage										
Stringency	0.0002	0.0006**	0.0004***	0.0000	0.0010*	0.0001	-0.0002***	-0.0002***	-0.0003***	-0.0002*
	(0.0002)	(0.0002)	(0.0002)	(0.0001)	(0.0005)	(0.0003)	(0.0000)	(0.0000)	(0.0001)	(0.0001)
# COVID-19 infections	0.0002					-0.0000*				
	(0.0002)					(0.0000)				
Observations	72	72	72	45	27	68	68	68	38	30
$F-1^{st}$ *stage*	11.790	7.212	8.004	0.062	3.394	16.309	31.537	44.169	19.671	4.599
AR F-test	19.368	21.934	20.107	0.824	3.295	19.743	23.107	20.339	0.630	4.245
AR F-test p-value	0.000	0.000	0.000	0.379	0.107	0.000	0.000	0.000	0.443	0.069

Notes: All regressions include control variables; estimated coefficients of industry/trade value-added, VAT listings, unemployment rate, % urban population, the natural logarithm of population, and public sector corrupt exchanges omitted for brevity. Col's (1), (2), (3) and (4-5) include estimates additionally adjusted by the COVID-19 infection rate, government expenditures, public debt growth and tax morale, respectively. Standard errors clustered at country level in parentheses. AR F-Test refers to the Anderson-Rubin (AR) F-test for weak-instrument robust inference (Baum et al., 2007), the Hansen J statistic is a test for over-identification. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

C Funding & Competing Interests

C.1 Funding & Non-financial Support

Albrecht Bohne acknowledges funding from the German Research Foundation for a research stay at the University of Michigan (Walter Benjamin Program grant BO 5782/1).

Antonios M. Koumpias recognizes support from the Undergraduate Research Opportunity Program at the University of Michigan in the form of student research assistance under Project #204.

C.2 Competing Interests

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

References

Alognon, A., Koumpias, A. M., and Martinez-Vazquez, J. (2021). The impact of plastic money use on vat compliance: Evidence from eu countries. *Hacienda Publica Espanola*, (239):5–26. https://dx.doi.org/10.7866/HPE-RPE.21.4.1.

Artavanis, N., Morse, A., and Tsoutsoura, M. (2016). Measuring income tax evasion using bank credit: Evidence from greece. *The Quarterly Journal of Economics*, 131(2):739–798. https://doi.org/10.1093/qje/qjw009.

Bartscher, A. K., Seitz, S., Siegloch, S., Slotwinski, M., and Wehrhöfer, N. (2021). Social capital and the spread of covid-19: Insights from european countries. *Journal of health economics*, 80:102531. https://doi.org/10.1016/j.jhealeco.2021.102531.

Baum, C. F., Schaffer, M. E., and Stillman, S. (2007). Enhanced routines for instrumental variables/generalized method of moments estimation and testing. *The Stata Journal*, 7(4):465–506. https://doi.org/10.1177/1536867X0800700402.

Becker, G. S. (1968). Crime and punishment: An economic approach. *Journal of political economy*, 76(2):169–217. https://www.jstor.org/stable/1830482.

Bellon, M., Dabla-Norris, E., Khalid, S., and Lima, F. (2022). Digitalization to improve tax compliance: Evidence from vat e-invoicing in peru. *Journal of Public Economics*, 210:104661. https://doi.org/10.1016/j.jpubeco.2022.104661.

Bjørnskov, C. (2003). *Corruption and social capital*. Aarhus School of Business Aarhus. https://econpapers.repec.org/scripts/redir.pf?u=http%3A%2F%2Fwww.hha.dk%2Fnat%2Fwper%2F03-13_chbj.pdf;h=repec:hhs:aareco:2003_013.

Cattaneo, M. D., Crump, R. K., Farrell, M. H., and Feng, Y. (2019). On binscatter. *arXiv preprint arXiv:1902.09608*. https://doi.org/10.48550/arXiv.1902.09615.

Danchev, S., Gatopoulos, G., and Vettas, N. (2020). Penetration of digital payments in greece after capital controls: Determinants and impact on vat revenues. *CESifo Economic Studies*, 66(3):198–220. https://doi.org/10.1093/cesifo/ifz019.

Das, S., Gadenne, L., Nandi, T., and Warwick, R. (2023). Does going cashless make you tax-rich? evidence from india's demonetization experiment. *Journal of Public Economics*, 224:104907. https://doi.org/10.1016/j.jpubeco.2023.104907.

European Central Bank (2022). *Transactions per type of payment service*, volume Payments and Settlement Systems Statistics. Frankfurt. https://data.ecb.europa.eu/data/data-categories/payment-statistics/payment-services-large-value-payment-systems-and-retail-payment-systems/transactions-type-payment-service.

Eurostat (2023). *Statistics Explained*, volume Payments and Settlement Systems Statistics. Brussels. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Main_Page.

Hale, T., Angrist, N., Goldszmidt, R., Kira, B., Petherick, A., Phillips, T., Webster, S., Cameron-Blake, E., Hallas, L., Majumdar, S., et al. (2021). A global panel database of pandemic policies (oxford covid-19 government response tracker). *Nature human behaviour*, 5(4):529–538. https://doi.org/10.1038/s41562-021-01079-8.

Holá, A., Arltová, M., and Zídková, H. (2022). Vat listings within the eu member states and their impact on tax evasion. *CESifo Economic Studies*, 68(3):297–318. https://doi.org/10.1093/cesifo/ifac002.

Hondroyiannis, G. and Papaoikonomou, D. (2017). The effect of card payments on vat revenue: New evidence from greece. *Economics Letters*, 157:17–20. https://doi.org/10.1016/j.econlet.2017.05.009.

Hondroyiannis, G. and Papaoikonomou, D. (2020). The effect of card payments on vat revenue in the euro area: evidence from a panel vecm. *Journal of Economic Studies*, 47(6):1281–1306. https://doi.org/10.1108/JES-03-2019-0138.

Immordino, G. and Russo, F. F. (2018). Cashless payments and tax evasion. *European Journal of Political Economy*, 55:36–43. https://doi.org/10.1016/j.ejpoleco.2017.11.001.

Klemm, A. and Mauro, P. (2022). Pandemic and progressivity. *International tax and public finance*, 29(2):505–535. https://doi.org/10.1007/s10797-021-09700-2.

Kleven, H. J., Knudsen, M. B., Kreiner, C. T., Pedersen, S., and Saez, E. (2011). Unwilling or unable to cheat? evidence from a tax audit experiment in denmark. *Econometrica*, 79(3):651–692. https://doi.org/10.3982/ECTA9113.

Kopczuk, W. and Slemrod, J. (2006). Putting firms into optimal tax theory. *American Economic Review*, 96(2):130–134. https://doi.org/10.1257/000282806777212585.

Kotkowski, R. and Polasik, M. (2021). Covid-19 pandemic increases the divide between cash and cashless payment users in europe. *Economics letters*, 209:110139. https://doi.org/10.1016/j.econlet.2021.110139.

Madzharova, B. (2020). Traceable payments and vat design: Effects on vat performance. *CESifo Economic Studies*, 66(3):221–247. https://doi.org/10.1093/cesifo/ifaa003.

Pomeranz, D. (2015). No taxation without information: Deterrence and self-enforcement in the value added tax. *American Economic Review*, 105(8):2539–2569. https://doi.org/10.1257/aer.20130393.

Poniatowski, G., Bonch-Osmolovskiy, M., Sojka, A., and Pechcińska, A. (2023). *VAT gap in the EU : report 2023*. Publications Office of the European Union. https://doi.org/10.2778/911698.

Russo, F. F. (2022). Cash thresholds, cash expenditure and tax evasion. *Fiscal Studies*, 43(4):387–403. https://doi.org/10.1111/1475-5890.12311.

Sands, P., Weisman, B., Campbell, H., and Keatinge, T. (2017). Limiting the use of cash for big purchases: Assessing the case for uniform cash thresholds. https://www.hks.harvard.edu/sites/default/files/centers/mrcbg/files/80_limiting.cash.pdf.

Shy, O. (2022). Interchange fees with cashless stores, cashless consumers, and cash-only consumers. *Economics Letters*, 212:110284. https://doi.org/10.1016/j.econlet.2022.110284.

Slemrod, J., Collins, B., Hoopes, J. L., Reck, D., and Sebastiani, M. (2017). Does credit-card information reporting improve small-business tax compliance? *Journal of Public Economics*, 149:1–19. https://doi.org/10.1016/j.jpubeco.2017.02.010.

Teorell, J., Sundström, A., Holmberg, S., Rothstein, B., Alvarado Pachon, N., and Dalli, C. M. (2022). The quality of government standard dataset, version jan22. *University of Gothenburg: The Quality of Government Institute, https://www. gu. se/en/quality-government doi*, 10. https://doi.org/10.18157/qogstdjan23.

Treasury, U. (2021). The american families plan tax compliance agenda. *Department of Treasury, Washington, DC*. https://home.treasury.gov/system/files/136/The-American-Families-Plan-Tax-Compliance-Agenda.pdf.

Ufier, A. (2017). The effect of vats on government balance sheets. *International Tax and Public Finance*, 24(6):1141–1173. https://doi.org/10.1007/s10797-016-9406-3.

Waseem, M. (2023). Overclaimed refunds, undeclared sales, and invoice mills: Nature and extent of noncompliance in a value-added tax. *Journal of Public Economics*, 218:104783. https://doi.org/10.1016/j.jpubeco.2022.104783.

Download ZEW Discussion Papers:

https://www.zew.de/en/publications/zew-discussion-papers

or see:

https://www.ssrn.com/link/ZEW-Ctr-Euro-Econ-Research.html
https://ideas.repec.org/s/zbw/zewdip.html

IMPRINT

ZEW – Leibniz-Zentrum für Europäische Wirtschaftsforschung GmbH Mannheim
ZEW – Leibniz Centre for European Economic Research

L 7,1 · 68161 Mannheim · Germany
Phone +49 621 1235-01
info@zew.de · zew.de