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Abstract

The digitalization of transaction processes through tools such as electronic invoicing (e-invoicing) aims to improve tax compliance and reduce administrative costs. Another important aspect of digitalization is its potential to reduce tax evasion. We analyze the impact of the widely introduced e-invoicing in Italy on cross-border value-added tax fraud. As a proxy for this tax fraud, we make use of the discrepancy in trade data that is double-reported in both the importing and exporting country (trade gap). We calculate trade gaps based on product flows on the most detailed level between Italy and the remaining countries of the European Union. Our results suggest a significant decline in cross-border fraud in response to the introduction of mandatory e-invoicing, providing an important rationale for the application of this measure by other countries. Furthermore, we estimate that e-invoicing decreased the Italian revenue loss by €0.6 billion to €1 billion in 2019. This is in line with the statements of the Italian Ministry of Finance, which are probably based mainly on the revenue development. In this context, we underpin the suitability of the trade gap as an approach for the study of anti-fraud measures and provide a more accurate estimate of cross-border fraud. In addition, our study suggests that fraudsters shift their activities to similar products and drive honest traders out of the market.

JEL-Codes: F140, H210, H260, K340, K400.

Keywords: e-invoicing, digitalization, international trade, VAT fraud, trade gap.

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1 Introduction

Digitalization promises to improve tax enforcement and to reduce tax evasion regarding direct and indirect taxes. A main reason is the acceleration of data collection that enables tax administrations to monitor transactions in real-time (Jacobs 2017). As a result, digitizing tax collection is gaining noticeable popularity in tax policy debates and is attracting increasing interest among academics. Many non-European tax administrations, especially within Latin America and Asia, already use digitized transaction processes, i.e. through mandatory business-to-business (B2B) electronic invoicing systems (e-invoicing) to monitor economic processes. In Europe, Italy is the first country to have introduced such a system on a mandatory basis for B2B and B2C (business-to-customer) transactions.[1]

Tax research on digital tools, including e-invoicing systems, focuses primarily on the potential to improve tax compliance and collection (Bellon et al. 2022; Alonso et al. 2021; Fan et al. 2020; Hernandez and Robalino 2018; Bérgolo et al. 2018; Ramirez et al. 2018; Templado and Artana 2018; Lee 2016) and cost implications for both tax administrations and firms (Giannotti et al. 2019). Although theoretical considerations on the use of digital tools against tax fraud in Europe go back a long time (see e.g. Ainsworth 2006), empirical studies on the tax fraud-reducing effect of digitalization are scarce. Most recently, Kitsios et al. (2022) conducted an empirical study that examines the impact of digitalization efforts on cross-border value-added tax (VAT) fraud using aggregated trade data. They confirm that digitalization correlates with lower tax fraud. However, their analysis focus on the relationship between aggregated trade data within the European Union (EU) and the Online Service Index conducted by the

[1] In many EU countries, the e-invoices are mandatory only for B2G transactions (Giannotti et al. 2019). Poland introduced B2B e-invoicing on a voluntary basis in January 2022, which was planned to become mandatory April, 1 2023 (EU Commission 2022a). However, the introduction date was postponed and is now planned to be obligatory starting January, 1 2024 to at least December, 31 2026 (EU Commission 2022b). France introduced Article 153 of Finance Law No. 2019-1479 to introduce a mandatory B2B e-invoicing system from July 1, 2024 (the planned date of January 1, 2023 was postponed by the Council of Ministers' minutes of September 15, 2021) for large companies, gradually expanding its scope to all firms. It is planned to cover all firms by January 2026 (EU Commission 2021).

United Nations as proxy for digitalization efforts. Such a highly generalized index cannot disentangle single digital measures. Moreover, cross-border tax fraud is a product-specific phenomenon that can only be studied to a limited extent with aggregated data. Against this background, the implication of certain digitalization measures with regard to cross-border tax fraud has been insufficiently examined. Such empirical evidence is essential to evaluate ongoing implementation efforts and to support tax policy in future debates as the digitalization of tax administrations become increasingly important. This demonstrates the example of the current debate on a harmonized e-invoicing system in Europe (EU Commission 2020). While especially in Latin America, e-invoicing is attested to have considerable anti-fraud potential (Barreix and Zambrano 2018), the question remains how it affects cross-border tax fraud in Europe. We address this research gap by examining the introduction of e-invoicing in Italy in 2019 on all B2B and B2C transactions using gaps in double-reported bilateral trade data between Italy and the remaining EU countries at the most detailed product code level of the combined nomenclature (CN).

VAT (in some countries also called GST[2]) as the main form of consumption tax is implemented in 170 countries and generates about one third of all tax revenue in the OECD (Organisation for Economic Co-operation and Development) countries (OECD 2020). This type of consumption tax has the potential to create high revenue at relatively low administrative and economic costs.[3] However, VAT is also prone to fraud as firms themselves collect the tax on behalf of the state. VAT is payable by the acquirer to the supplier in both B2B and B2C transactions. The supplier is obliged to forward the received VAT to the tax authorities after

[2] For example, Australia, India or Canada refer to their consumption tax as "Goods and Services Tax (GST)". The GST is very similar to the VAT because both tax the value added to the sale of products or services (OECD 2020). Therefore, we only use the term "VAT" in this document as it also refers to a GST.

[3] The design of the VAT makes it neutral with regard to business decisions. By principle, VAT does not affect the choice of the legal form, financing structure and investment projects. This applies not only to domestic activities but also to cross-border transactions. Taxation in the importing country (destination principle) links VAT to the place of consumption, making the location decision of companies irrelevant for this tax and considerably reducing the scope for tax planning (McLure 1993; Cnossen 1998).

deducting the input tax he or she had from own purchases. The damage resulting from VAT fraud, under which the supplier does not remit the received tax from the acquirer, is partially reduced if the right to deduct the input VAT for the supplier is denied and is thus limited to the tax amount on his or her profit margin ("value added"). However, the fraudster's plunder, and thus the VAT loss increases significantly if the fraudster is able to avoid paying the input VAT. VAT-exemption on cross-border supplies opens up this possibility. The fraudster imports goods without VAT, sells them with VAT on the domestic market and disappears with the gross amount received.[4] Due to the disappearance, the fraudster is called "missing trader". The straightforward name of this scheme is 'missing trader intra-Community' (MTIC) fraud and is responsible for the bulk of the VAT losses within the EU. Estimations range from €50 billion (EU Commission 2016; Frunza 2016) to €64 billion (Braml and Felbermayr 2021) annually.[5]

Double-reported cross-border trade flows provide research opportunities regarding VAT fraud reactions to certain measures. Recent studies have shown that trade gaps on the product level, i.e. the gap between the export of a product reported by exporting country and the corresponding import reported by importing country, serve as an indicator of MTIC fraud (Stiller and Heinemann 2019, 2021; Bussy 2020).[6] Our empirical strategy exploits a difference-in-differences framework accounting for group and time fixed effects, focusing on Italy's bilateral trade with the remaining EU countries for all products at the level of the eight-digit CN code 12 months before and after the introduction of e-invoicing in January 2019. We assign to the control group products that fall under the previously introduced reverse charge

[4] The buyer must declare the import VAT (while the same amount can be deducted as input VAT). This reporting obligation is delayed because the import VAT is not collected at the border when the supply is made, but must be declared in the next regular VAT return. This creates a time lag during which fraudsters can intensively carry out EU imports and domestic supplies before the tax authority can detect the fraud (Sergiou 2012).

[5] MTIC fraud can be divided further into "acquisition fraud" and "carousel fraud". The latter differs from the former in that the goods imported by the missing trader circulate, so that they are imported several times, allowing VAT to be evaded at each "turn" of the carousel.

[6] Trade gaps are extensively used in tariff evasion research; see e.g. Fisman and Wei (2004).

mechanism (RCM), for which empirical evidence shows that tax fraud is reduced significantly (see Stiller and Heinemann 2019, 2021; Bussy 2020). Applied only to B2B transactions, RCM is a VAT blocking mechanism under which the buyer is obliged to pay the VAT to the tax authorities instead of paying it to the supplier. Thus, the VAT does not come under control of the fraudster. Therefore, we identify the difference in trade gaps before and after the reform between products potentially not affected by e-invoicing (RCM products) as the control group and all remaining products (non-RCM products) as the treatment group. Considering various controls as well as group and time fixed effects, we find that the introduction of e-invoicing is associated with a significant decrease in tax fraud expressed by the trade gap. To check whether our analysis picks up a non-fraud related downward trend within the treatment group that is unrelated to RCM products, we change our control group to non-RCM products of comparable EU countries, i.e., Greece, Lithuania, Romania, and Slovakia. According to the estimation carried out by Poniatowski et al. (2020), these countries had the highest VAT gaps in 2018 together with Italy. This approach confirms the fraud-reducing effect of e-invoicing for non-RCM products in Italy.

To quantify the fraud-reducing effect, we run our baseline model separately for each exporting country to capture the exporter-specific effects of the reform. In this way, we estimate a reduction in cross-border tax fraud due to the adoption of e-invoicing of between €0.6 billion and €1 billion for 2019. Our results are close to the overall estimates provided by Italy (EU Commission, 2021). This underpins the suitability of the trade gap as a proxy for cross-border tax fraud, confirms its immense share in the total revenue losses, and contributes to a better assessment of the reform effects. Since administrative costs in relation to the system are low (running cost of €10 million) and firms are supposed to benefit from reliefs in terms of administrative costs (EU Commission 2021), e-invoicing provides a promising way to tackle cross-border tax fraud in other countries.

With this paper, we contribute to several strands of the literature. First, this paper joins the ongoing empirical research on the examination of measures against VAT fraud and its impact on tax revenues using trade gaps as evasion proxy (Stiller and Heinemann 2019, 2021; Bussy 2020). In this sense, we also contribute more broadly to the overall literature on the analysis of the trade gap as a cross-border evasion proxy (Fisman and Wei 2004; Mishra et al. 2008; Javorcik and Narciso 2008; Stoyanov 2012; Javorcik and Narciso 2017).

Additionally, our paper contributes to the emerging empirical research on the relationship between digitalization and tax fraud. Kitsios et al. (2022), Strango (2021) and Poniatowski et al. (2021) find that higher digitalization of tax reporting obligations is correlated with less (cross-border) tax fraud. All these papers, however, focus on aggregated country-level data and proxies for general digitalization efforts. We extend this literature stream i.e. by using disaggregated product-level data and a single reform, uncovering the impacts of digitalization on tax fraud on a more detailed level.

The rest of this paper is structured as follows. In Section 2, we provide an overview of the e-invoicing system in Italy and formulate our hypothesis. In Section 3, we define our proxy for cross-border tax fraud, present the data, and our estimation method. Section 4 is devoted to the presentation and discussion of the results. Section 5 presents additional analyses and robustness checks. Section 6 concludes.

2 The E-Invoicing Reform in Italy

In June 2013, Italy implemented mandatory e-invoicing for supplies to central administrations (B2G; business-to-government). Shortly thereafter (March 2014), the obligation was extended to include transactions to all administrations. An essential part of the Italian approach to an e-invoicing system is the transmission of electronic invoices through a central system of the revenue authority: Sistema di Interscambio (SdI). In addition to the investment expenses of

€2.5 million, the operation of the SdI costs €0.5 million per year. Approximately 30 million B2G-invoices from one million suppliers to 23 thousand public authorities pass through the system annually. An extension of e-invoicing to B2B transactions came in 2017 with the obligation to send invoice data to the revenue authority on a quarterly basis. Taxpayers were enabled to avoid the obligation to submit quarterly reports through optional participation in the e-invoicing procedure. However, only 7 thousand (out of a total of about 5.5 million) VAT taxable persons chose the optional regime for B2B e-invoicing (Ministry of Economy and Finance Italy 2018). Already during the first year of the optional e-invoicing system for B2B transactions, Italy requested the Council of the European Union to authorize the introduction of a mandatory e-invoicing for all taxable persons and the processing of the invoices through the SdI. The arguments for the generalized e-invoicing system stated by Italy are straightforward. It would allow gathering real time information that enables Italy to "carry out timely and automatic consistency checks between the amounts of VAT declared and paid" to "combat fraud and evasion, boost efforts at digitalization and simplify tax collection" (European Council 2018).

The authorization of the Council was followed by the generalized system of mandatory e-invoicing introduced in Italy from January 2019 for both B2B and B2C transactions if the Italian operator exceeds an annual turnover of €65 thousand.[7] This system covers about 80% of all taxable persons and processes up to 2 billion invoices per year. The running cost are estimated to about €10 million annually (Ministry of Economy and Finance Italy 2018).

The EU Council limited the application of the mandatory e-invoicing to December 31, 2021. In March 2021, Italy successfully applied to the European Commission for an extension of this measure (until the end of 2024). According to the Commission, Italy has reported the

[7] However, B2C transactions are only covered by the system when the consumer demands for an electronic invoice.

achievement of the objectives pursued by the mandatory e-invoicing system. In addition to simplifying tax compliance, increasing tax collection efficiency and reducing administrative costs for businesses, the measure has contributed to the fight against tax fraud. According to Italy, the fraud reduction effect of the mandatory e-invoicing is a result of faster fraud detection as well as the preventive effect of this measure. Italy estimates that around €2 billion of additional revenue can be attributed to the reform. According to the Italian government, it was "possible to identify companies involved in intra-Community fraud mechanisms carried out between the last months of 2019 and 2020" that were linked to non-existent transactions of about €1 billion (EU Commission 2021).

However, to the best of our knowledge, Italy provides no insights on the calculation regarding those estimates. Inspecting the development of Italian VAT revenue in the course of introduction, displayed in Table 1, we observe that in 2019 VAT revenue is about €2 billion higher compared to 2018 (see Table 1, Column 1). This increase corresponds to the estimated €2 billion that the Italian government associates with the introduction of the mandatory e-invoicing. To examine the effect with respect to VAT evasion, a common indicator for its development is the yearly VAT gap estimated by Poniatowski et al. (2021). It represents the compliance gap in a VAT system and indicates the amount of VAT not received by tax administrations due to legal and illegal activities (e.g. bankruptcies or legal tax avoidance vs. VAT evasion and fraud). In absolute terms, Italy experienced a significant reduction of the VAT gap by €2.3 billion from 2018 to 2019 (see Table 1, Column 2). In comparison, the EU average shows a decrease of only €0.237 billion (see Table 1, Column 4). This could speak for an effect of the reform, Italy, however, shows a decreasing (increasing) trend in the development of the VAT gap (VAT revenue) even in the years before.

Accordingly, the ratio of the VAT gap to the VTTL (theoretically VAT revenues expected under full compliance), as an indication of the relative size of the VAT gap in a

Member State, decreases by about 1.61 percentage points compared to 2018 (see Table 1, Column 3). The reduction magnitude is double the size compared to the EU average for which the ratio decreases only by about 0.82 percentage points (see Table 1, Column 5). However, Italy is still suffering from a relatively high VAT gap even after the introduction of the e-invoicing system. Given these indications, a more in-depth analysis has to be carried out to disentangle the real effect of the reform.

Table 1. VAT Revenue and VAT Gap in Italy

Year	Italy			EU Average	
	VAT Revenue in million euros (1)	VAT Gap in million euros (2)	VAT Gap / VTTL (3)	VAT Gap in million euros (4)	VAT Gap / VTTL (5)
2016	102,086	36,852	26.52%	5,159	13.35%
2017	107,576	32,611	23.26%	5,204	12.90%
2018	109,333	32,415	22.87%	5,038	11.70%
2019	**111,464**	**30,106**	**21.26%**	4,801	10.88%

Notes: Data on VAT revenue (VAT, receivable) were obtained from Eurostat using the dataset Government revenue, expenditure and main aggregates "gov_10a_main". Data on the VAT gap and VTTL (VAT Total Tax Liability, which represents the theoretical VAT revenues under full compliance) are obtained from Poniatowski et al. (2021) and are available until 2019.

So far, only few studies dealt with the question whether digitalization affects cross-border tax fraud and to which extent. As part of the annually designed VAT gap study, Poniatowski et al. (2021) use a sample that includes all EU Member States and they find a statistically significant negative correlation between the VAT gap and digital reporting obligations, including VAT listing, Standard Audit File - Tax, real-time and e-invoicing. However, this estimation aims to identify the overall impact of digital reporting obligations in the EU rather than single measures. Nevertheless, it shows the importance of improved tax reporting. Further empirical evidence that general digitalization efforts tackles VAT fraud is provided by Kitsios et al. (2022) and Strango (2021). In contrast, a study conducted by Giannotti et al. (2019) finds no significant effect of the growing use of e-invoices on the fight against VAT fraud in the EU. Noteworthy, however, is the specificity of the Italian system, where e-invoices are sent to the recipient through the SdI. Without the invoice authorization from the system managed by the

Revenue Agency, the recipient is not entitled to the input VAT deduction. The anti-fraud potential of e-invoices is therefore not solely due to their electronic form, but rather to the timely control and approval by the tax authorities. This feature is widely recognized as a key characteristic to fight tax evasion (Barreix and Zambrano 2018). Against this background, a clearance procedure in which an e-invoice becomes valid upon confirmation by the tax authorities enables prompt identification of fraudsters. This is especially true for a generalized system of mandatory e-invoicing, therefore, we predict:

***Hypothesis**: The introduction of mandatory e-invoicing in Italy significantly reduces cross-border tax fraud.*

3 Fraud Proxy, Data and Estimation Method

3.1 Proxy for Cross-Border Tax Fraud

A growing literature that examines the effectiveness of VAT fraud measures increasingly exploits discrepancies in double-reported trade data, the so-called trade gaps (Kitsios et al. 2022; Stiller and Heinemann 2019, 2021; Bussy 2020). Fisman and Wei (2004) first used trade gaps to study tariff evasion on the product-level between China and Hong Kong. This approach has found wide use in other studies related to tariff evasion (Mishra et al. 2008; Javorcik and Narciso 2008; Stoyanov 2012; Javorcik and Narciso 2017).

European taxpayers are generally obliged to report imports and exports not only in the regular advance VAT return but also in the Intrastat system.[8] The application of the trade gap as a proxy for cross-border VAT fraud is based on the theoretical argument that the fraudster does not report imports in the Intrastat system. Since the fraudster imports goods tax-free, i.e. without deductible input tax, he or she has no incentive to comply with the obligations to file

[8] Only if the trader does not exceed certain thresholds, set by each EU country individually, no Intrastat declarations are necessary.

tax returns and Intrastat declarations. However, we only observe respective trade gaps if exporters report trade within the Intrastat systems while fraudulent importers fail to do so. We rely on the assumption that exporters fulfill their reporting obligations. This assumption can be justified by the fact that the exporter does not have to be aware of the fraud. Even if the exporter were a fraudster, compliance with the declaration requirements could be used as an argument by the exporter that he or she was unknowingly involved in the fraud in case of detection. Therefore, the exporter can claim the refund of the input tax. Such a line of reasoning does not help the fraudulent importer, as he or she does not pay the tax due to the tax authority. The declaration of imports could possibly help the fraudster not to be immediately detected by the tax administration. However, this strategy in the absence of tax payment can only work for a short time. In summary, it is possible that on the one hand, exports (to the fraudsters) are not declared and on the other hand, fraudsters declare imports. If both parties involved in the fraud (fail to) report, we will observe no gap in the trade data. This implies that we can only estimate a lower bound of cross-border fraud carried out within Italy. We are aware that also other factors can lead to trade gaps, which we control for with our model.

According to Fisman and Wei (2004), we define the trade gap as the difference in log[9] exports and the corresponding log imports of product p at the eight-digit CN product level at time t (monthly between January 2018 and December 2019) from exporting country e to importing country i reported by country e and i, respectively:

$$Trade\ Gap_{eipt} = ln\, Export_{eipt} - ln\, Import_{eipt} = ln\left(\frac{Export_{eipt}}{Import_{eipt}}\right). \qquad (1)$$

Equation (1) implies positive values for $\frac{Export_{eipt}}{Import_{eipt}} > 1$ (case with prevalent fraud) and negative values for $\frac{Export_{eipt}}{Import_{eipt}} < 1$, as well as the value zero for $\frac{Export_{eipt}}{Import_{eipt}} = 1$. Besides fraud, trade gaps

[9] Throughout the paper, we refer to "log" as the logarithm to the base e (natural logarithm).

can occur due to different valuations of exports and imports. Since exports are valued as free-on-board while imports are include also cost of insurance and freight, the latter should be slightly higher by default resulting in a slightly negative trade gap (Eurostat 2009).

3.2 Data

We use Eurostat's freely accessible database[10], which contains detailed information on exports and imports between EU member states (intra-EU) for all goods distinguished by the eight-digit CN code, the most detailed level available, in values and quantities. The data on intra-EU trade are based on statistical surveys conducted as part of the Intrastat system (Eurostat 2020). For our baseline sample, we collect monthly intra-EU-import data on products using the eight-digit CN code reported by Italy from the 27 remaining EU Member States and intra-EU-exports reported by the remaining EU Member States to Italy. Later, we extend our baseline sample by corresponding data for Greece, Lithuania, Romania and Slovakia as importing countries. The observation period ranges from January 2018 to December 2019, resulting in 12 months before and 12 months with mandatory e-invoicing in Italy (introduction of e-invoicing on January 1, 2019). Observations including the value of zero for exports were omitted from the sample since our dependent variable requires non-zero values. There were no reported zero values for imports. We further exclude fuels from our baseline sample since these products were already affected by mandatory e-invoicing six months prior to the generalized introduction.

Table 2 presents the descriptive statistics for the trade gap. We expect mean trade gaps to be (if at all slightly below) zero in case without fraud. The mean trade gap of the control group consisting of RCM products (TREAT=0) before and after e-invoicing at 0.0266 and -0.0332, respectively, is relatively stable and close to zero. In contrast, treatment products (TREAT=1) show an about ten times higher mean trade gap before e-invoicing (0.2624), which

[10] Available at https://ec.europa.eu/eurostat/home.

indicates potential fraud within this group. The mean trade gap of 0.0683 for TREAT in the period with e-invoicing is significantly lower and close to zero, however, it is still higher than its counterpart for the control group, indicating that some fraud activity could be left over. Nonetheless, the mean trade gaps suggest that the mandatory e-invoicing system in Italy significantly reduces fraud in the treatment group. However, we do not want to infer actual effects from descriptive statistics alone.

Table 2. Descriptive Statistics of the Trade Gap

Trade Gap (Dependent Variable)		Observations	Mean	Standard Deviation	Minimum	Maximum
TREAT = 0	if POST = 0	12,200	0.0266	1.8705	-12.1698	11.9568
	if POST = 1	13,259	-0.0332	1.9731	-12.6402	10.8908
TREAT = 1	if POST = 0	617,474	0.2624	1.8838	-15.1976	14.2156
	if POST = 1	679,090	0.0683	1.9699	-14.2465	16.7204

Notes: Equation (1) shows the calculation method for the trade gap. POST is a time dummy that equals zero 12 months before e-invoicing became mandatory for all products in Italy in January 2019 and equals one 12 months after December 2018. TREAT is a dummy equal to one if the product is assigned to the treatment group (non-RCM) and zero if it is assigned to the control group (RCM).

3.3 Estimation Method

We investigate the effect of the mandatory e-invoicing system on the trade gap (cross-border VAT fraud) for all products traded (except for fuels) between Italy and the remaining 27 Member States during the observation period (January 2018 to December 2019) using a difference-in-differences framework including fixed effects. We choose products that were most likely not affected by fraud in the run-up to the mandatory e-invoicing. Studies by Stiller and Heinemann (2019, 2021) and Bussy (2020) provide theoretical and empirical support that the introduction of the RCM tackles VAT fraud in the importing country as it excludes the fraudster from receiving the output tax.[11] Therefore, products that are subject to RCM serve as control group (see for RCM applications Table A1, Appendix). All other products are not protected by RCM and form the treatment group. According to our hypothesis, the application

[11] RCM is applicable to B2B transactions and therefore does not (directly) address fraud at the B2C level.

of the mandatory e-invoicing in Italy reduces cross-border tax fraud (trade gap) with products not falling under the RCM. Thus, we estimate the following difference-in-differences model:

$$Trade\ Gap_{eipt} = \beta_0 + \beta_1\ POST_t * TREAT_p + \beta \sum X_{eipt} + a_t + a_{ep} + u_{eipt} \qquad (2)$$

where the trade gap – as a proxy for fraud – is defined by equation (1). $POST_t$ is a dummy equal to one from January 2019 on and zero otherwise. $TREAT_p$ is a dummy equal to one if a product p belongs to the treatment group and zero if the product is protected by RCM.[12] All variables with explanations are displayed in Table A2 (Appendix). See also Table A3 (Appendix) for descriptive statistics on all control variables. Due to the hypothesized fraud-reducing effect of e-invoicing in Italy, we predict a negative coefficient β_1 for the interaction between $POST_t$ and $TREAT_p$. Our panel data enables us to include group fixed effects (a combination of exporting country and the eight-digit product code) and time fixed effects. Consequently, we individually include $POST_t$ and $TREAT_p$ as long as no time or group fixed effects are included. Eventually, these main effects drop out as soon as we include the full set of fixed effects. However, we also test alternative fixed effects specifications that allow us to include the main effects in the regression equation.

Regarding the set of control variables, $\sum X_{eipt}$ is a vector that contains the variables $THRESHOLD\ GAP_{eit}$, $REDUCED\ A_p$, $REDUCED\ B_p$, $REDUCED\ C_p$, and $EURO_{eit}$. Evidence for the inclusion of $THRESHOLD\ GAP_{eit}$ is provided by Stiller and Heinemann (2021). This variable captures differences in reported exports and imports due to different thresholds for reporting obligations for these trade flows that each country is required to set within the Intrastat system (see for thresholds Table A4, Appendix).[13] The variables $REDUCED\ A_p$,

[12] There is no change in product allocation between both groups within the observation period.

[13] The calculation follows Stiller and Heinemann (2021): $THRESHOLD\ GAP_{eit} = ln\left(\frac{THRESHOLD_{eit}}{THRESHOLD_{eit}}\right)$. EU Member States are obliged to estimate missing trade due to thresholds, fraud and other reasons. However, since we obtain eight-digit CN codes from the bulk download option provided by Eurostat (see

$REDUCED\ B_p$ and $REDUCED\ C_p$ are dummies equal to one if the VAT rate in Italy on the specific product p is reduced to 10%, 5% or 4%, respectively, and zero otherwise. These dummies serve to capture VAT rate effects.[14] Further, we include $EURO_{eit}$ that serves to absorb differences in trade data that could occur due to currency conversion (Loschky 2006). a_t represents time fixed effects as month-year combinations and a_{ep} reflects group fixed effects as exporter-product combinations. The error term is represented by u_{eipt}. Note that time-invariant exporter controls drop out as soon as group fixed effects are included.

Given our difference-in-differences approach, treatment and control groups must share similar pre-trends. Figure 1 graphically confirms the assumption of a common pre-reform trend showing the difference in the mean trade gap between the treatment and control groups four months before and during the reform. It can be seen that the difference remains stable before the introduction of e-invoicing. In January 2019, the difference visibly drops down but does not reach zero, as indicated by the descriptive statistics.

https://ec.europa.eu/eurostat/data/bulkdownload), those estimations are excluded as they are indicated by alphanumeric product codes.

[14] The reduced (10%, 5% and 4%) and standard (22%) VAT rates in Italy remain constant within the observation period.

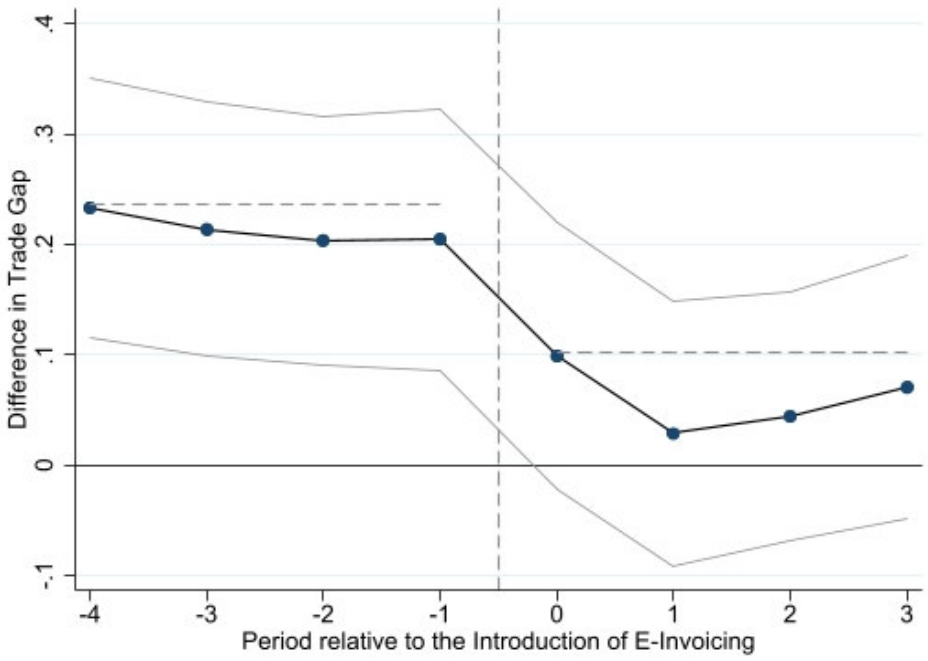

Figure 1. Parallel Trend of Baseline Specification.

Notes: The graph shows the difference in the mean trade gap between treatment (non-RCM and non-FUELS products) and control group (RCM products) in Italy 4 months prior and 4 months after the introduction of e-invoicing in Italy in January 2019.

4 Results

4.1 Baseline Results

Table 3 presents our baseline results for the trade gap displaying all variables included in the model. The coefficient of POST is negative, but statistically significant only when including group or alternative time fixed effects and suggests a general decreasing trend in trade gaps in Italy. TREAT, on the other side, shows throughout positive coefficients indicating that the treatment group suffered from higher trade gaps prior to the reform compared to the control group. This result confirms our rationale for identifying RCM products as a treatment group.

The main variable of interest is the interaction of both variables. The corresponding coefficient is negative and statistically significant throughout the specifications (see Table 3,

Columns 1 to 6). Noteworthy, fixed effects control for a large share of the variation as the adjusted R^2 increases significantly after including group fixed effects. Simultaneously, the coefficient of the interaction drops from -0.136 in Column 2 to -0.073 in Column 3 (see Table 3). The inclusion of time fixed effects does not change the effect (see Table 3, Column 4).

Modifying group and time fixed effects by including them on a higher hierarchy allows us to examine a more traditional difference-in-differences approach. We use country-pair-4-digit HS codes instead of country-pair-8-digit CN codes regarding group fixed effects and quarters instead of months as time fixed effects. As expected, including the alternative set of fixed effects lowers the adjusted R^2 since these fixed effects capture less variation. The interaction effect increases slightly in magnitude to -0.103 (see Table 3, Columns 5 and 6). Nevertheless, we believe that the specification from Column 4 gives us the best estimate, controlling for the biggest share of variation and lets us observe the preferred within variation of exporter-eight digit product combinations. Finding this robust negative effect throughout the specifications strongly supports our hypothesis, that mandatory e-invoicing reduces cross-border tax fraud in Italy. Using the baseline model from Column 4 (Table 3), that includes group and time fixed effects, the application of e-invoicing in Italy is associated with a reduction in the ratio of exports to imports ($\frac{Export_{eipt}}{Import_{eipt}}$) by about 7%. Later, we make use of this estimate to calculate fraud tackled by e-invoicing.

Our first control variable EURO is positively correlated with the trade gap (see Table 3, Column 2; due to collinearity with group fixed effects, the variable drops out from column 3). This result can be explained by the fact that intra-Eurozone fraud avoids currency exchange risks and is therefore more lucrative. Concerning THRESHOLD GAP, the negative coefficient is plausible as the variable sets the reporting threshold for exports in relation to the reporting threshold for imports. An increase in this variable reflects a relative increase in non-reported exports to imports, which reduces the trade gap. Note that country-specific estimations for non-

reportable trade below the thresholds are not included in the trade figures. REDUCED A and (in some cases) REDUCED C show a negative and statistically significant coefficient as well, indicating that reduced VAT rate products are less appealing to fraudsters. This result is reasonable since a lower tax rate reduces the profit of the fraudster. REDUCED B is omitted from all specification including fixed effects due to collinearity with the group fixed effects.

Table 3. Baseline Results – Italy

	Trade Gap, no FE	Trade Gap, no FE	Trade Gap, with group FE	Trade Gap, with group and time FE	Trade Gap, with alternative group FE	Trade Gap, with alternative group and time FE
	(1)	(2)	(3)	(4)	(5)	(6)
POST	-0.060	-0.059	-0.108***			-0.084**
	(0.037)	(0.037)	(0.033)			(0.035)
TREAT	0.236***	0.261***			0.314**	0.314**
	(0.040)	(0.040)			(0.135)	(0.135)
POST*TREAT	-0.134***	-0.136***	**-0.073****	**-0.073****	-0.103***	-0.103***
	(0.037)	(0.037)	**(0.033)**	**(0.033)**	(0.035)	(0.035)
EURO		0.081***				
		(0.012)				
THRESHOLD GAP		-0.049***	-0.360***	-0.360***	-0.364***	-0.364***
		(0.009)	(0.043)	(0.043)	(0.045)	(0.045)
REDUCED A		-0.201***	-0.712***	-0.720***	-0.299*	-0.298*
		(0.019)	(0.003)	(0.006)	(0.156)	(0.156)
REDUCED B		0.031				
		(0.157)				
REDUCED C		-0.243***			-0.417	-0.418
		(0.030)			(0.380)	(0.380)
Observations	1,322,023	1,322,023	1,322,023	1,322,023	1,322,023	1,322,023
Adjusted R^2	0.003	0.005	0.484	0.484	0.137	0.137
Group FE	No	No	Yes	Yes	No	No
Time FE	No	No	No	Yes	Yes	No
Country-pair*4-digit HS Code FE	No	No	No	No	Yes	Yes
Quarter FE	No	No	No	No	No	Yes

Notes: The dependent variable is the trade gap defined in equation (1). The importing country is Italy. Exporting countries are all other EU Member States. For explanations on variables, see Table A2 in the Appendix. The corresponding correlation matrix is displayed in Table A5, Panel A in the Appendix. The group identifier for Group FE is a combination of country-pair and the 8-digit product code. Regressions are calculated using OLS. Robust standard errors are clustered by the group FE identifier and are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

4.2 Quantification of Fraud tackled by E-Invoicing

The previous results provide strong support that e-invoicing effectively tackled cross-border VAT fraud. We make use of the results from our baseline regression in Table 3 and estimate the amount of fraud combatted by e-invoicing in terms of VAT revenue. The coefficient of the interaction POST*TREAT of -0.073 (Table 3, Column 4) represents the average decrease in

the ratio $\left(\frac{Export_{eipt}}{Import_{eipt}}\right)$ for all products over all exporting countries which is 7.04%. To make the estimation more precise, we run the specification from equation (2) separately for each exporting country to obtain exporter-specific coefficients (see Table 4). In our approach, we use both the overall coefficient of POST*TREAT ($\beta_{overall}$) from Column 4 of Table 3 and the significant and negative exporter-specific coefficients ($\beta_{specific}$) from Table 4 to estimate tax fraud that was potentially carried out the year prior to the reform. The calculation is displayed in the Appendix (Table A6). Our estimate represents a range of two alternatives (based on exports or imports). The introduction of the mandatory e-invoicing system eliminates the fraudulent importers and thus previously unreported imports. The possible consequence is that the previously declared exports to the fraudsters are eliminated, reducing the trade gap (export-based estimation). The other possible outcome is that honest importers pushed out of the market by fraudsters become more active, increasing declared imports, which decreases the trade gap (import-based estimation). We address this issue later in an additional robustness check, where we use log exports and log imports as alternative dependent variables.

Using the overall coefficient, we estimate that e-invoicing removed fraud between €3.2 and €3.4 billion. However, if we analyze the effect of e-invoicing at the level of the respective exporting country (using the exporter-specific coefficients), we estimate that fraud of between €633 million and €969 million has been eliminated. We assume that using the exporter-specific coefficients yields the closest estimate.[15] This estimation undercuts by about €1 billion to €1.4 billion the increase in VAT revenues in 2019, as stated by the Italian government as the effect of e-invoicing. First, this deviation could indicate that e-invoicing not only removed cross-border related fraud but also other types of domestic VAT evasion. Second, - as we pointed out

[15] We observe one positive and statistically significant coefficient for Estonia, see Table 4, Column 8. This implies that fraud was even lower before e-invoicing. We include Estonia into our estimation, however, due to low trade figures between Italy and Estonia, it does not change the results substantially.

earlier - we are probably only able to estimate a lower bound, namely for the case where the exporter reports an export while the importer does not report the corresponding import. Nevertheless, our estimation underpins the significant extent of cross-border VAT fraud and helps to assess the effects of the reform more precisely. Considering the comparably low running cost of the mandatory e-invoicing system, amounting to €10 million, our results provide a strong argument in favor of this tool for combating VAT fraud.

Table 4. Baseline Specification by each Exporting Country

Dependent Variable: Trade Gap	Austria (1)	Belgium (2)	Bulgaria (3)	Cyprus (4)	Czech Republic (5)	Germany (6)	Denmark (7)
POST*TREAT	0.069	-0.158	0.481	-0.744	-0.030	-0.067	-0.112
	(0.155)	(0.158)	(0.469)	(0.616)	(0.101)	(0.064)	(0.174)
Observations	92,773	92,363	20,794	1,980	63,179	148,438	43,708
Adjusted R^2	0.476	0.447	0.505	0.534	0.498	0.449	0.476
	Estonia (8)	Spain (9)	Finland (10)	France (11)	United Kingdom (12)	Greece (13)	Croatia (14)
POST*TREAT	**0.564***	-0.092	0.003	-0.019	-0.014	**-0.314***	-0.135
	(0.322)	(0.102)	(0.347)	(0.073)	(0.095)	**(0.162)**	(0.203)
Observations	3,476	110,660	15,936	129,528	97,843	20,376	25,642
Adjusted R^2	0.500	0.462	0.415	0.475	0.430	0.540	0.493
	Hungary (15)	Ireland (16)	Lithuania (17)	Luxembourg (18)	Latvia (19)	Malta (20)	Netherlands (21)
POST*TREAT	**-0.554*****	-0.226	-0.928	0.129	0.943	0.126	-0.120
	(0.141)	(0.242)	(0.773)	(0.491)	(0.621)	(0.356)	(0.113)
Observations	42,073	11,807	11,982	12,834	6,366	2,025	106,418
Adjusted R^2	0.468	0.499	0.468	0.466	0.469	0.665	0.511
	Poland (22)	Portugal (23)	Romania (24)	Sweden (25)	Slovenia (26)	Slovakia (27)	
POST*TREAT	-0.072	-0.410	0.316	0.142	0.021	**-0.416***	
	(0.129)	(0.491)	(0.335)	(0.186)	(0.126)	**(0.229)**	
Observations	69,769	28,251	51,147	42,451	39,307	30,897	
Adjusted R^2	0.489	0.471	0.528	0.465	0.531	0.551	

Notes: The dependent variable is the trade gap defined in equation (1). The importing country is Italy. Exporting countries are separated and indicated above the regressions. For explanations on variables, see Table A2 in the Appendix. All regressions include group and time fixed effects. Regressions are calculated using OLS. Robust standard errors are clustered by group FE identifier and are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

We want to emphasize that we are aware of endogeneity concerns regarding our estimation method. Clearly, the observed VAT revenue and fraud-reducing effect is an Italian specific estimate. Since the level of pre-reform cross-border fraud is an important factor regarding the effectiveness of this digital tool, generalizations for other countries from the results need to be made with caution.

5 Further Analysis and Robustness Checks

5.1 Alternative Control Group

One can argue that trade with RCM products could still contain fraud, since B2C transactions are not fully covered by this mechanism. We are convinced by the empirical evidence that the RCM removes fraud to a significant extend. This can be underpinned by the nature of cross-border VAT fraud, which is based on high-value transactions taking place at the B2B rather than the B2C level. Nevertheless, we want to address this concern. Therefore, we additionally make use of an alternative control group to check the robustness of our initial results. We modify our empirical setting and exchange the initial control group of RCM products to non-RCM products in other importing countries. Considering the 2018 VAT gap study by Poniatowski et al. (2020), Greece, Lithuania, Romania and Slovakia show similar levels of VAT gaps for the year 2018 and are therefore used as an alternative control group.

According to the above-mentioned strategy, we modify regression equation (2) as follows. The POST estimator remains unchanged and the dummy variable TREAT takes on the value of one if the importing country is Italy and zero if the importing country is Greece, Lithuania, Romania or Slovakia. The set of control variables remains unchanged.[16] Note that according to our baseline model, time-invariant controls drop out as soon as group fixed effects are included. The correlation matrix (Table A5, Panel B) and the descriptive statistics (Table A7) regarding the alternative control group are displayed in the Appendix.

Referring to the descriptive statistics, we can observe that the mean trade gap of the selected importing countries is relatively low and increases slightly from 0.0167 to 0.0302 after the introduction of mandatory e-invoicing in Italy. Despite the high VAT gaps, the low trade gap indicates less cross-border VAT fraud activity in these countries before the Italian reform.

[16] However, we drop REDUCED A, REDUCED B and REDUCED C from the set, as we have not enough data on these variables.

The parallel trends graph (see Figure A1, Appendix) shows the differences in the mean trade gap for treatment (Italy) and control countries (Greece, Lithuania, Romania and Slovakia) regarding non-RCM products. The level of the Italian trade gaps is visibly higher pre-reform and significantly closer to zero afterwards.

Table 5 displays the regression table for our alternative specification using control countries instead of RCM products. We can observe a negative and statistically significant interaction POST*TREAT throughout the specifications. The coefficient of interest is -0.201 (see Table 5, Column 4) in our main specification. Thus, non-RCM products in Italy show a considerably lower trade gap after the introduction of e-invoicing compared to the control countries. This finding gives us additional confidence that our baseline specification does not pick up a simple trend in non-RCM products.

The change in effect magnitude throughout the different fixed effects is similar to our baseline regressions. After introducing group and time fixed effects, the interaction term decreases in magnitude (Columns 3 and 4) compared to the models without fixed effects (Columns 1 and 2) and increases slightly when we change group and time fixed effects to a higher hierarchy (Columns 5 and 6). Noteworthy, the effect shows a higher magnitude than the initial results, reflecting a more severe decrease of the treatment group compared to the control group. However, this higher magnitude is most likely due to the slight increase in trade gaps regarding the control countries. We want to emphasize that we primarily run this model to test if our baseline results hold under different conditions. We are aware that we cannot control if the assigned control countries pick up possible spillovers due to the e-invoicing reform in Italy, which in theory could be responsible for the larger magnitude. In this regard, we observe a positive coefficient for the main effect POST when it is included. This indicates that within our alternative sample, absent the reform trade gaps would have developed slightly upwards. This is contrary to our baseline results (we observed a downward trend absent the reform) and

probably relates to this spillover hypothesis. Finally, the coefficient on TREAT is positive when included. This confirms that treatment products suffered higher fraud activities prior to the reform.[17]

Table 5. Alternative Control Group

	Trade Gap, No FE	Trade Gap, No FE	Trade Gap, With group FE	Trade Gap, With group and time FE	Trade Gap, With alternative group FE	Trade Gap, With alternative group and time FE
	(1)	(2)	(3)	(4)	(5)	(6)
POST	0.013***	0.014***	0.018***			0.014***
	(0.003)	(0.003)	(0.002)			(0.003)
TREAT	0.246***	0.251***				
	(0.006)	(0.009)				
POST*TREAT	-0.208***	-0.208***	**-0.201***	**-0.201***	-0.203***	-0.203***
	(0.006)	(0.006)	**(0.005)**	**(0.005)**	(0.005)	(0.005)
Observations	4,520,922	4,520,922	4,520,922	4,520,922	4,520,922	4,520,922
Adjusted R^2	0.002	0.002	0.455	0.456	0.128	0.128
Group FE	No	No	Yes	Yes	No	No
Time FE	No	No	No	Yes	Yes	No
Country-pair*4-digit HS Code FE	No	No	No	No	Yes	Yes
Quarter FE	No	No	No	No	No	Yes
Controls	No	Yes	Yes	Yes	Yes	Yes

Notes: The dependent variable is the trade gap defined in equation (1). This sample consists only of non-RCM products and in case of Italy also non-FUELS products and contains the importing countries Italy, Greece, Lithuania, Romania and Slovakia. Exporting countries are all other EU Member States. For explanations on variables, see Table A2 in the Appendix. The corresponding correlation matrix is displayed in Table A5, Panel B in the Appendix. Controls include THRESHOLD GAP and EURO. The group identifier for Group FE is a combination of country-pair and the 8-digit product code. Regressions are calculated using OLS. Robust standard errors are clustered by the group FE identifier and are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

5.2 Differentiation of Products according to their Susceptibility to Fraud

In this section, we aim to identify products that were most affected by e-invoicing to check if certain products drive the results. We separate products within the treatment group that could potentially be more affected by fraud prior to mandatory e-invoicing and refer to them as RCM POTENTIAL. This group includes products that could theoretically fall under RCM according to the VAT Directive[18], but Italy has not (yet) decided to introduce this mechanism on these products (for an overview of RCM applications see Table A1, Appendix). The Council of the European Union classifies fraud-sensitive products as a potential scope of the RCM. However,

[17] Note that in Column 5, Table 5, TREAT is omitted even with the inclusion of alternative group fixed effects.

[18] Council Directive 2006/112/EC of 28 November 2006 on the common system of value added tax.

the lack of inclusion in the RCM could indicate that Italy does not identify fraud within the particular product group. Therefore, the expected relationship is unclear and needs to be tested. Furthermore, we include FUELS in our sample. We recall that we initially excluded these products since they were already covered by the e-invoicing obligation six months before the general introduction. Given the overall effect of e-invoicing, FUELS are eligible as a further control acting as a placebo test. If our assumption holds, we would expect no effect of the generalized introduction of the mandatory e-invoicing on FUELS. To prevent bias due to reform overlap, we exclude all observations for trade with these products before July 2018. The variable OTHER captures the non-RCM products remaining after the described separation process. An explanation on the assignment of products to each group is presented in Table A8 (Appendix).

We make use of our baseline model from equation (2), however, we exchange the TREAT variable with $GROUP_p$. This variable represents each of the above-described three groups of products (RCM POTENTIAL, FUELS and OTHER). According to the baseline model, the RCM products form the control group.

Referring to the descriptive statistics displayed in Panel A of Table A9 (Appendix), it appears that all three product groups show a considerably high mean trade gap before e-invoicing. Before the reform, the trade gap of (0.2805) suggests that RCM POTENTIAL are only slightly more affected by fraud than OTHER (0.2581). The average trade gap for RCM POTENTIAL decreases after the reform, at 0.1371, however, remains considerably greater than zero. Unexpectedly, FUELS show the highest pre-reform trade gap (0.4437), even though e-invoicing was introduced for this group six months earlier. After the general implementation, the trade gap for FUELS remains on the highest level of the three product groups (0.1920). In this regard, one possible concern is the poor number of observations for this group. Therefore,

outliers are more likely to considerably distort the mean values. Ultimately, the mean trade gap for OTHER shows the most significant reduction along the reform, from 0.2561 to 0.0451.

Table 6 presents the corresponding regression output. We first note that the interaction POST*RCM POTENTIAL shows a negative coefficient that is significant in the first two specifications without fixed effects (see Table 6, Columns 1 and 2). Including the fixed effects, we observe a lower magnitude of the effect and missing statistical power (see Table 6, Columns 3 and 4). Together with the descriptive statistics that show a comparably high mean trade gap after e-invoicing (0.1371), we suggest that e-invoicing was not as effective compared to other products. The coefficients on POST*FUELS are insignificant throughout the specifications, confirming our expectation for this placebo test. Regarding OTHER (the remaining non-RCM products), we observe statistically significant and negative coefficients throughout the different specifications, indicating that the overall effect of e-invoicing is mainly driven by this product group. The effect magnitude of -0.089 (Table 6, Column 4) is slightly higher than our baseline result (-0.073, Table 3, Column 4).

Table 6. Differentiation of Products – Susceptibility of Fraud

	Trade Gap, no FE (1)	Trade Gap, no FE (2)	Trade Gap, with group FE (3)	Trade Gap, with group and time FE (4)
POST	-0.060	-0.059	-0.108***	
	(0.037)	(0.037)	(0.033)	
RCM POTENTIAL	0.254***	0.261***		
	(0.041)	(0.041)		
POST*RCM POTENTIAL	-0.083**	-0.085**	-0.027	-0.028
	(0.038)	(0.038)	(0.034)	(0.034)
FUELS	0.417	0.404		
	(0.265)	(0.263)		
POST*FUELS	-0.192	-0.190	-0.261	-0.283
	(0.283)	(0.283)	(0.281)	(0.280)
OTHER	0.230***	0.267***		
	(0.041)	(0.041)		
POST*OTHER	-0.151***	-0.153***	-0.089***	-0.089***
	(0.038)	(0.038)	(0.033)	(0.034)
Observations	1,322,455	1,322,455	1,322,455	1,322,455
Adjusted R^2	0.003	0.004	0.484	0.484
Group FE	No	No	Yes	Yes
Time FE	No	No	No	Yes
Controls	No	Yes	Yes	Yes

Notes: The dependent variable is the trade gap defined in equation (1). The importing country is Italy. Exporting countries are all other EU Member States. For explanations on variables, see Table A2 in the Appendix. Controls include THRESHOLD GAP, EURO, REDUCED A, REDUCED B and REDUCED C. Due to collinearity, Column 3 and 4 include only THRESHOLD GAP and REDUCED A. The group identifier for Group FE is a combination of country-pair and the 8-digit product code. Regressions are calculated using OLS. Robust standard

errors are clustered by group FE identifier and are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

5.3 Differentiation of Products based on First-Digit HS Code

As a second alternative, we differentiate products according to the first digit of their product code (called HS1). However, this approach is mostly descriptive by nature to give additional insights and understandings of the distribution of the reform effect across the sample. Therefore, we identify ten different product groups as treatment.[19] A first look at the descriptive statistics (Table A9, Panel B, Appendix) shows that the groups are not potentially affected in a similar way. HS1 classes 5, 6 and 9 have the highest pre-reform mean trade gap considerably above our baseline results (0.4852, 0.5576 and 0.41, respectively). After the reform, however, the mean trade gap remains on a very high level for HS1 classes 5 and 6 (0.2764 and 0.3438, respectively). Descriptively, the lowest pre-reform mean trade gaps show HS1 classes 0, 1 and 2. HS1 classes 3, 4, 7 and 8 are most near to the baseline. To check, which class is most affected by e-invoicing, we run our baseline model on each of these groups separately. Therefore, we restrict the treatment group to each of the HS1 classifications and therefore obtaining interaction terms of POST and TREAT for each of the ten HS1 classes. In all cases, the RCM products serve as the control group. For reference, the number of observations for the control group is 25,459 and remains unchanged throughout the specifications.

Table 7 summarizes the regression results from which we draw the effect of the mandatory e-invoicing on specific product classes. The strongest effects are observed within HS1 classes 3 and 9 (see Table 7, Column 1, Rows (4) and (10), -0.139 and -0.206, respectively). These HS1 classes mainly contain products made by the chemical industry, optical and photographical instruments, clocks and watches, musical instruments, arms and

[19] For example: HS1 equals to 7 regarding the eight-digit product code "71089080". Therefore, we can construct 10 different groups from 0 to 9 within our data set.

ammunition and art work. However, also the HS1 classes 4 and 7 show a significant decrease of the trade gap (fraud) after e-invoicing of -0.114 and -0.092 (see Table 7, Column 1, Rows (5) and (8)). These classes mainly cover raw hides and skins, leather and a range of wood and wood products as well as natural and cultured pearls, precious and semi-precious stones and metals. However, we cannot observe a significant effect regarding the HS1 classes 5 and 6, which show the highest mean trade gaps prior to the reform.

Prior RCM implementations may explain why we observe stronger effects for certain product groups. The RCM is mainly concentrated among HS1 classes 1, 4, 7, 8 and 9. Three out of those five product groups show significant reductions in trade gaps after e-invoicing (namely 4, 7 and 9; see Table 7, Columns 5, 8 and 10, respectively). An explanation for this could be that fraudsters switched to similar products in the past after the RCM was introduced on a specific product. Consequently, we observe strong effects in these HS1 groups, since these groups contain the most fraud. Therefore, the results speak for a prior shift of fraud within Italy, finally tackled by e-invoicing. We address this issue more in detail in the following section.

Table 7. Differentiation of Products – First-Digit HS Code

HS Section	Coefficient POST*TREAT	No. of Observations	Adjusted R^2
	(1)	(2)	(3)
(1) HS 1 = 0	-0.056	120,465	0.551
	(0.048)		
(2) HS 1 = 1	0.026	83,283	0.509
	(0.050)		
(3) HS 1 = 2	0.004	139,170	0.446
	(0.047)		
(4) HS 1 = 3	-0.139***	144,283	0.480
	(0.050)		
(5) HS 1 = 4	-0.114**	127,479	0.511
	(0.053)		
(6) HS 1 = 5	-0.056	96,861	0.460
	(0.052)		
(7) HS 1 = 6	-0.070	198,450	0.450
	(0.049)		
(8) HS 1 = 7	-0.092*	156,697	0.469
	(0.049)		
(9) HS 1 = 8	-0.041	343,359	0.489
	(0.046)		
(10) HS 1 = 9	-0.206***	141,107	0.495
	(0.051)		

Notes: The dependent variable is the trade gap defined in equation (1). The importing country is Italy. Exporting countries are all other EU Member States. For explanations on variables, see Table A2 in the Appendix. HS1=0 to HS1=9 are independent regressions that split the initial sample from Table 3 into 10 different groups based on the first digit of the HS code. All regressions include group and time fixed effects and controls, consisting

of THRESHOLD GAP and REDUCED A. Regressions are calculated using OLS. The group identifier for Group FE is a combination of country-pair and the 8-digit product code. Robust standard errors are clustered by group FE identifier and are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

5.4 Differentiation of Products based on similar HS Codes

Following on from the previous results, we restrict the group of treated products to those that fall under the same two-digit or four-digit HS code as the RCM products.[20] This procedure modifies the treatment group with the aim to make it more comparable to the control group. Note that in both cases RCM products form the control group and consists of the exact same products.

Table 8 presents the results. The statistically significant coefficient of the interaction POST*TREAT within the two-digit HS code sample is very close to our initial result (-0.074 in Table 8, Column 1 vs. -0.073 in Table 3, Column 4). The corresponding coefficient from the regression based on the four-digit HS code is with -0.215 almost three times higher (Table 8, Column 2). In this case, the sample size is significantly smaller due to the reduction of the treatment group, which consequently becomes more similar to the control group. This finding supports the previous suggested spillover effect of the fraudulent activity. The earlier introduction of RCM on fraud-prone products might have caused fraudsters to use other but comparable products. Fraudsters switched to other products of the same product category rather than to a complete different product group since they may installed an effective supply chain including exporters, fraudsters and other involved firms. Under the premise that e-invoicing reduces fraud, we consequently observe stronger effects with these fraud-prone products.

Table 8. Differentiation of Products – Same Two- and Four-Digit HS Code

[20] In this case, we use the first two or four digits from the eight-digit product code. We are aware of further matching procedures like propensity score matching or entropy balancing. However, these procedures rely on the identification of matches (in this case matched treatment and control products) based on a set of factors that have an effect on the assignment to treatment or control group and the outcome variable. Those (product specific) factors are unobservable which is why we refrain from these procedures.

	Trade Gap, Same two-digit HS Code Treatment Group (1)	Trade Gap, Same four-digit HS Code Treatment Group (2)
POST*TREAT	-0.074**	-0.215***
	(0.034)	(0.069)
Observations	454,661	34,484
Adjusted R^2	0.480	0.504
Group FE	Yes	Yes
Time FE	Yes	Yes
Controls	Yes	Yes

Notes: The dependent variable is the trade gap defined in equation (1). The importing country is Italy. Exporting countries are all other EU Member States. In contrast to our baseline model, TREAT only contains treatment products falling under the same two-digit HS code (Column 1) or four-digit HS code (Column 2) in respect to the RCM products. For explanations on variables, see Table A2 in the Appendix. Controls include in these specifications only THRESHOLD GAP. Regressions are calculated using OLS. The group identifier for Group FE is a combination of country-pair and the 8-digit product code. Robust standard errors are clustered group FE identifier and are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

5.5 Alternative Dependent Variables

In this last section, we check if our initial results hold when we change the dependent variable. First, we use the trade gap calculated analogous to equation (1) using quantities instead of values. Second and third, we use the trade gap in values, but we winsorize and trim the variable at the bottom and top 1% by each exporting country, respectively. Therefore, we control for outliers in the data. Fourth and fifth, we examine the effect on log Exports and log Imports. In this case, we include the opposite trade flow (log Imports or log Exports, respectively) into the model as control variables. In this way, we test our estimation assumptions used in Section 4.2, according to which we expect to observe falling exports and/or rising imports.

Table 9 presents the results for all described alternative dependent variables. The coefficient of -0.063 for trade gaps in quantities (see Table 9, Column 1) is statistically significant and comparable to our initial result (-0.073 in Table 3, Column 5). This strongly confirms our baseline result and indicate that fraudsters underreport values and quantities, which strengthens the assumption that missing trader fail to report imports at all. Winsorizing and trimming the trade gap and therefore excluding outliers hardly affect our estimation (see coefficient in Table 9, Columns 2 and 3). That gives us additional confidence regarding our baseline model.

Interestingly, the coefficient on POST*TREAT regarding log Exports is insignificant (see Table 9, Column 4), suggesting that export values not change after e-invoicing. On the other side, we find a positive and statistically significant coefficient regarding log Imports (see Table 9, Column 5). This result supports the assumption that honest importers take over the trade from the forced out fraudsters and unlike the latter, declare the imports.

Table 9. Alternative Dependent Variables

	Trade Gap in Quantities	Winsorized Trade Gap	Trimmed Trade Gap	Log Exports	Log Imports
	(1)	(2)	(3)	(4)	(5)
POST*TREAT	-0.063*	-0.073**	-0.070**	0.002	0.095***
	(0.034)	(0.031)	(0.028)	(0.026)	(0.029)
Observations	1,299,168	1,322,023	1,295,633	1,322,023	1,322,023
Adjusted R^2	0.494	0.485	0.458	0.863	0.840
Group FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes

Notes: In Column 1, the dependent variable is the trade gap using quantities instead of values analogously to equation (1). In Columns 2 to 3, the dependent variable is the trade gap as defined in equation (1). Observations of the trade gap are winsorized and trimmed, respectively, at the bottom and top 1% by each exporting country. In Columns 4 and 5, the dependent variable is the natural logarithm of exports reported by the exporting country to Italy and the natural logarithm of imports from the exporting country reported by Italy, respectively. Exporting countries are all other EU Member States. For explanations on variables, see Table A2 in the Appendix. Controls consisting of THRESHOLD GAP and REDUCED A and in Columns 4 and 5 also of the natural logarithm of imports and exports, respectively. Regressions are calculated using OLS. The group identifier for Group FE is a combination of country-pair and the 8-digit product code. Robust standard errors are clustered by the group FE identifier and are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

6 Conclusion

The numerous measures taken against VAT fraud (such as RCM), as well as the significant revenue losses that continue to result from it, make studies on the effectiveness of these countermeasures particularly important. In 2019, Italy introduced a mandatory e-invoicing system for B2B and B2C supplies, taking a pioneering role in the EU in the timely recording and control of transactions. This paper examines the effect of digitalization in form of e-invoicing in Italy on cross-border tax fraud using trade data between Italy and the remaining EU Member States on product flows based on the eight-digit product code. As control group, we use products falling under RCM since recent studies provide empirical evidence on the fraud removal effect of this measure. All other products serve as the treatment group. We find

a significant reduction of the cross-border tax fraud with the introduction of the mandatory e-invoicing system. This result holds for a modified control group as well as for a number of further robustness checks. We use our estimates to quantify the reform in Italy and find that cross-border tax fraud has been reduced generating between €0.6 and €1 billion more tax revenue. In addition, our study suggests that because of RCM, fraudsters shift their activities to similar products and drive honest traders out of the market. Our findings indicate a desirable fraud-reducing effect of a mandatory e-invoicing system easily exceeding the set-up and running costs of such a system. The results provide key insights into the benefits of digitalization and should encourage other countries to follow the Italian path.

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References

Ainsworth, Richard Thompson. 2006. "Carousel Fraud in the EU: A Digital Vat Solution." *Tax Notes International*, p. 443, May 1, 2006. Boston Univ. School of Law Working Paper No. 06-23.

Alonso, Cristian, Ledys Feliz, Patricia Gil, and Miguel Pecho. 2021. "Enhancing Tax Compliance in the Dominican Republic Through Risk-based VAT Invoice Management." *IMF Working Papers 2021.231*.

Barreix, Alberto, and Raul Zambrano. 2018. "Electronic Invoicing in Latin America: Process and Challenges." In *Electronic Invoicing in Latin America*, edited by Alberto Barreix and Raul Zambrano, 4-46. URL: https://publications.iadb.org/publications/english/document/Electronic-Invoicing-in-Latin-America.pdf.

Bellon, Matthieu, Era Dabla-Norris, Salma Khalid, and Frederico Lima. 2022. "Digitalization to improve tax compliance: Evidence from VAT e-Invoicing in Peru." *Journal of Public Economics* 210 (2022): 104661. doi: https://doi.org/10.1016/j.jpubeco.2022.104661.

Bérgolo, Marcelo, Rodrigo Ceni, and María Sauval. 2018. "Factura electrónica y cumplimiento tributario: Evidencia a partir de un enfoque cuasi-experimental." Discussion Paper. *Inter-American Development Bank*. URL: https://publications.iadb.org/es/factura-electronica-y-cumplimiento-tributario-evidencia-partir-de-un-enfoque-cuasi-experimental.

Bussy, Adrien. 2020. "Cross-border Value Added Tax Fraud in the European Union." *Working Paper*. URL: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3569914.

Cnossen, Sijbren. 1998. "Global Trends and Issues in Value Added Taxation*." International Tax and Public Finance* 5: 399-428.

European Commission. 2016. European Commission – Fact Sheet, Action Plan on VAT: Questions and Answers. URL: https://ec.europa.eu/commission/presscorner/detail/en/MEMO_16_1024.

European Commission. 2018. Report from the Commission to the Council and the European Parliament on the effects of Articles 199a and 199b of Council Directive 2006/112/EC on combatting fraud, COM/2018/0118 final.

European Commission. 2020. Communication from the Commission to the European Parliament and the Council, an Action Plan for Fair and Simple Taxation Supporting the Recovery Strategy, COM(2020) 312 final from 15.7.2020.

European Commission. 2021. Proposal for a Council Implementing Decision amending Implementing Decision (EU) 2018/593 as regards the duration and scope of the derogation from Articles 218 and 232 of Directive 2006/112/EC, COM(2021) 681 final from 05.11.2021.

European Commission. 2021. Proposal for a Council Implementing Decision authorising France to introduce a special measure derogating from Articles 218 and 232 of Directive 2006/112/EC on the common system of value added tax, COM(2021) 753 final from 1.12.2021.

European Commission. 2022a. Proposal for a Council Implementing Decision authorising the Republic of Poland to apply a special measure derogating from Articles 218 and 232 of Directive 2006/112/EC on the common system of value added tax, COM(2022) 136 final from 30.3.2022.

European Commission. 2022b. Council Implementing Decision (EU) 2022/1003 of 17 June 2022 authorising the Republic of Poland to apply a special measure derogating from Articles 218 and 232 of Directive 2006/112/EC on the common system of value added tax, 2022 O.J. (L 168) 81.

European Council. 2018. Council Implementing Decision (EU) 2018/593 of 16 April 2018 authorising the Italian Republic to introduce a special measure derogating from Articles 218 and 232 of Directive 2006/112/EC on the common system of value added tax, OJ EU 2018, No L 99/14.

Eurostat. 2009. MEDSTAT II: Asymmetry in foreign trade statistics in Mediterranean partner countries. URL: https://ec.europa.eu/eurostat/de/web/products-statistical-working-papers/-/ks-ra-09-016.

Eurostat. 2020. International trade in goods (ext_go_agg). URL: https://ec.europa.eu/eurostat/cache/metadata/de/ext_go_agg_esms.htm.

Fan, Haichao, Yu Liu, Nancy Qian, and Jaya Wen. 2020. "Computerizing VAT Invoices in China." *National Bureau of Economic Research*. Working Paper 24414. doi: 10.3386/w24414.

Federal Statistical Office Germany. 2018. "Guide to intra-Community trade statistics" [Leitfaden zur Intrahandelsstatistik]. URL: https://www-idev.destatis.de/idev/doc/intra/doc/Intrahandel_Leitfaden.pdf.

Braml, Martin T., and Gabriel J. Felbermayr. 2021. "The EU self-surplus puzzle: An indication of VAT fraud?." *International Tax and Public Finance*. doi: https://doi.org/10.1007/s10797-021-09713-x.

Fisman, Raymond, and Shang-Jin Wei. 2004. "Tax Rates and Tax Evasion: Evidence from „Missing Imports" in China." *Journal of Political Economy* 112 (2): 471-496.

Frunza, Marius. 2016. "Cost of the MTIC VAT fraud for European Union members." *Working Paper*. URL: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2758566.

Giannotti, Enrico, Giacomo Luchetta, and Grzegorz Poniatowski. 2019. "Study the evaluation of the invoicing rules of Directive 2006/112/EC." Final Report. URL: https://data.europa.eu/doi/10.2778/771345.

Hernandez, Karla, and Juan Robalino. 2018. "Evidence of the Impact of Electronic Invoicing of Taxes in Latin America." In *Electronic Invoicing in Latin America*, edited by Alberto Barreix and Raul Zambrano, 47-62. URL: https://publications.iadb.org/publications/english/document/Electronic-Invoicing-in-Latin-America.pdf.

Jacobs, Bas. 2017. "Digitalization and Taxation." In *Digital Revolutions in Public Finance,* edited by Sanjeev Gupta, Michael Keen, Alpa Shah, and Genevieve Verdier, 25-55. International Monetary Fund. URL: https://doi.org/10.5089/9781484315224.071.

Javorcik, Beata, and Gaia Narciso. 2008. "Differentiated products and evasion of import tariffs." *Journal of International Economics* 76 (2): 208-222.

Javorcik, Beata, and Gaia Narciso. 2017. "WTO accession and tariff evasion." *Journal of Development Economics* 125: 59-71.

Keen, Michael. 2013. "The Anatomy of the VAT." *National Tax Journal* 66: 423-446.

Kitsios, Emmanouil, João Tovar Jalles, and Geneviève Verdier. 2022. "Tax evasion from cross-border fraud: does digitalization make a difference?" *Applied Economics Letters* : 1-7. URL: https://www.tandfonline.com/doi/full/10.1080/13504851.2022.2056566.

Lee, Hyung Chul. 2016. "Can Electronic Tax Invoicing Improve Tax Compliance? A Case Study of the Republic of Korea's Electronic Tax Invoicing for Value-Added Tax." *World Bank Policy Research Working Paper Series 7592*. URL: http://hdl.handle.net/10986/23931.

Loschky, Alexander. 2006. "Asymmetries in foreign trade statistics." [Asymmetrien in der Außenhandelsstatistik]. *Wirtschaft und Statistik* March 2006: 257-263.

McLure, Charles E. 1993. "Economic, Administrative, and Political Factors in Choosing a General Consumption Tax." *National Tax Journal* 46 (3): 345-358.

Ministry of Economy and Finance Italy [Ministero dell´Economia e delle Finanze]. 2018. "eInvoicing in Italy: Pioneering in mandate B2B eInvoicing. Brussels." 4 December 2018. URL: https://documents.pub/document/einvoicing-in-italy-20181204-a-jan-2017-obligation-for-all-vat-taxable.html.

Mishra, Prachi, Arvind Subramanian, and Petia Topalova. 2008. "Tariffs, enforcement, and customs evasion: Evidence from India." *Journal of Public Economics* 92 (10–11): 1907-1925.

OECD. 2020. "Consumption Tax Trends 2020: VAT/GST and Excise Rates: Trends and Policy Issues." URL: https://doi.org/10.1787/152def2d-en.

Poniatowski, Grzegorz, Mikhail Bonch-Osmolovskiy, and Adam Śmietanka. 2020. "Study and Reports on the VAT Gap in the EU-28 Member States: 2020 Final Report." URL: https://data.europa.eu/doi/10.2778/2517.

Poniatowski, Grzegorz, Mikhail Bonch-Osmolovskiy, and Adam Śmietanka. 2021. "VAT Gap in the EU: Report 2021." URL: https://data.europa.eu/doi/10.2778/447556.

Ramirez, Jose, Nicolas Oliva, and Mauro Andino. 2018. "Facturacion Electronica en Ecuador: Evaluacion de impacto en el cumplimiento tributario." Discussion Paper. *Inter-American Development Bank*. URL: https://publications.iadb.org/es/facturacion-electronica-en-ecuador-evaluacion-de-impacto-en-el-cumplimiento-tributario.

Sergiou, Loukia. 2012. "Value added tax (VAT) carousel fraud in the European Union." *The Journal of Accounting and Management* 2 (2): 9-21.

Stiller, Wojciech, and Marwin Heinemann. 2019. „Reverse-Charge-Mechanism – An effective Method against VAT Fraud in Germany and Austria?." [Reverse-Charge-Verfahren – Eine wirkungsvolle Maßnahme gegen den Umsatzsteuerbetrug in Deutschland und Österreich?]. *Betriebswirtschaftliche Forschung und Praxis* 72 (2): 177-193.

Stiller, Wojciech, and Marwin Heinemann. 2021. "Do More Harm than Good? The Optional Reverse Charge Mechanism Against VAT Fraud." *Working Paper*. doi: 10.13140/RG.2.2.13802.44482.

Stoyanov, Andrey. 2012. "Tariff Evasion and Rules of Origin Violations under the Canada–U.S. Free Trade Agreement." *Canadian Journal of Economics* 45 (3): 879-902.

Strango, Cristina. 2021. "Does Digitalisation in Public Services Reduce Tax Evasion?." *The Economic Research Guardian* 11 (2): 221-235.

Templado, Ivana, Daniel Artana. 2018. "Analisis del impacto de la Factura Electronica en la Argentina." Discussion Paper No. 562. *Inter-American Development Bank.*

Appendix

FIGURES

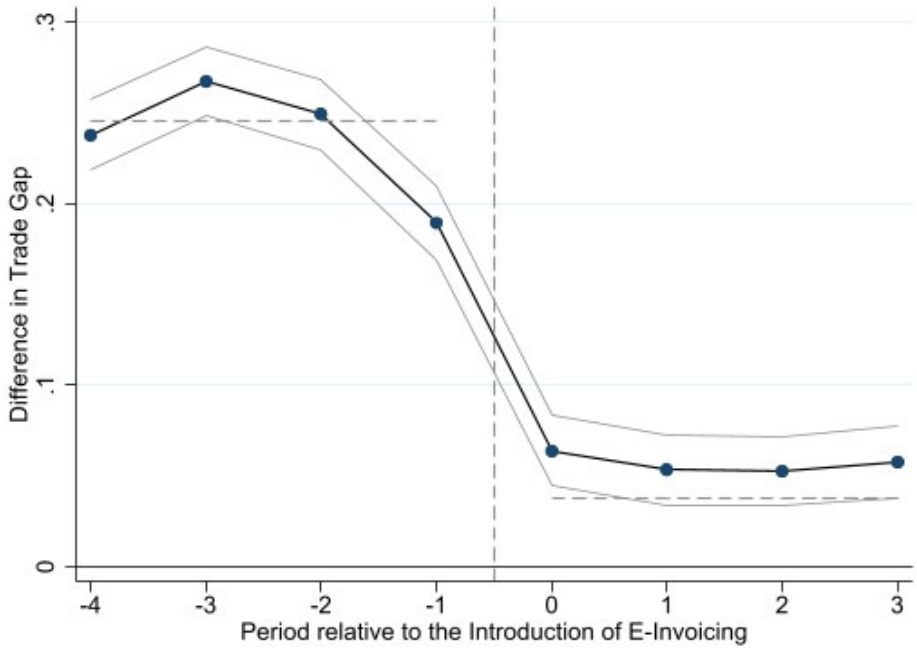

Figure A1. Parallel Trend of Alternative Control group.

Notes: The treatment group is defined in accordance to the baseline model as non-RCM and non-FUELS products in Italy. The control group consists of non-RCM products in Greece, Lithuania, Romania and Slovakia.

TABLES

Table A1. RCM Products

Product Group	Date of Introduction	Source
Italy		
Mobile Phones	1.4.2011	Circular of 23/12/2010 no. 59
Integrated Circuits	1.4.2011	Circular of 23/12/2010 no. 59
Game Consoles	2.5.2016	Legislative Decree No. 24 of 11 February 2016
Laptops and Tablet-PCs	1.4.2011	Circular of 23/12/2010 no. 59
Waste and Scrap Metals	Since 2003	Art. 74 of Decree No. 633/1972
Selected non-precious Metals	Since 2003	Art. 74 of Decree No. 633/1972
Greece		
Mobile Phones	1.8.2017	Law 4484/2017
Game Consoles	1.8.2017	Law 4484/2017
Laptops and Tablet-PCs	1.8.2017	Law 4484/2017
Waste and Scrap Metals	1.1.2007	Law 3522/2006
Lithuania		
Mobile Phones	1.8.2019	Amendment No. 900
Laptops and Tablet-PCs	1.8.2019	Amendment No. 900
Hard Disks	1.8.2019	Amendment No. 900
Selected Wood	1.1.2008	Amendment No. 900
Waste and Scrap Metals	1.1.2008	Amendment No. 900
Romania		
Mobile Phones	1.1.2016	Law 227/2015
Integrated Circuits	1.1.2016	Law 227/2015
Game Consoles	1.1.2016	Law 227/2015
Laptops and Tablet-PCs	1.1.2016	Law 227/2015
Waste and Scrap Metals	1.1.2005	Law 571/2003
Wood	1.1.2005	Law 2572/2009
Selected Cereals	1.6.2011	Emergency Order No. 49
Slovakia		
Mobile Phones	1.1.2014	360/2013 Coll.
Integrated Circuits	1.1.2014	360/2013 Coll.
Iron and Steel	1.1.2014	360/2013 Coll.
Selected Cereals	1.1.2014	360/2013 Coll.
Gold	1.4.2009	83/2009 Coll.
Waste and Scrap Metals	1.4.2009	83/2009 Coll.

Table A2. Variables

Variable	Explanation	Source
Trade Gap	Logarithmic ratio of exports reported by the exporting country to imports reported by the importing country.	Eurostat
POST	Dummy variable that takes on the value of 0 for observations 12 months before the introduction of e-invoicing on all products in Italy in January 2019 and 1 for observations 11 months after.	Italian Government
TREAT	Regarding the baseline sample: a dummy variable that takes on the value of 1 if the product is a non-RCM (then 0) and non-FUELS product (then excluded from sample). The dummy turns zero if the product is a RCM product. Regarding the alternative control group: a dummy variable that takes on the value of 1 if the importing country is Italy and zero if the importing country is Greece, Lithuania, Romania or Slovakia.	See Tables A1 and A8 in the Appendix
RCM	Dummy variable that takes on the value of 1 if the product is included in the RCM category and 0 otherwise.	See Table A8 in the Appendix
FUELS	Dummy variable that takes on the value of 1 if the product is included in the FUELS category and 0 otherwise.	See Table A8 in the Appendix
RCM POTENTIAL	Dummy variable that takes on the value of 1 if the product is included in the POTENTIAL RCM category and 0 otherwise.	See Table A8 in the Appendix
OTHER	Dummy variable that takes on the value of 1 if the product is in the NON RCM product category but not in the FUELS or POTENTIAL RCM category and 0 otherwise.	See Table A8 in the Appendix
REDUCED A	Dummy variable that takes on the value of 1 if the reduced VAT rate of 10% is applicable to the specific product and 0 otherwise.	Hand-collected from Italian VAT Law
REDUCED B	Dummy variable that takes on the value of 1 if the reduced VAT rate of 5% is applicable to the specific product and 0 otherwise.	Hand-collected from Italian VAT Law
REDUCED C	Dummy variable that takes on the value of 1 if the reduced VAT rate of 4% is applicable to the specific product and 0 otherwise.	Hand-collected from Italian VAT Law
THRESHOLD GAP	Difference in the logarithm of the yearly Intrastat threshold of the exporting Member State and the importing Member State.	Eurostat, see Table A3 in the Appendix
EURO	Dummy variable that takes on the value of 1 for all observations where both Member States use the euro as the official currency and zero otherwise.	Website European Union

Table A3. Descriptive Statistics for Control Variables - Baseline Specification

Control Variables					
	N	Mean	Std. Dev.	Minimum	Maximum
REDUCED A	1,322,023	0.0738	0.2614	0	1
REDUCED B	1,322,023	0.0007	0.0273	0	1
REDUCED C	1,322,023	0.0303	0.1713	0	1
THRESHOLD GAP	1,322,023	-0.6183	0.6333	-7.0413	0.40547
EURO	1,322,023	0.7287	0.4447	0	1

Notes: This table displays the descriptive statistics for all control variables used in the baseline model specified in equation (2). For explanations on all variables, see Table A2 in the Appendix. The corresponding correlation matrix is displayed in Table A5 (Panel A) in the Appendix.

Table A4. Intrastat Thresholds

Year	2018		2019	
Code	Arrivals	Dispatches	Arrivals	Dispatches
AT	750,000	750,000	750,000	750,000
BE	1,500,000	1,000,000	1,500,000	1,000,000
BG	219,856	132,936	235,193	143,161
CY	130,000	55,000	160,000	55,000
CZ	320,000	320,000	465,960	465,960
DE	800,000	500,000	800,000	500,000
DK	833,000	631,000	897,197	669,550
EE	230,000	130,000	230,000	130,000
ES	400,000	400,000	400,000	400,000
FI	550,000	500,000	600,000	600,000
FR	460,000	460,000	460,000	460,000
GB	1,711,645	285,274	1,668,870	278,145
GR	150,000	90,000	150,000	90,000
HR	252,000	133,333	296,516	161,736
HU	550,000	325,000	528,700	311,000
IE	500,000	635,000	500,000	635,000
IT	800,000	400,000	800,000	400,000
LT	250,000	150,000	250,000	150,000
LU	200,000	150,000	200,000	150,000
LV	250,000	100,000	250,000	100,000
MT	700	700	700	700
NL	1,000,000	1,200,000	800,000	1,000,000
PL	688,000	458,000	929,880	464,940
PT	350,000	250,000	350,000	250,000
RO	195,746	196,746	192,807	192,807
SE	940,000	470,000	880,290	440,145
SI	140,000	220,000	140,000	220,000
SK	200,000	400,000	200,000	400.000

Notes: All values in euros. Eurostat thankfully provided us with the threshold values.

Table A5. Correlation Matrix

Panel A: Baseline						
Variables	Trade Gap	REDUCED A	REDUCED B	REDUCED C	THRESHOLD GAP	EURO
Trade Gap	1.000					
REDUCED A	-0.025***	1.000				
REDUCED B	0.001	-0.008***	1.000			
REDUCED C	-0.020***	-0.047***	-0.005***	1.000		
THRESHOLD GAP	-0.011***	0.024***	0.004***	0.010***	1.000	
EURO	0.014***	0.031***	0.006***	0.033***	0.228***	1.000

Panel B: Alternative Control Group			
Variables	Trade Gap	THRESHOLD GAP	EURO
Trade Gap	1.000		
THRESHOLD GAP	-0.023***	1.000	
EURO	0.001***	-0.086***	1.000

Notes: Pairwise correlations for all variables included in Table 3 regarding Panel A and Table 4 regarding Panel B. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table A6. Estimation of Fraud tackled by e-Invoicing

						Fraud Base				Lost VAT			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Export Country	Products by VAT rate	$\beta_{overall}$	$\beta_{specific}$	Sum of 2018 exports (in million euros)	Sum of 2018 imports (in million euros)	Exports $\beta_{overall}$	Imports $\beta_{overall}$	Exports $\beta_{specific}$	Imports $\beta_{specific}$	Based on Exports $\beta_{overall}$	Based on Imports $\beta_{overall}$	Based on Exports $\beta_{specific_{all}}$	Based on Imports $\beta_{specific_{all}}$
AT	22%	-0.073		7,382.82	6,918.49	519.74	523.94	0.00	0.00	114.34	115.27	0.00	0.00
AT	10%	-0.073		654.00	559.38	46.04	42.36	0.00	0.00	4.60	4.24	0.00	0.00
AT	5%	-0.073		1.16	0.89	0.08	0.07	0.00	0.00	0.00	0.00	0.00	0.00
AT	4%	-0.073		478.83	527.05	33.71	39.91	0.00	0.00	1.35	1.60	0.00	0.00
BE	22%	-0.073		17,603.97	16,903.25	1,239.30	1,280.09	0.00	0.00	272.65	281.62	0.00	0.00
BE	10%	-0.073		675.86	789.87	47.58	59.82	0.00	0.00	4.76	5.98	0.00	0.00
BE	5%	-0.073		0.24	0.17	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
BE	4%	-0.073		276.08	265.40	19.44	20.10	0.00	0.00	0.78	0.80	0.00	0.00
BG	22%	-0.073		1,686.52	1,732.04	118.73	131.17	0.00	0.00	26.12	28.86	0.00	0.00
BG	10%	-0.073		48.96	43.54	3.45	3.30	0.00	0.00	0.34	0.33	0.00	0.00
BG	5%	-0.073		0.05	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BG	4%	-0.073		130.58	137.35	9.19	10.40	0.00	0.00	0.37	0.42	0.00	0.00
CY	22%	-0.073		7.88	7.45	0.55	0.56	0.00	0.00	0.12	0.12	0.00	0.00
CY	10%	-0.073		0.13	2.03	0.01	0.15	0.00	0.00	0.00	0.02	0.00	0.00
CY	5%	-0.073		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CY	4%	-0.073		2.81	2.31	0.20	0.17	0.00	0.00	0.01	0.01	0.00	0.00
CZ	22%	-0.073		5,580.28	5,505.47	392.85	416.93	0.00	0.00	86.43	91.73	0.00	0.00
CZ	10%	-0.073		93.37	79.82	6.57	6.04	0.00	0.00	0.66	0.60	0.00	0.00
CZ	5%	-0.073		0.19	0.16	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
CZ	4%	-0.073		76.72	77.23	5.40	5.85	0.00	0.00	0.22	0.23	0.00	0.00
DE	22%	-0.073		57,896.70	59,026.12	4,075.88	4,470.08	0.00	0.00	896.69	983.42	0.00	0.00
DE	10%	-0.073		2,848.09	2,643.33	200.50	200.18	0.00	0.00	20.05	20.02	0.00	0.00
DE	5%	-0.073		1.59	1.78	0.11	0.13	0.00	0.00	0.01	0.01	0.00	0.00
DE	4%	-0.073		1,023.77	1,097.25	72.07	83.09	0.00	0.00	2.88	3.32	0.00	0.00
DK	22%	-0.073		1,319.34	1,464.37	92.88	110.90	0.00	0.00	20.43	24.40	0.00	0.00
DK	10%	-0.073		597.52	522.57	42.06	39.57	0.00	0.00	4.21	3.96	0.00	0.00
DK	5%	-0.073		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DK	4%	-0.073		17.76	19.65	1.25	1.49	0.00	0.00	0.05	0.06	0.00	0.00
EE	22%	-0.073	0.564	86.89	76.19	6.12	5.77	-65.84	-32.84	1.35	1.27	-14.48	-7.23
EE	10%	-0.073	0.564	15.74	13.95	1.11	1.06	-11.92	-6.01	0.11	0.11	-1.19	-0.60
EE	5%	-0.073	0.564	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EE	4%	-0.073	0.564	0.06	0.01	0.00	0.00	-0.05	-0.01	0.00	0.00	0.00	0.00
ES	22%	-0.073		17,051.17	15,324.09	1,200.39	1,160.50	0.00	0.00	264.09	255.31	0.00	0.00
ES	10%	-0.073		1,696.01	1,718.16	119.40	130.12	0.00	0.00	11.94	13.01	0.00	0.00
ES	5%	-0.073		1.81	0.08	0.13	0.01	0.00	0.00	0.01	0.00	0.00	0.00
ES	4%	-0.073		1,810.90	1,907.83	127.49	144.48	0.00	0.00	5.10	5.78	0.00	0.00
FI	22%	-0.073		1,207.90	1,237.73	85.04	93.73	0.00	0.00	18.71	20.62	0.00	0.00
FI	10%	-0.073		5.55	3.91	0.39	0.30	0.00	0.00	0.04	0.03	0.00	0.00
FI	5%	-0.073		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FI	4%	-0.073		1.85	1.87	0.13	0.14	0.00	0.00	0.01	0.01	0.00	0.00
FR	22%	-0.073		28,174.60	29,013.25	1,983.47	2,197.19	0.00	0.00	436.36	483.38	0.00	0.00
FR	10%	-0.073		3,213.65	3,227.55	226.24	244.42	0.00	0.00	22.62	24.44	0.00	0.00
FR	5%	-0.073		2.77	2.39	0.20	0.18	0.00	0.00	0.01	0.01	0.00	0.00
FR	4%	-0.073		1,153.83	1,218.88	81.23	92.31	0.00	0.00	3.25	3.69	0.00	0.00
GB	22%	-0.073		9,956.98	9,164.91	700.96	694.06	0.00	0.00	154.21	152.69	0.00	0.00
GB	10%	-0.073		329.94	336.51	23.23	25.48	0.00	0.00	2.32	2.55	0.00	0.00
GB	5%	-0.073		0.16	0.16	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
GB	4%	-0.073		140.95	169.98	9.92	12.87	0.00	0.00	0.40	0.51	0.00	0.00
GR	22%	-0.073	-0.134	1,008.53	815.17	71.00	61.73	126.48	116.89	15.62	13.58	27.83	25.72
GR	10%	-0.073	-0.134	349.62	329.98	24.61	24.99	43.85	47.32	2.46	2.50	4.38	4.73
GR	5%	-0.073	-0.134	31.53	32.16	2.22	2.44	3.95	4.61	0.11	0.12	0.20	0.23
GR	4%	-0.073	-0.134	503.23	553.76	35.43	41.94	63.11	79.40	1.42	1.68	2.52	3.18
HR	22%	-0.073		1,263.36	1,176.04	88.94	89.06	0.00	0.00	19.57	19.59	0.00	0.00
HR	10%	-0.073		195.75	151.54	13.78	11.48	0.00	0.00	1.38	1.15	0.00	0.00
HR	5%	-0.073		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HR	4%	-0.073		152.75	154.66	10.75	11.71	0.00	0.00	0.43	0.47	0.00	0.00
HU	22%	-0.073	-0.554	3,658.19	3,467.43	257.53	262.59	1,556.02	2,566.59	56.66	57.77	342.32	564.65
HU	10%	-0.073	-0.554	332.90	349.75	23.44	26.49	141.60	258.88	2.34	2.65	14.16	25.89
HU	5%	-0.073	-0.554	0.75	0.69	0.05	0.05	0.32	0.51	0.00	0.00	0.02	0.03
HU	4%	-0.073	-0.554	402.45	454.82	28.33	34.44	171.18	336.66	1.13	1.38	6.85	13.47
IE	22%	-0.073		2,972.11	3,162.27	209.23	239.48	0.00	0.00	46.03	52.69	0.00	0.00
IE	10%	-0.073		245.62	257.03	17.29	19.46	0.00	0.00	1.73	1.95	0.00	0.00
IE	5%	-0.073		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IE	4%	-0.073		3.99	11.40	0.28	0.86	0.00	0.00	0.01	0.03	0.00	0.00
LT	22%	-0.073		399.10	388.40	28.10	29.41	0.00	0.00	6.18	6.47	0.00	0.00
LT	10%	-0.073		85.84	59.59	6.04	4.51	0.00	0.00	0.60	0.45	0.00	0.00
LT	5%	-0.073		0.18	0.11	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
LT	4%	-0.073		15.68	16.77	1.10	1.27	0.00	0.00	0.04	0.05	0.00	0.00
LU	22%	-0.073		389.85	345.53	27.44	26.17	0.00	0.00	6.04	5.76	0.00	0.00

LU	10%	-0.073		0.75	0.67	0.05	0.05	0.00	0.00	0.01	0.01	0.00	0.00
LU	5%	-0.073		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LU	4%	-0.073		3.60	6.94	0.25	0.53	0.00	0.00	0.01	0.02	0.00	0.00
LV	22%	-0.073		100.37	88.28	7.07	6.69	0.00	0.00	1.55	1.47	0.00	0.00
LV	10%	-0.073		19.37	13.76	1.36	1.04	0.00	0.00	0.14	0.10	0.00	0.00
LV	5%	-0.073		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LV	4%	-0.073		2.06	2.08	0.14	0.16	0.00	0.00	0.01	0.01	0.00	0.00
MT	22%	-0.073		101.01	116.14	7.11	8.80	0.00	0.00	1.56	1.93	0.00	0.00
MT	10%	-0.073		8.90	8.49	0.63	0.64	0.00	0.00	0.06	0.06	0.00	0.00
MT	5%	-0.073		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MT	4%	-0.073		0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NL	22%	-0.073		16,064.20	14,944.57	1,130.91	1,131.76	0.00	0.00	248.80	248.99	0.00	0.00
NL	10%	-0.073		2,074.51	1,945.25	146.04	147.32	0.00	0.00	14.60	14.73	0.00	0.00
NL	5%	-0.073		7.04	8.91	0.50	0.67	0.00	0.00	0.02	0.03	0.00	0.00
NL	4%	-0.073		419.71	403.90	29.55	30.59	0.00	0.00	1.18	1.22	0.00	0.00
PL	22%	-0.073		8,450.18	7,974.44	594.89	603.91	0.00	0.00	130.87	132.86	0.00	0.00
PL	10%	-0.073		845.68	807.41	59.53	61.15	0.00	0.00	5.95	6.11	0.00	0.00
PL	5%	-0.073		0.11	0.29	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00
PL	4%	-0.073		122.66	135.22	8.64	10.24	0.00	0.00	0.35	0.41	0.00	0.00
PT	22%	-0.073		1,815.01	1,552.32	127.78	117.56	0.00	0.00	28.11	25.86	0.00	0.00
PT	10%	-0.073		89.00	93.96	6.27	7.12	0.00	0.00	0.63	0.71	0.00	0.00
PT	5%	-0.073		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PT	4%	-0.073		141.68	167.08	9.97	12.65	0.00	0.00	0.40	0.51	0.00	0.00
RO	22%	-0.073		6,784.26	6,419.67	477.61	486.16	0.00	0.00	105.07	106.96	0.00	0.00
RO	10%	-0.073		169.94	167.48	11.96	12.68	0.00	0.00	1.20	1.27	0.00	0.00
RO	5%	-0.073		0.39	0.21	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00
RO	4%	-0.073		233.76	229.73	16.46	17.40	0.00	0.00	0.66	0.70	0.00	0.00
SE	22%	-0.073		3,015.05	3,511.00	212.26	265.89	0.00	0.00	46.70	58.50	0.00	0.00
SE	10%	-0.073		335.36	252.59	23.61	19.13	0.00	0.00	2.36	1.91	0.00	0.00
SE	5%	-0.073		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE	4%	-0.073		19.18	18.37	1.35	1.39	0.00	0.00	0.05	0.06	0.00	0.00
SI	22%	-0.073		2,832.57	2,302.82	199.41	174.39	0.00	0.00	43.87	38.37	0.00	0.00
SI	10%	-0.073		280.19	212.70	19.73	16.11	0.00	0.00	1.97	1.61	0.00	0.00
SI	5%	-0.073		0.33	0.33	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
SI	4%	-0.073		209.31	202.02	14.74	15.30	0.00	0.00	0.59	0.61	0.00	0.00
SK	22%	-0.073	-0.416	3,309.81	2,963.59	233.01	224.43	1,126.39	1,528.88	51.26	49.38	247.81	336.35
SK	10%	-0.073	-0.416	44.61	33.55	3.14	2.54	15.18	17.31	0.31	0.25	1.52	1.73
SK	5%	-0.073	-0.416	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SK	4%	-0.073	-0.416	69.50	56.88	4.89	4.31	23.65	29.34	0.20	0.17	0.95	1.17
Sum				222,837.53	218,112.18	15,679.54	16,517.75	3,193.94	4,947.52	3,227.85	3,393.53	632.87	969.31

Notes: Values are express in million euros. The coefficients $\beta_{overall}$ and $\beta_{specific}$ are obtained from Table 3, Column 4 and Table 5, Columns 8, 13, 15 and 27, respectively. The fraud base based on exports is calculated as follows: sum of 2018 exports for a given exporter only for treatment products multiplied by the percentage change in $\beta_{overall}$ or $\beta_{specific}$ that is for each $[e^{(\beta)} - 1]$ %. To calculate the fraud base based on imports, the calculation of the percentage change is as follows: $\frac{1}{(1+e^{(\beta)}-1)} - 1$. The lost VAT prior to e-invoicing is calculated multiplying the fraud base with the VAT respective rate.

Table A7. Descriptive Statistics Alternative Control Group

Trade Gap (Dependent Variable)		N	Mean	Std. Dev.	Minimum	Maximum
Italy as Importing Country / TREAT are non-RCM and non-FUELS						
TREAT = 1	if POST = 0	617,474	0.2624	1.8838	-15.1976	14.2156
	if POST = 1	679,090	0.0683	1.9699	-14.2465	16.7204
Greece, Lithuania, Romania and Slovakia as Importing Countries / non-RCM products						
TREAT = 0	if POST = 0	1,583,476	0.0167	2.0007	-15.0509	14.4814
	if POST = 1	1,640,882	0.0302	1.9957	-15.9226	14.8371
Independent Variables						
THRESHOLD GAP		4,520,922	0.3712	0.8806	-7.0413	2.0794
EURO		4,520,922	0.5445	0.4980	0	1

Notes: Equation (1) shows the calculation method for the trade gap. POST is a time dummy that equals zero 12 months before e-invoicing became mandatory for all products in Italy in January 2019 and equals one 12 months after December 2018. TREAT is a dummy variable that equals one if the importing country is Italy and zero if the importing country is Greece, Lithuania, Romania or Slovakia. For all variables, see Table A2 in the Appendix.

Table A8. Product Categories

Product Category	Explanation
FUELS	Italy introduced the mandatory e-invoicing for fuels in July 2018 (Circular No. 8/E of 30th April 2018). Since Italy does not provide certain HS codes for fuel products falling under the e-invoicing regime, we hand collected these codes by matching the definition by the Italian government with the corresponding HS Codes. „Supplies of petrol or diesel fuel intended for use as motor fuel as well as for services rendered by subcontractors and sub-subcontractors of the supply chain within the framework of a works, services or supply contract entered into with a public administration", as stated in the Circular No. 8/E Date of 30th April 2018, "Premessa" (translated into English).
RCM	We defined the RCM category as products for which the reverse charge mechanism (RCM) applies in the importing country and the products are detectable in the VAT Directive and the corresponding HS code. In general, neither the VAT Directive nor the domestic VAT code of the importing country provide a comprehensive overview of HS codes linked to the products falling under the RCM regime. Thus, we had to hand collect HS codes when not provided in the VAT Act. The RCM is codified in Art. 199 to 199c VAT Directive. Introduction dates on products and sources are displayed in Table A1.
RCM POTENTIAL	RCM POTENTIAL includes products that could theoretically fall under the RCM in the importing country (since they are included in Art. 199 to 199c VAT Directive) but so far were not included in the importing countries' RCM regime. In cases where neither the national VAT law nor the VAT Directive provide for HS codes, we have manually collected the corresponding HS codes. We excluded those products that are not entirely falling under the RCM rather than only under certain circumstances. E.g. art. 199 Paragraph 1 letter e) VAT ´Directive subsumes the supply of goods provided as security.

Table A9. Descriptive Statistics of Product Classifications

Panel A: Differentiation based on Susceptibility to Fraud						
Trade Gap (Dependent Variable)		N	Mean	Std. Dev.	Minimum	Maximum
TREAT (=1) consists of …						
RCM POTENTIAL	if POST = 0	159,205	0.2805	1.8241	-14.1202	13.5252
	if POST = 1	171,483	0.1371	1.9058	-13.3833	14.1178
FUELS	if POST = 0	142	0.4437	2.1294	-9.1924	6.4974
	if POST = 1	290	0.1920	2.5550	-10.4650	11.6051
OTHER	if POST = 0	458,269	0.2561	1.9041	-15.1976	14.2156
	if POST = 1	507,607	0.0451	1.9906	-14.2465	16.7204
RCM (TREAT = 0)	if POST = 0	12,200	0.0266	1.8705	-12.1698	11.9568
	if POST = 1	13,259	-0.0332	1.9731	-12.6402	10.8908
Panel B: Differentiation based on HS1 Code						
Trade Gap (Dependent Variable)		N	Mean	Std. Dev.	Minimum	Maximum
Results only for Treatment Group (TREAT = 1)						
HS1 = 0	if POST = 0	45,754	-0.0155	1.9343	-12.5983	11.1270
	if POST = 1	49,252	-0.1749	2.0462	-14.2465	10.6878
HS1 = 1	if POST = 0	27,543	0.0189	1.9473	-12.2107	11.4752
	if POST = 1	30,281	-0.0911	2.0315	-12.7930	11.1586
HS1 = 2	if POST = 0	55,133	0.0601	1.7359	-13.7462	14.2156
	if POST = 1	59,010	-0.0502	1.8522	-13.1722	16.7204
HS1 = 3	if POST = 0	56,439	0.1647	1.7719	-14.1280	12.6174
	if POST = 1	62,385	-0.1086	1.8752	-12.9723	12.4979
HS1 = 4	if POST = 0	48,284	0.2325	1.9201	-12.9055	11.6113
	if POST = 1	53,736	-0.0044	2.0306	-13.0351	12.2494
HS1 = 5	if POST = 0	33,944	0.4852	1.8895	-11.1719	11.4873
	if POST = 1	37,458	0.2764	1.9935	-11.1550	12.8515
HS1 = 6	if POST = 0	82,539	0.5576	1.8768	-13.1126	11.1571
	if POST = 1	90,452	0.3438	1.9470	-12.1303	12.2835
HS1 = 7	if POST = 0	62,808	0.2339	1.8367	-14.0677	11.3578
	if POST = 1	68,430	0.0235	1.9801	-13.3833	14.1178
HS1 = 8	if POST = 0	151,259	0.2589	1.9142	-15.1976	13.5252
	if POST = 1	166,641	0.1165	1.9697	-13.3967	13.4032
HS1 = 9	if POST = 0	53,913	0.4100	1.9201	-12.5014	12.4048
	if POST = 1	61,735	0.0861	1.9731	-13.1747	10.7098

Notes: Equation (1) shows the calculation method for the trade gap. POST is a time dummy that equals zero 12 months before e-invoicing became mandatory for all products in Italy in January 2019 and equals one 12 months after December 2018. TREAT is a dummy variable that equals to one if the product is assigned to the treatment group (non-RCM and non-FUELS products) and zero if the product is assigned to the control group (RCM products). For explanations on RCM POTENTIAL, FUELS and OTHER see Table A8 in the Appendix. HS1 refers to the first-digit HS code and therefore divides the underlying eight-digit product codes into ten different groups based on the first digit of the product code.