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Do more harm than good? The optional reverse charge mechanism against cross-border tax fraud

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ABSTRACT

The so-called 'missing trader intra-community' (MTIC) fraud causes enormous losses in value-added tax (VAT) revenue. The fraudsters take advantage of the zero-rated cross-border supplies within the European Union (EU) and resell the goods domestically without paying the received VAT to the tax authorities. One of the most prominent measures to combat this scheme is the optional reverse charge mechanism (RCM) that shifts the VAT liability from the supplier to the customer in business-to-business transactions. Using asymmetries in international trade (trade data gap, TDG), we identify the fraud-reducing effect of the RCM. For the observation period (2003 – 2019) within the EU, we quantify this effect in terms of the VAT revenue between 7.5 and 7.7 billion euros using a midpoint estimate. Additionally, we are the first to provide empirical evidence of a harmful fraud relocation from RCM countries to non-RCM countries. This explains the domino effect of RCM introductions in the EU and calls for a unified approach to VAT fraud.

1. Introduction

Consumption taxes, such as value-added tax (VAT), are an important contributor to overall tax revenues in most countries.[3] One third of tax revenue of countries within the Organization for Economic Co-operation and Development (OECD) is generated by consumption taxes (OECD, 2020). VAT is considered an efficient and less distortive tax (Keen & Lockwood, 2006 and Keen & Lockwood, 2010). The tax collection on every stage is considered self-enforcing (Keen & Smith, 2006).[4] However, the VAT design is known to be vulnerable to fraud (European Court of Auditors, 1998). The reason for the susceptibility to fraud is the zero-rating of exports[5] within a border control free single market, as created by the European Union (EU) in 1993. Hence, a domestic supplier can purchase a good free of VAT from a foreign supplier in another EU Member State and subsequently sell this good to a domestic customer while charging VAT on the net price. This domestic supplier is obliged to remit the received tax to the authorities, however, tax revenue from the transaction is lost if the tax payment fails due to the disappearance of the fraudulent supplier ('missing trader'). This so-called 'acquisition fraud' scheme extends if the traded good returns to the foreign supplier and is once again imported by the fraudster, hence the name 'carousel fraud'. The fraudsters gain every time the good circulates, while the concerned Member State suffers a loss, as it refunds the VAT – received but not remitted by the missing trader – to the fraudsters' customer as input tax.

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3 According to OECD (2020), 170 countries are currently using a VAT system.

4 Pomeranz (2015) finds suggestive empirical evidence that the generated paper trails on each transaction stage is a significant feature of the self-enforcing mechanism of the VAT. It increases the audit probability and enables higher tax enforcement compared to sectors without these paper trails "since a paper trail facilitates detection of evasion during the audit" (Pomeranz, 2015).

5 The European VAT law distinguishes between cross-border transactions within versus outside the EU ("intra-Community supply" versus "exportation" and "intra-Community acquisition" versus "importation"). For reasons of simplification, we only use the terms exports and imports throughout this paper, referring to intra-Community transactions.

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These cross-border fraud schemes are different forms of the so-called 'Missing Trader Intra-Community (MTIC) fraud'.[6]

Given the possibility of obtaining and evading VAT by a domestic supplier, Member States have developed the so-called reverse charge mechanism (RCM). This measure shifts the tax liability from the supplier to the customer. The application of the RCM that is restricted to business-to-business (B2B) transactions eliminates the VAT payments as well as the incentive for fraud outlined above up to the last supply to the end consumer (business-to-customer, B2C) and partially converts the VAT into a retail sales tax.

We use a generalized difference-in-differences model to study the effect of the RCM. We analyse the trade data for products that have been subject to the RCM in at least one EU Member State between 2003 and 2019. The treatment group consists of products that fall under the RCM in the importing or exporting country while the control group consists of products not falling under the mechanism within the same or other countries. Our proxy for MTIC fraud is the trade data gap (TDG) that measures the relation between the product-specific export value reported by the exporting country and the corresponding import value reported by the importing country. A decrease in this variable suggests the closing of fraud since imports are assumed to be underdeclared by fraudsters. In our baseline specification, we find that the RCM in the importing country is associated with a decrease of the TDG, supporting the hypothesis that the measure tackles MTIC fraud in the country with RCM. This effect is stronger if the exporting country already applies the RCM, which suggests the (earlier) fraud relocation effect of this measure to another country without RCM. Accordingly, we expect a significant effect of RCM adoption in the exporting country if the importing country does not apply this measure. In this case, however, we hypothesize two opposing effects: a fraud-increasing relocation effect and a fraud-reducing removal of fictitious exports.[7] Against this background, it is plausible that we observe the relocation effect rather via a stronger response of our fraud proxy to the RCM application in the importing country than in the exporting country itself. Nevertheless, the relocation effect is flanked by a positive statistically significant coefficient on RCM in the exporting country when we consider the trade data gap in quantities. In addition, we find a positive statistically significant coefficient for rule of law in the exporting country, suggesting that fraudsters target countries with lower enforcement. With this study, we address the relocation between countries since it is neglected empirically within the literature. While e.g. Bussy (2021) analyses whether fraud shifting occurs between product groups, we focus on the fraud shift between countries.

Next, we account for potential heterogeneity by examining the reform by each EU Member State. This exercise supports a stable effect of the RCM in the importing country. The effect of the RCM regarding fictitious exports and relocations is highly dependent on the country suggesting why we do not see a clear domino effect of RCM application among the countries. Ultimately, we estimate fraud combated during the sample period 2003 to 2019 between 7.5 and 7.7 billion euros (3.9 to 4.0 billion euros using the lower bound and up to 11 to 11.6 billion euros using the upper bound estimate). However, harmful relocation effects are estimated at about 0.5 billion euros (0.1 billion euros using the lower bound and 0.9 billion euros using the upper bound estimate). Compared to the roughly estimated compliance cost of the RCM by EY (2014) of about 5.1 billion euros during this time, the positive effect of this measure appears to exceed these costs. We note, however, that we can probably only identify the last step of the fraud carousel, and that is when fraudsters stop reporting properly and disappear.

Empirical tax research on the effectiveness of the RCM against cross-border VAT fraud helps to understand the underlying mechanisms and stresses the quantification of such measures (Stiller & Heinemann, 2019; Arltová et al., 2020; Bussy, 2021). In summary, the literature attests the RCM a fraud-reducing effect with respect to MTIC fraud. However, we believe that the effectiveness of RCM in one country may depend on the use of this mechanism abroad and may influence fraud in other countries. There is hardly any empirical evidence for such relocation effect of RCM. In fact, there is a presumption that the RCM introduction in one Member State leads to shift of fraud to other EU countries that have not (yet) implemented this measure (European Commission, 2018a; EY, 2014). Knowing the impact in the overall context is essential for effectively combating VAT fraud.[8] Thus, we address this research gap by examining all product-related introductions of the RCM within the EU between 2003 and 2019 using trade data gaps, i.e. differences in double-reported bilateral trade data between all possible country-pair combinations within the EU at the most detailed product code level of the combined nomenclature (CN). EU Member States are obliged to report to the European Commission on the effectiveness of the methods used to combat fraud (European Council, 1989). They have confirmed the effectiveness of the RCM as a measure against tax fraud (European Commission, 2018a). By their nature, however, EU Member States consider the impact of such a measure at the national rather than the European level. Consequently, we lack an empirical investigation considering these harmful relocations that questions the effectiveness of the RCM.

With this paper, we contribute to the following strands of literature. We extend the empirical literature on the examination of the RCM as an anti-fraud tool (Stiller & Heinemann, 2019; Arltová et al., 2020; Bussy, 2021; Buettner & Tassi, 2023). Studies in this field concentrate on the effects within single countries; however, we argue that the interplay between the actions of both trading partners needs to be further investigated to determine the effects of the RCM in the overall context. We fill this research gap and demonstrate the usefulness of trade data when examining cross-border fraud, contributing to the literature that uses discrepancies in trade statistics (Fisman & Wei, 2004; Mishra et al., 2008; Javorcik & Narciso, 2008; Stoyanov, 2012; Gradeva, 2014; Javorcik & Narciso, 2017; Braml & Felbermayr, 2021).

In the remaining part of the paper, we introduce our fraud proxy in Section 2. In Section 3, we explain the MTIC fraud scheme more in detail and develop our hypotheses. Thereafter, we describe the data and the estimation methods in Section 4. In Section 5, we present the results and in Section 6, we carry out additional tests. Section 7 elaborates the approximation of fraud, and Section 8 concludes.

2. Proxy for cross-border VAT fraud

Several studies determine VAT losses based on the VAT gap, which is defined as the difference between expected VAT revenues and the VAT actually collected (see e.g. Poniatowski et al., 2023). Besides tax fraud,

[6] In addition to the monetary damage, the danger of MTIC fraud lies in its expected distortion of competition and the use of funds gained through tax evasion to finance illegal activities such as terrorism or drug trafficking (PwC, 2011).

[7] This approach is based on pretending a domestic transaction as an export at zero rate. Hence, the fraudster reports no output VAT, however, collecting VAT from its customer due to the actual domestic supply. See Section 3 for more details.

[8] Despite the political efforts at the EU level to make the VAT system more fraud-proof, in particular by abolishing zero-rated intra-Community supplies by mid-2022, the current treatment of cross-border supplies remains. So far, it has not been possible to create consensus among the Member States regarding this new 'definitive' VAT system. The EU finance ministers decided on 3 June 2022 to extend the RCM application until at least the end of 2026: Council Directive (EU) 2022/890 of 3 June 2022 amending Directive 2006/112/EC as regards the extension of the application period of the optional reverse charge mechanism in relation to supplies of certain goods and services susceptible to fraud and of the Quick Reaction Mechanism against VAT fraud (2022), Official Journal L 155/1, p. 1.

VAT gaps result from sources such as insolvencies, bankruptcies, administrative errors, and legal tax optimization measures (Onji, 2009; Poniatowski et al., 2023). Studies taking this approach to calculate VAT losses contribute to a better understanding of the VAT gap (Agha & Haughton, 1996; Nam et al., 2001; Poniatowski et al., 2023). However, they do not (aim to) separate MTIC fraud from non-fraudulent causes of VAT losses and other VAT evasion schemes.[9]

By 2000, the European Commission had already pointed out that trade figures may serve as fraud indicator. Addressing the trade effect of the currency union, Baldwin (2006) refers to MTIC fraud as a significant distorting factor and stresses the need to estimate the effect of VAT fraud on trade statistics. To the best of our knowledge, Ruffles et al. (2003) were the first to link asymmetries in UK foreign trade statistics with MTIC fraud. This asymmetry, defined as the trade data gap (TDG), is expressed as the difference between the export from country A to country B, reported by country A and the corresponding import reported by country B. In case of fraud, the TDG potentially shows an export surplus since fraudulent importers are assumed to neither remit the relevant VAT to the tax authority nor declare their imports in the Intrastat system. Simultaneously, the corresponding exporters are assumed to report their intra-Community exports since they either are unconscious participants in the fraud or pretend to be unaware of it (see information flows in Fig. 1). Using asymmetries in trade statistics is not a new method for investigating evasion behaviour. Fisman & Wei (2004) initiated a series of studies that find a positive relationship between tariffs and evasion using the TDG as a proxy (Mishra et al., 2008; Javorcik & Narciso, 2008; Stoyanov, 2012; Javorcik & Narciso, 2017). Thus, a growing literature examines the TDG concerning cross-border consumption tax fraud (Gradeva, 2014; Stiller & Heinemann, 2019; Bussy, 2021; Braml & Felbermayr, 2021; Kitsios et al., 2022). The TDG is calculated for a specific product p as the difference between exports reported by the exporting country e and the corresponding imports reported by the importing country i at time t for every possible EU country pair combination. Taking the natural logarithm leads to

$$\ln TDG_{eipt} = \ln Export_{eipt} - \ln Import_{iept} = \ln\left(\frac{Export_{eipt}}{Import_{iept}}\right) \tag{1}$$

According to the logarithmic definition, this implies positive values of $\ln TDG$ for $\frac{Export_{eipt}}{Import_{iept}} > 1$, negative values for $\frac{Export_{eipt}}{Import_{iept}} < 1$, and the value zero for $\frac{Export_{eipt}}{Import_{iept}} = 1$. Since imports are expressed CIF (cost, insurance, freight) and exports are reported FOB (free on board), the former should be higher by default.[10] This would result in a reference case where $\ln TDG$ is slightly negative without fraud. Accordingly, positive values of $\ln TDG$ indicate MTIC fraud.

An important aspect that influences export and import data are thresholds within the Intrastat system in which traders must report when exceeding the country-specific threshold.[11] Eurostat gathers these Intrastat data and provide them in their database. Estimates of missing trade below the thresholds are not included in the data as they are separated by alphanumeric codes according to Eurostat (2016) that are excluded by our data generating process. Therefore, the TDG can occur simply by diverging thresholds and missing trade reporting between exporting and importing country. We control for this feature of the TDG by including the country-specific thresholds in our estimation model.

3. Hypothesis development

Fig. 1 illustrates a supply chain through three countries A, B and C, where an importer I supplies products within each country to an exporter E and the latter resells them across the border to an importer in another country. None of the countries is the place of consumption and, therefore, does not generate VAT revenue in relation to these transactions. Applying the destination principle, according to which exports should not be subject to consumption taxation in the country of origin, the cross-border supplies from E to I do not trigger any VAT payments. In a legally compliant case in country A and C, E pays the tax to I and I remits the VAT to the tax authority (TA). The cycle of tax payments closes with the refund of input tax from TA to E.

This payment cycle illustrates the desired neutrality of the tax for B2B transactions and is broken by a fraudulent importer in country B. This so-called missing trader I^{MT} collects VAT from E_B and disappears without paying this tax to TA_B. Country B suffers a revenue loss from this fraud as TA_B refunds VAT_B to the exporter (E_B) that the latter paid to the fraudster (I^{MT}). The fraudster's failure to declare imports results in a TDG in the form of the deviation of exports from the corresponding imports from country A to B (see Fig. 1).

However, under the RCM in country B the exporter E_B, rather than the importer I_B, becomes the tax-liable party (see Fig. 2). The tax liability (VAT_B) of the purchaser E_B corresponds to the refundable input VAT so that there is no tax payment in country B. The missing trader I^{MT} (from Fig. 1) can no longer charge VAT and could be replaced by a permanent importer I_B who declares the imports. Alternatively, such trade vanishes when it was for fraudulent purpose only. As a result, RCM in country B should significantly reduce the MTIC fraud as well as the TDG (compare Figs. 1 and 2). This applies to B2B transactions, as B2C supplies do not fall under the scope of the RCM.

Against this background, we hypothesize the following:

H1. : The introduction of the RCM in the *importing* country (RCM^{Imp}) reduces B2B related MTIC fraud in this country and therefore reduces the TDG.

Eliminating the fraud opportunity in country B creates an incentive for the missing trader to move to a country without RCM or shift his/her activities to other products. However, the latter implies that fraudsters need to include new trading partners whereas shifting the activity to another country has the advantage of maintaining the established supply chains already installed. Against the background that MTIC fraud is expected to be carried out by larger criminal networks operating in many different countries,[12] country C (in Fig. 2) provides the optimal new location for the fraudulent activity of the missing trader since RCM does not apply in this country. This is especially important since not all traders in the supply chain are knowingly involved in the MTIC fraud. Experiences from EU Member States confirm this shift to other countries (European Commission, 2018a; European Commission, 2018b).

The expected shift of the MTIC fraud from a RCM country (B) to a non-RCM country (C) may even be intensified by the fact that the detection risk in the former country (B) is reduced by the RCM application in this country (B). MTIC fraud in country C is either detected by

[9] For other VAT evasion schemes than explained in this paper see, e.g., Gordon and Nielsen (1997) and Hopland and Ullmann (2019).

[10] The trade value of exports and imports is presented in the data base as statistical value, i.e. "the amount which would be paid in the event of sale or purchase at the time and place the goods cross the national border of the reporting Member State" (Eurostat 2022). However, not every EU Member State collects the statistical value from its traders and must perform an estimation based on invoice value, delivery terms and transportation mode where the taxable amount is the base. In either case, exports are said to be FOB and imports are said to be CIF (Eurostat 2022).

[11] For brevity, we do not include the thresholds across the EU Member States for our observation period from 2003 to 2019. They are provided upon request. However, export thresholds exceed import thresholds on average during the sample period. Therefore, there should be a tendency of lower export reporting that would lead to a negative $\ln TDG$.

[12] See e.g. the comments on this by Europol, the law enforcement agency in charge of the EU, URL: https://www.europol.europa.eu/crime-areas-and-statistics/crime-areas/economic-crime/mtic-missing-trader-intra-community-fraud.

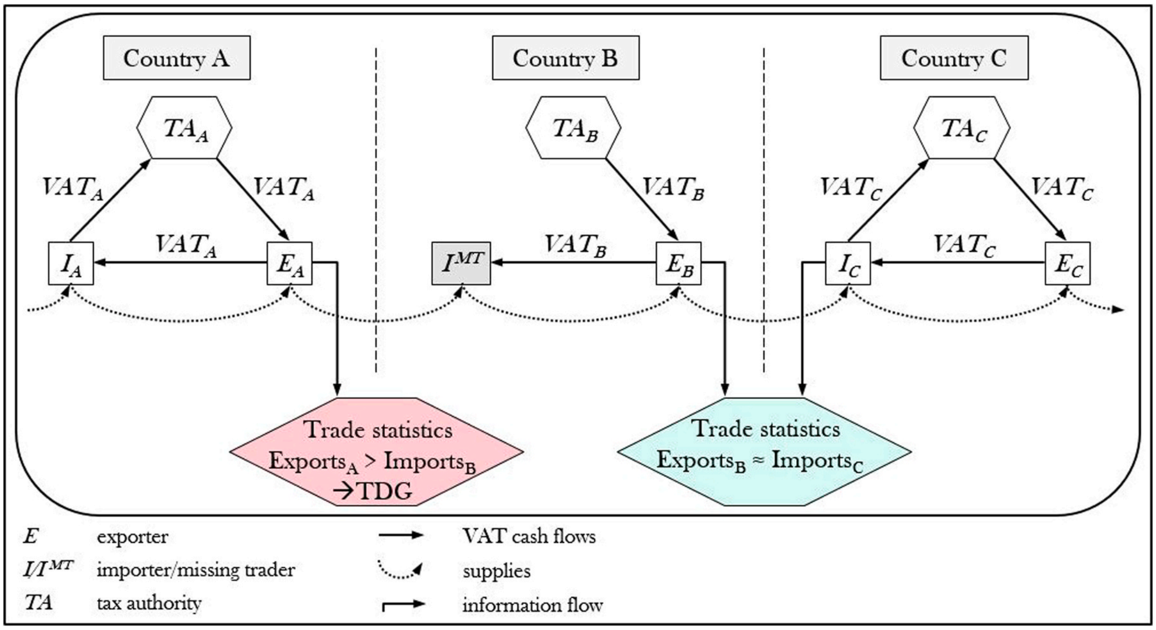

Fig. 1. International Trade and MTIC Fraud.

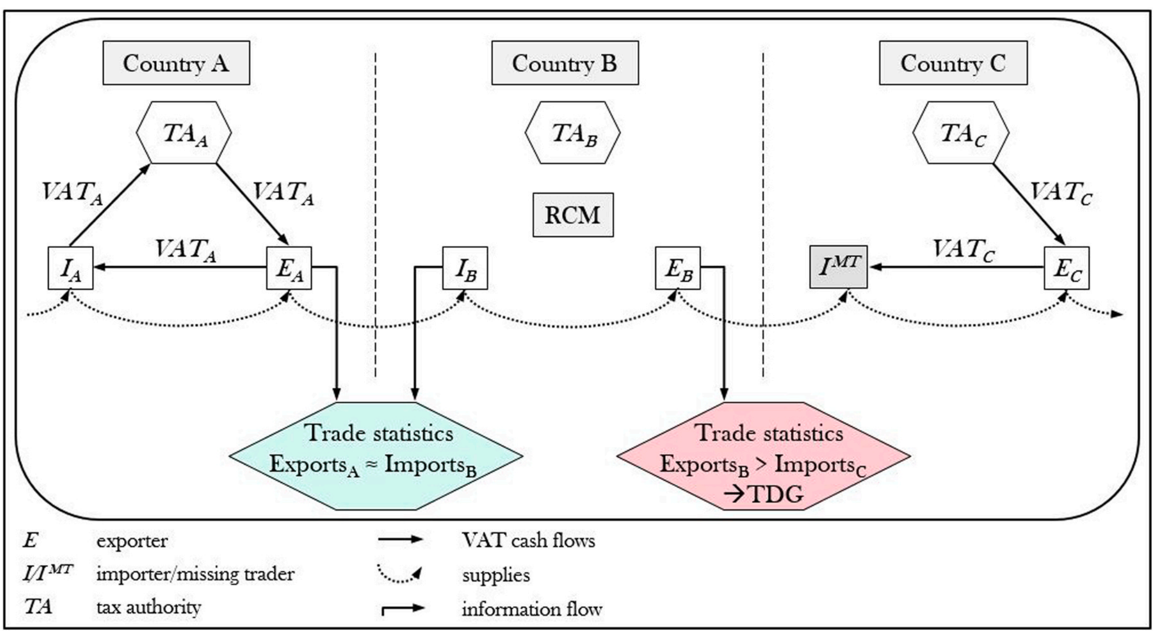

Fig. 2. International Trade, MTIC Fraud and RCM.

the TA_C, determining that the tax to be refunded to E_C has not been paid by the missing trader I^{MT} (see Fig. 2). Another channel of detection is by the TA_B, verifying whether the VAT-exempt export reported by E_B actually took place and was thus declared as an import by the missing trader in country C (see Fig. 2). Detection of the MTIC fraud by the tax authority in the exporting country (TA_B) is often triggered by the exporteŕs VAT refund claim since the tax authority finds input tax surpluses especially suspicious (Jaras et al., 2015). However, the RCM in country B eliminates the refund of input tax to the exporter E_B (compare Figs. 1 and 2) and thus significantly reduces the risk of MTIC fraud detection by the tax authority in this country. This is supported by the results of the PwC survey, according to which the increased risk of audit or investigation is one of the common reasons for not submitting a VAT reimbursement claim (PwC, 2019). We call this shift from RCM countries to non-RCM countries 'relocation effect' and formulate the following hypothesis:

H2a:. The introduction of the RCM in the *exporting* country *(RCM^{Exp})* leads to a relocation effect that increases the MTIC fraud and therefore the TDG in the importing country.

However, the RCM can also have an additional fraud-reducing effect. The idea behind this is that traders report fictitious tax-free exports in order not to pay the output VAT on the real domestic supplies that actually takes place (European Commission, 2018b). Since these 'fictitious exports' are not matched by imports, a TDG arises. Introducingthe RCM in the exporting country potentially prevents the fraudulent exporter from charging VAT on domestic B2B-supplies, which would reduce this fraud scheme.

H2b:. The introduction of the RCM in the *exporting* country (RCM^{Exp}) combats fictitious exports in this country and therefore reduces the TDG.

4. Identification strategy

4.1. Data

To calculate ln*TDG* (see Eq. (1)), we use the publicly available database provided by Eurostat.[13] We collect monthly intra-EU import and export data for all possible country pair combinations and all products that fall under the RCM within our sample period January 2003 to December 2019 in at least one EU Member State. For clarification, this means that the data set includes products that have not ever been subject to the RCM in one or more countries, as neither the time of RCM introduction nor the products concerned are uniform across the EU Member States. Intra-EU trade data are based on Intrastat declarations by taxpayers exceeding the respective country-specific threshold.[14] The observation period covers most RCM implementations on the supply of goods and allows us to capture long-term effects of the reforms (see Table A1 in the Appendix for RCM introduction dates). A RCM implementation is included in the sample when the mechanism applies during the sample period. Any event prior to the sample period or prior to the EU accession of a country is excluded since we cannot measure the effect of RCM in these cases. From this data, we construct a monthly and a quarterly sample. The calculation of ln*TDG* requires non-missing and non-zero exports and imports for the same period.[15]

We exclude trade with gold (4-digit product codes '7108′ and '7109′) entirely from the data set. Some countries introduced the RCM on these products, but gold can only fall under the RCM if it has a purity of 325 thousandths or greater,[16] therefore, the respective product codes might contain RCM and non-RCM gold supplies. Additionally, EU countries treat investment gold as VAT-exempt, therefore, trade data can be further biased. The resulting sample covers 39 time points between 2003 and 2019 with RCM introductions spanning over 24 EU countries (see Table A1, Appendix).

Besides the above-mentioned measures against tax fraud, additional tools were implemented and used during the observation period. Member States generally monitor traders in markets prone to MTIC fraud using their own risk-analysis systems (Borselli, 2011). Therefore, the success of combatting fraud using self-developed systems is dependent on the EU Member State. We assume constant differences between the countries over time. However, we relax this assumption in the heterogeneity analysis regarding the country-specific effects. In addition, the VAT information exchange system (VIES) enables companies to check their trading partners' VAT status, which is commonly used within the EU. VIES also allows the Member States to monitor and control intra-Community trade to detect fraud at the very first stage. Every EU country has access to this tool. Therefore, we expect its success to be constant between the countries. Furthermore, the EU Member States initiated 'Eurofisc' in 2010, which acts as a multilateral warning system and provides a forum for the EU countries to exchange information about fraudulent traders and transactions. Since 2019, Eurofisc uses the electronic transaction network analysis (TNA) data-mining tool that allows the EU Member States quick access to information on cross-border transactions to detect MTIC fraud considerably faster.

Other measures to combat tax fraud include the split payment mechanism (SPM), the standard audit file for tax (SAF-T), VAT listings, real-time reporting and electronic invoicing. The SPM isolates the fraudster from access to the VAT charged, as the payment for goods and services splits into the net amount and the tax amount. The buyer transfers the VAT to a separate blocked VAT account, which the tax authority controls. An implementation was made by Italy in 2017, Romania in 2018, and Poland in 2019. However, Italy applies the SPM only to transactions regarding public authorities and companies listed on the stock exchange. Romania discontinued the SPM in the beginning of 2020, which was applied only to firms in insolvency or with VAT debts. Poland applied the mechanism to several fraud-prone products for which partly, however, the RCM applied beforehand.

To assist tax auditors, the OECD introduced SAF-T in 2005. In general, SAF-T is a standardized file (with some optional elements) including tax-relevant transaction data generated by taxpayers and provided to the tax authority (OECD, 2019). VAT listings require traders to provide B2B transaction-based data to the tax authorities. Real-time reporting, currently only implemented in Spain and Hungary within the EU (Luchetta et al., 2022), and electronic invoicing that is currently only applied mandatorily on B2B basis in Italy (Heinemann & Stiller, 2024), require traders to provide invoice data in real time. We control for such inventions over the course of the observation period. However, since the SPM was implemented in Poland not only on RCM but also on other products, we exclude data from November 2019 onwards for Poland as importing or exporting country.

4.2. Empirical framework

We examine the relationship between RCM and ln*TDG* using a two-way fixed effects model with staggered treatments. Since we examine trade flows for each country pair in both directions, RCM in a country can either be determined as RCM in the importing country (RCM^{Imp}) or as RCM in the exporting country (RCM^{Exp}), depending on whether this country is treated as an importing or exporting country for a given country pair constellation. The full regression model including all interactions and variables is as follows:

$$\ln TDG_{eipt} = \alpha_{eip} + \gamma_t + \beta_1 RCM^{IMP}_{eipt} + \beta_2 RCM^{EXP}_{eipt} + \beta_3 \left(RCM^{IMP}_{eipt} \times RCM^{EXP}_{eipt} \right) + \phi X_{eipt} + \varepsilon_{eipt} \tag{2}$$

RCM^{Imp} (RCM^{Exp}) is constructed as a dummy variable equal to one if product p supplied from country e to country i at time t is subject to the reverse charge mechanism in the importing (exporting) country i (e) and zero otherwise. Thus, all country pair-product combinations on which RCM does not apply at time t serve as the control group. α and γ are country-pair-8-digit CN product code (unit) fixed effects and year-month (time) effects, respectively.

According to our first hypothesis (H1), the application of the RCM in the importing country (RCM^{Imp}) reduces related cross-border fraud, therefore, we expect to obtain a negative coefficient for β_1. The application of the RCM in both countries prevents fraud entirely, as its relocation is no longer possible. Hence, β_3 for the interaction term is expected to be negative as well. The RCM introduction in the exporting country (RCM^{Exp}), has two opposing hypotheses when RCM^{Imp} is not in force. Therefore, we expect a positive coefficient β_2 if the increase in

[13] We use the dataset '*EU trade since 1988 by HS2–4-6 and CN8*′ with the code '*DS-045409*′ freely available at https://ec.europa.eu/eurostat/web/main/data/database.

[14] The legal basis for data collection via the Intrastat system is provided by European Commission (2004). "Commission Regulation (EC) No. 1982/2004 of 18 November 2004 implementing Regulation (EC) No 638/2004 of the European Parliament and of the Council on Community statistics relating to the trading of goods between Member States and repealing Commission Regulations (EC) No 1901/2000 and (EC) No 3590/92." *Official Journal* L 343/3.

[15] We refrain from modelling missing values into the estimation since missing values are not necessarily equal to zero but can occur because of reporting issues. However, we test the sensitivity of the restriction of non-zero observations by using the inverse hyperbolic sine transformation on exports and imports and the common $\ln(x+1)$ transformation to keep the zeros in the dataset. Note that zero values for either imports or exports account for 28,312 observations that is only about 0.07% of all observations. The regression results using both methods to include zeros compared to the baseline are quantitatively similar and are not displayed for brevity.

[16] Article 198 par. 2 VAT Directive

MTIC fraud due to relocation effects (H2a) outweighs the fight of fictitious exports (H2b). Otherwise, we should observe a negative coefficient β_2 or no effect at all. In cases where RCM^{Imp} applies, the marginal effect of RCM^{Exp} equals $\beta_2 + \beta_3$ and we expect a negative effect on the fraud proxy as RCM^{Exp} should curb only fictitious exports.

We emphasize that this empirical strategy relies on the identification of the response of the TDG to the implementation of the RCM, which is a country specific decision for certain products. However, the RCM is likely an endogenous event since high cross-border fraud activity could possibly be related to the introduction of such measure.[17] Thus, generalizations of causal effects and quantifications are limited to the treated and thus fraud-prone products we investigate in this paper. However, the static model from Eq. (2) includes all periods before and after the reform in the importing or exporting country. Thus, if high levels of fraud mostly occur during a shorter time window and not during the entire pre- and post-windows, examining longer periods could reduce this threat.

4.3. Event study

In addition to our baseline specification from Eq. (2), we study the dynamic RCM effects as well as the parallel trend assumption with the following event study design, separately for a sample that only allows RCM^{IMP} to switch from zero to one:

$$\ln TDG_{eipt} = \alpha_{eip} + \gamma_t + \sum_{k\neq -1; k=-K}^{K-1} \beta_k \left(RCM_{eipt}^{IMP}\right)^k + \phi X_{eipt} + \varepsilon_{eipt}, \quad \text{if } RCM_{eipt}^{EXP} = 0 \tag{3}$$

and for a sample that only allows RCM^{EXP} to switch from zero to one:

$$\ln TDG_{eipt} = \alpha_{eip} + \gamma_t + \sum_{k\neq -1; k=-K}^{K-1} \beta_k \left(RCM_{eipt}^{EXP}\right)^k + \phi X_{eipt} + \varepsilon_{eipt}, \quad \text{if } RCM_{eipt}^{IMP} = 0 \tag{4}$$

where the following applies for RCM_{eipt}^{IMP} and RCM_{eipt}^{EXP}, respectively: $(RCM_{eipt})^k = \mathbb{1}[t = Period\ of\ Event_{eip} + k]$. The model includes dummies that turn one when a specific event of a country pair-product combination eip is k periods away from the actual event. Therefore, Eqs. (3) and (4) include leads (pre-trends) and lags (dynamic effects) of the variables RCM^{IMP} and RCM^{EXP}, respectively. We define different event windows of 12, 6, and 3 months or quarters before and after the RCM ($t \in [-K, K-1]$ where K equals 12, 6 and 3, respectively). As baseline difference, we set the first lead ($k = -1$) to zero by convention.

4.4. Control variables

Our set of control variables X includes VAT^{Imp}, VAT^{Exp}, $\ln THRESHOLD^{Imp}$, $\ln THRESHOLD^{Exp}$, DRR, $EURO$, ROL^{Imp} and ROL^{Exp}. These capture several aspects that may affect the level of fraud and trade discrepancies in general other than the RCM. Empirical studies by Agha and Haughton (1996) and Christie & Holzner (2006) both show that VAT non-compliance is positively correlated with VAT rates. Results found by Gradeva (2014) suggest a positive correlation between VAT rates and fraud. However, the effects of tax rates on evasion remain ambiguous theoretically as well as empirically (Allingham & Sandmo, 1972; Yitzhaki, 1974; Andreoni et al., 1998; Slemrod & Yitzhaki, 2002; Slemrod, 2007). Under a constant net turnover and fraud cost, the fraudster's profit would maximize in the country with the highest tax rate. Due to these unrealistic assumptions, we do not expect a (significant) correlation between tax fraud and the tax rate. We use the VAT rates from the respective report conducted by the European Commission (2020) and display them in Table A2 in the Appendix.

Additionally, trade data gaps can occur simply due to different thresholds each EU Member States sets for the obligation of reporting in the Intrastat system ($\ln THRESHOLD^{Imp}$ and $\ln THRESHOLD^{Exp}$).[18] Each Member State has to ensure that the thresholds should be set to cover at least 93% of import and 97% of export reporting. Therefore, different thresholds for export and import of two trading countries might affect the trade data gap by nature. Thus, we control for different coverage of trade by including the respective thresholds into the model.[19]

DRR is a dummy variable that captures the development of digital reporting requirements. These consist of VAT-listings and SAF-T as periodic DRR and real-time reporting and e-invoicing as continuous DRR. Luchetta et al. (2022) find that DRR significantly increase (decrease) VAT revenues (VAT gaps). To prevent our analysis from confounding effects of these reporting obligations, we include DRR that takes the value one if the importing country applies DRR. Table A3 provides an overview of the DRR implementations.

The control variable $EURO$ intends to absorb differences in trading data that may occur due to currency conversion. Differences in currency exchange rates at the time of reporting by the exporter and importer might lead to a different valuation and, therefore, differences in import and export values (Loschky, 2006). We control for this issue by including a dummy variable, which takes on the value of one when both the exporting country and importing country are using the euro as their official currency at time t and zero otherwise.

ROL^{Imp} and ROL^{Exp} are proxies of enforcement efforts made by the importing and exporting Member State. In general, the extension to the tax evasion model from Allingham and Sandmo (1972) made by Yitzhaki (1974) suggests that the risk of increasing penalties should ultimately decrease tax evasion due to the modelled income effect (the penalty rises with increased evaded income) which found empirical validation (Pickhardt & Prinz, 2014). We assume, however, that penalties may not affect the level of MTIC fraud because fraudsters escape from penalties by disappearance. Meiselman (2018) provide evidence that nonfilers (taxpayers that do not intend to file a tax return at all) do not respond to increased risk of penalties. We assume that penalties are negligible, since the risk of detection of the criminal network in form of audits or technological possibilities to uncover the scheme by the tax authorities play a more central role. However, cross-border consumption tax fraud as real-world examples are complex structures and finding such an appropriate proxy seems difficult. Nonetheless, we try to capture certain trends that might affect the level of fraud especially regarding enforcement. Therefore, we include in our baseline model the rule of law (ROL^{Imp} and ROL^{Exp}). These variables measure the perception to which extent agents follow the rules and have confidence in them. It also covers contract enforcement, property rights, police and courts, crime and violence.

To account for possible heteroscedasticity and autocorrelation, we cluster the standard errors on the level of unit fixed effects. Table A3

[17] A common fix would be an instrumental variable approach. However, we are not aware of any usable instrumental variable that triggers a RCM introduction but does not influence or is not influenced by fraud itself, which is included in the TDG.

[18] Eurostat kindly provided information on the applicable Intrastat thresholds from 2006 to 2019, which we supplemented with the respective thresholds for the remainder of the period 2003 to 2005. We used the Quality Report on International Trade Statistics provided by the EU Commission and Eurostat, publicly available here https://ec.europa.eu/eurostat/documents/3888793/5838913/KS-AS-06–001-EN.PDF.

[19] Member States are responsible for estimating trade below the thresholds, for which data is not available due to non-responses or for missing trade due to fraud. However, Eurostat separates these estimates from the original trade figures when examining the most detailed trade flows on the 8-digit CN level (Eurostat, 2016). In our data collection process, we excluded these estimates.

(Appendix) provides explanations and sources on all included variables. Panel A of Table 1 displays the descriptive statistics of our baseline sample. As we pointed out in Section 2, $\ln TDG$ should be slightly negative without fraud. However, the mean value of the dependent variable in the overall sample is 0.053 (monthly) and 0.029 (quarterly), indicating the fraud susceptibility of these products. Panel B of Table 1 presents some underlying information about the products used.

5. Results

5.1. Event study

Fig. 3 presents the coefficients from Eqs. (3) and (4) for the monthly sample (graphics A and C) and for the quarterly sample (graphics B and D) using 12 periods pre- and post-RCM, respectively. In graphic A, the treatment group show a higher $\ln TDG$ in almost all periods in the run-up to the introduction of RCM^{Imp} compared to the control group. Post-RCM, $\ln TDG$ for treatment products decrease visibly. However, this effect does not appear to be immediate and reverses towards the end of the first year. To understand the development beyond the first year after the RCM implementation, we extend the time windows by adding two more years (8 quarters) before and after the RCM (graphic B) and we use the mean $\ln TDG$ by quarters to smooth out fluctuations in the dependent variable. The picture confirms the trend from the monthly analysis. First, we notice that pre-RCM, positive differences between treatment and control products occur especially in the year before (i.e. last four quarters before implementation). After the RCM applies in the importing country, the effect appears to be negative only in some periods after implementation. However, the rest of the coefficients are around zero post-RCM or even positive towards the end of the observation window that could be caused by other factors than RCM.

Accordingly, we display the coefficients for lags and leads of RCM^{Exp} in graphics C and D for the monthly and quarterly sample, respectively. Noteworthy, there is no evidence of a pre-trend since all coefficients up to the actual implementation are near zero and statistically insignificant in the monthly sample (graphic C). After the adoption of RCM^{Exp}, some post-RCM coefficients are positive and statistically significant, indicating an increase in $\ln TDG$ for the treatment group. The quarterly sample (graphic D) mostly confirms these results also for a longer observation period.

For brevity, we display the event study results using shorter pre- and post-RCM-periods in the Appendix (Figures A1 and A2, respectively). The results confirm that RCM in the importing country did not immediately reduce the TDG.

5.2. Baseline results

Table 2 presents the static baseline results for the monthly sample.[20] We predict a negative coefficient for the RCM introduction in the importing country (RCM^{Imp}) due to the attributed fraud-reducing effect. Throughout the specifications, RCM^{Imp} is associated with a decrease of the fraud-related ratio of exports to imports. However, for interpretation purposes, we need to distinguish between the coefficients of the first two columns as they represent unconditional effects of each RCM introduction in the importing and exporting country. Thus, RCM^{Imp} is associated with a decrease of our fraud proxy by about 5.8% on average (see Table 2, Columns 1 and 2). The magnitude of the average effect is slightly higher than the effect reported by Bussy (2021) who finds a magnitude for RCM^{Imp} of about 3% to 4%. On the other side, especially after including all controls, the coefficient of RCM^{Exp} is very close to zero with a coefficient of -0.005 and lack of statistical significance (see Table 2, Column 2). Since the opposing hypotheses H2a and H2b regarding RCM^{Exp} can dilute the effect, we further test these by including the interaction of RCM^{Imp} and RCM^{Exp}.

Examining the coefficients of the interaction model in Columns 3 and 4 of Table 2, the main effect for RCM^{Imp} still correlates negatively with the fraud proxy. We find a decrease by approximately 5% *if the exporting country does not apply RCM* (see Table 2, Column 4). It is striking that the introduction of RCM^{Exp} appears not to correlate with the fraud proxy *when the importing country does not apply RCM*, as evidenced by the lack of statistical significance of the main effect RCM^{Exp} (see Table 2, Columns 3 and 4). This becomes clear from the two opposite predictions of hypotheses H2a and H2b, because RCM^{Exp} represents ambiguous effects when RCM^{Imp} is not in force.[21] However, using quantities instead of values, we find that the coefficient of RCM^{Exp} is indeed positive and statistically significant (see Table 3, Column 1), suggesting the relocation effect.

The interaction term enables us to grasp a deeper understanding of the interplay between the RCM introductions in both countries. Our hypotheses suggest that the effect of RCM implementation depends on the country's trade status (exporting country vs. importing country). Fundamentally, we find that the interaction between RCM^{Imp} and RCM^{Exp} is negative and statistically significant (see Table 2, Columns 3 and 4).

In terms of RCM^{Imp} and inferring from H2a, we would expect the RCM of the importing country to have a stronger negative correlation due to RCM^{Exp} because of past relocation effects channelled through RCM countries as fraudsters make use of the established supply chains. Indeed, we find that the effect of RCM^{Imp} is associated with an additional decrease of approx. 5% when the RCM^{Exp} dummy equals one compared to when it equals zero.[22] This finding provides suggestive evidence that previous relocations of fraudsters lead to higher fraud (H2a) that RCM^{Imp} ultimately shuts down. This finding stresses the necessity of taking the RCM of the partner country into consideration when estimating the effect of RCM. The (total) marginal effect of RCM^{Imp} therefore results in a decrease of the TDG by 9.3%.[23]

The main effect for RCM^{Exp} shows a lack of statistical significance. This indicates the expected ambiguity in this case as H2a and H2b overlap. However, it may still influence the fraud proxy as soon as RCM^{Imp} equals one as indicated by the interaction term.[24] First, we perform a joint significance test for the marginal effect of RCM^{Exp} after the regression in Table 2, Column 4. The test rejects the null hypothesis that RCM^{Exp} together with the interaction effect is zero on the 5% level. Therefore, the (total) marginal effect of RCM^{Exp} on the fraud proxy is -4.2%.[25] This gives suggestive evidence for our hypothesis H2b as RCM^{Exp} – from a theoretical point of view – should reveal a negative

[20] Monthly trade data gaps can be highly volatile. We attempt to smooth the development over time by using quarterly data. We run the specification of Eq. (2) with the quarterly sample using year-quarter FE instead of year-month FE. The results are quantitatively similar to the baseline results in Table 2 and are not displayed here for brevity.

[21] Recall that we predict with H2a an increase in the trade data gap while we predict with H2b a decrease in the trade data gap. We should observe relocation effects (H2a) as well as the fight of fictitious exports (H2b), if the importing country has not introduced the RCM and hence, the dummy is zero so that both effects are plausible.

[22] We perform a joint significance test after the regression in Table 2, Column 4. The test rejects the null hypothesis that RCM^{Imp} together with the interaction effect is zero.

[23] Adding the main effect of RCM^{Imp} and the interaction term, hence: $(-0.048) + (-0.050) = -0.098$. The calculation for the exact effect is $[e^{-0.098} - 1] \times 100$.

[24] Note that interaction terms need to be interpreted from a theory point of view, as the effect is (statistically) purely symmetrical. In our case, we argue that RCM^{Exp} influences the effect of RCM^{Imp} and vice versa due to H2a and H2b.

[25] Adding the main effect of RCM^{Exp} and the interaction term, hence: $0.007 + (-0.050) = -0.043$. The calculation for the exact effect is $[e^{-0.043} - 1] \times 100$.

Table 1
Descriptive Statistics and Product Description.

Panel A: Descriptive Statistics					
Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
ln*TDG* (monthly)	38,631,103	0.053	1.907	-16.502	17.157
ln*TDG* (quarterly)	16,395,278	0.029	1.815	-15.873	15.603
RCM^{Imp}	38,631,103	0.022	0.148	0	1
RCM^{Exp}	38,631,103	0.022	0.148	0	1
VAT^{Imp}	38,631,103	20.767	2.477	15	27
VAT^{Exp}	38,631,103	20.549	2.308	15	27
$\ln THRESHOLD^{Imp}$	38,631,103	12.520	0.947	6.551	14.443
$\ln THRESHOLD^{Exp}$	38,631,103	12.752	0.648	6.551	14.221
DRR	38,631,103	0.124	0.329	0	1
EURO	38,631,103	0.431	0.495	0	1
ROL^{Imp}	38,631,103	1.213	0.5495	-0.130	2.130
ROL^{Exp}	38,631,103	1.318	0.542	-0.130	2.130

Panel B: Product Description		
First-Digit Product Code	Number of Unique Product Codes	Short Description
0	2	Coriander fruits
1	193	Cereals, rye, barley, oats, corn, rice, wheat, oil seeds, miscellaneous seeds and fruit
2	1269	Salt, ores, slag, inorganic and organic chemical products
3	12	Waste and scrap
4	262	Waste, firewood, raw wood, wood in various forms, paper
5	10	Silk waste, wool waste, yarn waste, waste of man-made staple fibres
6	435	Articles of clothing and other textiles
7	1256	Glass and glassware, pearls, iron, steel, copper, nickel, aluminium, lead, zinc
8	395	Tin, other base metals, electrical equipment
9	20	Photographic cameras, game consoles
Sum	3854	

Notes: Panel A: ln*TDG* is defined in Eq. (1). The observation period ranges from January 2003 to December 2019. The superscripts 'Imp' and 'Exp' mark the importing and exporting country, respectively. The RCM implementations by country are displayed in Table A1, Appendix. VAT rates by country are presented in Table A2, Appendix. For further explanations on each variable, see Table A3, Appendix. Panel B: The description is based on the products used in the sample and does not contain all products that fall under the respective first-digit product code.

relationship *if* RCM^{Imp} *equals one*. In this case, we argue that the effect is limited to the combat of fictitious exports, while relocations are unlikely, as fraudsters would choose countries without RCM.

After discussing the main variables of interest, we shortly turn our focus on the control variables. We predicted no significant correlation between VAT rates and our fraud proxy since other factors than the VAT rate might influence the location decision of fraudsters. However, we observe a negative and statistically significant coefficient for the VAT rate in the importing country (VAT^{Imp}) throughout the specifications including controls (see Table 2, Columns 2 and 4). We cannot rule out that tax authorities with higher VAT rates monitor fraud stricter compared to countries with lower VAT rates, which would dilute the tax rate effects in our model. This might also explain the effect why we find that a higher VAT rate in the exporting country (VAT^{Exp}) is associated with more fraud activity (see Table 2, Columns 2 and 4). This may speak for the fact that higher VAT rates in the exporting country attract fraudsters carrying out the fictitious export scheme from hypothesis H2b. However, if EU Member States with higher VAT rates are more vigilant, then fraud within country pairs where the importing (exporting) country has a lower (higher) VAT rate will consequently be more prevalent in the importing country.[26]

Concerning the different thresholds for Intrastat reporting in the importing and exporting countries, we find a positive and negative statistically significant coefficient, respectively. This appears plausible since higher thresholds set by the importing country should lead to lower reporting regarding imports compared to exports, which ultimately lead to a higher ln*TDG*. Export reporting thresholds lead to an opposite effect. The higher the threshold in the exporting country, the lower the reported exports relative to imports. This leads to lower or even negative ln*TDG* as exports decrease relative to imports. Note that no fraud estimations made by Member States are included in these trade figures.

Furthermore, *DRR* shows a positive and statistically significant coefficient when included. This counterintuitive correlation can be explained by the fact that DRR are mainly introduced by countries with a high level of fraud and the measures have no immediate or no significant effect. *EURO* is negative and statistically significant, demonstrating that when both countries have the same currency, the fraud proxy is lower on average. Regarding our enforcement proxy, we observe a negative and positive statistically significant coefficient for the importing and exporting country, respectively. A higher ROL^{Imp} is associated with a lower ratio of exports to imports, which is in line with the (favored) prediction that higher enforcement is associated with lower fraud. On the other side, a higher ROL^{Exp} positively correlates with our fraud proxy. This result may indicate that higher enforcement in the exporting country channels fraudsters into countries with lower enforcement.

6. Additional tests

6.1. Alternative dependent variables

In this section, we test whether the effect of RCM remains stable when we use alternative dependent variables. Table 3 summarizes the results for the different dependent variables. In the first specification, we exchange the baseline value-based ln*TDG* with a quantity-based ln*TDG* (see Table 3, Column 1). Unlike value-based, the unit-based ln*TDG* is not distorted by the application of different valuation systems (FOB and CIF)

[26] High VAT rates are found especially within the Scandinavian countries, which show low VAT gaps compared to the rest of the EU (Poniatowski et al. 2023).

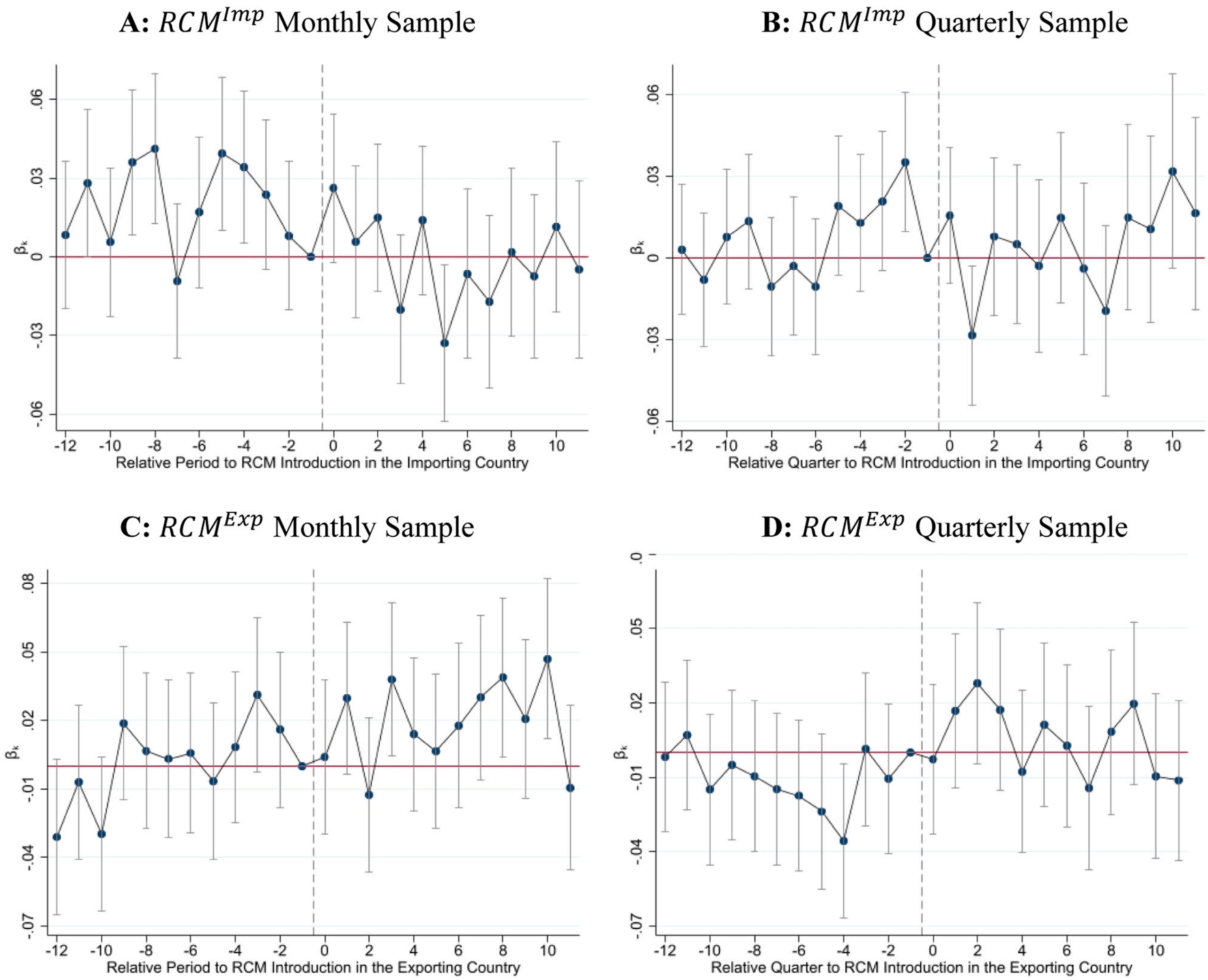

Fig. 3. Event Study Coefficients. Notes: Graphics A and B display the coefficients of lags (pre-trends) and leads (dynamic effects) of RCM^{Imp} from Eq. (3) for the monthly and quarterly sample, respectively. Graphics C and D display the coefficients of lags (pre-trends) and leads (dynamic effects) of RCM^{Exp} from Eq. (4) for the monthly and quarterly sample, respectively. The baseline period ($k = -1$), the period before the actual RCM^{Imp} or RCM^{Exp} implementation, is set to zero. The monthly (quarterly) sample consists of observations 12 months (quarters) prior and after RCM. Grey lines indicate the 90% confidence interval.

and should therefore be closer to zero in the non-fraud case (Javorcik & Narciso, 2017; Gradeva, 2014). The magnitude of the coefficients is comparable to our baseline. However, the main effect of RCM^{Exp} shows a positive and statistically significant sign whereas this variable does not show any statistical power in our baseline regressions. First, we conclude that fraudsters not only underreport import values but also import quantities. This gives us additional confidence we observe non-reporting due to MTIC fraud rather than only undervaluation, which supports our initial findings. Second, the positive coefficient of RCM^{Exp} indicates the expected fraud-rising relocation effect of RCM^{Exp} in line with H2a. Note, however, that a unit-based $\ln TDG$ should be treated as less reliable since the collection of quantities is not always required and missing data is estimated, which can distort the data to some extent (Eurostat, 2022).

Next, we winsorize and trim $\ln TDG$ by each country-pair at the top and bottom 1%, respectively, to control for outliers in the data. We show the corresponding results in Table 3, Columns 2 and 3. RCM^{Imp} remains stable while the coefficient for the interaction of the importing and exporting country's RCM slightly reduces in magnitude. However, they do not lose statistical power.

Finally, we use the natural logarithm of exports and imports as dependent variable, including the opposite trade flow in the regression, respectively.[27] We expect decreasing exports since RCM curbs trade that occurs solely to evade VAT. A prediction regarding imports is difficult, as two opposing effects are to be expected. On the one hand, they should decline analogously to the reduced exports for cases in which fraudsters report fraudulent imports. On the other hand, an increase in imports is expected since honest traders might take over the share of actual trade previous carried out by missing traders and previously not reported.

Concerning exports, we find a negative relationship between RCM^{Imp} and the fraud proxy *when* RCM^{Exp} *does not apply* (−0.063). However, *if* RCM^{Exp} *applies*, the effect turns out to be slightly positive as indicated by the marginal effect of 0.008 (−0.063 + 0.071). On the other hand, RCM^{Exp} seems to have an isolated decreasing effect *if* RCM^{Imp} *does not apply* (−0.006) suggesting that the fight of fictitious exports outweigh

[27] Using only exports and only imports instead of their ratio leads to issues regarding the control of size effects as certain country-pairs simply trade more or less than others. We include the opposite flow to control for these size effects since higher exports come naturally alongside with higher imports and vice versa.

Table 2
Baseline Results.

	(1)	(2)	(3)	(4)
RCM^{Imp}	-0.055 * **	-0.058 * **	-0.045 * **	-0.048 * **
	(0.009)	(0.009)	(0.010)	(0.010)
RCM^{Exp}	-0.021 * *	-0.005	-0.011	0.007
	(0.010)	(0.010)	(0.011)	(0.011)
$RCM^{Imp} \times RCM^{Exp}$			-0.046 * *	-0.050 * *
			(0.021)	(0.021)
VAT^{Imp}		-0.009 * **		-0.009 * **
		(0.001)		(0.001)
VAT^{Exp}		0.014 * **		0.014 * **
		(0.001)		(0.001)
$\ln THRESHOLD^{Imp}$		0.068 * **		0.068 * **
		(0.003)		(0.003)
$\ln THRESHOLD^{Exp}$		-0.054 * **		-0.054 * **
		(0.004)		(0.004)
DRR		0.012 * **		0.012 * **
		(0.004)		(0.004)
EURO		-0.019 * **		-0.019 * **
		(0.006)		(0.006)
ROL^{Imp}		-0.052 * **		-0.052 * **
		(0.009)		(0.009)
ROL^{Exp}		0.025 * *		0.025 * *
		(0.011)		(0.011)
Observations	38,631,103	38,631,103	38,631,103	38,631,103
Adjusted R^2	0.279	0.280	0.279	0.280
Unit FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes

Notes: The dependent variable is the monthly $\ln TDG$ defined in Eq. (1). The superscripts 'Imp' and 'Exp' mark the importing and exporting country, respectively. For explanations on variables, see Table A3, Appendix. The correlation matrix is displayed in Table A4, Appendix. Unit FE are country pair-8-digit product code combinations. Time FE are year-month combinations from January 2003 to December 2019. Standard errors are clustered by country pair-8-digit product code and are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table 3
Alternative Dependent Variables.

Dependent Variable	Unit-based $\ln TDG$ (1)	Winsorized $\ln TDG$ (2)	Trimmed $\ln TDG$ (3)	$\ln Exports$ (4)	$\ln Imports$ (5)
RCM^{Imp}	-0.074 * **	-0.047 * **	-0.043 * **	-0.063 * **	0.005
	(0.011)	(0.010)	(0.009)	(0.009)	(0.009)
RCM^{Exp}	0.042 * **	0.008	0.009	-0.006	-0.015
	(0.012)	(0.011)	(0.009)	(0.010)	(0.010)
$RCM^{Imp} \times RCM^{Exp}$	-0.065 * **	-0.045 * *	-0.036 * *	0.071 * **	0.134 * **
	(0.023)	(0.020)	(0.018)	(0.019)	(0.019)
Observations	32,502,037	38,631,103	37,859,204	38,631,103	38,631,103
Adjusted R^2	0.309	0.280	0.258	0.782	0.761
Controls	Yes	Yes	Yes	Yes	Yes
Unit FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes

Notes: Results are based on the monthly sample. The superscripts 'Imp' and 'Exp' mark the importing and exporting country, respectively. For explanations on variables, see Table A3, Appendix. In Column 1, the dependent variable is $\ln TDG$ using quantities instead of values analogously to Eq. (1). In Columns 2 to 3, the dependent variable is the winsorized and trimmed $\ln TDG$, respectively, at the bottom and top 1% by each country-pair. In Columns 4 and 5, the dependent variable is the natural logarithm of exports and the natural logarithm of imports, respectively. Unit FE are country pair-8-digit product code combinations and time FE are year-month combinations from January 2003 to December 2019. Standard errors are clustered by the unit FE identifier and are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

the relocation effect. However, the main effect is statistically insignificant. The total marginal effect of RCM^{Exp} *if* RCM^{Imp} *applies* is positive ($-0.006 + 0.071 = 0.065$). The overall effect reveals that exports hardly change ($-0.063 + -0.006 + 0.071 = 0.002$).

Regarding imports, we observe a statistically non-significant coefficient for the main effect of RCM in the importing country, likely due to the offsetting effects *if* RCM^{Exp} *does not apply* (see Table 3, Column 5). As soon as RCM^{Exp} *applies*, imports appear to increase substantially with a marginal effect coefficient of 0.139 ($0.005 + 0.134$). This gives suggestive evidence of an effective clearance of fraudsters from fraud-prone markets. Additionally, the main effect of RCM^{Exp} relates to an insignificant decrease of (reported) imports *if* RCM^{Imp} *does not apply*. A negative sign indicates the fraud relocation from an RCM-exporting to a non-RCM-importing country, where the fraudsters replace honest importers. We refrain from interpreting the interaction term with respect to a moderating effect of RCM^{Imp} on the effect of RCM^{Exp}. Because we expect no reactions of imports on RCM^{Exp} caused by fictitious exports since this fraud scheme should be limited to export values by its nature. Therefore, we expect RCM^{Exp} to moderate the effect of RCM^{Imp}, but not vice versa. In total, imports increase ($0.005 + -0.015 + 0.134 = 0.124$), suggesting that honest traders take over market shares previously held by fraudsters.

Table 4
Stacked Regressions.

	A: *Monthly Sample*		B: *Quarterly Sample*	
	(1)	(2)	(3)	(4)
RCM^{Imp}	-0.030 * **	-0.024 * **	-0.033 * **	-0.008
	(0.008)	(0.009)	(0.012)	(0.013)
RCM^{Exp}	-0.010 * *	-0.010 *	0.001	0.003
	(0.005)	(0.005)	(0.004)	(0.004)
$RCM^{Imp} \times RCM^{Exp}$		-0.033		-0.110 * **
		(0.020)		(0.025)
Observations	165,594,034	165,594,034	157,942,341	157,942,341
Adjusted R^2	0.001	0.001	0.000	0.000
Controls	Yes	Yes	Yes	Yes
Dataset-Unit FE	Yes	Yes	Yes	Yes
Dataset-Time FE	Yes	Yes	Yes	Yes

Notes: Panels A and B display the results for the monthly and quarterly sample, respectively. The dependent variable is $\ln TDG$ defined in Eq. (1). The superscripts ‘Imp’ and ‘Exp’ mark the importing and exporting country, respectively. For explanations on variables, see Table A3, Appendix. We identify 37 and 33 events for the monthly and quarterly sample, respectively. In both cases, the event-window covers 12 periods (months or quarters) before and after each event. Dataset-unit FE are country pair-8-digit product code combinations for each dataset covering one event. Dataset-time FE are year-month or year-quarter combinations for each dataset covering one event. Standard errors are clustered by the event-specific unit FE identifier and are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

6.2. Heterogeneity analysis

Recall that our baseline model includes all possible country pair-product combinations whereas potential heterogeneous effects regarding specific countries remains uncovered. Thus, we estimate our baseline model from Eq. (2) for each importing country separately. In Table A5 in the Appendix, we display these country-specific results for each EU Member State. Except for Germany (DE), all statistically significant coefficients of the main effect for RCM^{Imp} are negative und support the underlying fraud-reducing effect of the RCM in the importing country (H1) *for observations where the exporting country does not apply the RCM*.[28] We find a statistically significant effect in 11 out of 24 RCM countries.

The opposing hypotheses that the RCM adoption in the exporting country relocates fraud to the importing country (positive RCM^{Exp} main effect, see H2a) while curbing reported fictitious exports (negative RCM^{Exp} main effect, see H2b) are visibly reflected in the country-specific results. The fraud-reducing effect of the RCM in the exporting country *when* RCM^{Imp} *is not in force* seems to be prevalent for exports to Italy (IT) and Slovakia (SK), while countries such as Luxembourg (LU) and the Netherlands (NL) appear to suffer (more) from the relocation of fraud.

Such diverging effects are prevalent regarding the interaction term as well. For Germany (DE), Estonia (EE) and Hungary (HU), we find a negative and statistically significant interaction between both RCM implementations. As we discussed along the baseline results in Table 2, this suggests that the RCM in the importing country combats previous relocations and curbs fictitious exports. Surprisingly, Denmark (DK) and Slovakia (SK) show a positive interaction term that is statistically significant.

In conclusion, we state that the ambiguous effects from H2a and H2b regarding RCM^{Exp} are evident from the divergent coefficients of the variable across the (importing) country specific regressions. Moreover, the effect of RCM^{Imp} appears to be more distinct to the extent that a statistically noticeable effect can be observed and is entirely absent in several countries of application. This might shed some light on the real-world practices by EU Member States regarding the RCM application. Against the background of relocation effects, one might object the lack of a clear ‘domino effect’ of RCM applications within the EU. If RCM introduction in one country would unconditionally lead to an increase in fraud in other countries, we should consequently see RCM implementation in these countries. In fact, this is not the case and can be explained by the country (and product) specific relocation and fraud reducing effects.

6.3. Stacked regression

Two-way fixed effects (TWFE) models with staggered introductions are potentially biased due to possible treatment effect heterogeneity (Baker et al., 2022). If treated products are used as control products for later-treated products, TWFE regressions include these ‘bad comparisons’ as pointed out by the econometric literature. According to Baker et al. (2022), a first indication of this bias is given by a low percentage of never-treated observations.[29] Such control units that are never-treated are more suitable for identification and do not induce the above-mentioned bias. We emphasize that we expect never-treated units to serve as an appropriate control group since the extensive number of different importing country-product combinations never receiving the RCM is very likely to be free of any anticipatory or spillover effects. In our dataset, those never-treated observations in the importing and exporting country account for over 94% and 95%, respectively, of all observations.[30] This might already lower the threat to our identification design.

However, there are several ways to address the issue. We follow the advice of Baker et al. (2022) and estimate a stacked regression estimator according to Sun & Abraham (2021). The difference to the classical TWFE model is that the stacked difference-in-differences model uses dataset-specific unit and time fixed effects. Dataset-specific means that each individual event receives its own indicator that is interacted with the fixed effects. We estimate these stacked regressions using samples surrounding event windows in which treatment units receive RCM^{Imp}, and all other units that are never-treated in the importing country (clean

[28] Note that despite the positive main effect of RCM^{Imp} for Germany, the overall marginal effect of RCM^{Imp} is negative $(0.091 + (-0.170) = -0.079)$.

[29] Note that our dataset covers only products that receive RCM in at least one country during our sample period. However, all other importing country-product combinations never implementing the RCM are therefore never-treated units.

[30] There are 38,631,103 total observations in the sample with never-treated product-period observations of 36,317,716 and 36,756,188 regarding the importing and exporting country, respectively.

controls).[31] In this approach, we focus on event windows 12 months or quarters (hence, 3 years) before and after the introduction of RCM in the importing country, respectively. This leads to 37 (33) events in the monthly (quarterly) sample and decreases compared to the original 39 events by restricting treated units to have 12 pre-treatment periods. Table 4 displays the results for this 'treated vs. clean control' combinations. Note that choosing the event window is a question of research design. We choose a symmetric 12-period window around each event for computational capacity reasons. Given the constraints, such event window enables us to drop not too many events at the beginning or the end of the sample period. An additional benefit is that we minimize confounding effects over the long period examined in the baseline regressions.

Throughout the different specifications, we find a negative and statistically significant coefficient for RCM^{Imp}, except for the last column (see Table 4). RCM^{Exp} on the other side has a negative and statistically significant coefficient only in the monthly sample. Note that while the dummy for the RCM in the importing country only turns on for treated products, RCM in the exporting country can turn unity also for 'non-treated' country pair-product combinations (from the perspective of treatment in the importing country) within each specific dataset. Thus, relevant observations for the interaction between RCM^{Imp} and RCM^{Exp} are limited. In fact, the interaction term is not significant in the monthly sample but in the quarterly sample. However, the respective coefficient shows a negative sign in both samples as expected (see Table 4, Columns 2 and 4). This speaks for an unconditional effect of RCM^{Imp} and RCM^{Exp} within the event windows. Note that the adjusted R^2 decreases significantly compared to the baseline results from Table 2.

We take from this exercise that the introduction of the RCM in the importing country immediately affects our fraud proxy in the expected direction. Moreover, RCM^{Exp} shows a negative correlation when using a shorter time window suggesting the fraud-reducing effect in the form of shutting down fictitous exports (H2b). Overall and in line with the baseline results, if RCM in the importing and exporting country is in effect, $\ln TDG$ is lower.[32]

7. Fraud estimation

In Table A6 in the Appendix, we present back-of-the-envelope estimates of cross-border VAT fraud carried out before the introduction of RCM. To quantify the effect of the revenue impact of the RCM, we make use of the coefficients on RCM^{Imp} and RCM^{Exp} and their interaction from Column 4 in Table 2. The strategy grounds on the idea that the coefficients for RCM^{Imp} and RCM^{Exp} estimate the amount of fraud committed prior to the RCM introduction and tackled by the respective introduction. Since we measure fraud as the change in the ratio exports to imports, any change in fraud can be caused by exports or imports. As shown in Table 3, we argue that exports prior to RCM^{Imp} are abnormally high since the export values contain supplies to fraudsters that do not occur thereafter. At the same time, in terms of fraud, we expect lower (reported) imports as fraudsters capture market share from honest traders. We estimate fraud according to our hypotheses H1 (Table A6, Panel A), H2a (Panel B and C) and H2b (Panel D) (all Table A6, Appendix). To show how the estimates change within the respective confidence intervals, we calculate a lower bound, a midpoint, and an upper bound.

First (see Table A6, Appendix, Panel A), we make use of the main effect of RCM^{Imp} with a midpoint estimate of – 0.048 (see Table 2, Column 4) to quantify H1. This is equivalent to about 4.66% higher exports or 4.89% lower imports prior to its introduction *if RCM^{Exp} is not in force*.[33] We quantify the loss of tax revenue (*REVLOSS*) associated with MTIC fraud and tackled by RCM^{Imp} as the product of the lower bound, midpoint, and upper bound coefficient[34] and total exports and total imports prior to RCM^{Imp} (under the restriction that RCM^{Exp} does not apply) and the average VAT rate in the importing country for every treated country pair-product combination separated by the importing country.[35] The midpoint estimate of *REVLOSS* is about 5 to 5.1 billion euros in the observation period from 2003 to 2019 that RCM in the importing country has removed (see Table A6, Panel A, Columns 7 and 8). The lower bound and upper bound estimates are about 3 and 7.4 billion euros, respectively (see Table A6, Panel A, Columns 5, 6, 9 and 10).

Second (see Table A6, Appendix, Panel B), we quantify the effect of RCM^{Imp} for the case in which the exporting country applies the RCM (H2a). In this case, the effect magnitude is determined by the combination of RCM^{Imp} and the interaction coefficient that is – 0.098. Thus, we estimate a loss of VAT revenue tackled by RCM using the midpoint estimate between 1.3 and 1.4 billion euros during 2003 to 2019 (see Table A6, Panel B, Columns 7 and 8, Appendix). As the interaction term measures the additional effect of RCM^{Imp}, which we argue proxies for previous relocations, we estimate about 0.7 billion euros of relocations using the midpoint estimate of the interaction term only (see Table A6, Panel C, Columns 7 and 8, Appendix). The interval has a lower bound of 0.1 billion euros and an upper bound of 1.3 billion euros (see Table A6, Panel C, Columns 5, 6, 9 and 10, Appendix). This estimate appears to be small. However, we can only observe relocations in the limited case where the importing country reacted with an RCM application on these relocated fraud products. Therefore, the relocation effect is likely to be underestimated substantially.

Finally (see Table A6, Panel D, Appendix), we quantify the effect of RCM^{Exp} in the case where the importing country introduced the RCM (H2b). This estimation grounds on the midpoint estimate of RCM^{Exp} together with the interaction term.[36] However, we only use exports as the basis for the estimation since – from a theoretical point of view – imports should be unaffected by RCM^{Exp} in the context of H2b. We accordingly estimate curbed fraud of about 0.5 billion euros (see Table A6, Panel D, Column 5, Appendix).[37] The interval ranges from 0.1 to 0.9 billion euros in the lower and upper bound, respectively (see Table A6, Panel D, Column 4 and 6, Appendix).

To sum up, we estimate total fraud carried out prior to the RCM application within the EU between 7.5 and 7.7 billion euros using the midpoint estimates. This figure varies using the lower bound from between 3.9 and 4 billion euros and using the upper bound from between 11 and 11.6 billion euros.

In a simplified calculation, we find that only 0.35% of the annual

[31] Extending the observation period had to be weighed against the benefits for reasons of computational demand since an event span over 12 months or quarters already required a large amount of computational capacity.

[32] For the monthly sample that is – 0.067 (−0.024 - 0.010 - 0.033), see Table 4, Column 2. For the quarterly sample that is – 0.115 (−0.008 + 0.003 – 0.110), see Table 4, Column 4.

[33] For the calculation, see Table A6 in the Appendix.

[34] We use the midpoint estimate given as the coefficient in the baseline regression and as the lower and upper bound the lower and upper estimate of the 95% confidence interval of the coefficient.

[35] A treated country applies RCM^{Imp} at one point in time during the observation period.

[36] Recall our discussion of the baseline results towards RCM^{Exp}. The main effect is not statistically significant, however, a joint significant test of RCM^{Exp} and the interaction term revealed a statistically detectable effect of both coefficients together. Moreover, a meaningful effect is backed from a theory point of view. RCM^{Exp} should only show clear (negative) effects on the fraud proxy when RCM^{Imp} is not in force due to the expectation that fraudsters unlikely relocate to countries where the RCM applies.

[37] Note that regarding the estimation of H2b, treated products are now those that fall under RCM at one point in time in the *exporting* country.

VAT gap (based on 2019) has been tackled by the mechanism.[38] This undermines the importance of this measure in the fight against VAT fraud. However, we are very likely observing only the tip of the iceberg with our model. Carousel fraud can go on for a long time, unnoticed by our estimation, if the fraudsters first properly report their sales. One can assume that the fraudsters only refrain from reporting in the last step and disappear with the VAT. In this respect, we probably only observe this last step, which is why one must be careful when interpreting our estimates. Furthermore, our model fails to detect when fraudsters trade products that are not covered by RCM. In this respect, we cannot make a corresponding estimate either, so the total fraud within the EU may be significantly higher.

As additional drawback, we may shed light on the burden for firms when RCM applies. In a survey-based study, EY (2014) finds that the RCM creates about 0.13% additional compliance cost of turnover of the underlying firms. They extrapolated that result and estimate additional compliance cost of about 0.32 billion euros per year generated by the RCM. If these costs remain unchanged over the years, the compliance burden for firms can be estimated at about 5.1 billion euros during our observation period.[39] Holding this against the light of the estimated VAT fraud at the same time, we conclude that the effect of RCM outweighs the estimated compliance costs as well as the estimated relocations.

8. Conclusion

VAT is one of the main contributors to the EU Member States' budgets. However, the tax exemption on intra-Community supplies allows fraudsters to make tax-neutral acquisitions from other Member States and resell the products without paying the tax collected to the tax authorities (MTIC fraud). To tackle this fraud scheme, the RCM shifts the liability for the VAT payment to the customer. We quantify the effect of the RCM using asymmetries in international trade (trade data gap, TDG) as a proxy for MTIC fraud.

We find evidence that the introduction of RCM in the importing country removes MTIC fraud regarding the products that are covered by the mechanism. This is reflected by a significant reduction in the discrepancies of the double-reported cross-border trade data. For RCM products, we find that the ratio of exports reported by the exporting country to corresponding imports reported by the importing country decreases by about 5% after the installation of RCM in the importing country when the RCM in the exporting country is not in force. This effect increases to approximately 9.8% when the exporting country applies the RCM as well. This suggests that fraudsters previously relocated their activities to countries without RCM. The RCM implementation in one country intensifies MTIC fraud in countries that do not apply RCM. This explains the domino effect of RCM applications in the EU. However, why we do perhaps not see a clear domino effect is that countries deal with different levels of fraud and any country decides to implement the RCM based on a (predicted) cost-benefit analysis. Reality shows that many countries do not implement the RCM right after another country shuts down fraud using the mechanism. Some countries might be more drawn to other measures also explained in this study, experience less fraud when fraudsters relocate to not only a single other country and when implementing the RCM is too costly from a Member State's perspective. Moreover, there is evidence that the introduction of the RCM in the exporting country curbs a system of 'fictitious exports', in which fraudsters declare domestic supplies as zero-rated exports and thus do not remit the collected VAT to the tax authority.

For the observation period from 2003 to 2019, we estimate VAT losses from MTIC fraud tackled by RCM to range from 7.5 to 7.7 billion euros using the midpoint estimates in countries that have implemented RCM on these products. Of this, we estimate losses from fictitious exports of around 0.5 billion euros and from the relocation of MTIC fraud of around 0.7 billion euros using the midpoint estimate. Given the high compliance cost for firms (of about 5.1 billion euros in total) that must deal with two different VAT systems, the RCM as a selective intervention should be viewed critically.

However, referring to the question stated in the title of this paper, the benefits of RCM seem to outweigh the costs so that the mechanism does not cause more harm. However, we emphasize that despite this positive net result, we are only able to observe fraud reduced regarding the affected products in countries implementing the mechanism. Moreover, we likely underestimate fraud activity in cases where exporter and importer involved in the fraud report truthfully while carrying out a harmful carousel fraud scheme.

Our results are non-exclusive regarding the application within the EU. Non-EU-countries with VAT systems within free trade agreements (FTA) might consider mechanism like the RCM as well. The findings suggest that if at all RCM were to be applied, it should be used uniformly for all products and participating countries.

Declaration of Competing Interest

The authors have no relevant financial or non-financial interests to disclose.

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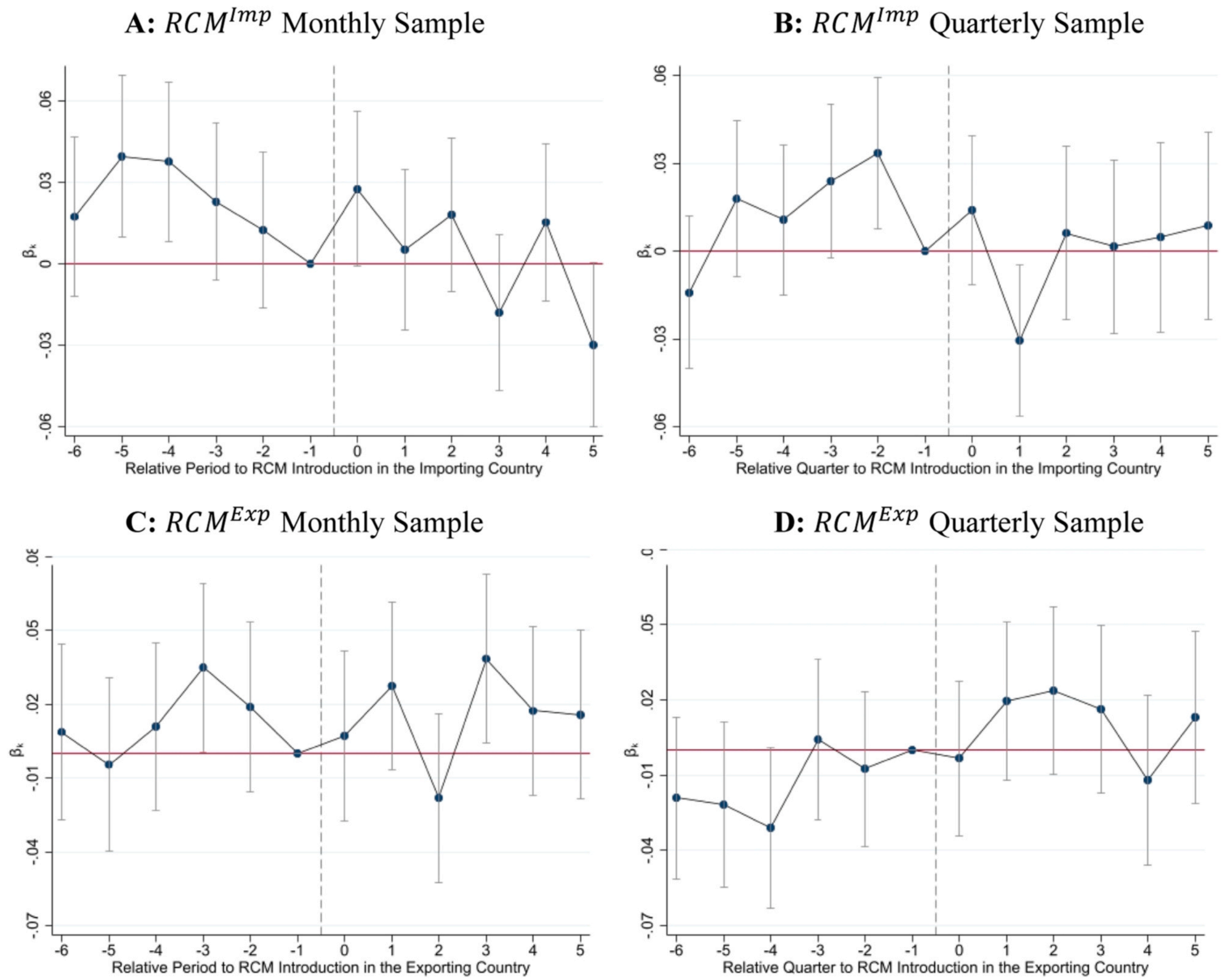
[38] Because the estimates are based on total exports and imports, we cannot provide an accurate measure of the exact annual fraud. Nonetheless, assuming constant fraud over the observation period shows that the total amount of 7.7 billion euros as the upper bound of the midpoint estimation divided by the 17 observations years is just 0.45 billion euros per year. This means that measured against the estimated EU VAT Gap by Poniatowski et. al (2021) of 134 billion euros in 2019, the proportion tackled by the RCM amounts to 0.34%. In terms of total VAT revenues, the shares represent only 0.04% of the 2019 revenues of 1.176 billion euros. We do not use the more recent study by Poniatowski et. al (2023) due to the exit of Great Britain from the EU.

[39] Note that the estimate of EY (2014) is not without drawbacks as it is based on a small sample of firms (36 firms from six member states) and only carried out for one year.

Appendix



Event Study Coefficients – 6 Periods before and after RCM. Notes: Graphics A and B display the coefficients of lags (pre-trends) and leads (dynamic effects) of RCM^{Imp} from Eq. (3) for the monthly and quarterly sample, respectively. Graphics C and D display the coefficients of lags (pre-trends) and leads (dynamic effects) of RCM^{Exp} from Eq. (4) for the monthly and quarterly sample, respectively. The baseline period ($k = -1$), the period before the actual RCM^{Imp} or RCM^{Exp} implementation, is set to zero. The monthly (quarterly) sample consists of observations 6 months (quarters) prior and after RCM. Grey lines indicate the 90% confidence interval.

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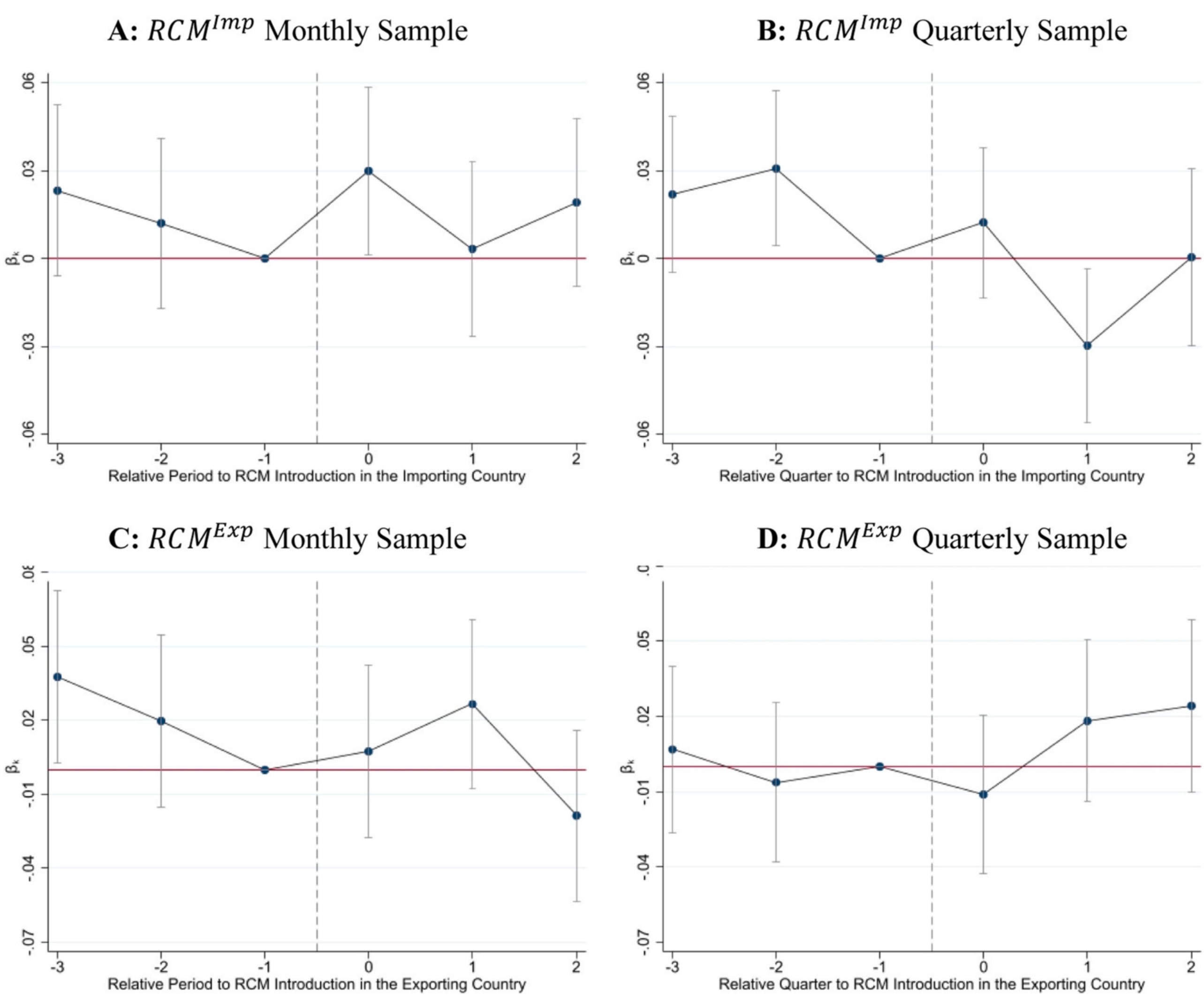

Fig. A2. . Event Study Coefficients – 3 Periods before and after RCM. Notes: Graphics A and B display the coefficients of lags (pre-trends) and leads (dynamic effects) of RCM^{Imp} from Eq. (3) for the monthly and quarterly sample, respectively. Graphics C and D display the coefficients of lags (pre-trends) and leads (dynamic effects) of RCM^{Exp} from Eq. (4) for the monthly and quarterly sample, respectively. The baseline period ($k = -1$), the period before the actual RCM^{Imp} or RCM^{Exp} implementation, is set to zero. The monthly (quarterly) sample consists of observations 3 months (quarters) prior and after RCM. Grey lines indicate the 90% confidence interval.

Table A1
All product-specific RCM implementations.

Country	Product Group	Date of Introduction	Source
Austria (AT)	Waste and Scrap Metals	2007/07/01	Scrap Value Added Tax Ordinance of 15.06.2007
	Mobile Phones	2012/01/01	§ 19 (1e) d) VAT Act
	Integrated Circuits	2012/01/01	
	Game Consoles	2014/01/01	§ 2 of the Ordinance of the Federal Minister of Finance on transactions for which the tax liability is transferred to the recipient of the service in order to combat VAT fraud (UStBBKV)
	Laptops and Tablet-PCs	2014/01/01	
	Metals	2014/01/01	
Bulgaria (BG)	Waste and Scrap Metals	2007/01/01	Part One of Annex 2 to Chapter 19 (a) (Art. 163 (a)) of the VAT Act
	Cereals/Industrial Crops	2014/01/01	Part Two of Annex 2 to Chapter 19 (a) (Art. 163 (a)) of the VAT Act
	Metals/Chemical Products	2019/07/01	Annex No. 3 to art. 167a of the VAT Act
Czech Republic (CZ)	Waste and Scrap Metals	2011/04/01	Annex No. 5 to Act No. 235/2004 Coll.
	Mobile Phones	2015/04/01	Annex No. 6 to Act No. 235/2004 Coll.
	Integrated Circuits	2015/04/01	
	Game Consoles	2015/04/01	
	Laptops and Tablet-PCs	2015/04/01	
	Agricultural Crops	2015/07/01	https://www.tmf-group.com/en/news-insights/articles/2015/august/czech-reverse-charge/
	of which Sugar Beets	2015/09/01	
Germany (DE)	Waste and Scrap Metals	2011/01/01	Art. 4 No. 8 in connection with. Art. 32 (5) JStG 2010 v. Dec. 8, 2010, BGBl. I 2010, 1768
	Mobile Phones	2011/07/01	Art. 6 in connection with. Art. 7 (1) of the Sixth Act Amending Excise Tax Laws of June 11, 2011, Federal Law Gazette I 2011, 1090.
	Integrated Circuits	2011/07/01	
	Game Consoles	2014/10/01	Art. 8 No. 2 letter a double letter bb in connection with. Art. 8 No. 5 in connection with. Art. 28 (4) KroatienStAnpG v. 25.7.2014, BGBl. I 2014, 1266.
	Laptops (without Tablet-PCs)	2014/10/01	
	Metals	2014/10/01	
Denmark (DK)	Waste and Scrap Metals	2012/07/01	Art. 3 of Law no. 590 of 18/06/2012
	Mobile Phones	2014/07/01	Art. 46 (1), Pos. 8-10 of the VAT Act.
	Integrated Circuits	2014/07/01	
	Game Consoles	2014/07/01	
	Laptops and Tablet-PCs	2014/07/01	
Estonia (EE)	Precious Metals	2014/07/01 and 2015/01/01	RT I, 06.06.2014, 2 and RT I, 06.06.2014, 2
	Scrap Metals	2014/07/01 and 2015/01/01	RTL 2004, 49, 843
	Metals	2017/07/01	RT I, 08.11.2016, 1; modified by RT I, 24.04.2018, 2
Spain (ES)	Waste and Scrap Metals	2004/01/01	Annex 7 VAT Act
	Non-precious Metals	2004/01/01	
	Mobile Phones	2015/04/01	Annex 10 VAT Act
	Game Consoles	2015/04/01	
	Laptops and Tablet-PCs	2015/04/01	
	Precious Metals	2015/04/01	
Finland (FI)	Scrap Metals	2015/01/01	Law 27/06/2014/507 modifying art 8d of the 30.12.1993/1501 VAT Act
France (FR)	(New) Industrial Waste and Recoverable Materials	2008/01/01	Law No. 2007-1824 of 25 December 2007 - art. 57
Great Britain (GB)	Mobile Phones	2007/06/01	Law of 2007 No. 1417
	Integrated Circuits	2007/06/01	
Greece (GR)	Waste and Scrap Metals	2007/01/01	Law 3522/2006
	Mobile Phones	2017/08/01	Law 4484/2017
	Game Consoles	2017/08/01	
	Laptops and Tablet-PCs	2017/08/01	
Croatia (HR)	Waste and Scrap Metals	2013/07/01	Art. 75 VAT Act
	Iron and Steel	2019/01/01	Art. 10 of OG 106/2018 modifying Art. 75 of the VAT Act
Hungary (HU)	Waste and Scrap Metals	2006/07/01	Act CXXVII of 2007 on VAT
	Selected Agriculture Commodities	2012/07/01	Act XLIX of 2012 on VAT
	Selected Metals	2015/01/01	Act XXXIII of 2014 on VAT

(*continued on next page*)

Table A1 (*continued*)

Country	Product Group	Date of Introduction	Source
Ireland (IE)	Waste and Scrap	2011/05/01	Art. 16 of VALUE-ADDED TAX CONSOLIDATION ACT 2010
Italy (IT)	Waste and Scrap Metals	Since 2003	Art. 74 of Decree No. 633/1972
	Selected non-precious Metals	Since 2003	
	Personal Computers	2007/01/01-2016/05/02	Circular of 12/27/2006 No. 296; Personal Computers exchanged by RCM on laptops and tablet-PCs
	Mobile Phones	2011/04/01	Circular of 23/12/2010 no. 59
	Integrated Circuits	2011/04/01	
	Game Consoles	2016/05/02	Legislative Decree No. 24 of 11 February 2016
	Laptops and Tablet-PCs	2016/05/02	
Lithuania (LT)	Selected Wood	2008/01/01	Resolution No. 1390 of 19.12.2007
	Waste and Scrap Metals	2008/01/01	
	Mobile Phones	2019/08/01	Resolution No. 395 of 24.4.2019
	Laptops and Tablet-PCs	2019/08/01	
	Hard Disks	2019/08/01	
Latvia (LV)	Wood (HS Code 4407)	1999/07/01	Law 133/135 of 30.04.1999
	Firewood and wood chips	2016/01/01	Law 2015/248.18
	Mobile Phones	2016/04/01	Law 2015/248.18
	Laptops and Tablet-PCs	2016/04/01	
	Integrated Circuits	2016/04/01	
	Selected Agriculture Products	2016/07/01	Law 2016/120.2
	Precious Waste and Scrap Metals	2017/01/01	Law 2016/241.48
	Game Consoles	2018/01/01	Law 2017/156.11
	Metals	2018/01/01-2019/07/01	Law 2017/228.10 (the RCM was repealed from July 2019 for some metal products)
	Household appliances and consumer electronics	2018/01/01-2020/01/01	
Netherlands (NL)	Clothing (without footwear)	1992-2013/04/01	Value Added Tax Implementing Ordinance OB 1968
	Waste and Scrap Metals	2007/01/01	Staatsblad. 2006, 684
	Mobile Phones	2013/04/01	Staatsblad 2012, 694 (from 1.6.2012 to introduction optional RCM)
	Integrated Circuits	2013/04/01	
	Game Consoles	2013/04/01	
	Laptops and Tablet-PCs	2013/04/01	
Poland (PL)	Selected Waste and Scrap Metals	2011/07/01	Product codes (so-called PKWiU) were gradually added to Annex 11 of the Polish VAT act and need to be converted into HS codes. From 1.11.2019 on all RCM products fall under the Split-Payment-Mechanism
	Additional Waste and Scrap Metals	2013/10/01	
	Mobile Phones	2015/07/01	
	Laptops and Tablet-PCs	2015/07/01	
	Game Consoles	2015/07/01	
	Selected Metals	2015/07/01	
	Additional Metals and Integrated Circuits	2017/01/01	
	Hard Disks	2018/01/01	
Portugal (PT)	Waste and Scrap Metals	2006/10/01	Law No. 33/2006
Romania (RO)	Waste and Scrap Metals	2005/01/01	Law 571/2003
	Wood	2005/01/01	
	Selected Cereals	2011/06/01	Emergency Order No. 49
	Mobile Phones	2016/01/01	Law 227/2015
	Integrated Circuits	2016/01/01	
	Game Consoles	2016/01/01	
	Laptops and Tablet-PCs	2016/01/01	
Sweden (SE)	Waste and Scrap Metals	2013/01/01	Law 2012, 755
Slovenia (SI)	Waste and Scrap Metals	2010/01/01	Official Gazette of the Republic of Slovenia, No. 85/2009, of 30 October 2009
Slovakia (SK)	Waste and Scrap Metals	2009/04/01	83/2009 Coll.
	Mobile Phones	2014/01/01	360/2013 Coll.
	Integrated Circuits	2014/01/01	
	Iron and Steel	2014/01/01	
	Selected Cereals	2014/01/01	

Notes: For gold (Art. 198 according to VAT Directive) RCM is only possible if min. 325 fineness; however, the CN Code does not distinguish; this therefore also includes supplies of investment gold, which are VAT-exempt in many countries. To gather information on RCM implementations, we collected the respective product codes and implementation dates by manually researching the national tax laws of each EU member state. Implementation dates are displayed using YYYY/MM/DD.

Table A2
Standard VAT Rate in the EU Member States Between 2003 and 2019.

EU Member State	VAT (in Percent)	Period
Austria (AT)	20	01.01.2003-31.12.2019
Belgium (BE)	21	01.01.2003-31.12.2019
Bulgaria[a] (BG)	20	01.05.2004-31.12.2019
Cyprus[a] (CY)	15	01.05.2004-28.02.2012
	17	01.03.2012-13.01.2013
	18	14.01.2013-12.01.2014
	19	13.01.2014-31.12.2019
Czech Republic[a] (CZ)	19	01.05.2004-31.12.2009
	20	01.01.2010-31.12.2012
	21	01.01.2013-31.12.2019
Germany (DE)	16	01.01.2003-31.12.2006
	19	01.01.2007-31.12.2019
Denmark (DK)	25	01.01.2003-31.12.2019
Estonia[a] (EE)	18	01.05.2004-30.06.2009
	20	01.07.2009-31.12.2019
Spain (ES)	16	01.01.2003-30.06.2010
	18	01.07.2010-30.08.2012
	21	01.09.2012-31.12.2019
Finland (FI)	22	01.01.2003-30.06.2010
	23	01.07.2010-31.12.2012
	24	01.01.2013-31.12.2019
France (FR)	19,6	01.01.2003-31.12.2013
	20	01.01.2014-31.12.2019
Great Britain (GB)	17,5	01.01.2003-30.11.2008
	15	01.12.2008-31.12.2009
	17,5	01.01.2010-03.01.2011
	20	04.01.2011-31.12.2019
Greece (GR)	19	01.01.2007-14.03.2010
	21	15.03.2010-30.06.2010
	23	01.07.2010-31.05.2016
	24	01.06.2016-31.12.2019
Croatia[a] (HR)	25	01.07.2013-31.12.2019
Hungary[a] (HU)	25	01.05.2004-31.12.2005
	20	01.01.2006-30.06.2009
	25	01.07.2009-31.12.2011
	27	01.01.2012-31.12.2019
Ireland (IE)	21	01.01.2007-30.11.2008
	21,5	01.12.2008-31.12.2009
	21	01.01.2010-31.12.2011
	23	01.01.2012-31.12.2019
Italy (IT)	20	01.01.2003-16.09.2011
	21	17.09.2011-30.09.2013
	22	01.10.2013-31.12.2019
Lithuania[a] (LT)	18	01.05.2004-31.12.2008
	19	01.01.2009-30.08.2009
	21	01.09.2009-31.12.2019
Luxembourg (LU)	15	01.01.2003-31.12.2014
	17	01.01.2015-31.12.2019
Latvia[a] (LV)	18	01.05.2004-31.12.2008
	21	01.01.2009-31.12.2010
	22	01.01.2011-30.06.2012
	21	01.07.2012-31.12.2019
Malta[a] (MT)	18	01.05.2004-31.12.2019
Netherlands (NL)	19	01.01.2003-30.09.2012
	21	01.10.2012-31.12.2019
Poland[a] (PL)	22	01.05.2004-31.12.2010
	23	01.01.2011-31.12.2019
Portugal (PT)	19	01.04.2003-30.06.2005
	21	01.07.2005-30.06.2008
	20	01.07.2008-30.06.2010
	21	01.07.2010-31.12.2010
	23	01.01.2011-31.12.2019
Romania[a] (RO)	19	01.05.2004-30.06.2010
	24	01.07.2010-31.12.2015
	20	01.01.2016-31.12.2016
	19	01.01.2017-31-12-2019
Sweden (SE)	25	01.01.2003-31.12.2019
Slovenia[a] (SI)	20	01.05.2004-30.06.2013
	22	01.07.2013-31.12.2019
Slovakia[a] (SK)	19	01.05.2004-31.12.2010
	20	01.01.2011-31.12.2019

Notes: Information on VAT rates are extracted from European Commission (2020).
[a] Time period starts with the date of respective EU accession.

Table A3
Variables.

Variable	Explanation	Source
ln*TDG*	Logarithmic ratio of exports to country B reported by country A and the corresponding imports from country A reported by country B.	Eurostat
RCM^{Imp}	Dummy variable that takes on the value of 1 if the product falls under the reverse-charge-mechanism (RCM) in the importing Member State and zero otherwise.	See Table A1, Appendix
RCM^{Exp}	Dummy variable that takes on the value of 1 if the product falls under the reverse-charge-mechanism (RCM) in the exporting Member State and zero otherwise.	See Table A1, Appendix
VAT^{Imp}	Standard value-added tax (VAT) rate in the importing Member State.	See Table A2, Appendix
VAT^{Exp}	Standard value-added tax (VAT) rate in the exporting Member State.	See Table A2, Appendix
$\ln THRESHOLD^{Imp}$	Logarithm of the yearly Intrastat threshold of the importing Member State.	Eurostat
$\ln THRESHOLD^{Exp}$	Logarithm of the yearly Intrastat threshold of the exporting Member State.	Eurostat
DRR	Dummy variable that takes on the value of one from time *t* that the importing country implemented one of the following digital reporting requirements according to Luchetta et al. (2022) and zero otherwise: VAT Listings in Bulgaria from 1.1.2006, Latvia from 1.1.2011, Slovakia from 1.1.2014, Estonia from 1.11.2014, Czech Republic 1.1.2016, Hungary from 1.1.2019; SAF-T in Portugal from 1.1.2013, Poland from 1.7.2016, Lithuania from 1.10.2016; Real-time reporting in Spain from 1.7.2017, Hungary from 1.7.2018; E-Invoicing in Italy from 1.1.2019.	Luchetta et al. (2022)
EURO	Dummy variable that takes on the value of 1 if both Member States use the euro as the official currency and zero otherwise.	Website European Union
ROL^{Imp}	"Perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence." Rule of law in the importing country proxies the overall willingness to follow rules.	Worldwide Governance Indicators from The World Bank
ROL^{Exp}	Same as ROL_{Imp} for the exporting country.	Worldwide Governance Indicators from The World Bank

Table A4
Correlation Matrix Baseline Regression.

	Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1.	ln*TDG*										
2.	RCM^{Imp}	-0.005 * **									
3.	RCM^{Exp}	0.004 * **	0.294 * **								
4.	VAT^{Imp}	-0.000 * *	0.020 * **	0.032 * **							
5.	VAT^{Exp}	0.017 * **	0.040 * **	0.028 * **	0.110 * **						
6.	$\ln THRESHOLD^{Imp}$	0.019 * **	0.070 * **	0.057 * **	0.217 * **	0.158 * **					
7.	$\ln THRESHOLD^{Exp}$	-0.003 * **	0.033 * **	0.053 * **	0.125 * **	0.194 * **	0.219 * **				
8.	*DRR*	-0.003 * **	0.115 * **	0.058 * **	0.104 * **	0.107 * **	0.012 * **	0.075 * **			
9.	*EURO*	0.002 * **	-0.000 * **	0.000	-0.265 * **	-0.247 * **	-0.034 * **	0.061 * **	-0.040 * **		
10.	ROL^{Imp}	0.015 * **	-0.020 * **	-0.017 * **	-0.098 * **	-0.004 * **	0.385 * **	0.034 * **	-0.323 * **	0.134 * **	
11.	ROL^{Exp}	-0.015 * **	-0.021 * **	-0.021 * **	0.011 * **	-0.134 * **	0.029 * **	0.452 * **	-0.067 * **	0.047 * **	0.112 * **

Notes: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table A5
Country-Specific Regressions.

	Importing Country	Variable			Observations	Adjusted R^2
		RCM^{Imp}	RCM^{Exp}	$RCM^{Imp} \times RCM^{Exp}$		
(1)	AT	0.007 (0.026)	-0.014 (0.110)	-0.079 (0.123)	1,758,718	0.284
(2)	BE		-0.033 (0.061)		1,966,249	0.292
(3)	BG	-0.016 (0.025)	-0.069 (0.060)	-0.065 (0.060)	644,986	0.248
(4)	CY		-0.160 (0.153)		382,306	0.215
(5)	CZ	-0.108 (0.066)	0.042 (0.035)	0.012 (0.104)	1,784,007	0.256
(6)	DE	0.091 * * (0.042)	0.046 (0.036)	-0.170 * ** (0.062)	3,065,795	0.310
(7)	DK	-0.231 * * (0.103)	-0.096 (0.079)	0.278 * (0.162)	1,467,327	0.331
(8)	EE	-0.089 * * (0.040)	-0.054 (0.070)	-0.261 * ** (0.097)	893,725	0.227
(9)	ES	-0.059 (0.098)	-0.081 (0.062)	0.142 (0.119)	1,961,549	0.280
(10)	FI	-0.419 * ** (0.143)	0.036 (0.058)	0.084 (0.331)	1,278,018	0.238
(11)	FR	0.139 (0.086)	0.029 (0.043)	-0.142 (0.134)	2,629,674	0.275
(12)	GB	-0.093 (0.156)	0.010 (0.065)	0.155 (0.166)	2,110,864	0.286
(13)	GR	-0.392 * (0.218)	0.084 (0.072)	0.454 (0.286)	993,325	0.230
(14)	HR	-0.019 (0.022)	0.040 (0.048)	0.006 (0.050)	518,704	0.239
(15)	HU	-0.078 * (0.041)	-0.005 (0.048)	-0.154 * * (0.074)	1,361,607	0.278
(16)	IE	0.242 (0.364)	0.196 (0.140)	-0.137 (0.458)	778,702	0.374
(17)	IT	-0.298 * ** (0.085)	-0.061 * (0.036)	0.037 (0.132)	2,296,930	0.229
(18)	LT	-0.079 (0.083)	0.022 (0.043)	0.302 (0.281)	971,884	0.217
(19)	LU		0.190 * (0.104)		852,143	0.296
(20)	LV	-0.076 * ** (0.028)	-0.033 (0.077)	0.087 (0.084)	911,621	0.210
(21)	MT		0.180 (0.188)		276,319	0.240
(22)	NL	-0.037 (0.069)	0.232 * * (0.094)	0.053 (0.126)	1,465,122	0.366
(23)	PL	-0.134 * ** (0.028)	-0.003 (0.060)	-0.060 (0.072)	1,847,178	0.269
(24)	PT	-0.528 * (0.284)	0.031 (0.076)	0.015 (0.311)	1,223,170	0.246
(25)	RO	-0.047 (0.125)	-0.037 (0.039)	-0.205 (0.150)	1,210,151	0.234
(26)	SE	0.034 (0.249)	0.069 (0.061)	-0.195 (0.260)	1,578,182	0.299
(27)	SI	-0.518 * (0.307)	0.015 (0.038)	-0.257 (0.317)	1,181,950	0.252
(28)	SK	-0.187 * ** (0.033)	-0.235 * ** (0.087)	0.271 * ** (0.098)	1,220,897	0.274

Notes: The dependent variable is the monthly $\ln TDG$ defined in Eq. (1). The Superscripts 'Imp' and 'Exp' mark the importing and exporting country, respectively. For explanations on variables, see Table A3, Appendix. All regressions include controls, unit FE and time FE. Unit FE are exporting-country-8-digit product code combinations and time FE are year-month combinations from January 2003 to December 2019. The grayed-out boxes indicate that RCM^{Imp} estimates cannot be made for these countries due to lack of implementation. Standard errors are clustered by the unit FE identifier and are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Table A6
Fraud Estimation.

Panel A: Estimation of H1 (RCM^{Imp} reduces fraud in the importing country)

Main Effect of RCM^{Imp} if $RCM^{Exp} = 0$

$\beta_1^{LB} = -0.028, \beta_1^{MP} = -0.048, \beta_1^{UB} = -0.068$

Country	Total Exports of treated products before RCM^{Imp} in million euros	Total Imports of treated products before RCM^{Imp} in million euros	Average VAT Rate VAT^{Imp} in %	Lower Bound Fraud Estimation Based on Exports $REVLOSS = \left(1 - e^{\beta_1^{LB}}\right) \bullet (2) \bullet (4)$ in million euros	Lower Bound Fraud Estimation Based on Imports $REVLOSS = (e^{-\beta_1^{LB}} - 1) \bullet (3) \bullet (4)$ in million euros	Midpoint Estimate Fraud Estimation Based on Exports $REVLOSS = (1 - e^{\beta_1^{MP}}) \bullet (2) \bullet (4)$ in million euros	Midpoint Estimate Fraud Estimation Based on Imports $REVLOSS = (e^{-\beta_1^{MP}} - 1) \bullet (3) \bullet (4)$ in million euros	Upper Bound Fraud Estimation Based on Exports $REVLOSS = (1 - e^{\beta_1^{UB}}) \bullet (2) \bullet (4)$ in million euros	Upper Bound Fraud Estimation Based on Imports $REVLOSS = (e^{-\beta_1^{UB}} - 1) \bullet (3) \bullet (4)$ in million euros
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
AT	70.799	69.604	20.0	388	392	660	680	926	974
BG	17.225	17.294	20.0	94	97	160	169	225	242
CZ	27.717	27.147	19.8	150	151	255	262	358	375
DE	194.691	187.352	18.0	959	948	1.630	1.646	2.289	2.357
DK	13.598	13.789	25.0	93	97	158	168	222	241
EE	3.096	2.727	19.2	16	15	28	26	39	37
ES	27.678	23.568	17.3	131	115	223	199	313	285
FI	2.062	2.021	22.1	12	13	21	22	30	31
FR	4.531	4.366	19.6	24	24	41	42	58	60
GB	1.429	1.482	17.5	7	7	12	13	16	18
GR	3.841	4.313	21.3	22	26	38	45	54	64
HR	3.301	3.536	25.0	23	25	38	43	54	62
HU	10.789	9.338	23.7	70	62	119	108	167	155
IE	121	201	21.1	1	1	1	2	2	3
IT	36.386	33.884	20.6	205	196	349	341	490	488
LT	2.482	2.759	19.6	13	15	23	26	32	38
LV	9.239	8.675	20.2	51	49	87	86	122	123
NL	30.421	32.357	19.0	159	174	270	301	379	431
PL	58.782	59.863	22.4	360	377	612	654	859	936
PT	150	198	19.4	1	1	1	2	2	3
RO	7.670	7.626	21.4	45	46	76	80	107	114
SE	2.010	2.488	25.0	14	18	23	30	33	44
SI	750	710	20.0	4	4	7	7	10	10
SK	19.747	19.600	19.4	105	107	178	185	250	265
Sum	548.515	534.900		2.947	2.961	5.012	5.137	7.037	7.356

Panel B: Estimation of H2a (RCM^{Exp} relocates/increases fraud to/in the importing country)

Joint Effect of RCM^{Imp} and the Interaction between RCM^{Imp} and RCM^{Exp} if $RCM^{Exp} = 1$
$\beta^{LB} = \beta_1^{LB} + \beta_3^{LB} = -0.059, \beta^{MP} = \beta_1^{MP} + \beta_3^{MP} = -0.098, \beta^{UB} = \beta_1^{UB} + \beta_3^{UB} = -0.136$

Country	Total Exports of treated products before RCM^{Imp} in	Total Imports of treated products before RCM^{Imp} in million euros	Average VAT Rate VAT^{Imp} in %	Lower Bound Fraud Estimation Based on Exports $REVLOSS = (1 - e^{\beta^{LB}}) \bullet (2) \bullet (4)$ in million euros	Lower Bound Fraud Estimation Based on Imports $REVLOSS = (e^{-\beta^{LB}} - 1) \bullet (3) \bullet (4)$ in million euros	Midpoint Estimate Fraud Estimation Based on Exports $REVLOSS = (1 - e^{\beta^{MP}}) \bullet (2) \bullet (4)$ in million euros	Midpoint Estimate Fraud Estimation Based on Imports $REVLOSS = (e^{-\beta^{MP}} - 1) \bullet (3) \bullet (4)$ in million euros	Upper Bound Fraud Estimation Based on Exports $REVLOSS = (1 - e^{\beta^{UB}}) \bullet (2) \bullet (4)$ in million euros	Upper Bound Fraud Estimation Based on Imports $REVLOSS = (e^{-\beta^{UB}} - 1) \bullet (3) \bullet (4)$ in million euros

(*continued on next page*)

Table A6 (*continued*)

	million euros								
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
AT	365	368	20.0	4	4	7	8	9	11
BG	403	396	20.0	5	5	7	8	10	12
CZ	8.499	7.691	20.2	98	95	159	159	218	226
DE	18.009	19.111	18.8	194	219	314	368	430	522
DK	1.655	1.229	25.0	24	19	38	31	52	45
EE	115	85	20.0	1	1	2	2	3	2
ES	4.612	4.227	20.0	53	52	86	87	117	123
FI	3.163	3.105	23.2	42	44	68	73	93	104
FR	294	326	19.6	3	4	5	7	7	9
GB	No Observations								
GR	1.771	1.241	23.2	24	18	38	29	52	42
HR	388	400	25.0	6	6	9	10	12	15
HU	594	394	27.0	9	6	15	11	20	15
IE	132	182	21.1	2	2	3	4	4	6
IT	8.406	8.435	21.4	103	110	167	185	229	263
LT	2.158	1.815	20.9	26	23	42	39	57	55
LV	566	342	21.0	7	4	11	7	15	10
NL	1.711	1.043	19.2	19	12	30	20	42	29
PL	7.529	7.669	22.7	98	106	158	178	216	252
PT	70	44	19.6	1	1	1	1	2	1
RO	2.255	2.177	23.6	31	31	49	53	68	75
SE	459	725	25.0	7	11	11	19	15	26
SI	108	133	20.0	1	2	2	3	3	4
SK	5.096	5.303	19.7	58	64	93	107	127	152
Sum	68.360	66.444		815	838	1.317	1.407	1.801	1.999

Panel C: Estimation of H2a (RCMExp relocates/increases fraud to/in the importing country)
Only Interaction between RCM^{Imp} and RCM^{Exp}
$\beta_3^{LB} = -0.008$, $\beta_3^{MP} = -0.050$, $\beta_3^{UB} = -0.091$

Country	Total Exports of treated products before RCM^{Imp} in million euros	Total Imports of treated products before RCM^{Imp} in million euros	Average VAT Rate VAT^{Imp} in %	Lower Bound Fraud Estimation Based on Exports $REVLOSS = (1 - e^{\beta_3^{LB}}) \bullet (2) \bullet (4)$ in million euros	Lower Bound Fraud Estimation Based on Imports $REVLOSS = (e^{-\beta_3^{LB}} - 1) \bullet (3) \bullet (4)$ in million euros	Midpoint Estimate Fraud Estimation Based on Exports $REVLOSS = (1 - e^{\beta_3^{MP}}) \bullet (2) \bullet (4)$ in million euros	Midpoint Estimate Fraud Estimation Based on Imports $REVLOSS = (e^{-\beta_3^{MP}} - 1) \bullet (3) \bullet (4)$ in million euros	Upper Bound Fraud Estimation Based on Exports $REVLOSS = (1 - e^{\beta_3^{UB}}) \bullet (2) \bullet (4)$ in million euros	Upper Bound Fraud Estimation Based on Imports $REVLOSS = (e^{-\beta_3^{UB}} - 1) \bullet (3) \bullet (4)$ in million euros
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
AT	365	368	20.0	1	1	4	4	6	7
BG	403	396	20.0	1	1	4	4	7	8
CZ	8.499	7.691	20.2	14	12	83	79	150	148
DE	18.009	19.111	18.8	27	29	164	183	296	344
DK	1.655	1.229	25.0	3	2	20	16	36	29
EE	115	85	20.0	0	0	1	1	2	2
ES	4.612	4.227	20.0	7	7	45	43	81	81
FI	3.163	3.105	23.2	6	6	35	37	64	69
FR	294	326	19.6	0	1	3	3	5	6
GB	No Observations								
GR	1.771	1.241	23.2	3	2	20	15	36	27
HR	388	400	25.0	1	1	5	5	8	10
HU	594	394	27.0	1	1	8	5	14	10

(*continued on next page*)

Table A6 (*continued*)

IE	132	182	21.1	0	0	1	2	2	4
IT	8.406	8.435	21.4	14	15	87	92	157	173
LT	2.158	1.815	20.9	4	3	22	19	39	36
LV	566	342	21.0	1	1	6	4	10	7
NL	1.711	1.043	19.2	3	2	16	10	29	19
PL	7.529	7.669	22.7	14	14	83	88	149	166
PT	70	44	19.6	0	0	1	0	1	1
RO	2.255	2.177	23.6	4	4	26	26	46	49
SE	459	725	25.0	1	1	6	9	10	17
SI	108	133	20.0	0	0	1	1	2	3
SK	5.096	5.303	19.7	8	8	49	53	88	100
Sum	68.360	66.444		113	111	687	700	1.238	1.315

Panel D: Estimation of H2b (RCM^{Exp} reduces fraud in the exporting country)

Joint Effect of RCM^{Exp} and the Interaction between RCM^{Imp} and RCM^{Exp} if $RCM^{Imp} = 1$

$\beta^{LB} = \beta_1^{LB} + \beta_3^{LB} = -0.005$, $\beta^{MP} = \beta_2^{MP} + \beta_3^{MP} = -0.043$, $\beta^{UB} = \beta_2^{UB} + \beta_3^{UB} = -0.081$

Country	Total Exports of treated products before RCM^{Exp} in million euros	Average VAT Rate VAT^{Exp} in %	Lower Bound Fraud Estimation Based on Exports $REVLOSS = (1 - e^{\beta^{LB}}) \bullet (2) \bullet (3)$ in million euros	Midpoint Estimate Fraud Estimation Based on Exports $REVLOSS = (1 - e^{\beta^{MP}}) \bullet (2) \bullet (3)$ in million euros	Upper Bound Fraud Estimation Based on Exports $REVLOSS = (1 - e^{\beta^{UB}}) \bullet (2) \bullet (3)$ in million euros
(1)	(2)	(3)	(4)	(5)	(6)
AT	6.111	20.6	6	53	98
BG	0	21.0	0	0	0
CZ	126	22.4	0	1	2
DE	13.968	23.0	15	135	251
DK	165	22.1	0	2	3
EE	58	21.7	0	1	1
ES	5.865	19.5	5	48	89
FI	No Observations				
FR	1.634	20.2	2	14	26
GB	12.458	21.0	12	110	204
GR	7	19.4	0	0	0
HR	6	20.0	0	0	0
HU	551	19.9	1	5	9
IE	No Observations				
IT	3.183	21.7	3	29	54
LT	14	21.4	0	0	0
LV	565	20.9	1	5	9
NL	7.370	20.9	7	65	120
PL	1.014	21.3	1	9	17
PT	102	20.1	0	1	2
RO	635	22.2	1	6	11
SE	59	24.0	0	1	1
SI	139	20.5	0	1	2
SK	1.137	21.8	1	10	19
Sum	55.167		55	495	919

Notes: Belgium, Cyprus, Luxembourg and Malta are not included as no RCM was introduced in these countries (no treatment products). Coefficients of main effects and the interaction are from the baseline regression in Table 2, Column 4. In panel A, B, and C, treated products are products that fall under RCM in the importing country and in panel D, products that fall under RCM in the exporting country. The estimation of vat revenue lost (*REVLOSS*) based on exports is calculated as follows: total exports of treated products for a given importer multiplied with the average VAT rate of the respective period and the percentage change of $\ln TDG$ using the average treatment effect from Table 2, Column 4. The calculation is shown above the respective column. β^{LB}, β^{MP}, β^{UB} refer to the lower bound, midpoint and upper bound estimates of the coefficient within the 95% confidence interval, respectively. To calculate the sum of coefficients we use the linear combination (lincom code in Stata).

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