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Improving VAT compliance by switching who remits the tax: Evidence from construction firms

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Improving VAT compliance by switching who remits the tax: Evidence from construction firms*

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Abstract

Many countries use a reverse charge mechanism (RC) in the value added tax (VAT) system to combat tax evasion in specific high-risk sectors. The RC shifts the liability to remit VAT from the seller to the buyer. We study the adoption of RC in the construction sector in Finland in 2011 using tax return data on the universe of Finnish firms. Using a difference-in-differences design, we find that reported net VAT liabilities in the construction sector increased by 5%. According to our results, changing the remittance policy decreased VAT evasion by small subcontractors that provide services for large firms. Using a theoretical model, we show that reverse charge increases tax revenue relative to conventional VAT unless downstream firms increase tax evasion beyond the level previously undertaken by upstream firms, a response that requires a high degree of non-compliance.

Keywords: *tax compliance; value added tax; reverse charge mechanism; firm behavior.*

JEL Classification: *H25; H26; L74; O17; Z18.*

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1 Introduction

Collecting consumption taxes is one of the central tools of state funding. The majority of countries around the globe, including all OECD countries with the exception of the U.S., have adopted a value added tax (VAT) for this purpose (OECD, 2022). The widespread adoption of VAT is largely due to VAT's efficiency in tax collection, particularly its built-in mechanisms embedded in its remittance structure that help prevent tax evasion (Keen, 2008; Pomeranz, 2015).[1] Despite these advantages, VAT evasion remains prevalent even in developed tax systems. For instance, the VAT gap in the EU was estimated at 7% in 2022 (European Commission, 2024). A growing literature shows that remittance rules can play an important role in determining tax revenue (Kopczuk et al., 2016; Bibler et al., 2021; Kaçamak et al., 2023; Garriga and Tortarolo, 2024, among others). Accordingly, more than 50 countries have adopted a reverse charge (RC) mechanism, which reverses the remittance obligation in business-to-business transactions, to improve VAT compliance in high-risk sectors.[2]

The reverse charge shifts VAT liability from the seller to the buyer, altering the central feature of VAT collection. By moving remittance to the purchaser, RC eliminates the VAT evasion opportunity of the upstream firms (sellers). At the same time, the reform places the entire remittance obligation on the downstream firm, making RC similar to the sales tax, which is typically considered more vulnerable to evasion. As a result, the effect of RC on tax revenue depends on how downstream firms respond to the shift in tax liability. Despite its widespread adoption, empirical evidence on the effects of reverse charge policies remains limited.

This paper provides quasi-experimental evidence on the effects of a reverse charge policy using firm-level tax return data. The empirical analysis is based on the introduction of the reverse charge mechanism in the Finnish construction sector in 2011. The policy made the main contractors liable to remit the VAT of their subcontractors when buying construction services. The construction sector is of particular interest for studying reverse charge policies: it is widely regarded as high risk for VAT evasion, and reverse charge has been implemented in this sector in at least 29 countries (EY, 2024). The construction sector is characterized by long and sprawling contract chains, which can make tax evasion hard to detect for the tax authority despite the paper trail created by the VAT system. Our data, com-

[1] Under the VAT system, sellers remit VAT on their sales while deducting VAT paid on their purchases, creating incremental payments along the production chain. This process generates a paper trail, as businesses retain receipts to claim deductions, thereby reducing opportunities for tax evasion compared to sales tax systems, where the final seller bears full tax liability.

[2] According to our calculations, 52 countries have implemented a domestic reverse charge for some good or service. For a complete list, see Appendix Table A2.

prising of the universe of Finnish firms, allow us to observe firms' VAT liabilities and reverse charge remittances, enabling a detailed assessment of how changes in remittance rules affect tax reporting.

We estimate the effect of reverse charge using a differences-in-differences design. We compare firms in the construction sector, which became subject to the RC, to firms in other sectors that continued under the normal VAT system. To improve comparability, we use coarsened exact matching (CEM) to produce regression weights. After re-weighting, the firm groups have similar size and age distributions, as well as parallel trends before the policy.[3]

We find that the policy increased sales and tax liabilities reported by construction firms. On average, reported net VAT increased by 5% compared to the year before the policy was enacted. This is a substantial impact when considering that RC covered only 20% of sales in the sector. The results hold under a battery of robustness checks. Despite the reduction of evasion gains, we find no evidence of an effect on firm survival, suggesting that the policy had no large negative real effects on registered firms.

The results indicate an increase in overall tax compliance following the reform. This pattern suggests that the policy reduced tax evasion by subcontractors (upstream firms) without inducing an offsetting increase in evasion by main contractors (downstream firms). Consistent with this interpretation, our heterogeneity analysis shows that VAT accrued from small firms increases relatively more, while we find a negligible effect on the largest firms, which tend to act as main contractors remitting reverse charge payments.

The absence of a response among downstream firms can be rationalized by the institutional design not changing the evasion opportunities for them. In particular, the policy shifted remittance obligations without changing reporting requirements, thereby preserving the VAT paper trail. The key information the tax authority uses for VAT enforcement remains unchanged. As a result, the reform shut down an upstream evasion channel without weakening downstream enforcement. The policy shifted remittance to main contractors that are typically large firms, which are also likely to be more compliant at baseline, as they face stricter monitoring (Almunia & Lopez-Rodriguez, 2018), a higher risk of whistleblowing (Kleven et al., 2016), and potential reputational costs from tax evasion.

To formalize this intuition, we introduce a theoretical model of VAT evasion that includes the paper trail effect and a misreporting penalty, building on the canonical model by Allingham and Sandmo (1972). The model shows that reverse charge increases total tax revenue relative to the conventional VAT system

[3]Even without re-weighting, the differences in trends before the reform are small.

when downstream firms are relatively compliant, that is, when they do not evade more than their tax base, as their evasion costs do not change. In this case, reverse charge shuts down the evasion channel of upstream firms while leaving the optimal level of evasion of downstream firms unchanged, which is consistent with the empirical patterns we document. The key mechanism is that the misreporting penalty induces upstream firms to report their sales correctly, thereby preserving the paper trail generated under conventional VAT. In contrast, when downstream firms are highly evasive or fraudulent (evading more than their tax base) reverse charge may increase downstream evasion by making collusive evasion feasible, making the revenue effects ambiguous. Finally, the model implies that even when downstream firms are non-compliant, a VAT system with reverse charge generates higher tax revenue than a sales tax, due to the deterrence effect of the paper trail.

In addition to an increase in reported sales and net VAT, we observe an increase in reported deductions. This suggests that RC reduced under-reporting of sales as a mechanism of tax evasion rather than reducing over-reporting of costs. Over half of the increase in gross VAT liabilities is offset by a simultaneous rise in reported deductions. This response is in line with previous literature, where policy interventions are also followed by an unexpected increase in declared tax deductions (Carrillo et al., 2017; Konda et al., 2022). The increase in deductions can be explained by two factors. First, firms may have under-reported both their sales and deductions to obfuscate the true scale of their operations. Second, there could be an increase in false claims of deductions. A less likely explanation is an increase in prices of subcontractors, as it would show as increased input costs, particularly for large main contractors, i.e., those who remit the RC, yet we observe the biggest increases for small firms that rarely purchase construction services.

Finally, we investigate spillovers to reporting labor costs as well as the impact of subsequent tax enforcement policies implemented in the construction sector that increased contractors' reporting liabilities in 2013 and 2014. Together with RC, these policies increased the third-party information available to the Tax Administration on subcontractors' sales and employment. First, we observe an increase in payroll tax and withholding of personal income tax after the adoption of RC. This suggests spillovers of VAT enforcement to other tax bases. In particular, under-reporting of the scale of business operations potentially requires under-reporting of employment or vice versa. Second, we find that increasing the amount of third-party reporting after adopting RC may further increase the reporting of payroll taxes and withholding of personal income tax, but it does not increase the accrued VAT.

Our findings contribute to three strands of literature. First, this paper is among the first to evaluate the effects of reverse charge mechanisms in VAT.[4] We provide firm-level evidence from the construction sector, where reverse charge has been implemented in many countries. Relatedly, Buettner and Tassi (2023) study reverse charge using industry-level data in Germany, focusing on sectors targeted by refund fraud. Our evidence shows that reverse charge can also improve tax compliance in the context of domestic VAT evasion.

Second, our work relates to a broader literature on VAT enforcement properties and compliance. Waseem (2022) shows how the built-in withholding feature of VAT is significant in increasing reported sales, making VAT particularly suitable in environments where the upstream firms are more formal. Pomeranz (2015) and Naritomi (2019) study the significance of third-party information and Pomeranz (2015) also highlight the role of asymmetric incentives to cheat. Our results show that these enforcement channels may be insufficient in settings where upstream firms can evade despite the existence of a paper trail, and remittance design can therefore still matter for compliance. Other features related to VAT systems are discussed in e.g. Brusco and Velayudhan (2025) and Gadenne et al. (forthcoming) on VAT inducing segmentation in the economy; Harju et al. (2019) on compliance costs; Benzarti and Carloni (2019), Benzarti et al. (2020) and Bernardino et al. (2025) on incidence.

Finally, our paper relates to a growing literature on the importance of remittance rules for tax compliance. Kopczuk et al. (2016) find that diesel tax collection increases when the tax is levied on wholesalers rather than retailers. Garriga and Tortarolo (2024) show that appointing large firms to remit turnover tax on behalf of small businesses in Argentina led to significant improvements in tax reporting by their small-business partners. More broadly, other studies document compliance gains from shifting remittance or withholding obligations from fragmented taxpayers to larger intermediaries, including platforms, online retailers, and financial institutions (Bibler et al., 2021; Kaçamak et al., 2023; Brockmeyer and Hernandez, 2022). We add to this literature by providing evidence from VAT, which already has several beneficial enforcement properties, and from a high tax-capacity setting, finding that shifting tax remittance obligations to main contractors improves compliance.[5]

The rest of the paper is structured as follows. In the next section, we discuss the institutional context and the reverse charge policy. In Section 3, we present the data and the identification strategy. Section 4 presents the empirical results on the

[4]A recent working paper by Cipullo et al. (2024) studies RC in the Italian construction sector and also finds a positive effect on VAT revenues using balance sheet data.

[5]Finland has a tax-to-GDP ratio of 42%, one of the highest in the OECD (OECD, 2024), and little perceived corruption (Transparency International, 2023).

effects of RC on reported VAT. In Section 5, we summarize the theoretical model and discuss the conditions when RC increases tax revenue. Then, we present additional results and robustness analysis in Section 6. Finally, Section 7 concludes.

2 Institutional context

2.1 Value added taxation and the reverse charge VAT

VAT payments in a value chain

Value added tax is an ad valorem tax that is included in all transactions of goods and services. Businesses pay VAT on their sales and can deduct the VAT that is included in their input costs. This ensures that the tax is revenue-neutral as each company pays VAT based on its own value added. The VAT system is preferred by many governments due to its self-enforcing features and generation of incremental payments throughout the value chain in comparison to a sales tax (Keen, 2008; Pomeranz, 2015).

The self-enforcing nature of conventional VAT stems from how VAT is paid and deducted in business-to-business transactions. Table 1 describes VAT payments under the conventional system in column (1) in a short value chain with three firms. The upstream firm u sells production of value s_u to the intermediary, adding VAT at rate τ on the sales price, and pays τs_u in taxes, which is the VAT accrued from the transaction in column (3). The intermediary sells s_i to the downstream firm, creating value added of $s_i - s_u$, pays τs_i in VAT but deducts τs_u, with net payments of $\tau s_i - \tau s_u$. The total VAT accrued up to this transaction is τs_i. Finally, the downstream firm sells value τs_d to final consumers with net VAT payments of $\tau s_d - \tau s_i$. The total VAT accrued is $\tau * s_d$, which is collected incrementally in the value chain. The incremental collection throughout the value chain makes the VAT less vulnerable to the non-compliance of the final seller in comparison to a sales tax (Waseem, 2022).

Firms can engage in tax evasion, denoted by τe in Table 1, by under-reporting sales or over-reporting costs to reduce the tax burden. However, the incentives for upstream and intermediate firms to evade VAT are constrained by the behavior of intermediate and downstream firms. In order to claim the tax deduction on their costs, buyers need to acquire and store receipts for sales by the upstream firms. Collusion is less appealing, since upstream and downstream firms have asymmetric incentives for misreporting (Pomeranz, 2015). This generates a paper trail for the transactions that can be accessed by the tax authorities in a tax audit. The paper trail increases the probability of detection for the seller, which creates a self-

Table 1: VAT payments in a production chain

		(1) Conventional VAT		(2) Reverse Charge		(3) Accrued VAT
Upstream	Value added	s_u		s_u		
	VAT payment	$\tau * s_u$		0		
	VAT deduction	0		0		
	Net VAT	τs_u	$-\tau e_u$	0		τs_u
Intermediary	Value added	$s_i - s_u$		$s_i - s_u$		
	VAT payment	τs_i		τs_u		
	VAT deduction	τs_u		τs_u		
	Net VAT	$\tau s_i - \tau s_u$	$-\tau e_i$	0		$\tau s_i - \tau s_u$
Downstream	Value added	$s_d - s_i$		$s_d - s_i$		
	VAT payment	τs_d		$\tau s_d + \tau s_i$		
	VAT deduction	τs_i		τs_i		
	Net VAT	$\tau s_d - \tau s_i$	$-\tau e_d$	τs_d	$-\tau e_d^{RC}$	$\tau s_d - \tau s_i$
Total	liability	τs_d		τs_d		τs_d
	reported	$\tau(s_d - e_u - e_i - e_d)$		$\tau(s_d - e_d^{RC})$		

Notes: The table shows VAT liabilities in a value chain with upstream, subscript u, intermediary i and downstream d firms under conventional VAT in column (1) and a reverse charge mechanism in column (2), and how much value added tax is accrued from each transaction in column (3), and the total collected VAT in the last row. The downstream firm sells the final good or service to consumers and uses inputs sold by the intermediary. The intermediary buys inputs from another upstream firm. Reported sales are s_f for firm f, evasion is $e = v_f - \overline{v_f}$ where $v_f = s_f - c_f$ is the true value added, i.e. sales minus costs, and $\overline{v_f}$ is the reported value added.

enforcing feature in the VAT system (Pomeranz, 2015). For example, because the intermediary stores receipts of sales s_u the detection probability for the upstream firm is higher.

However, the self-enforcing mechanism is weaker when the supply chains are complex and long, and the transactions become hard to track. This can create opportunities for tax evasion where an upstream firm invoices the VAT, entitling the buyer to deductions, but does not remit the VAT to the tax authority. In other words, the seller and the buyer send conflicting tax returns, and the government ends up reimbursing the buyer for unpaid taxes. Consider the value chain in Table 1 when the upstream firm does not comply: The intermediate firm still deducts τs_u and the total collected VAT is now $\tau s_d - \tau s_u$. The authorities may observe that the value of goods and reported taxes does not add up, but identifying evaders in complex supply chains is costly.

Reverse charge payments in a value chain

Reverse charge VAT switches the remittance of the tax in business-to-business transactions to the buyer. Column (2) in Table 1 describes VAT payments under an RC mechanism. The upstream firm sells the service s_u to the intermediary, but does not invoice or pay VAT. Instead, the intermediary must remit the VAT τs_u to the authorities. This payment is referred to as the reverse charge. As with regular VAT, the reverse charge VAT is tax deductible so the intermediate can deduct τs_u and has net VAT liability of zero. Similarly, the intermediate sells s_i to the downstream firm, and the downstream firm must remit the tax τs_i, and can deduct it. At the final sale, the downstream firm is liable to remit VAT on its sales s_d, and pays the total VAT τs_d accrued in the value chain.

The second to last row in Table 1 shows that the total VAT paid under the conventional system and reverse charge is the same without tax evasion. With the changed remittance, the full tax liability is paid at the final sale. This makes the system more similar to a sales tax, with a key difference that the upstream and intermediary firm are still liable to report their sales in the VAT form, thus preserving the paper trail in the VAT system.

The reverse charge removes the possibility of VAT evasion τe for the upstream and intermediary firms. The total tax evasion is dependent on the behavior of the downstream firm.

2.2 VAT in Finland

Filing VAT

In Finland, all businesses that sell goods or services are required to report and pay value-added taxes, with exemptions for micro firms. At the time of our policy reform, the standard VAT rate was 23%. Finland does not have transaction-level VAT reporting, as firms only report their aggregate taxes, sales, and deductions. The VAT form is a streamlined document that requires no information about trading partners or individual transactions. Hence, relatively little information is sent to the tax authority through VAT returns. However, firms must hold on to their receipts available for an audit for at least six years. More detailed description of the Finnish VAT system is provided in Appendix A.1 including an example of the VAT form.

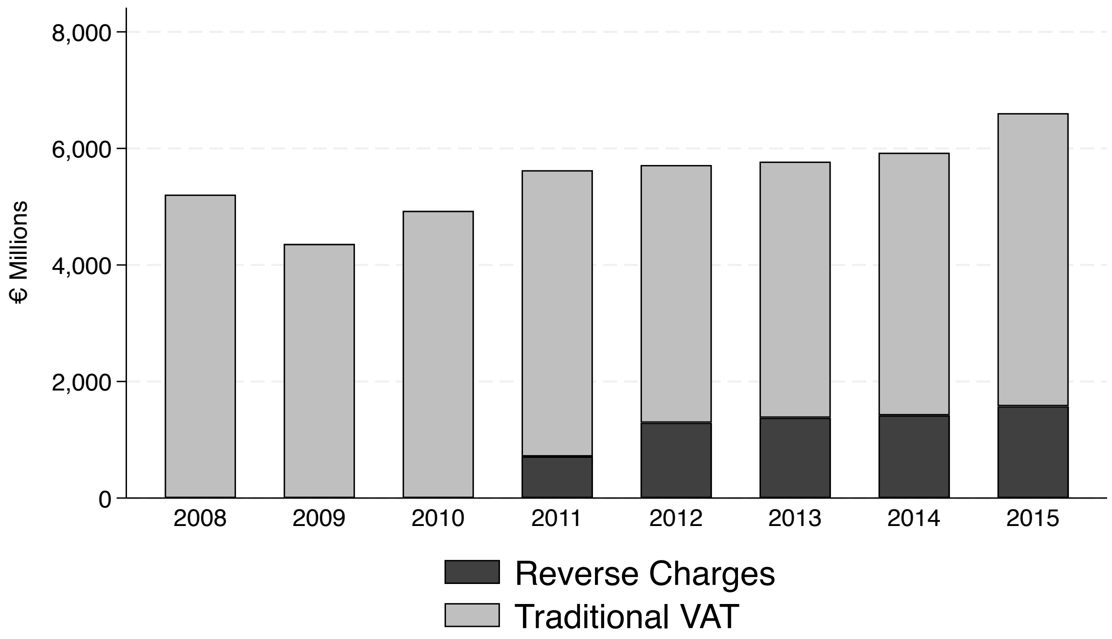

Figure 1: Reported gross VAT in the construction sector.
Notes: The figure presents the evolution of aggregate reported gross VAT in the construction sector from 2008 to 2015, divided into tax reported through conventional VAT in lighter shade and that reported as reverse charge in darker shade. The reverse charge policy took place in April 2011.

Reverse charge in the Finnish construction sector

Finland adopted a reverse charge policy in construction services in April 2011 with the goal of reducing tax evasion by subcontractors, i.e., upstream firms. Liability for value added tax was switched from the seller to purchaser when the following conditions are met: i) construction services are sold, ii) the purchaser is a business that sells construction services on a regular basis[6], and iii) the service is sold in Finland. The RC policy always applies if the business purchasing construction services has registered its main industry as construction. The reverse charge policy was immediately applied to any new contracted work.[7] When RC is applied, the purchaser is liable for remitting the tax but both parties must report the value of the transaction in their VAT returns. Subcontractors itemize their sales under reverse charge separately from other sales in their tax form.[8]

Reverse charges contributed 19.7% of the annual gross VAT reported in the construction sector after the reform. Figure 1 depicts the evolution of the total amount of VAT in the construction sector divided into conventional and reverse charge. In

[6]In practice, "regular basis" means annually.
[7]More details of the adoption of the policy are provided in Appendix A.1.
[8]Appendix A.1 shows the VAT form.

2010, total VAT is approximately €4.9 billion. In 2012, this is approximately €5.7 billion, of which approximately €1.3 billion is reverse charge payments. The share of reverse charge payments is smaller in 2011, when not all contracts were under reverse charge, but the share is steady after 2012. In 2008–2015, there was around 50,000 businesses registered as construction firms.

The RC policy was implemented in the construction sector as the industry was perceived particularly susceptible for evasion. The Finnish construction sector features long and sprawling contract chains that create opportunities for tax evasion. The industry's cyclical nature and project-focused structure discourage the retention of an extensive in-house workforce. In addition, large construction projects may require many different types of specialized labor. Firms and workers are contracted on a project-by-project basis. Construction projects often include multiple contractors and agency-hired labor. Due to the structure of the value chains, a handful of large downstream firms account for a large fraction of total sales: the top 1% of firms had 52% of sales, whereas 97 % of firms had annual revenues below €2 million.

Later tax enforcement policies in the construction sector

Reverse charge has been one of several actions and policies aimed at addressing tax evasion in the construction sector in recent decades. The other policies targeted untaxed labor in particular. According to the tax authorities, VAT evasion often takes place together with other types of evasion such as evasion of labor taxes. Companies that employ undocumented labor aim to hide their true sales since otherwise it might suggest a larger workforce than that reported. Fabricated receipts produce financial gains, but they are also used to claim that the company's workforce is contracted from other providers. Appearing smaller on paper enables non-compliant companies to avoid a considerable amount of payroll taxes as well as direct taxes.

Figure 2 plots a timeline of tax enforcement policies introduced in the construction sector and Appendix Table A1 collects the dates when the policies were announced and implemented. Before our study period, a 2007 law on contractors' obligations and liability for hired labor required that a contractor[9] is obligated to ensure that their business partners have registered with the appropriate tax registers, including the VAT register, and that vendors have no outstanding tax debt. While the policy was implemented for the whole economy, it affected construction sector in particular. In 2008–2012, the Tax Administration ran a dedicated construc-

[9]The policy applies when an enterprise hires temporary workers for more than 10 days or more than €9,000.

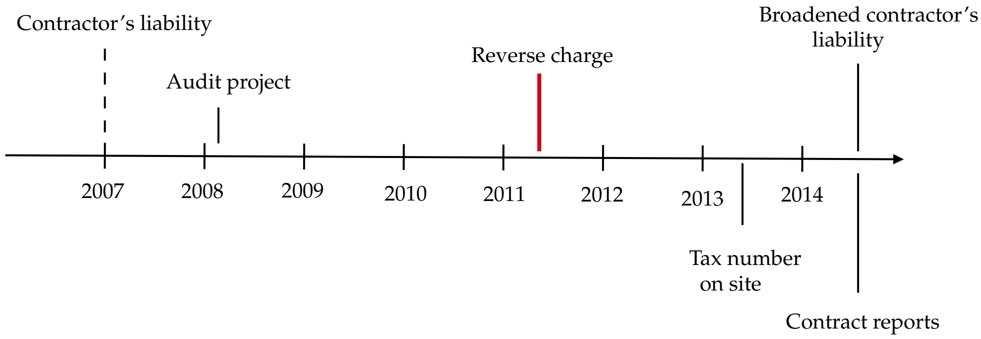

Figure 2: Timeline of new tax policies in the Finnish construction sector.
Notes: This figure shows the timeline of tax enforcement policies impacting the construction sector. Solid lines show construction-specific reforms. The reverse charge (thick) was implemented in April 2011. In 2007, contractors became obligated to ensure their business partner has registered with the appropriate tax registers and have no outstanding tax debt. In 2008, the tax authority increased the audit rates in the construction sector. In 2013, workers at shared construction sites were required to wear a tag with their photo, name, and tax number to show that they are a registered taxpayer and in 2014, reporting requirements for construction services were increased.

tion audit project aimed at developing monitoring tools and supporting legislative reforms; audit coverage nevertheless remained low (below 2% of firms annually) and broadly stable over time.[10] Reverse charge was implemented in 2011. Subsequent reforms expanded third-party information in 2013–2014: a tax number requirement introduced in 2013 was designed as a preparatory step toward broader reporting obligations implemented in July 2014. The 2013 law required all workers at shared construction sites to wear a tag with their photo, name, and tax number to show that they are a registered taxpayer.[11] Starting July 2014, anyone who contracts construction services valued above €15,000 is required to file a report to the tax authorities that includes the contractor's name, the amount invoiced, and details of the worksite. In addition, the project supervisor - most often the project's main contractor - is required to report information on the workers at the site, including their tax numbers. Failure to comply with the information reporting requirements results in fines. This policy improved the tax monitoring ability of the tax authority.

Importantly, immediately before and after the RC policy adoption, there were no other policy changes that confounded with the policy. While our main focus is on the impact of reverse charge, we leverage the later years in our data to analyze

[10]More information of the policy is provided in Appendix A.1.1
[11]This was implemented starting in September 2012 in new sites and by March 2013 in all worksites.

the additional impact of these later enforcement policies in Section 6.1.

3 Data and identification strategy

3.1 Data description and summary statistics

We use the universe of tax returns in Finland from 2008 to 2017. After dropping firms that never reported their industry and firms with missing IDs, we link the VAT returns to firms' annual business income tax returns to obtain more background information such as company form, labor costs and number of employees. We are able to link 93.9% of the entities that have filed VAT returns to business tax returns. After this, we drop non-business company forms.[12] After the sample restrictions, we retain a panel of 726,345 unique firms. We also link the monthly employer returns that include wage costs, payroll taxes and withholding of employees' personal income tax.

We aggregate the VAT return data to the annual level for comparability, as firms can report at different frequencies. This also helps to deal with seasonal trends. In the regression analysis, continuous variables are winsorized at 1% at the top and the bottom to deal with extreme outliers.

Table 2 presents summary statistics on the full sample in the construction sector in column (1) and other industries in column (2). Construction firms are smaller when measured by average annual sales or employee count. On average, construction firms have 4.52 employees and €448,000 of sales versus 7.40 employees and €834,000 of sales in other industries. Notably, construction firms report more net VAT liabilities on average. This reflects the fact that construction is labor-intensive, so input costs are driven by wages, rather than VAT-deductible purchases. The construction sector is also composed of younger firms, highlighting the fact that turnover of firms in the sector is relatively high. Less than half of the construction firms were more than 10 years old, while two thirds of the comparison firms have operated for more than ten years in 2010.

The reform targeted sales of construction services, which limits its coverage to the construction sector and some adjacent sub-industries such as landscaping and renting of labor in the construction sector. Three quarters (76.1%) of all reverse charge payments are remitted by firms registered as being in the construction sector. The rest of the payments are mainly remitted by large enterprises and public

[12] We include sole proprietors, partnerships, co-operatives and corporations. VAT register also includes other types of legal units such as decedent's estates, municipalities, public sector entities, non-profits and housing associations, which we exclude.

Table 2: Sample Summary Statistics

	Full Sample		Weighted		Pruned
	Construction	Comparison	Construction	Comparison	
	(1)	(2)	(3)	(4)	(5)
Panel A. VAT items in 2010					
Sales	448,045	833,974	448,045	644,892	146,575,613
	(6,602,798)	(43,899,357)	(6,602,798)	(16,138,540)	(906,294,516)
Net VAT	35,152	26,232	35,152	26,109	2,000,392
	(405,461)	(2,268,636)	(405,461)	(948,087)	(44,968,192)
Gross VAT	100,416	144,682	100,416	120,068	21,373,429
	(1,490,983)	(5,896,579)	(1,490,983)	(2,480,970)	(115,595,918)
Deductibles	65,238	118,418	65,238	93,913	19,373,037
	(1,130,116)	(5,275,921)	(1,130,116)	(2,553,892)	(103,457,465)
Panel B. Age distribution in 2010					
$\leq$ 3 years old	0.27	0.15	0.27	0.24	0.19
4-10 years old	0.28	0.16	0.28	0.25	0.33
10+ years old	0.45	0.69	0.45	0.51	0.48
Observations	49,086	414,134	49,086	413,300	834
Panel C. Number of employees in 2010					
Employees	4.5	7.4	4.5	4.5	625.3
	(40.2)	(117.3)	(40.2)	(41.9)	(1,783.4)
Observations	46,134	241,574	46,134	240,740	834
Panel D. RC Coverage 2011 - 2015					
Share of sales	0.26	0.01	0.24	0.01	0.01
Any sales	0.55	0.03	0.55	0.05	0.12
L1 Measure	0.12		0.056		

Notes: Columns (1)-(2) show firm-level mean (standard deviation), aggregated to the annual level for the full sample. Columns (3)-(4) show the same with CEM weights from our preferred specification. Column (5) shows summary statistics for companies that receive zero weight in the comparison group. Construction refers to companies that belong to the construction sector. Comparison refers to the rest of the firms in the register. Age distribution describes the proportion of each age group within the comparison group. Share of sales is the proportion of sales covered by the reverse charge mechanism of all sales, each year, between 2011 and 2015. Any sales is an indicator of the firm conducting any sales transaction covered by reverse charge during the year. Descriptions of the variables are given in Appendix Table A3. L1 measure on the last row captures the absolute distance between histograms composed for each matching variable and shows a clear improvement after the weighting.

sector organizations such as municipalities, which both sell and purchase construction services occasionally. Panel D in Table 2 demonstrates that since we exclude public sector entities, municipalities, and housing associations from the sample, reverse charge covers a negligible share of sales in the comparison group. On average, 56.7% of the firms registered in the construction sector reported some sales covered by the policy. Columns (3) and (4) show the summary statistics for the weighted sample based on CEM matching and Column (5) the non-matched comparison firms. We discuss these and the matching procedure in more detail in the end of Section 3.2.

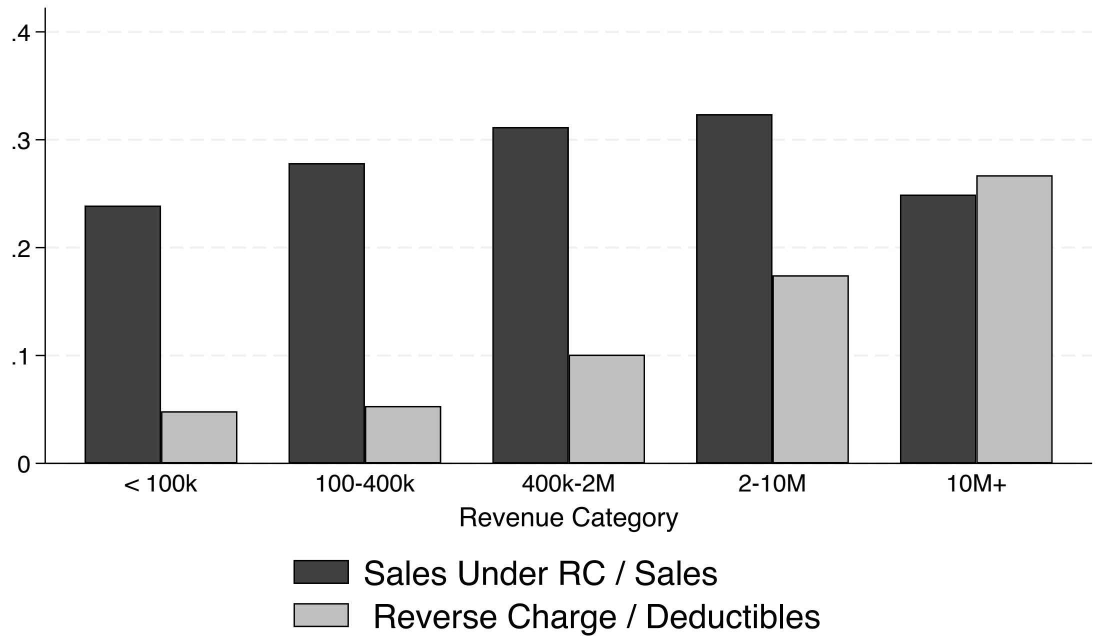

Figure 3: RC coverage in the construction sector.
Notes: This figure presents the coverage of RC in the construction sector in 2011–2015. Construction firms are divided into size categories based on their annual sales. The dark-shaded bars show annual firm-level averages for the proportion of RC sales of the firm's total sales, showing relatively similar shares of sales reported under reverse charge of VAT across the size distribution. The gray bars show the annual firm-level averages of RC of the firm's overall deductibles, showing that larger firms are more likely to to collect the reverse charge VAT of other firms by acting as the main contractor.

Figure 3 illustrates the coverage of reverse charge of firms' sales and costs by firm size as measured by revenue category. On average, RC applies to about a quarter (26%) of the annual sales of a firm. Taking into account the fact that RC only applies to business to business sales, the coverage of the policy is wide. The coverage of sales is similar across the firm size distribution, varying between 24 and 31% by size category. In other words, there are firms that sell construction services to other firms in all size categories. The coverage is different for costs. Reverse charge deductibles account for 6% of deductions on average, but there are large differences by firm size: reverse charges make up less than a tenth of VAT deductions claimed by firms with annual sales below €2 million but about a quarter for firms with revenue above €10 million. This indicates that the main contractors are typically large firms. The largest firms purchase more construction services in both relative and absolute terms. Two thirds of all reverse charges are paid by a handful of companies with more than €10 million in annual revenues.

Technical note on calculating VAT liabilities under reverse charge policy

The reverse charge mechanically changes the reported VAT both for buyers and sellers, as it switches who remits them. Consequently, the returns under conventional and reverse charge VAT are not directly comparable. We account for this by constructing a variable for the VAT accrued from each firm, regardless of who is responsible for paying the tax. This strategy allows for a one-to-one comparison between VAT returns in a traditional VAT regime and a reverse charge regime. This is possible because firms must report their sales of construction services under reverse charge and reverse charge separately from other VAT items. We add the VAT from the sales of construction services under the reverse charge to the seller's VAT liability (these sales are reported in their VAT form). Correspondingly, we deduct the reverse charge remittances from purchasers' returns.

3.2 Identification strategy

We estimate the effect of reverse charge on firms in the construction sector using a difference-in-differences (DD) method with firms in other sectors as a comparison group. This approach identifies the intent to treat (ITT) effect of the policy. From a policy perspective, this is the relevant estimate, as it reflects the overall effectiveness of the policy. We cannot estimate the effect on firms subject to reverse charge within the construction sector using, for example, firms that only sell to final consumers as a control group, because we do not observe which firms were subcontractors before the reform. In addition, the post-reform data shows that firms are likely to act both as main and subcontractors, i.e., positions in the production chains are not fixed.

To quantify the effects of the policy, we estimate the following regression:

$$Y_{it} = \alpha_i + \lambda_t + \beta \times (\mathit{Post} \times \mathit{Construction}_i) + \epsilon_{it} \tag{1}$$

where Y_{it} is the outcome of interest for firm i at time t, α_i the firm fixed effect, λ_t the year fixed effects and ϵ_{it} the error term. *Construction* takes a value of one if a firm i is in the construction sector and *Post* takes a value of one if $t \geq 2011$. The effect of the reverse charge policy is captured by β under the assumptions of parallel trends between the treatment and comparison group, no spillovers, no other simultaneous policy changes and no anticipation effect of the policy. In addition, we trace out the dynamics of the policy intervention using a dynamic difference-in-differences design:

$$V_{it} = \alpha_i + \lambda_t + \sum_{t=2008}^{2013} \beta_t \times \textit{Construction}_i + \epsilon_{it} \tag{2}$$

that allows us to assess the plausibility of similar time trends. The model's coefficients of interest, β_t, are yearly differences between the construction sector and the comparison group relative to the baseline year 2010 (one year before the policy). We cluster the standard errors at the one-digit industry level. This aligns with the level where the policy is assigned, following the recommendation of Abadie et al. (2022). Clustering at a one-digit level allows for serial correlation between firms within 21 aggregate sectors.

The main threat to the validity of the design is the comparability of firm trends between the construction sector and other sectors. For one thing, the composition of the construction sector is different from other sectors. Construction companies are comparatively younger, smaller and more labor-intensive. Secondly, construction projects may be more responsive to business cycles and the availability of credit. RC was implemented after the Finnish economy had recovered from a recession, which had momentarily reduced the demand for construction. For these reasons, the between-industry parallel trends assumption is likely violated. We plot the Dynamic DD estimates for the full sample of firms in Appendix A.5.1. The graphical evidence suggests that pre-reform trends are broadly similar, with only minor and occasionally statistically significant differences.

We improve trend comparability by assigning regression weights using coarsened exact matching (CEM). After this, the pre-reform trend differences attenuate. The details of CEM matching are discussed in the end of this section. Moreover, we study the sensitivity of the estimates to possible violations of the parallel trends assumption following Rambachan and Roth (2023) in Section 6.4.

The second potential threat to identification arises from other tax enforcement policies in the construction sector, discussed in Section 2.2. While none of these policies were implemented in 2011, their later introduction could in principle affect firms' reporting behavior. We address this concern in three ways. First, the Tax Administration's construction audit campaign began in 2008, when our observation period starts, and audit coverage remained limited at less than 2% of firms. Second, the enforcement measure most likely to affect reporting, the contractor reporting requirement, was introduced only in July 2014. To avoid contamination, we restrict our main analysis period to 2008–2013. Third, the 2013 tax number requirement had limited direct enforcement content and was primarily introduced as a preparatory step toward the 2014 information reporting reform. These later measures mainly targeted hidden labor, and their deterrence effects were expected to operate through the subsequent expansion of third-party reporting. Moreover, the dynamics of VAT reporting allow us to assess whether the observed pattern aligns more with effects of the reverse charge or with anticipation of subsequent policies. Finally, in Section 6.1, we explicitly examine changes after these subsequent enforcement policies using data through 2017.

Other identifying assumptions do not pose a significant threat to our design. First, the policy does not affect tax liabilities or tax enforcement prior to the adoption, so firms do not have an incentive to react before. Second, the policy has negligible spillover effects on firms in other sectors, as the policy is limited to the construction services supply chain. Only a small fraction of firms in the comparison group are directly affected by the policy: just 1% of sales outside the construction sector are covered by the reverse charge mechanism. Lastly, as the policy is enacted at the same time for all firms, heterogeneous treatment effects do not pose a threat to identification.

We estimate the models described in equations (1) and (2) for net VAT, sales, gross VAT and deductibles. The dependent variables are in euros, as they are frequently zero or negative, and for a large number of small firms changes in VAT liabilities between tax periods can be large in relative terms, but not economically significant in absolute values. In other words, we estimate the changes in how much taxable value added businesses claim to generate, or how much VAT is accrued from firms.

CEM and parallel trends.

We address the concern of parallel trends violation by producing regression weights with coarsened exact matching (CEM), as described by Iacus et al. (2012). CEM weighting accounts for common trends that affect firms with similar matching variables non-parametrically. In CEM, firms that belong to exactly the same bins of all matching variables form a stratum, and then only firms in strata with both treated and control firms are used. The weighting method produces weights such that the number of treated firms in a stratum equals the weighted number of control firms.[13]

We match the firms based on three pre-policy variables in 2010: number of employees, mean wages per employee, and a dummy variable for zero revenue. Data

[13] All treated units receive weight of one. Weights for control unit i in strata s, denoted by w^c_{is}, are calculated by first dividing the number of treated units by the number of control units in each strata and then normalizing by multiplying the weights with the ratio of treated to controls in the whole sample: $w^c_{is} = \frac{n^t_s}{n^c_s} \times \frac{n^c}{n^t}$. Trends with raw means for matched firms are presented in Figure A.3.

descriptions for the matching variables are given in Appendix Table A3. Employee bins are coarsened according to Statistics Finland's size classifications (Statistics Finland, 2014). Zero sales is matched exactly. Mean salary is coarsened by following Sturge's rule for the optimal number of bins.

After matching, we retain all 49,086 of the firms that were registered as being in the construction sector in the year prior to the reform. The comparison group retains 99.8% (413,300) of the firms registered in other industries. Summary statistics for the weighted sample are shown in columns (3) and (4) of Table 2 and for firms receiving zero weights in column (5). Since we match based on 2010 characteristics, firms that are not in the VAT register that year are also excluded from the matched sample.

With weighting, differences in means of sales, gross VAT and deductibles are smaller. Pruning removes the largest firms from the comparison group as similar companies do not exist in the construction sector. Intuitively, the re-weighting process shifts the size distribution of comparison firms towards that of firms in the construction sector. Bottom row of Table 2 shows the L1 measure, which measures the absolute distance between histograms composed for each matching variable, improves by half after matching (6.4 pp). Matching also changes the industry composition of the comparison group by decreasing the share of firms in the agricultural sector. Correspondingly, firms in industries such as retail trade, manufacturing and the professional services sector receive extra weight. The composition of industries in the comparison group is shown in Appendix Figure A.2.

4 Results on reported VAT

4.1 Main results

Figure 4 plots the development of the net VAT, sales, gross VAT and deductibles during the examination period for the construction sector and the comparison group.[14] The construction sector and the comparison group appear to follow similar trajectories in the pre-reform period. After the reform there is an increase in VAT for both groups, but there is a clear jump in the level for the construction sector.

Figure 5 plots the corresponding yearly DD coefficients based on Equation 2. Graphical evidence in the figure shows that no pre-treatment coefficient alone is statistically different from the baseline. In addition to visual inspection, we as-

[14] We additionally plot quarterly estimates with a sample that excludes annual returns in Appendix Figure A.10.

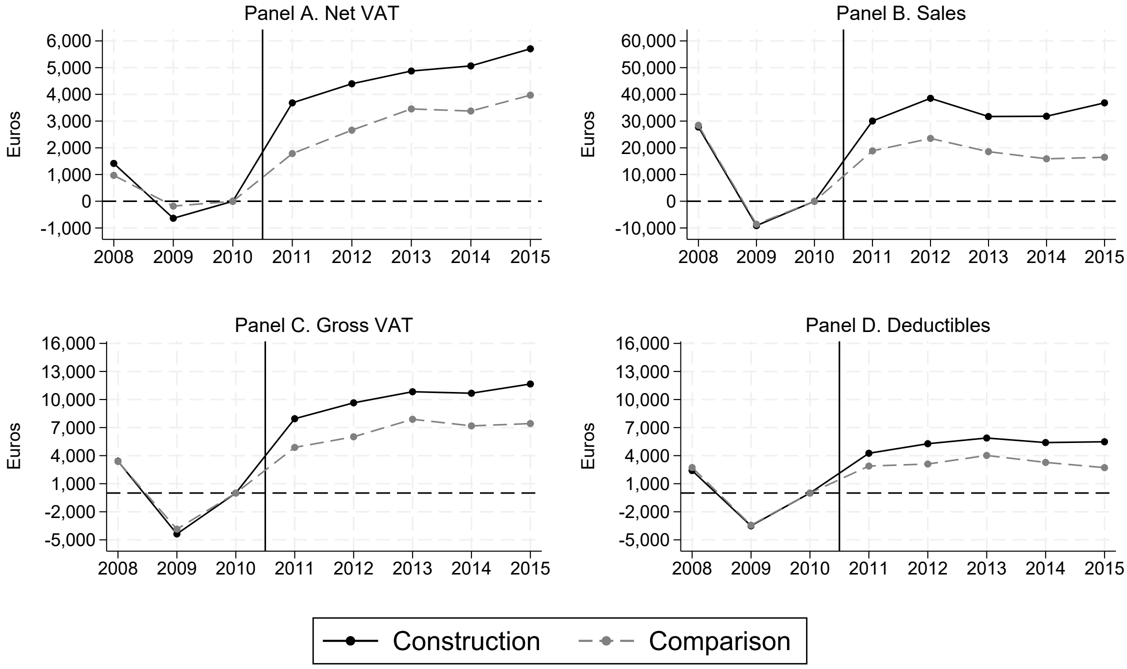

Figure 4: Evolution of firm level variables for the weighted sample.
Notes: Net VAT in Panel A is the gross VAT minus deductibles, sales in Panel B refer to annual sales without VAT included, gross VAT in Panel C is the total reported VAT from output, and deductibles in Panel D are the total reported VAT deductions from purchases. The coefficients are estimated by regressing the dependent variable on a year dummy on the dependent variable separately for both groups and controlling for firm fixed effects. The coefficients are in relation to the last year before the reform (2010), which is normalised to zero. Dependent variables are winsorized at 1% at both tails.

sess the plausibility of parallel trends by running a Wald test on the pre-treatment coefficients. We test whether the pre-treatment coefficients are different from the baseline difference in 2010. The joint hypothesis that the coefficients are zero is maintained for gross VAT, deductibles, and sales. However, it is rejected for net VAT at $p < 0.05$. In Section 6.4, we study the sensitivity of the result for various magnitudes of violations of exact parallel trends.

There is a discontinuous jump in comparison to the baseline in all of the outcome variables in 2011 that remains steady through the observation period. This pattern suggests that the adoption of the reverse charge policy had a positive effect on VAT accrued from construction firms.[15] As the policy aimed at increasing VAT collection, the main outcome of interest is the treatment effect on net VAT, which is shown in Panel A of Figure 5. There is a clear increase of about €2,000 in average reported net VAT after the reform. The dynamics indicate that the policy took full effect in 2011. This might be because the subcontractors affected more strongly by

[15]Alternatively, VAT items could increase in anticipation of subsequent policies or due to increased monitoring in the construction sector. However, these would be expected to generate a gradual adjustment rather than a discontinuous jump.

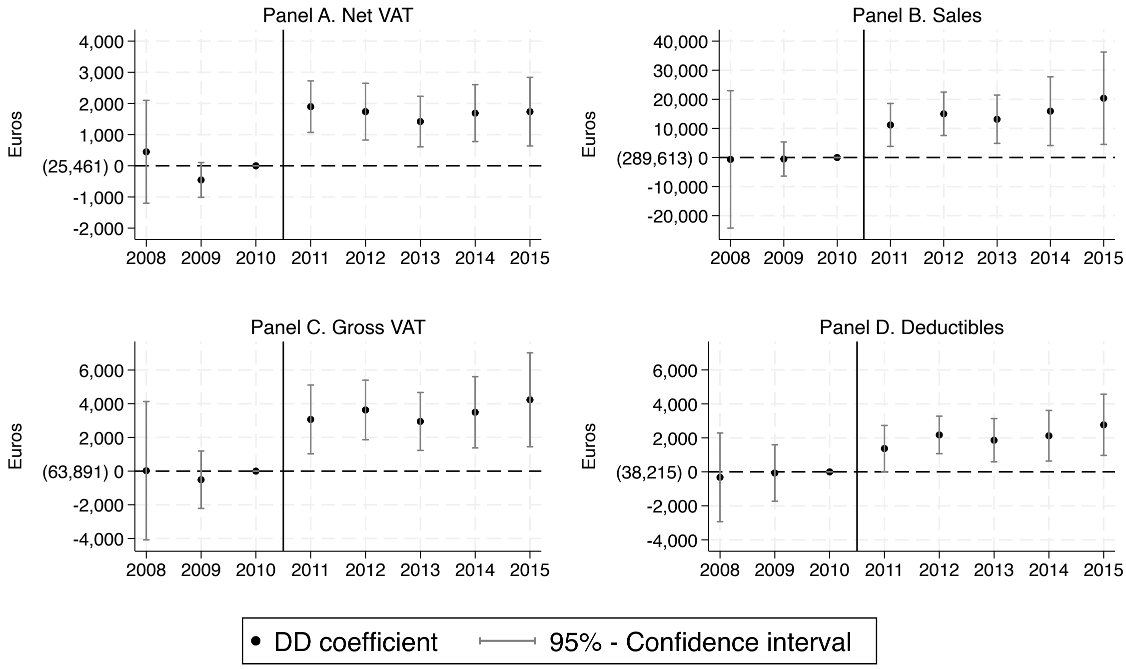

Figure 5: Responses to the 2011 RC policy – dynamic DD with the weighted sample.
Notes: Net VAT in Panel A is the gross VAT minus deductibles, sales in Panel B refer to annual sales without VAT included, gross VAT in Panel C is the total reported VAT from output, and deductibles in Panel D are the total reported VAT deductions from purchases. The DD coefficients, estimated using Eq. 2, show the yearly differences between treated and control group with 2010 as a baseline difference, and controlling for company and year fixed effects. Standard errors are clustered by one-digit industry codes and dependent variables are winsorized at 1% at both tails. The pre-trend p-values are 0.0395 for net VAT, 0.9798 for sales, 0.772 for gross VAT and 0.861 for deductibles.

the policy do not have long contracts continuing under traditional VAT past the first year.

Panels B and C in Figure 5 show that also reported sales and gross VAT increase discontinuously after the reverse charge mechanism is introduced. A similar, but comparatively smaller, increase in deductions (panel D) dampens the net increase in tax remittances.

Table 3 reports the corresponding pooled results of equation (1) for the key outcomes using data from 2008–2013. Annual VAT accrued from construction firms increases by €1,781.9 on average. The estimate translates into an increase of 5.07% relative to the mean net VAT of €35,152 in the treatment group in the year before the policy. Sales increase by €13,829 and gross VAT by €3,494. Table 3 also shows an increase of €1,962 in VAT deductions. This means that firms partly offset the increase in value added by reporting more VAT deductions. Increases in tax deductions offset 56.5% of the increases in gross VAT. We discuss potential explanations for this in Section 4.3. In Section 6.4, we show that the main findings are robust to alternative sample selections and matching specifications.

Table 3: Impact of reverse charge on VAT returns

	(1) Net VAT	(2) Gross VAT	(3) Sales	(4) Deductibles
Construction × *Post*	1,781.9***	3,494.4***	13,828.5**	1,961.7**
	(449.2)	(866.9)	(4,280.1)	(583.4)
Observations	2,516,771	2,516,771	2,516,771	2,516,771
R^2	0.89	0.94	0.94	0.93
Construction average (2010)	35,152.2	100,415.8	448,044.8	65,238.1
Scaled estimate	0.0507	0.0348	0.0309	0.0301

Notes: Estimations for equation (1), data covering years 2008–2013. Net VAT is the gross VAT minus deductibles, sales refer to annual sales without VAT included, gross VAT is the total reported VAT from output, and deductibles are the total reported VAT deductions from purchases. Dependent variables are winsorized at 1% at both tails. Standard errors clustered by one-digit industry codes in parentheses. Scaled estimate shows the treatment effect divided by the average outcome of a construction firm in 2010. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4.2 Effects by firm size

The effects of RC on firms likely depend on firm size for two reasons: (i) baseline compliance among firms likely differs by firm size as large firms are typically considered more compliant[16] and (ii) small firms are likely to act as subcontractors (upstream firms) that the RC affects directly, but large firms may be both contractors and subcontractors according to Figure 3.

To study how the effects depend on firm size, we assign firms to size categories according to their level of sales in 2010. Category-specific effects are estimated with the following specification:

$$Y_{it} = \alpha_i + \lambda_t + \eta_{qt} + \sum_{q=1}^{k} \beta_q(\{Q_q = q\} \times Post \times Construction) + \epsilon_{it} \quad (3)$$

where q denotes the category a firm belongs to. We capture category-specific time trends with η_{qt}. Now, β_q identifies the policy's effect on construction firms in a given category, in relation to the comparison firms in the same category.

The level of the outcomes varies between firm categories. We scale the estimates to make the effects comparable across categories by dividing the estimate and the confidence interval by the 2010 average outcome for construction firms in the category. Consequently, the scaled effect corresponds to the effect relative to the mean in the category.

Figure 6 plots the scaled estimates for all outcomes by sales categories. The relative effects of the reverse charge reform are decreasing in size. The effect on micro

[16] See e.g. Kleven et al., 2016.

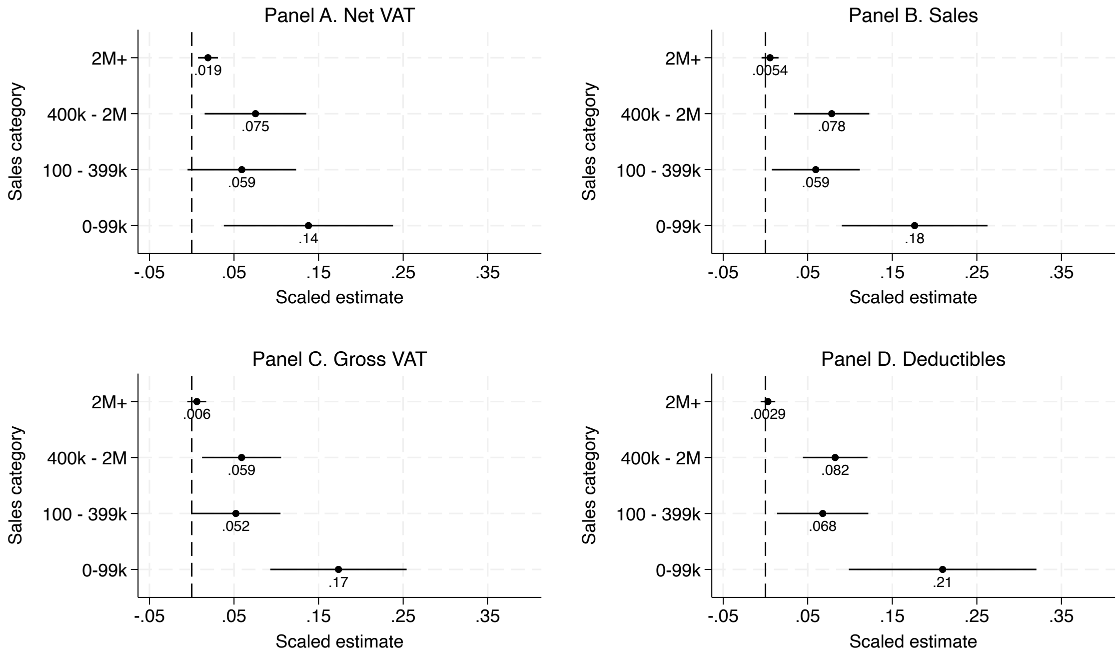

Figure 6: Heterogeneity in the relative response to the reform by sales category.
Notes: This figure plots the estimated responses (Eq. 3) to the RC policy by size categories, showing the biggest impacts among the smallest firms. The horizontal lines represent the 95% confidence interval. The DD point estimates and confidence intervals are scaled by the group average in 2010 for comparability. Standard errors clustered by one-digit industry codes and dependent variables are winsorized at 1% at both tails.

firms, those with sales below €100,000, is large in relative terms (13.7% increase in net VAT), but smaller than the average ITT effect in absolute terms (€599.3 increase in net VAT). The most significant effect financially is for firms with sales between €400,000 and €2M. On average, VAT from these firms increases by €6,024, which is 7.5% of the group mean and amounts to a €33.7 million aggregate annual increase in value added taxes.

The policy has little effect on the largest construction firms with estimates close to zero and only statistically significant for net VAT, with an increase of 1.9%. These construction firms in the largest revenue category in Figure 6 are liable for 86.5% of the reported reverse charges. This means that VAT remitted by these firms includes most of the taxable value added created in the supply chain.

4.3 Interpreting the results

Our results show an increase in reported net VAT driven by higher reported sales and, consequently, higher gross VAT. Thus, RC mainly reduces evasion from under-reporting of sales, not over-reporting of costs. This is reasonable as the policy did not remove the possibility to over-report costs, but by shifting the VAT remitting liability, the RC eliminated the opportunity to evade output VAT of subcontracted work.

The effect is driven by an increase in reporting of sales by small and medium size subcontractors. The decreasing effect by firm size is consistent with higher baseline tax evasion in small firms. The effects are small and mostly insignificant for large firms, which is consistent with little effects on main contractors and a high baseline compliance of large firms. The fact that large firms do not decrease their reported VAT, although they are now liable for the VAT accrued in the whole production chain, is key for the reform being effective in improving aggregate tax revenues.

Part of the increase in gross VAT is offset by increased deductions. This is not a direct consequence of RC, as RC should in fact reduce the possibilities for using fake receipts to over-report deductions, as the firm is now liable for the VAT of its subcontractors. However, there are many potential explanations for the increase in reported deductions. For one, non-compliant firms may have previously under-reported actual expenses in order to under-report the scale of their operations and escape detection by the tax authority or to reduce compliance costs. Second, firms could try to offset the decrease in tax evasion gains of output VAT by over-reporting costs, in other words, by switching from one way of VAT evasion to another. These explanations are consistent with our findings that the deductions increase for the same groups of firms that have an increase in net VAT. However, we cannot distinguish whether the increased deductions represent increased compliance or increased evasion through cost reporting, as they are observationally identical. A third potential explanation could be a price increase by subcontracting firms to offset the reduced gains of evasion. However, this would show up as an increase in deductions for the large firms, as they are most likely acting as buyers or main contractors (Figure 3). However, we do not see an increase in deductions for the largest firms that are responsible for the most of contracting. It is possible that RC disrupted this kind of pricing between small and medium sized firms, with an increase in deductions among these firms, but this does not seem to extend to sales to the large firms.

5 Conceptual analysis of the effects of RC

To help generalize our empirical findings, we next summarize how RC affects tax compliance relative to conventional VAT and sales tax using a theoretical framework of tax evasion in the spirit of the model by Allingham and Sandmo (1972).

5.1 Framework

We develop a theoretical model of tax evasion in a two-firm production chain with an upstream and a downstream firm. The tax evasion model is an adaptation of Allingham-Sandmo for VAT evasion. A firm i maximizes profits π_i taking into account evasion as the difference of VAT on actual and reported sales and the cost of evasion.

$$\pi_i = (1+\tau)v_i - \tau\overline{v}_i - g_i(e_i) = v_i + \tau e_i - g_i(e_i) \tag{4}$$

where $v_i = s_i - c_i$ is the value added, i.e., sales minus deductible costs, of the firm and $e_i = v_i - \overline{v}_i$. A more detailed description of the model is provided in Appendix B, and the exact profit function and evasion cost function are determined by the tax system and firm's position in the value chain.

The key features we include are: (i) interdependence of firm audits, where the audit of firm i can detect sales or purchases by j in i's accounting with a probability ρ, (ii) increase in audit rate for reported negative value added, and (iii) a penalty for misreporting sales or purchases even when it does not cause tax deficit. We consider unilateral tax evasion, where firms set their level of tax evasion independently, and collusive tax evasion, where firm firms can collude to hide information on their transaction.

First, the interdependence of tax audits produces the well-known paper trail deterrence effect of VAT: the upstream firm evades less because its sales are recorded as purchase of the downstream firm. Second, the increase in audit rate for negative value added is also an important deterrence feature in the VAT decreasing the tax evasion by downstream firms, as discussed in, e.g., Waseem (2022).

Third, we introduce a penalty for misreporting that is not typically considered in tax evasion models, but it reflects real-life tax audit policy. The tax auditor wants to enforce the truthfulness of third-party reports, even when there is no direct tax consequence for the agent who misreports, because it needs this information for tax monitoring. This feature is relevant for deterrence in the reverse charge mechanism.

Our model reproduces the well-known results of conventional VAT. Namely, that the system reduces the evasion of the upstream firm, because of the information held by the downstream firm, and that the last-mile problem is alleviated by the withholding structure.

5.2 When can RC increase tax revenue?

Result 1: Reverse charge increases tax revenue when downstream firms are relatively compliant. Relatively compliant here means that the downstream firms do not report negative value added in the conventional VAT system.

The effect on tax revenue is dependent on the compliance response of the downstream firm. This happens because the RC simply removes the opportunity for evasion of the upstream firm. However, RC retains the reporting requirement for the upstream firm, which allows the tax authority to get information on the value added of the downstream firm. Under unilateral tax evasion, the first-order condition for the optimal level of tax evasion of the downstream firm under the conventional system and reverse charge are exactly the same, meaning the downstream firm evades the same amount under both systems. Thus, tax revenue increases because evasion by the upstream firm decreases.

The first-order condition for the downstream firm evasion is characterized by the equation:

$$FOC : 1 = (1 + \theta)(a_d'(e_d)e_d + a_d(e_d) + \alpha_d I(\overline{s}_d < s_u)), \tag{5}$$

where θ is tax evasion penalty rate, $a_d(e_d)$ audit rate of firm d for evasion level e_d, a_d' the first-order derivative, α_d increase in the audit rate for reporting negative value added, and $I(\overline{s}_d < s_u)$ indicator equal to one when the firm reports negative value added. The incentives of VAT ensure that the firm reports its costs equal to s_u, i.e., the sales of u firm d purchased.[17] Here the left-hand side is the marginal benefit of evading one euro and the right-hand side is the expected marginal cost of evading that euro. There are three solutions: (i) where the firm reports positive value added and the FOC holds and where the level of evasion is not yet effectively constrained by α, (ii) bunching close to zero value added where the FOC does not hold and evasion is deterred by α because increasing evasion would lead to the cost being higher than one, as the audit rate increases discretely, and (iii) firm reporting negative value added where the FOC holds.

Collusive evasion is not feasible in either conventional or reverse charge models when the downstream firm reports positive value added. The intuition is that engaging in collusion would mean a higher detected tax deficit at audit, as the firm would get penalized for a fraction of the upstream firms evasion for not having receipts for the deductions, but the optimal evasion choice is still characterized by

[17] The interdependence term ρ does not appear in the FOC condition for firm d, because of incentives to report full costs. Hence, there is no evasion or misreporting that can be discovered in firm u's audit in the optimum.

the equation 5. The downstream firm would need to get the full extra evasion by the upstream firm for collusion to be profitable for it. But this leaves no additional benefit for the upstream firm.

Reverse charge also decreases collusive evasion by downstream firms that are so-called "bunchers" (see above alternative (ii)). These are the firms effectively deterred by the higher likelihood of audit for negative value added. For these firms the first-order condition in equation 5 does not hold: their optimal tax evasion would be slightly higher without the additional increase in audit rate, so they bunch close to zero. Collusive evasion decreases the value added observed by the tax authority, as the upstream firm reports lower sales, decreasing the audit rate and enabling downstream firms to evade more. This makes collusive evasion feasible. However, the upstream firm does not directly benefit from collusion in the RC system. Hence, to collude the downstream firm has to share some of its increased evasion with the upstream firm, which increases its marginal cost of evasion. This leads to lower collusive tax evasion by the downstream firm in RC compared to conventional VAT.

Result 2: The effect of RC on tax revenue is ambiguous when downstream firms are high evaders. High evaders here means firms that report negative value added, i.e., their tax evasion is higher than their tax base. Tax evasion of this level is typically referred to as fraud.

Under unilateral tax evasion, the evasion choice of the downstream firm is the same under both conventional and reverse charge systems, characterized by the equation 5. Collusion in the conventional system is not feasible for the same intuition as for the positive value added downstream firm. However, under RC collusion may be feasible for the fraudulent firm. Collusive evasion enables the firm to report lower costs, thus enabling higher evasion without the additional evasion cost of α. In this case the downstream firm increases evasion relative to the conventional VAT. The tax revenue effect of RC is then determined by whether the increase in the downstream firm's evasion is higher than what the upstream firm evades in the conventional system, which is an empirical question.

Result 3: RC has higher tax revenue than sales tax even when downstream firms are not relatively compliant.

This is because RC has the paper trail effect like the conventional VAT, which reduces evasion opportunities for downstream firms. RC can only increase downstream firm evasion for fraudulent downstream firms if they collude with upstream firms. However, this can be deterred by a high enough audit rate and misreporting penalty for the upstream firms. In other words, even in the RC system compliant upstream firms can help enforcement of VAT.

5.3 Discussion of empirical findings in light of the model

Our empirical findings are broadly consistent with the model and with the assumption that the downstream firms, i.e., the main contractors in the construction sector are typically relatively compliant firms. The downstream firms in charge of reverse charge payments are typically large firms, that tend to be more compliant in the baseline and heavily monitored by the tax authority. In the model, this connection with size can be incorporated through higher evasion costs of larger firms leading to lower optimal evasion and, in particular, lower probability of fraud. We do not observe a significant effect for these firms in line with the model.

We observe an increase in the reported value added for small and medium sized firms that tend to be the subcontractors, i.e., whose sales are now under the reverse charge mechanism, consistent with their reduced tax evasion opportunities. Small firms tend to face lower audit rates and have higher non-compliance in the baseline, which can explain the increase.

6 Additional results and robustness

6.1 Impact of subsequent policies

We leverage the addition of new policies targeted at construction firms to study how information reporting interacts with changes to remittance rules. In the final quarter of 2012, a tax number register for construction workers was established, and by May of 2013 workers at shared construction sites were mandated to wear an identification card that included their tax number. As discussed in Section 2.2, starting in 2014, new laws required purchasers of construction services to send information about their contracts and worksites to the tax authorities.

Figure 5 plots the yearly coefficients until 2015. There is no further increase in reported VAT items after 2013. To further compare the effects of policies, we divide the *Post* variable from equation (1) into two separate indicators. The first variable indicates the first two years after the reverse charge policy was implemented, while the latter indicates the years when construction-specific information policies were put in place (after 2013). The first period dummy identifies the effect of RC alone and the latter the combined effect of RC and the subsequent policies. Estimates for the impacts of bundling compliance policies are reported in Table 4. Since we want to measure the impact of later policies on VAT compliance, we now utilize the data from 2008 to 2016.

Our key finding is that additional policies do not affect net VAT liabilities. Column 1 shows that differences in net VAT between compliance regimes are negli-

Table 4: Impact of later policies on tax returns

	(1) Net VAT	(2) Gross VAT	(3) Sales	(4) Deductions	(5) Emp. remittance
RC Only	1,807.7***	3,453.5***	13,239.3**	1,859.1**	674.1**
	(441.8)	(864.5)	(3,810.6)	(562.6)	(214.4)
Policy Bundle	1,651.9*	4,196.2**	19,313.0*	2,807.6**	957.0**
	(589.5)	(1,352.9)	(8,869.7)	(871.9)	(333.9)
Observations	3,547,181	3,547,181	3,547,181	3,547,181	3,547,181
R^2	0.87	0.92	0.92	0.91	0.92
Construction average (2010)	35,152.2	100,415.8	448,044.8	65,238.1	24,409.4
Policy bundle - RC	-155.9	742.7	6,073.8	948.4	282.9
	(277.4)	(957.1)	(6,005.0)	(707.9)	(151.3)

Notes: Firm responses to tax policies 2008–2016. *RC Only* takes a value of one if the firm is in the construction sector and the year is 2011 or 2012. *Policy bundle* takes a value of one if the firm is in the construction sector and the year $\geq$ 2013. Policy Bundle - RC is the estimated difference between the estimates. Emp. Remittance refers to payroll taxes and employees' personal income tax remitted by the firm. Dependent variables are winsorized at 1% at both tails. Standard errors clustered by one-digit industry codes in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

gible. The last row in the table reports the difference in the impact of all policies minus the RC, showing that increases in additional gross liabilities are offset by deductions. This evidence underlines the significance of remittance for tax revenue in comparison to the later information requirement policies.

6.2 Spillovers to labor taxes

The later policies were more focused on fighting grey labor. Thus, we investigate the spillover effect of RC and the effect of the later policies on employers' remittances of payroll taxes and withholding of employees' personal income tax with a similar set-up. Firms may engage in schemes where their employees provide work through self-employment to avoid income taxes and collect additional income from VAT evasion, or collude in evading labor taxes. The increased reporting requirements aim to hinder such practices. Closing this channel of evasion could encourage workers to provide work as salaried employees and increase taxes remitted by employers.

Figure 7 plots the DD coefficients on employers' remittances. The employers' remittances include payroll taxes and income taxes withheld from employees' wages. First, the remittances increase by a magnitude of €500 in 2011-2012, when RC is adopted. This suggests a spillover effect on taxes remitted by employers. We also observe an increase of similar magnitude in the number of reported workers, as documented in Appendix A.5.3. The findings indicate that the RC policy did

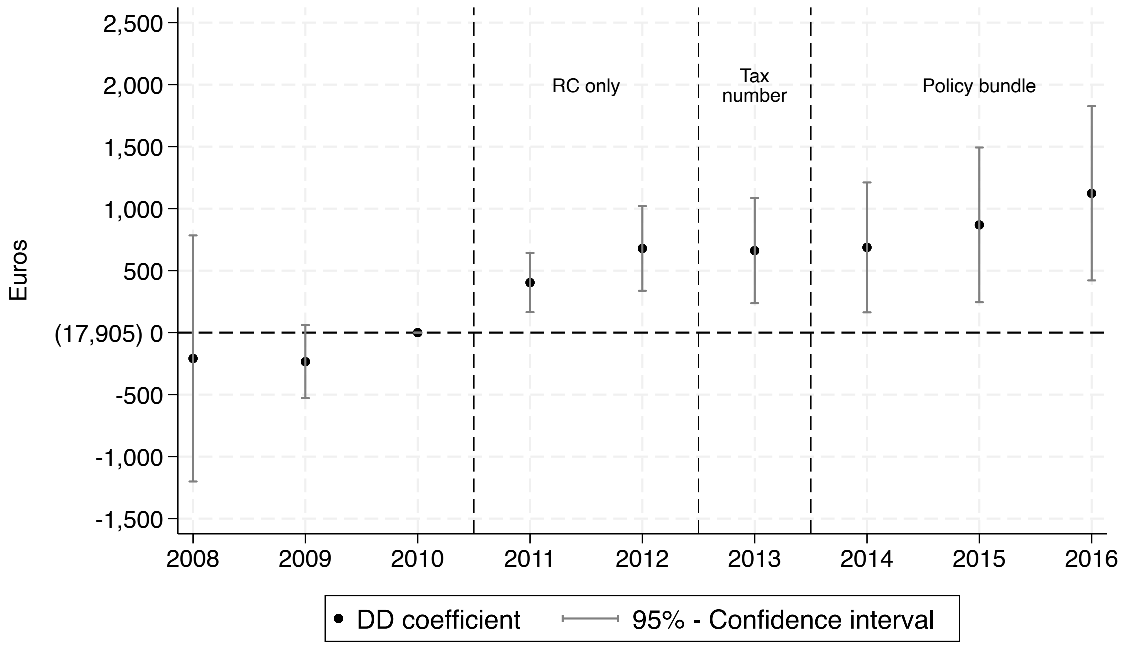

Figure 7: Dynamic DD of employers' remittances with the weighted sample.
Notes: The DD coefficients, estimated using Eq. 2, show the difference in reported employers' remittances between the treatment and control group with 2010 as the baseline and controlling for company and year fixed effects. Employers' remittances include income tax withholding of workers and their payroll taxes (pension and social secority contributions). Standard errors are clustered by one-digit industry codes and dependent variables are winsorized at 1% at both tails. The pre-trend p-value from a Wald test for pre-policy effects is 0.075.

reduce the use of grey labor in the construction sector by removing the evasion gains.

Second, employers' remittances start to increase after 2014 when additional policies are implemented. Column (5) in Table 4 shows that the estimated differences between RC and the policy bundle on payroll taxes (and withholding of personal income tax) are two-fifts of the spillover effect of RC (41.9% increase). However, differences between the effects of RC alone and with the policy bundle are not statistically different at $p > 0.05$.

6.3 Analysis of firm exits

A marginally profitable firm may exit the market when RC reduces its benefit from tax evasion. Transferring from a small business to hired labor would also lead to some of the evidence we find as increased labor taxes. To analyze exit rates, we aggregate the full sample to the stratum-level and compare exit rates across comparison groups before and after the policy. We define exit year as the last observed non-zero return. In the preferred analysis above, we considered firms that are matched based on their returns in 2010. By definition, these firms have

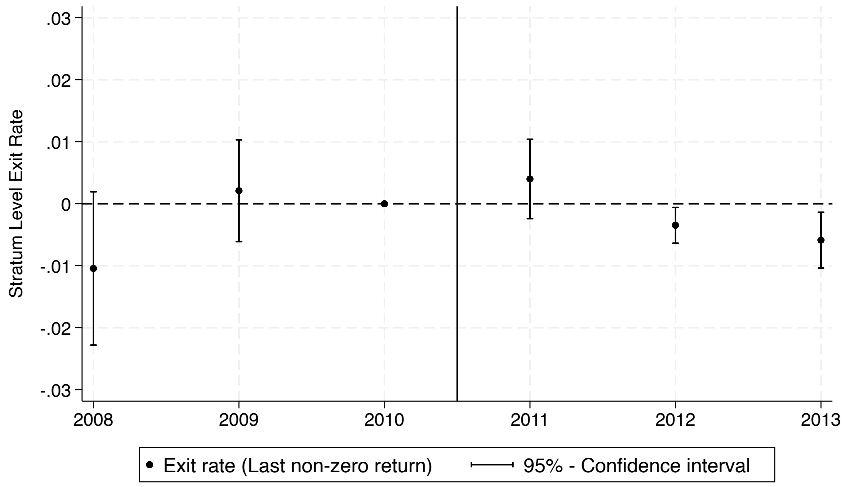

Figure 8: The impact on CEM stratum-level exit rates.
Notes: This figure plots the dynamic DD estimates of CEM stratum level exit rates at the construction sector relative to other sectors with 2010 as a baseline, and controlling for stratum and year fixed effects (Eq. 6). There are 322 CEM strata and each stratum is weighted by their relative size in the firm population. Standard errors are clustered by one-digit industry codes.

survived until then, and we cannot establish a baseline pre-policy exit rate for the matched sample.

We construct the sample for exit analysis in two steps. First, we assign each annualized return to a corresponding CEM stratum generated for the matching procedure. Then we split each stratum by treatment group to produce a repeated cross-section of annual exit rates for each *treated* × *stratum* cell (N = 322). Exit rates are defined as the number of exits divided by the number of firms that remain or exit. Each stratum is then weighted according to its share of the firm population in 2010. The tax authority removed a significant number of firms from the VAT registry in 2015 with an unknown criteria. Therefore, we limit the analysis until 2013 to avoid confounding policy measures.

We estimate the following linear probability model to assess whether RC causes exit rates to change.

$$\textit{Exit Rate}_{st} = \alpha_s + \lambda_t + \sum_{t=2008}^{2013} \beta_t \textit{Construction}_s + \epsilon_{it} \tag{6}$$

Where α_s captures the group-stratum fixed effects, λ_t controls for common time trends and $\textit{Construction}_t$ is one when the cell consists of construction firms. The error term is ϵ_{it}.

We find essentially a null effect on the exit decisions of construction firms. Figure 8 depicts a small uptick in exit rates in 2011 that is not statistically significant and the coefficients for 2012 and 2013 are negative. The point estimate in 2011 corresponds to excess exits of around 250 firms, but otherwise there is no evidence that the reform causes construction firms to exit the industry. This signals the fact that evasion rents from subcontracting are not necessary for the companies to remain in business, at least to a large extent.

We aim to examine entry behavior, yet the availability of a suitable counterfactual limits the possibility to make causal interpretation of the findings. We discuss the analysis and the associated challenges in Appendix A.5.2.

6.4 Sensitivity analysis and robustness checks

In this section, we first address the sensitivity of the main results to the parallel trends assumption. Then, we discuss the robustness of the results to alternative regression specifications.

We construct consistent confidence intervals to account for violations of the exact parallel trends assumption following Rambachan and Roth (2023). We focus on the sensitivity of the causal estimates for net VAT since the Wald test rejects the hypothesis of parallel pre-trends only for that variable. Panel A in Figure 9 presents confidence intervals for DD coefficients after the treatment is first introduced, $t = 2011$, with varying magnitudes of maximal pre-trend violations. We observe that the null hypothesis (reform has no effect) is rejected up to a violation multiplier of 1.25, when the policy is first enacted. In other words, if the parallel trend violations are similar in magnitude to those observed in 2009, the confidence intervals do not include zero. The housing market experienced a significant slump in 2009, so it is unlikely that trend violations in the post-treatment period would be as large. Sensitivity analysis shows that a deviation from exact trends in 2011 would have to be 25% larger than during the recession before the positive effect from the reform is rejected. Considering a deviation in trend of 50% of the pre-trend violation, we can still reject an effect smaller than €1,000, which is 2.8% of the outcome mean.

Panel B in Figure 9 presents the sensitivity of mean causal effect for each post-treatment period. Setting bounds for consecutive periods means that the confidence interval includes cumulative parallel trend violations. As a result, the confidence intervals for later years are much wider. The observed breakdown point appears at 0.5. This means that if true time trends add 50% of the maximal pre-trend violation to differences between groups in each post-treatment period, the null effect cannot be rejected. Since the dynamic estimates in Figure 5 appear relatively stable, it is unlikely that the weighted groups have a great magnitude of divergence in trends.

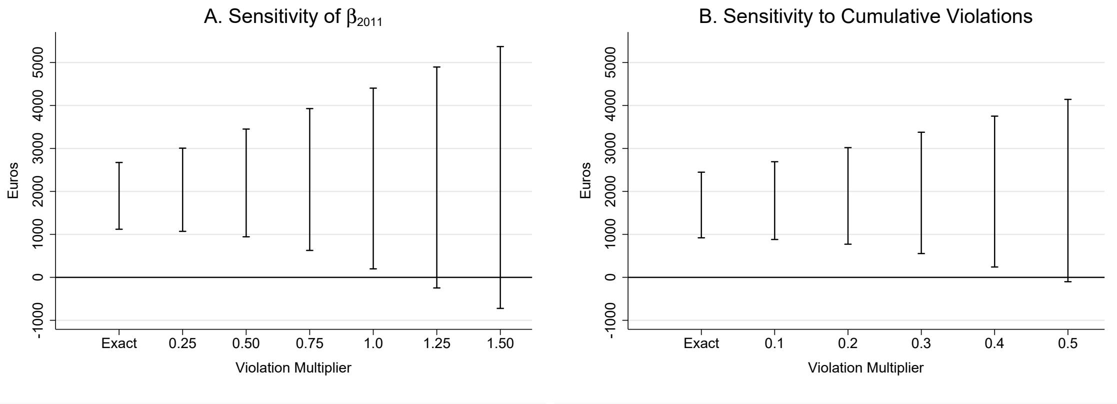

Figure 9: Sensitivity tests for dynamic DD parameters with net VAT as the outcome.
Notes: The x-axis shows violation multipliers for maximum pre-trend violations. Panel A shows the sensitivity ofβ_{2011} and Panel B shows the sensitivity of our mean causal effect under consecutive shocks. The confidence intervals include a true parameter 95% of the time when the parallel trends violation is bounded within a given magnitude. Standard errors are clustered at the one-digit industry level. "Exact" shows the 95% CI with exact parallel trends.

We now turn to test the robustness of the main results to alternative sample and weighting specifications. In the main analysis, the intention-to-treat group is constructed from companies that were registered in the construction sector in 2010. The panel is not balanced. A notable characteristic of the Finnish construction sector is that its firm population is relatively young. The bottom rows of Table 2 highlight the fact that before the reform was enacted, less than half of the companies had operated for over 10 years. The company base of the construction sector renews faster as a higher share of firms exit the sector annually than in most other industries[18]. This leads to more attrition in the ITT group.

The estimates are robust to restricting to a balanced sample of companies that remain in the sample from 2008 to 2015. We report the results for this specification in column (3) of Appendix Table A5. We also examine how differences in firm exits affect the main estimates when zero returns are imputed for firms after they leave the register. The mechanical effect of attrition is visualized in Appendix Figure A.8. Since construction firms exit the industry more often, artificially setting differences to zero mechanically reduces the dynamic DD estimates over time. We show that the RC reform's effects last as the company base renews, by producing a stratum-level cross-section of VAT returns. This estimation strategy allows for market entries and exits after the policy is enacted. We plot the Dynamic DD coefficients and describe the estimation strategy in more detail in Appendix Figure A.9.

[18]In 2008 and 2010, an average of 6.65% of construction firms exited the VAT register against 4.73% for the rest of the sample. Overall, the number of construction firms increased each year from 2008 to 2015.

ITT effects remain stable, which confirms RC's lasting effects on public finances.

Our main results are also robust to changes in the matching specification and levels of winsorizing. Difference-in-differences estimates for alternative CEM specifications are presented in Appendix Table A5 and sensitivity to alternative winsorizing levels is presented in Appendix Table A6. The motivation for the CEM-weighting procedure was to account for differences in size distribution between the treatment groups. We show that the results hold when company size is matched by sales instead of employee count and average salaries. Dynamic coefficients for the alternative weighting scheme are shown in Appendix Figure A.12. Changing the matching year to an earlier year yields point estimates that are at the lower bound of the preferred results. Nevertheless, we observe that the dynamics are analogous to the main specification. Results for the alternative matching years are presented in Appendix Figure A.13.

Finally, we test that the identification strategy does not capture changes in real demand for construction by means of a falsification study in Appendix Figure A.14. In the falsification analysis, we remove construction firms from the full sample and appoint real estate activities as a placebo treatment group. Matching is then performed analogously to the main analysis using CEM. This placebo study yields a null effect on sales and gross VAT. Increases in net VAT are statistically insignificant and driven by reduction in deductibles.

7 Conclusion

This study leverages the introduction of a construction sector-level reverse charge policy for VAT in Finland to study whether tax compliance can be improved with this tool. Our empirical results show that adopting a reverse charge mechanism had a sharp and lasting effect on the reporting behavior of construction firms in Finland. The average effect was around a 5% increase in net VAT, which is both economically and statistically significant. The increase in reported VAT was the strongest among small firms, consistent with lower baseline compliance among subcontractors. In addition, we demonstrate that a subsequent implementation of an information reporting policy did not change net VAT liabilities, but the policy bundle may have improved compliance for payroll taxes. In labor-intensive sectors, VAT fraud is frequently associated with tax evasion on labor-related taxes and social contributions, namely undeclared work. This suggests that VAT policy may have broader implications for outsourcing practices and grey labor beyond its direct effects on VAT revenues.

Our theoretical model demonstrates that the reverse charge mechanism increases tax revenue in comparison to conventional VAT when downstream firms are relatively compliant, but effects are ambiguous when downstream firms are highly non-compliant or fraudulent. Furthermore, our model suggests that VAT with reverse charge outperforms sales tax even with non-compliant main contractors/final sellers, as it retains the paper trail feature of conventional VAT.

A back-of-an-envelope-type calculation using the matched sample and multiplying the average increase in net liabilities by the number of construction firms in the entire VAT register yields an increase of €89.9 million in annual net liabilities reported. Alternatively looking backward, this represents €86.6 million in missed tax revenues before the reform in 2010. For comparison, the construction sector contributed €1.8 billion in value added taxes in the same year. The overall costs of the RC system – arising, for instance, from increased administrative and compliance burdens – are hard to quantify, but are likely moderate due to the limited VAT reporting requirements in the Finnish context. Furthermore, improved tax compliance helps level the playing field between compliant firms and those engaging in tax evasion.

Our findings highlight that who remits the tax plays a key role for revenue collection even when all of the firms operate in a formal sector monitored by various authorities and with the self-enforcing mechanism of VAT already in place. Our evidence suggests that VAT reverse charge is a simple and effective policy tool to combat VAT evasion in a sector where downstream firms are larger relatively compliant companies and upstream firms are non-compliant. In our setting, changing remittance rules appears to be more effective for improving VAT compliance than expanding third-party information reporting, particularly when remittance reform is implemented first.

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A Appendix

A.1 VAT system in Finland

VAT plays a central role in state funding and contributes 22% of total tax revenue in Finland, which is close to the average in OECD countries[19] (OECD, 2023). The estimated VAT gap in Finland is one of the smallest in the European Union, with a 7.5% gap against a median gap of 10.3% (Poniatowski et al., 2019). Finland is a developed economy with a tax-to-GDP ratio of 42%, which is one of the highest in the OECD (OECD, 2024), and little perceived corruption (Transparency International, 2023).

All businesses that sell goods or services in Finland are required to report and pay value added taxes, with exemptions for small firms. Following the EU standard, Finland has a standard VAT rate that applies to the majority of goods and services, and two lowered and zero rates for specific product types. In 2011, the standard rate was 23%.[20] VAT law also exempts sales of medical services, financial services, and the sale or rental of real estate from the tax. Businesses or other entities producing these services do not have to register with the VAT register.

Companies in the VAT register file VAT returns with different frequencies, depending on their annual sales. Until 2010, all firms filed VAT returns on a monthly basis. Since 2010, firms with annual revenues below €50,000 have the option to file returns quarterly, and firms with revenue below €25,000 can file annually.[21] Businesses with annual revenue below a threshold of €8,500 are exempt from value added taxes.[22] If a firm in the VAT register is inactive during a tax period, it is still required to file a "zero return".

Finland does not have transaction-level VAT reporting, as firms only report their aggregate taxes, sales and deductions. The VAT form is a stripped-down document that requires no information about trading partners or individual transactions. Hence, relatively little information is sent to the tax authority through VAT returns. However, firms must hold on to their receipts available for an audit for at least six years. An example of the Finnish VAT form is given in Appendix Figure

[19] The United States remains the only OECD country that employs a sales tax as its primary tool for taxing consumption.

[20] The standard rate started at 22% in 1994, was increased by a percentage point in both 2010 and 2013 and in 2024 to 25.5%.

[21] The VAT tax periods correspond to calendar year (reporting deadline end of February of the next year), quarter (deadline 12th of the second month after the quarter) or month (deadline 12th of the next month).

[22] These firms are not required to register for VAT but can do so voluntarily. When their sales cross the VAT threshold, they pay VAT on all of their sales but are entitled to partial relief. The threshold has been raised to €15,000 after our study period.

A.1.

The reverse charge policy for the construction sector was implemented in April 2011. Liability for value added tax was switched from the seller to the purchaser when the following conditions are met: i) construction services are sold ii) the purchaser is a business that sells construction services on a regular basis and iii) the service is sold in Finland. The RC policy always applies if the business purchasing construction services has registered its main industry as construction[23]. Renting labor for construction purposes is considered to be a construction service. Sales of construction materials and tools remain under traditional VAT unless they are bundled with services. The transition to the new system was not completely immediate, as reverse charge did not apply to contracts that started before the policy adoption and firms completed existing projects at different times. Firms deemed to provide construction services on a continuous basis had to apply reverse charge immediately. The switch to the reverse charge mechanism was pre-announced well in advance. The law was passed in July 2010, nine months before it came into force, the Finnish Tax Administration held briefings around Finland on the policy and increased its phone helpline services during the transition period.

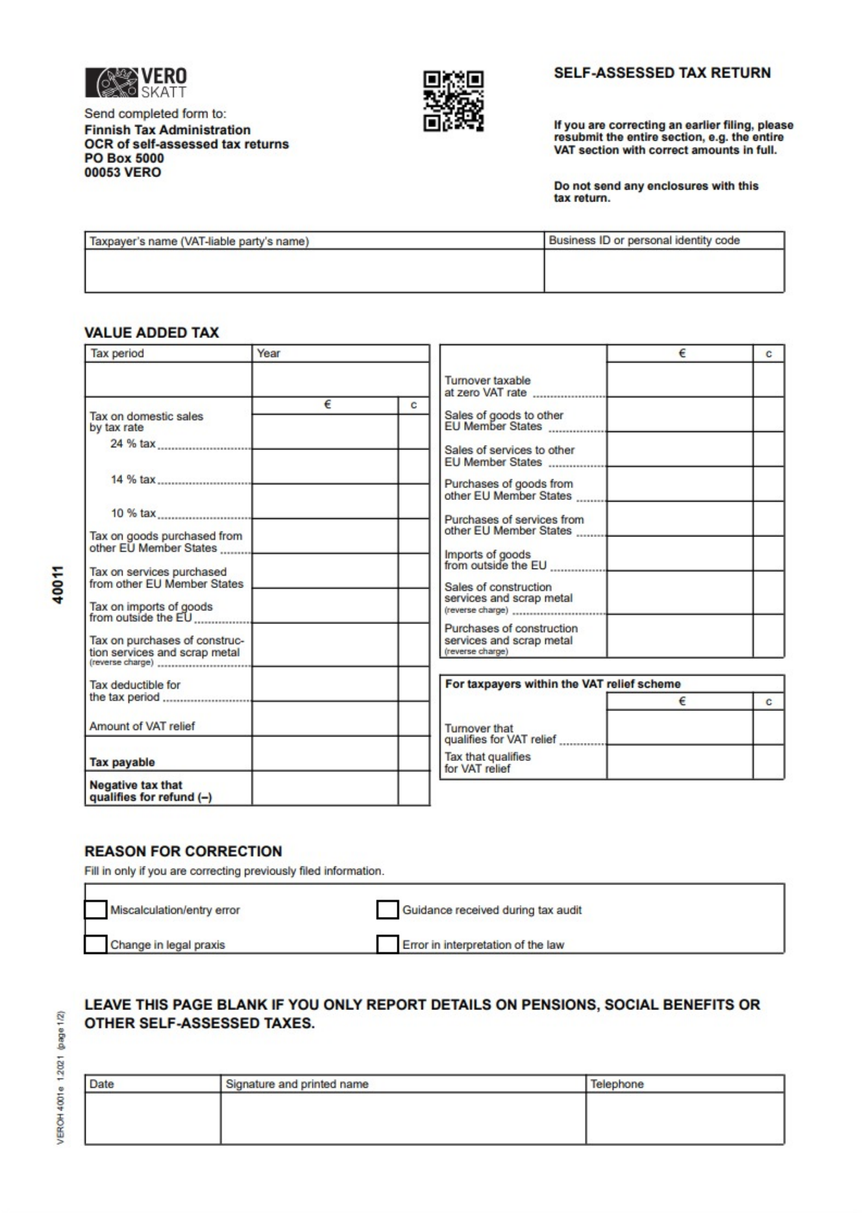
A.1.1 Auditing project in the construction sector

The Finnish Tax Administration conducted an auditing project in the construction sector in 2008-2012, with increased tax auditing and a report on tax evasion in the industry. The aim of the project was to develop tax monitoring tools in the construction sector and prevent grey economy. The project was also intended to support the development of legislation at the Finnish Tax Administration. This means that the reverse charge reform was accompanied by a period of higher tax enforcement effort. Because the higher auditing activity started before the RC reform and the number of audits remained similar across years, it does not bias our results. The number of yearly audits relative to the number of firms in the sector was also less than 2%. [24] Moreover, a higher tax audit presence is not unusual in the construction sector: already before the project there was a higher-than-average audit rate and there were regional targeted tax enforcement efforts. However,

[23]Statistics Finland classifies construction as "[. . .] the creation, management, renovation, repair, or extension of fixed assets in the form of real estate, land improvements of civil engineering nature and other constructions such as roads, bridges, and dams. This also includes related installation and assembly work, site preparation and general construction, as well as specialized services such as painting, plumbing, and demolition." Statistics relating to the construction sector use this definition unless stated otherwise. The definition covers a wide variety of construction activities from painting to groundwork.

[24]The number of audits peaked at 832 in 2009 and was between 619 and 748 in the other years, and the share of audits in construction was between 18% in 2008 and 25% in 2009.

the increased monitoring effort may have increased the effectiveness of RC due to higher monitoring during the transition period. The project revealed €200.7 million in unpaid taxes, of which unpaid VAT accounted for €62.1 million (Karvonen & Muinonen, 2014).



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SELF-ASSESSED TAX RETURN

If you are correcting an earlier filing, please resubmit the entire section, e.g. the entire VAT section with correct amounts in full.

Do not send any enclosures with this tax return.

Taxpayer's name (VAT-liable party's name)	Business ID or personal identity code

VALUE ADDED TAX

Tax period	Year		
		€	c
Tax on domestic sales by tax rate 24 % tax			
14 % tax			
10 % tax			
Tax on goods purchased from other EU Member States			
Tax on services purchased from other EU Member States			
Tax on imports of goods from outside the EU			
Tax on purchases of construction services and scrap metal (reverse charge)			
Tax deductible for the tax period			
Amount of VAT relief			
Tax payable			
Negative tax that qualifies for refund (–)			

	€	c
Turnover taxable at zero VAT rate		
Sales of goods to other EU Member States		
Sales of services to other EU Member States		
Purchases of goods from other EU Member States		
Purchases of services from other EU Member States		
Imports of goods from outside the EU		
Sales of construction services and scrap metal (reverse charge)		
Purchases of construction services and scrap metal (reverse charge)		

For taxpayers within the VAT relief scheme	€	c
Turnover that qualifies for VAT relief		
Tax that qualifies for VAT relief		

REASON FOR CORRECTION

Fill in only if you are correcting previously filed information.

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Figure A.1: The VAT form.
Notes: Sales and purchases of construction services are itemized in the right column, while reverse charge and other tax remittances are recorded on the left side. Taxes and deductions are aggregated by rates and there are no attachments required.

Table A1: Construction-sector policy measures and key dates (year–month)

Policy Measure	Government Bill	Act Passed	Entry into Force
VAT Reverse Charge	2010–04	2010–07	2011–04
Law on Tax Number Registry	2011–10	2011–12	2011–12
Tax Number on Site ID Card	— (by decree)	2012–05	2012–09 (new); 2013–03 (all)
Contractor's Reporting Liability	2012–09	2013–05	2014–07

A.2 Countries with domestic RC

Table A2: Countries with domestic RC

Country	Construction	Precious metals	Scrap	Electronics	Certificates	Cereal	Telecom services	Other
Australia		X						
Austria	X	X	X	X	X			
Belgium	X	X			X			
Bulgaria		X	X		X	X		
Chile								X
China			X					
Croatia	X		X		X			X
Cyprus	X	X	X	X				
Czech Republic	X	X	X	X	X	X	X	
Denmark		X	X	X	X		X	X
Estonia		X	X					X
Ethiopia								X
Finland	X	X	X		X			
France	X	X	X		X		X	X
Georgia								X
Germany	X	X	X	X	X		X	X
Greece	X	X	X	X	X			
Guatemala								X
Honduras								X
Hungary	X		X	X	X	X	X	X
India								X
Ireland	X		X		X			
Israel	X							
Italy	X	X	X	X	X			X
Rebublic of Korea								X
Kosovo	X							
Latvia	X	X	X	X	X	X		
Lithuania	X		X	X				X
Luxembourg				X				X
Malta	X							
Moldova								X
Montenegro								X
Nepal	X							
Netherlands	X	X	X	X	X		X	
North Macedonia	X		X					
Norway		X			X			
Poland	X	X			X			X
Portugal	X		X		X			
Romania		X	X	X	X	X		X
São Tomé and Príncipe	X							X
Serbia	X							
Singapore				X				
Slovak Rebublic	X	X	X	X	X			X
Slovenia	X		X		X			
South Africa		X						
Spain	X	X	X	X	X			X
Sweden	X	X	X	X	X			
Swizerland								X
United Arab Emirates		X		X				X
United Kindom	X			X	X		X	X
Uruguay								X
Zambia								X
Zimbabwe								X

Notes: Columns refer to most common goods and services subject to RC found by screening (EY, 2024).

A.3 Data description

Table A3: Data descriptions for selected variables

Variable	Description
Difference-in-Differences Analysis	
Gross VAT	Total reported VAT for the year. This is the sum of value added taxes for each rate and VAT from purchases made from other EU countries. Taxes from sales of construction services are added by multiplying tax free sales by the standard rate. Reverse charge is excluded.
Deductibles	Total reported VAT deductions for the year. This is the sum of VAT included in input costs.
Net VAT	Gross VAT - Deductibles - VAT Relief = Net VAT. VAT liabilities for the year.
Sales	Total sales for the year without VAT included. This also includes sales made under zero rate.
Employer's remittance	Includes payroll taxes and income taxes withheld from employees' wages.
Sector Industry Code (SIC)	Five-digit code determined by the industry where a firm produces most value added.
Coarsened Exact Matching	
Indicator for Zero Revenue	Takes value of one, if sales is equal to zero that year.
Number of employees	Average number of employees, divided into 11 categories. (NA, 0, 1-4, 5–9, 10–19, 20–49, 50–99, 100–249, 250–499, 500–999 and 1 000+)
Mean wages	Annual wages divided by the number of employees. Winsorized at 0.1% to deal with extreme outliers. Coarsened according to the Sturge's rule.

Notes: All variables are at firm level. The firm's industrial classification is determined as the activity where it created the most value added. A business registered to one industry may conduct several types of production in other industries too. Classifications are internationally standardized and the classifications considered in this paper are entirely comparable with the European Classification of Economic Activities (NACE) and the International Standard Industrial Classification (ISIC).

A.4 Industries in the control group

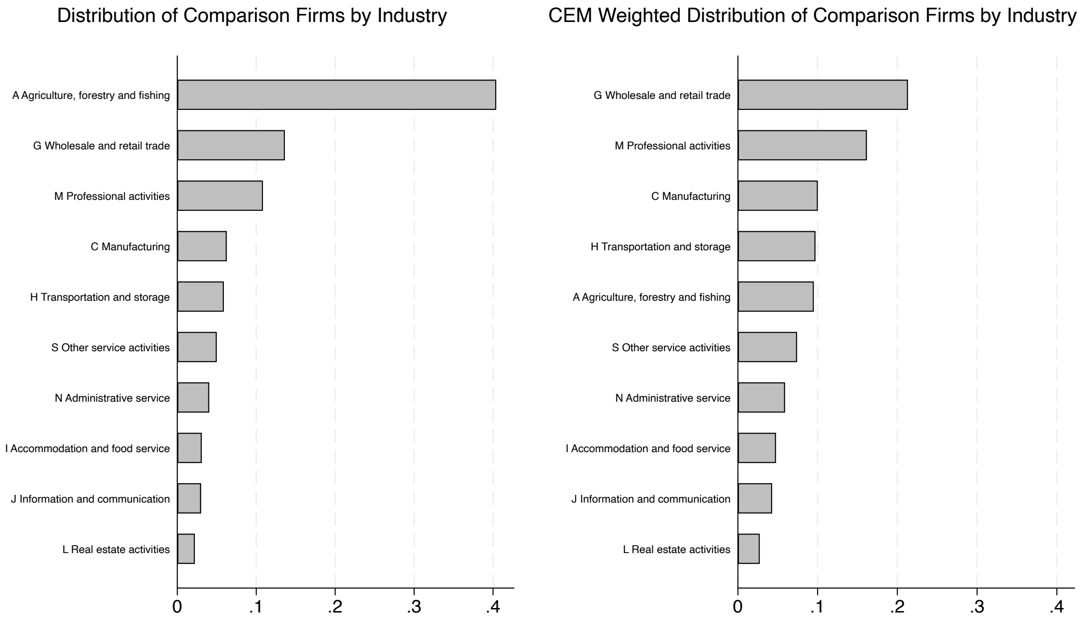

Figure A.2: Industries in the control group pre- and post-weighting.
Notes: The panels in this figure depict industry shares measured by the number of firms in the VAT register. In the left panel, each firm is counted once (equal weights). On the right, shares are calculated according to each sector's sum of CEM weights.

Our preferred weighting scheme reduces the influence of primary producers on the estimates. The CEM algorithm redistributes the weight from these firms mainly to retail, professional services and manufacturing. The large share of firms in sector A is due to widespread forestland ownership. The sale of timber and maintenance of forest assets is part of the VAT base.

A.4.1 Raw means between the construction sector and the pruned comparison group

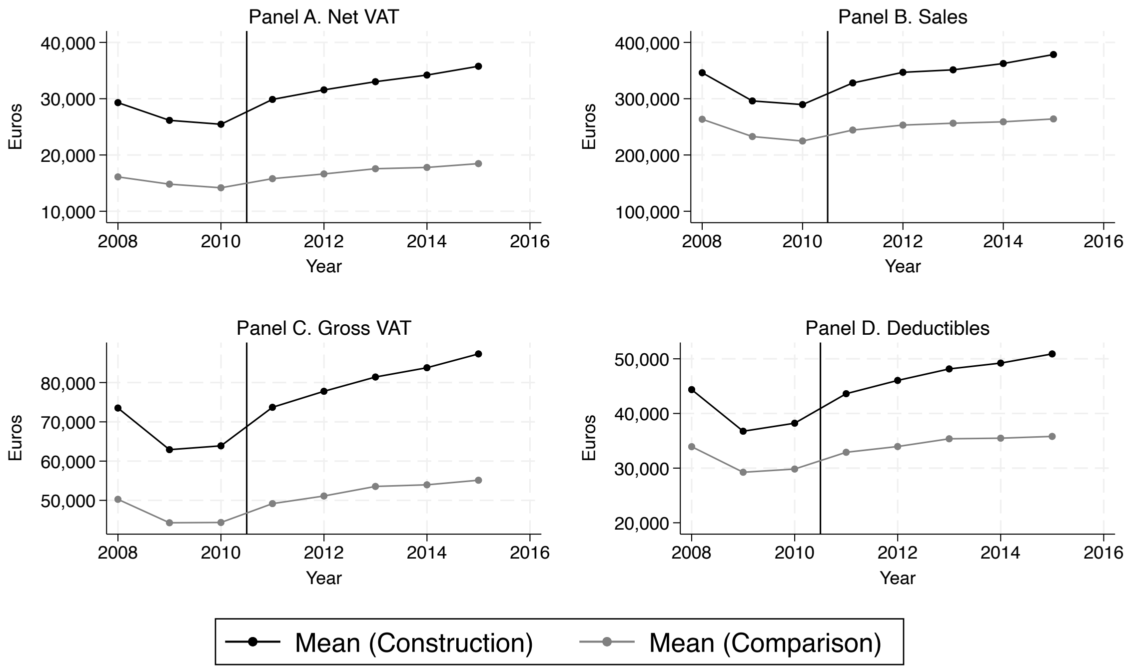

Figure A.3: Raw means between construction sector and pruned comparison group 2008-2015
Notes: This figure plots the average Net VAT, Sales, Gross VAT and deductibles for construction sector and comparison group, excluding comparison firms that were not matched in the first stage of the CEM procedure.

A.5 Robustness checks

A.5.1 Full sample

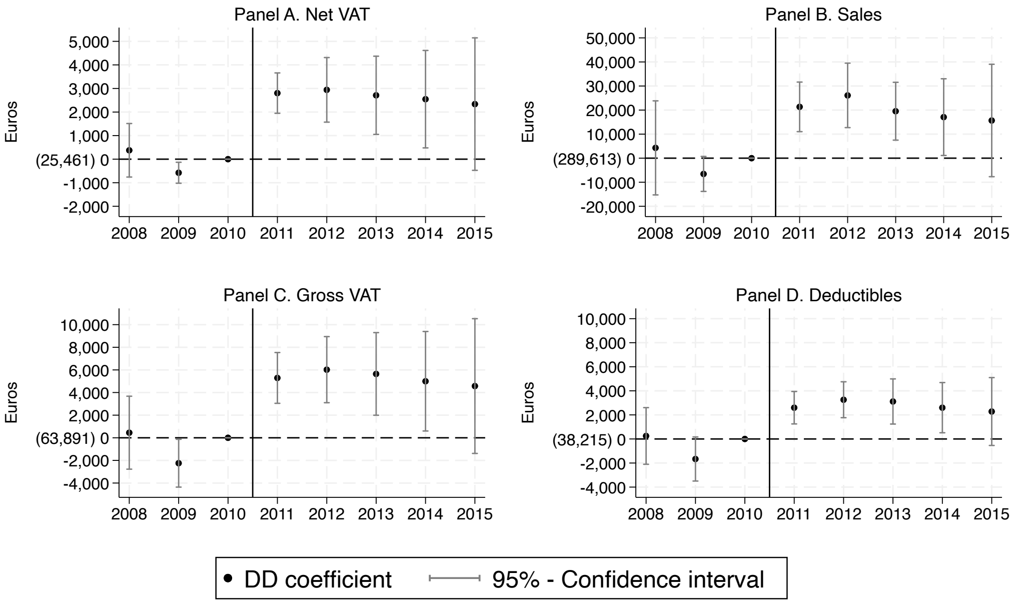

Figure A.4: Responses to 2011 RC policy – dynamic DD without CEM weights.
Notes: This figure plots DD coefficients with 2010 as a baseline year, controlling for company and year fixed effects and using the non-weighted data. Standard errors are clustered by one-digit industry codes and dependent variables are winsorized at 1% at both tails. The pre-trend p-values are 0.0022 for net VAT, 0.1835 for sales, 0.052 for gross VAT and 0.026 for deductibles.

Pre-trends between the construction industry and the rest of the firms indicate that construction is more cyclical. Construction firms' reports are relatively more sensitive to business cycles prior to the policy, which signals that they are likely to affect differences in VAT reports in the post-treatment period as well. It is very likely that with this specification the DD coefficients are biased since exact parallel trends do not appear plausible.

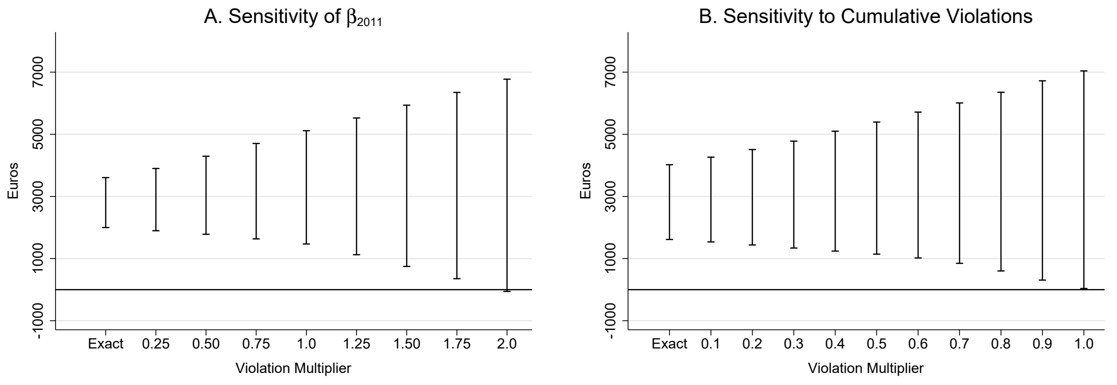

Figure A.5: Full sample sensitivity tests for dynamic DD parameters with net VAT as the outcome. *Notes:* The x-axis shows violation multipliers for the maximum pre-trend violations. Panel A shows the sensitivity ofβ_{2011} and Panel B shows the sensitivity of our mean causal effect under consecutive shocks. The confidence sets include the true parameter 95% of the time when the parallel trends violation is bounded within a given magnitude. The standard errors are clustered at the one-digit industry level. "Exact" shows the 95% CI with exact parallel trends.

Sensitivity analysis of the unweighted estimates demonstrates that rejecting a null effect of the policy requires very large deviations from the parallel trends. The right panel shows that additive shocks to construction firms would have to be as large as with the 2009 recession *each year* before we would not be able to reject the null. Correspondingly, unless a trend violation in 2011 were to be twice as large as after the financial crisis, we conclude that the RC reform increased net VAT. As discussed in Appendix A.4, we prefer the more conservative CEM-weighted estimates since the matched groups are more comparable.

Table A4: Unweighted difference-in-differences estimates

	(1) Net VAT	(2) Gross VAT	(3) Sales	(4) Deductibles
Construction $\times$ *Post*	2,673.9***	5,582.5**	20,408.8.8**	3,057.0**
	(678.8)	(1,709.6)	(6,645.9)	(922.2)
Observations	2,521,382	2,521,382	2,521,382	2,521,382
R^2	0.90	0.94	0.94	0.94
Construction average (2010)	35,152.2	100,415.8	448,044.8	65,238.1
Scaled estimate	0.0761	0.0556	0.0456	0.0469

Notes: Dependent variables are winsorized at 1% at both tails. Standard errors clustered by one-digit sector industry codes in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

A.5.2 Entry into the construction sector

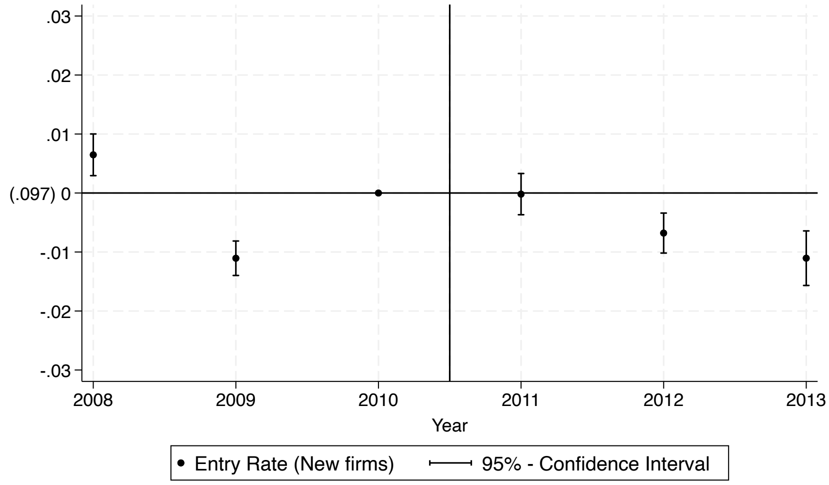

Figure A.6: Responses to the 2011 RC policy – Dynamic DD estimates for industry-level entry rates.
Notes: This figure plots the DD estimates of industry level entry rates, controlling for year and one-digit industry fixed effects. Industries are weighted by their size in 2010, Standard errors are clustered at one-digit industry codes. The entry rate is defined as the share of new firms in an industry relative to the number of firms operating at the end of the previous year and is based on information on Statistics Finland's Enterprise Openings and Closures module.

Analyzing market entry in our context presents a few challenges. First, we cannot appropriately weight new firms, as there is no prior information available on their characteristics. Second, it is not possible to distinguish new entrants from incumbent firms in the first year of the panel (2008). To address these limitations, we draw on auxiliary industry-level data from Statistics Finland's Enterprise Openings and Closures module, which reports the number of new, incumbent, and exited firms. The entry rate is defined as the share of new firms in an industry relative to the number of firms operating at the end of the previous year.

Figure A.6 presents the dynamic difference-in-differences estimates of entry rates, controlling for year and one-digit industry fixed effects. Industries are weighted by their size in 2010, and standard errors are clustered at the industry level. We find no clear evidence of changes in the share of new entrants in the year when reverse charge is introduced. However, entry rates appear to be about 10% lower (– 1 percentage point) in 2013, which may partly reflect a decline in firm exits after 2011, as discussed in the main text. The pre-treatment dynamics indicate that the parallel trends assumption may not hold in the absence of matching.

A.5.3 Estimates on the number of workers

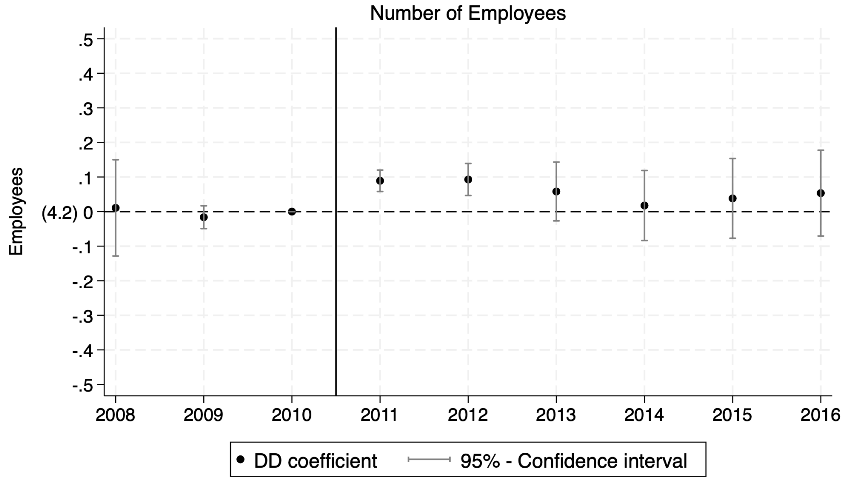

Figure A.7: Responses to reported number of employees - dynamic DD with CEM weights.
Notes: This figure plots DD coefficients with 2010 as a baseline year, controlling for company and year fixed effects and using the CEM weighted data. Standard errors are clustered by one-digit industry codes and dependent variables are winsorized at 1% at both tails.

We extend the analysis to examine changes in the number of employees in construction. Figure A.7 reports the results for the number of employees. We note that since we also match on the number of employees, these results should be interpreted with caution. In this specification, if a firm has not reported any employees, we impute zero employees for that year.

A.5.4 Estimates for alternative specifications

Table A5: Difference-in-differences estimates for alternative specifications

	(1) Alt. Coarsening	(2) Alt. Size Var	(3) Balanced panel	(4) Matching 2008	(5) Matching 2009
Net VAT	1,787.4***	2,030.1*	1,636.4**	1,385.5**	1,396.8**
	(457.4)	(749.5)	(493.9)	(477.9)	(444.7)
R^2	0.89	0.89	0.90	0.90	0.89
Mean (2010)	35,155.8	35,152.2	46,251.1	39,502.8	37,595.0
Gross VAT	3,476.0***	3,869.6*	2,698.1*	2,692.3**	2,660.7**
	(874.6)	(1,550.6)	(1,229.3)	(934.1)	(838.2)
R^2	0.94	0.93	0.95	0.94	0.94
Mean (2010)	100,417.6	100,415.8	133,036.9	112,889.7	107,094.0
Sales	13,758.2**	17,370.1*	8,880.6*	11,071.0	10,248.7*
	(4,360.8)	(7,925.4)	(3,724.3)	(5,600.9)	(4,566.5)
R^2	0.94	0.93	0.95	0.94	0.94
Mean (2010)	448,053.9	448,044.8	594,265.6	504,856.1	478,353.4
Deductibles	1,945.6**	2,118.4*	1,344.0	1,501.7*	1,496.5*
	(588.4)	(752.4)	(1,055.7)	(593.6)	(548.2)
R^2	0.93	0.92	0.94	0.93	0.93
Mean (2010)	65,236.3	65,238.1	86,762.4	73,361.3	69,473.4
Observations	2,517,077	2,521,382	1,811,952	2,397,280	2,527,934

Notes: Difference-in-differences estimates for alternative CEM criterion and sample restrictions. The dependent variables are winsorized at 1% at both tails. Mean refers to the average outcome for construction firms in 2010. The standard errors are clustered by one-digit sector industry codes in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

1. Alternative coarsening: alternative choice of coarsening for employee bins: missing value, sole entrepreneur, micro (1-9 employees), small (10-49), medium (50-249) and large (250+).

2. Alternative Size Variable: CEM specification with only sales and zero sales dummy in 2010 as matching variable.

3. Balanced panel: firms that remain in the sample from 2008 until 2015.

4. Matching "year": preferred matching specification conducted using data from other years.

A.5.5 Imputed sample

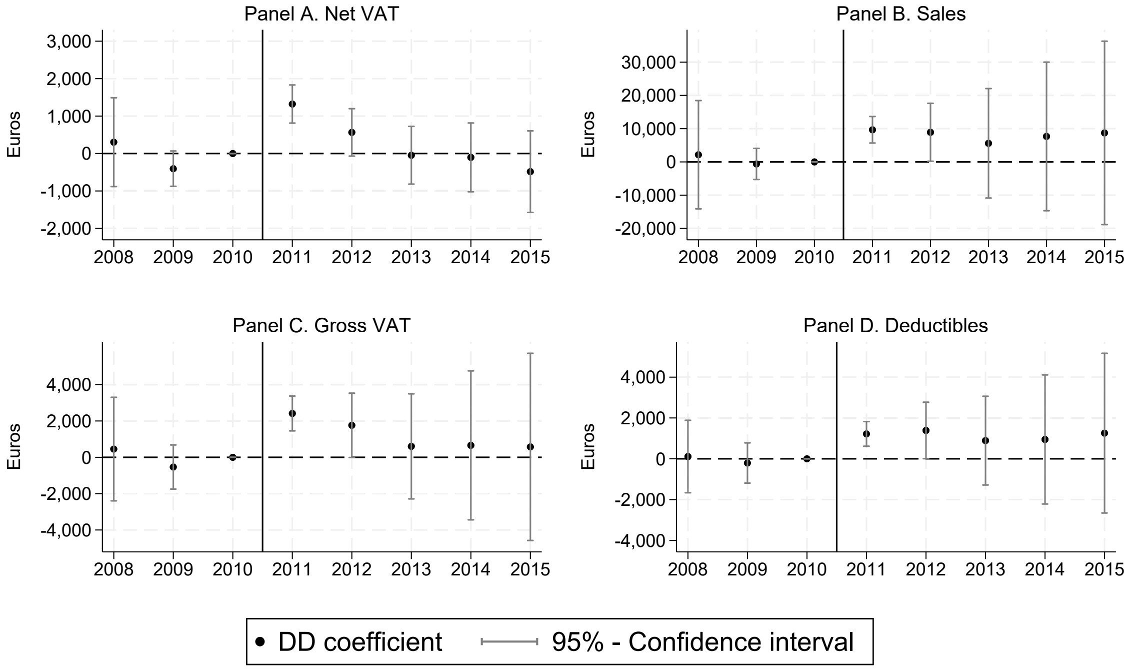

Figure A.8: Responses to the 2011 RC policy – Dynamic DD with a weighted sample where firms exiting the register are kept in the sample by imputing zero returns.
Notes: This figure plots the dynamic DD estimates (Eq. 2) using the weighted sample where firms that exit the register are kept in the sample by imputing zero returns. DD coefficients show the differences between construction and control industries with 2010 as the baseline, and controlling for company and year fixed effects. The standard errors are clustered by one-digit industry codes and the dependent variables are winsorized at 1% at both tails.

In figure A.8, we use the weighted sample, where we also impute zero returns for firms after they have left the register. Since relatively more construction firms leave each year, the differences decrease mechanically with time.

A.5.6 Stratum-level dynamic DD estimates

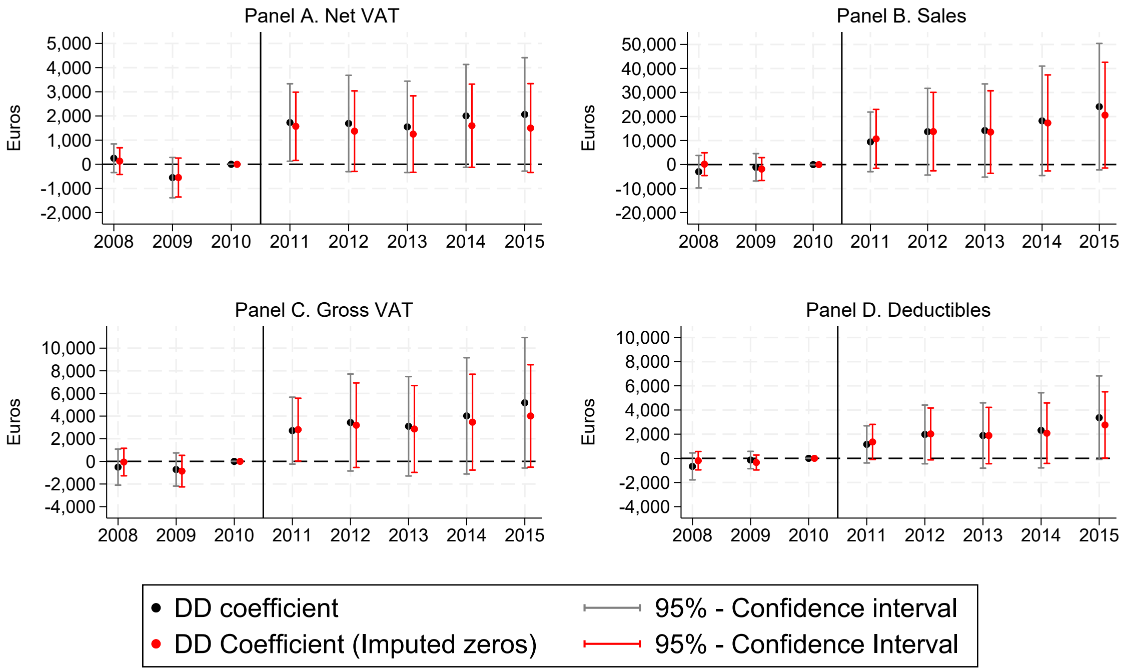

Figure A.9: Responses to the 2011 RC policy – Dynamic DD on stratum-level average outcomes. *Notes:* This figure plots the dynamic DD estimates using a repeated cross-section of CEM strata, which allows for firm exits and entries. The DD coefficients show the differences between construction and control industries with 2010 as the baseline, and controlling for group-stratum and year-fixed effects. Firms that exit the register are assigned zero returns. The standard errors are clustered by stratum and the dependent variables are winsorized at 1% at both tails before aggregation.

We study the permanence of the ITT effect by constructing a repeated cross-section of CEM strata. This allows for firm exits and entries. We use the coarsened bins that were generated with the preferred CEM specification. First we assign each firm to a stratum according to its annual returns. Then we split each stratum into a construction-stratum group and a comparison-stratum group. After each firm has been assigned its respective group, we aggregate the groups and calculate the averages for outcomes of interest. Finally, we weight the groups to make the treatment and comparison cells comparable. A treated stratum receives a weight equal to the number of units in the stratum in 2010. Weights for the control stratum are calculated in two steps. First, we divide the number of treatment units in the corresponding stratum by the number of control units in 2010. Secondly, we normalize the weight so that the control group's weights sum up to the number of comparison firms in 2010. This process is analogous to CEM matching with individual firms, but we now can observe how the ITT effect evolves as new firms enter and old ones exit the market. The estimates are plotted in Figure A.9.

A.5.7 Quarterly dynamic DD estimates

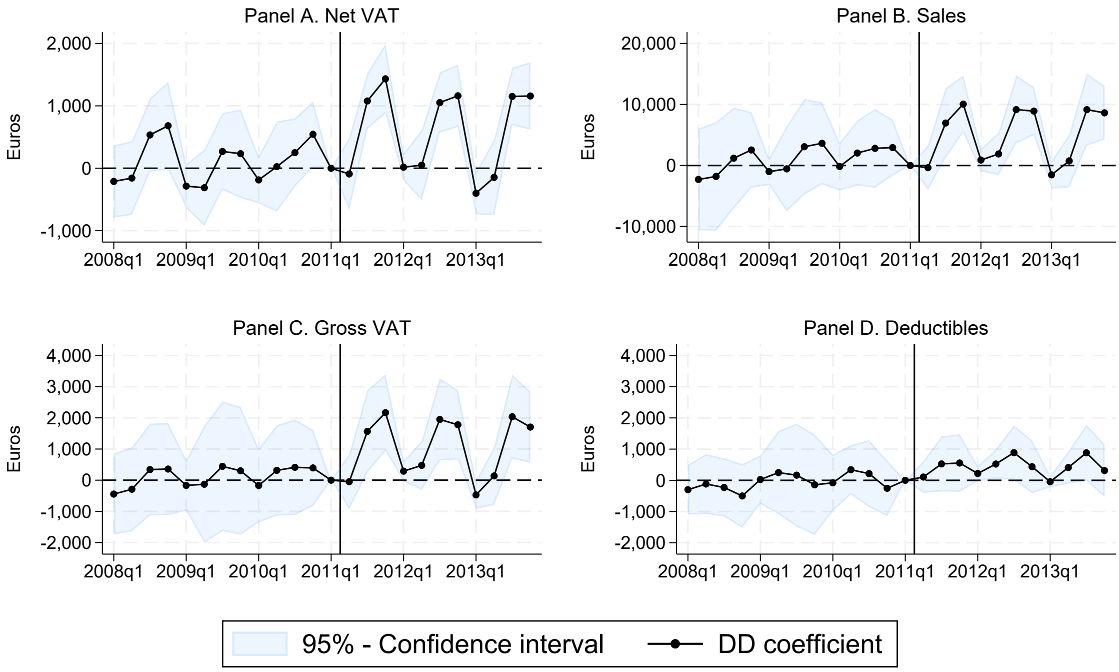

Figure A.10: Quarter-level responses to the RC policy.
Notes: This figure plots the dynamic DD estimates with weighted sample of firms that file VAT returns quarterly or monthly (N = 271,209). The baseline difference is normalized to zero and it is the last quarter before the reverse charge mechanism was implemented. The specification includes fixed effects for *firm*, *quarter* × *year* and *quarter* × *industry*, to deal with seasonal trends. The standard errors are clustered by one-digit industry codes and the dependent variables are winsorized at 1% at both tails.

A.5.8 Dynamic DD estimates conditional on surviving

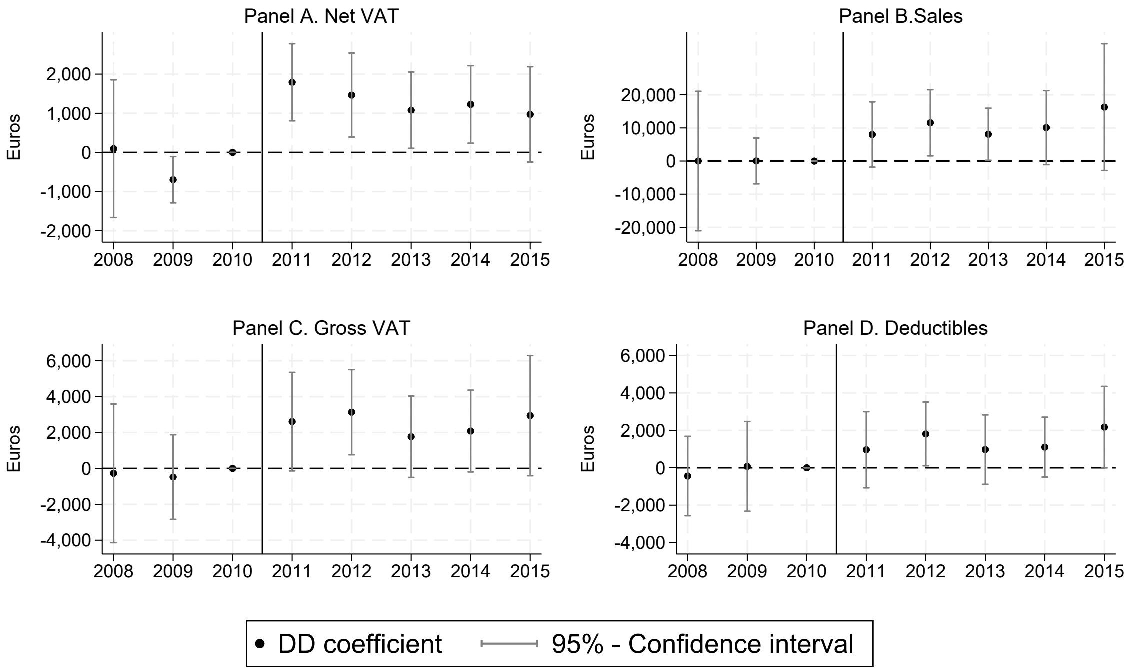

Figure A.11: Responses to the 2011 RC policy – dynamic DD with the weighted sample and conditional on surviving.
Notes: This figure plots the dynamic DD estimates using the weighted sample where firms remain in the register between 2008-2015. DD coefficients show the differences between construction and control industries with 2010 as the baseline, and controlling for company and year fixed effects. The standard errors are clustered by one-digit industry codes and the dependent variables are winsorized at 1% at both tails.

Figure A.11 plots the dynamic DD estimates for a sample restricted to firms that remain in the register from 2008 to 2015.

A.5.9 Results using alternative matching variable

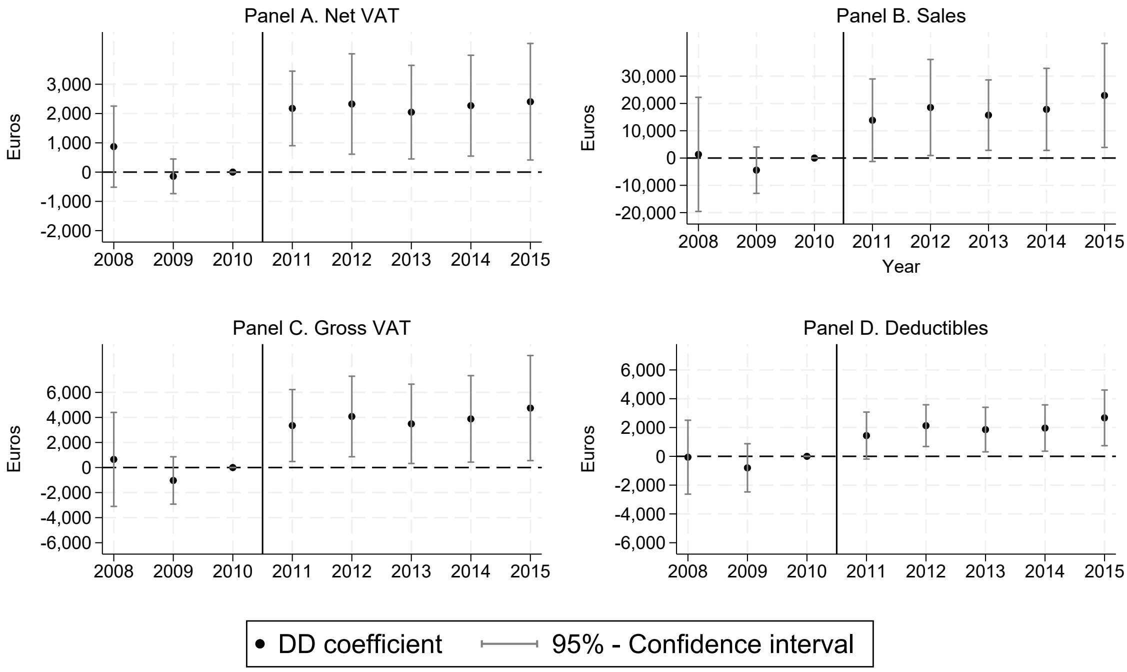

Figure A.12: Responses to the 2011 RC policy – Dynamic DD with alternative matching variables. *Notes:* This figure plots the dynamic DD estimates (Eq. 2) using a matched sample where employee count and average salary are replaced by sales as a matching variable. Coarsening (in thousands): 0–39 , 40–99 , 100–399 , 400–1,999 , 2,000–9,999 , 10,000–39,999 , 40,000–199,999 and 200,000+. The DD coefficients show the differences between construction and control industries with 2010 as the baseline, and controlling for company and year fixed effects. The standard errors are clustered by one-digit industry codes and the dependent variables are winsorized at 1% at both tails.

A.5.10 Results using alternative matching year

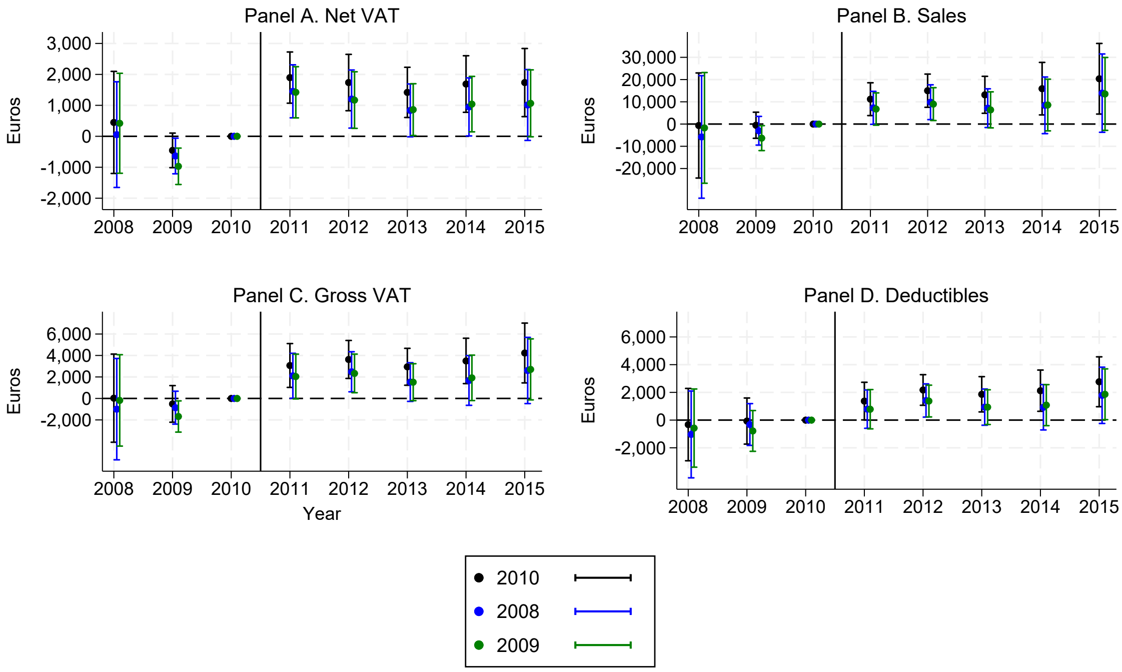

Figure A.13: Responses to the 2011 RC policy – Dynamic DD with alternative matching years.
Notes: This figure plots the dynamic DD estimates (Eq. 2) using the same matching variables as with the preferred specification, and varying the years used for matching. Results for the main specification (2010) are in black, results with the 2009 matching data are in green and with 2008 data in blue. The standard errors are clustered by one-digit industry codes and the dependent variables are winsorized at 1% at both tails.

Table A6: Difference-in-differences estimates for alternative winsorizing levels

	(1) 1%	(2) 0.1%	(3) 3%
Net VAT	1,781.9***	1,930.5*	1,231.5**
	(449.2)	(701.2)	(336.5)
R^2	0.89	0.89	0.88
Construction average (2010)	35,152.2	35,152.2	35,152.2
Gross VAT	3,494.4***	4,620.5*	2,592.4**
	(866.9)	(2,102.3)	(697.7)
R^2	0.94	0.95	0.93
Construction average (2010)	100,415.8	100,415.8	100,415.8
Sales	13,828.5**	20,997.6**	10,738.3*
	(4,280.1)	(5,626.6)	(3,914.2)
R^2	0.94	0.94	0.93
Construction average (2010)	448,044.8	448,044.8	448,044.8
Deductibles	1,961.7**	2,796.1	1,562.8**
	(583.4)	(1,699.4)	(483.3)
R^2	0.93	0.94	0.92
Construction average (2010)	65,238.1	65,238.1	65,238.1
Observations	2,516,771	2,516,771	2,516,771

Notes: Difference-in-differences estimates of the preferred specification in column 1 and with alternative levels of winsorizing at both tails in columns 2 and 3. Standard errors clustered by one-digit sector industry codes in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

A.5.11 Falsification study

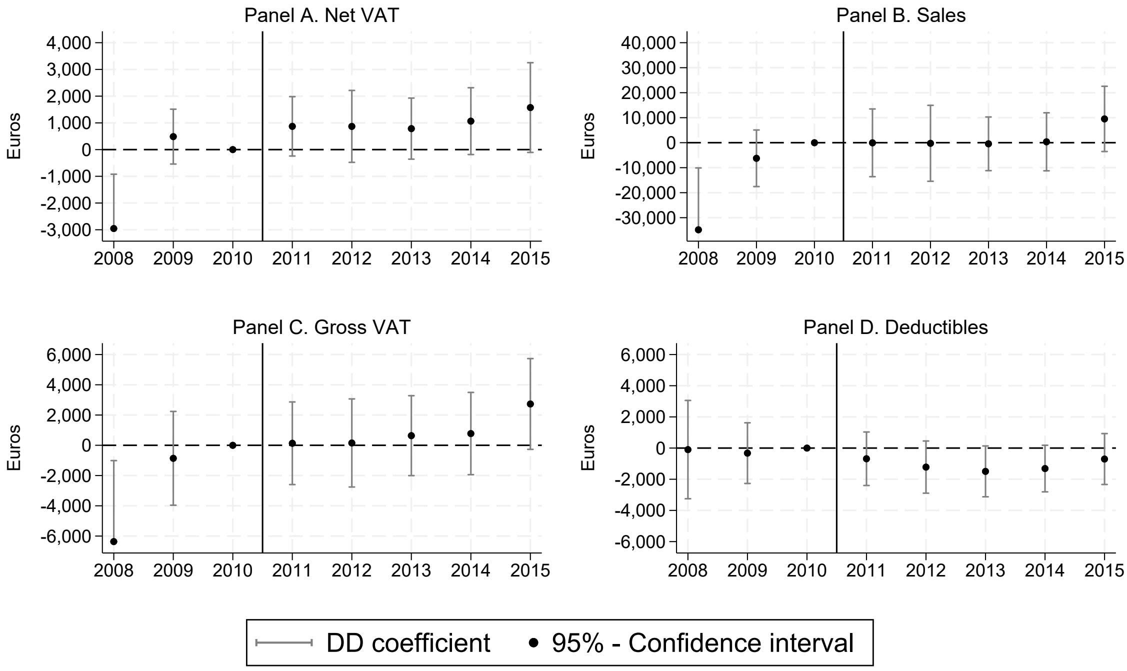

Figure A.14: Responses to the 2011 RC policy – Dynamic DD with a placebo treatment group.
Notes: This falsification exercise plots the dynamic DD estimates (Eq. 2) using a placebo group of real estate activities and removing construction sector from the sample. The DD coefficients show the differences between real estate and control industries with 2010 as the baseline, and controlling for company and year fixed effects. The standard errors are clustered by one-digit industry codes and the dependent variables are winsorized at 1% at both tails. The lower bound of the 2008 confidence interval in panels A, B and C is truncated for readability of the figures.

We use a falsification study to check that the results in the construction industry are not driven by a demand shock by examining an adjacent industry, real estate activities[25], where the remittance rule remained the same. The industry classification covers buying, selling and operating real estate as well as real estate activities on a fee or contract basis. If the reported increase in construction services is driven by real economic factors, we expect to see similar increases for real estate agencies and managers. The falsification study repeats the steps in the main analysis with two changes. First, we remove construction firms from the full sample. Second, we use firms registered in real estate activities as a placebo treatment group (N = 9,184). The dynamic difference-in-differences estimates are plotted in Figure A.14.

We do not observe similar dynamics between the designated placebo group and firms that were affected by the actual reform. After a significant drop in 2008, sales and gross VAT in the placebo group remain stable compared to the their baseline difference, while deductions decrease. A reduction in deductibles drives increases in net VAT.

[25](NACE 2008 Classification: L)

B Theoretical model

B.1 Set-up

Consider tax evasion in a two firm set-up with an upstream firm u that sells inputs to downstream firm d. Compared to Table 1, this excludes the intermediary firm for simplicity. The firms have sales s_u and s_d. The downstream firm has input costs $c_d = s_u$, and the upstream firm u does not have costs. The firms have to pay VAT of rate τ on their value added v_i for firm i. The firms can evade taxes by misreporting their value added; let $\overline{s}_i$ denote reported sales and $e_i = v_i - \overline{v}_i$. For u $v_i = s_i$ and for firm d $v_d = s_d - s_u$ and $\overline{v}_d = \overline{s}_d - \overline{c}_d$.

Tax enforcement policy: The firms face a penalty θ for tax evasion. We make two novel additions to the model by Allingham and Sandmo (1972). First, we include interdependence of firm audits that formalizes the paper trail into the model. Second, we include a penalty θ^r on misreporting. Typically the literature only considers a penalty for evasion, but in reality the tax agencies can also penalize firms for misrepresenting their accounting, even if it did not decrease their tax liabilities. This misreporting penalty serves the purpose of enforcing the reliability of third party information by dis-incentivizing collusion. Below, we discuss that this misreporting penalty is important for reverse charge compliance, essentially making it not equivalent to a sales tax regime.

The total tax audit rate of firm i is

$$a_i(e_i) + \alpha_i I(\overline{v}_i < 0) + \rho a_j \tag{7}$$

where $a_i(e_i) + \alpha_i I(\overline{v}_i < 0)$ is the firm's own tax audit rate depending on its level of tax evasion and including a higher audit rate for firms that report negative tax liability.[26] A higher audit rate for negative reported tax liability is discussed in, e.g., Waseem (2022) and is an important feature of the self-enforcement mechanism in VAT. The tax audit probability can depend on the firm type, e.g. firm size. As an addition to prior models, we include interdependence of firm audits captured by ρ. This reflects the VAT paper trail feature: upon audit of firm j, the tax administration could detect evasion by i. We assume that the true sales and value added is discovered at the firm i's own audit, firm j's audit discovers sales of i reported as costs by j, but firm j's audit does not recover sales of i not reported by j.

Costs of evasion: For simplicity of notation we only include the expected cost of evasion as a function of the audit probability (assuming detection upon audit) and

[26] Actually, the audit probability is $\min\{a_i(e_i) + \alpha_i I(\overline{v}_i < 0) + \rho a_j(e_j), 1\}$ as it cannot exceed one, but we use the simple notation and just implicitly assume this.

penalty rate. The cost of evasion through only own audit is defined by:

$$g_i(e_i) = (a_i(e_i) + \alpha_i I(\overline{v}_i < 0))(1+\theta)\tau e_i. \tag{8}$$

However, the firm can face different costs of evasion too, such as reputational harm or evasion, managerial or owner preference for compliance or higher detection probability arising from the firm's characteristics (e.g. larger firms more likely to have internal whistleblowers). For our purposes, these additional costs can be thought to be included in either the firm's own audit probability $a_i(e_i)$ (higher likelihood of detection, preference for compliance) or the penalty rate (e.g. reputational harm of getting caught of evasion).[27]

B.2 Conventional VAT

Let us consider first unilateral tax evasion, i.e. firms decide alone on their own level of tax evasion. Then we discuss collusive evasion, where firms can collude in order to decrease the risk of detection.

The expected profit function for the upstream firm u is:

$$\pi_u = s_u + \tau e_u - (a_u(e_u) + \alpha_u I(\overline{s}_u < 0))(1+\theta)\tau e_u - \rho a_d(1+\theta)\tau(\overline{c}_d - \overline{s}_u) \tag{9}$$

where $e_u = s_u - \overline{s}_u$. Their expected payoff depends on their own evasion and audit rate, but also the reporting behavior and audit rate of firm d: the last argument gives the penalty for reporting less sales than what d reports as purchase (assuming paper trail only holds for costs they report). In other words, the tax administration considers $\overline{c}_d$ as the lower bound of s_u.

The expected profit for firm d is:

$$\pi_d = v_d + \tau e_d - (a_d(e_d) + \alpha_d I(\overline{s}_d < \overline{c}_d))((1+\theta)\tau e_d + \theta^r|\overline{c}_d - s_u|) - \rho a_u(e_u)\theta^r|\overline{c}_d - s_u| \tag{10}$$

which also includes a penalty for misreporting c_d and where $e_d = v_d - \overline{v}_d$. The firm wants to report more costs to increase the expected profit. However, the misreporting penalty makes tax evasion through over-reporting of costs more expensive than through under-reporting of sales. Hence, the firm reports the true purchase as costs and $\overline{c}_d = s_u$. Plugging in this the profit function becomes:

$$\pi_d = v_d + \tau e_d - (a_d(e_d) + \alpha_d I(\overline{s}_d < s_u))(1+\theta)\tau e_d. \tag{11}$$

[27] Directly modelling these additional costs does not change the results but would introduce additional notation.

The FOC for optimal level of tax evasion is:

$$FOC : 1 = (1 + \theta)(a'_d(e_d)e_d + a_d(e_d) + \alpha_d I(\overline{s}_d < s_u)). \tag{12}$$

In this equation the left-hand side is the marginal benefit of evading one euro and the right-hand side is the expected marginal cost of evading that euro. There is a jump in the audit probability for reporting negative value added. There are three possible solutions: (i) an inner solution where $\overline{s}_d > s_u$ and the FOC holds, (ii) bunching solutions where

$$(1 + \theta)(a'_d(e_d)e_d + a_d(e_d) + \alpha_d) > 1 > (1 + \theta)(a'_d(e_d)e_d + a_d(e_d)) \tag{13}$$

where firms report either 0 or close to zero value added, and their evasion is effectively deterred by α_d, or (iii) outer solution where $\overline{s}_d < s_u$, i.e., firm reports negative value added.

Now, we can plug in $\overline{c}_d = s_u$ in equation 9 for the profit function of firm u. This gives the first-order condition for optimal level of tax evasion:

$$FOC : 1 = (1 + \theta)(a'_u(e_u)e_u + a(e_u) + \alpha_u I(\overline{s}_u < 0) + \rho a_d). \tag{14}$$

The audit probability of firm d decreases the tax evasion of the upstream firm if ρ is positive making the cost of evading one euro higher than without the paper-trail. Without the paper trail, $\rho = 0$ and the upstream firm evades more. Similarly as for the upstream firm the firm can have inner, bunching or outer solution.

Consequently, this model reproduces the well-known tax evasion deterrence features of the VAT model: the paper trail, captured by interdependent audits, decreases evasion of upstream firms, and the paper trail combined with a higher audit rate for reported negative value added decreases the evasion of the downstream firm.

Collusive evasion: Consider now collusive evasion such that firm u pays a share ϕ of evasion to firm d, and they agree to destroy evidence on a purchase (e.g. no receipt, payment in cash). We still assume the firm's true evasion can be detected at their own audit, but the audit cannot reveal the transaction. Now the payoff function for firm u is:

$$s_u + \tau e_u - \phi\tau e_u - (a_u(e_u) + \alpha_u I(\overline{s}_u < 0))(1 + \theta)\tau e_u - \rho a_d(e_d)(1 + \theta)\tau(\overline{s}_u - \overline{s}_u) \tag{15}$$

as the last term cancels out, this gives the FOC condition:

$$FOC: 1 = (1+\theta)(a_u'(e_u)e_u + a(e_u) + \alpha_u I(\bar{s}_u < 0)) + \phi. \tag{16}$$

Firm u evades more under collusion if $\phi \leq \rho a_d(1+\theta)$, which is also the feasibility condition for u to participate in collusion.

The expected profit for firm d is:

$$v_d + \tau e_d + \phi\tau e_u - (a_d(e_d) + \alpha_d I(\bar{s}_d < \bar{s}_u))((1+\theta)\tau(e_d + e_u) + \theta^r|\bar{c}_d - \bar{s}_u|) - \rho a_u(e_u)\theta^r|\bar{c}_d - \bar{s}_u|. \tag{17}$$

Here firm d gets penalized for the evasion by firm u, as it has no receipts to justify the true costs. However, the firm faces a lower audit rate in the range $s_u > \bar{s}_d > \bar{s}_u$, allowing to report sales less than the true purchase from u. The FOC for firm d is:

$$FOC: 1 = (1+\theta)(a_d'(e_d)(e_d + e_u) + a_d(e_d) + \alpha_d I(\bar{s}_d < \bar{s}_u)). \tag{18}$$

If the optimal evasion choice without collusion is either inner or outer solution, the FOC and, thus, the level of own evasion is the same. For these levels of evasion, i.e., $\bar{s}_d < \bar{s}_u$ or $\bar{s}_d > s_u$, collusion would only be feasible if $\phi \geq a_d(e_d)(1+\theta)$, making collusion only feasible when $\rho = 1$ after accounting for feasibility for u. The firm d's evasion only changes from non-collusion if it is a buncher without collusion, defined by equation 13, because the deterrence effect from α_d is removed for $s_u > \bar{s}_d > \bar{s}_u$. Now feasibility is determined whether the benefit of lower tax audit probability plus compensation from u is larger than the expected penalty for u's evasion for d. The condition is $\phi \geq (1+\theta)(a_d(e_d) - \alpha_d \frac{e_d}{e_u})$. Now we get the feasibility condition for collusive evasion:

$$\rho a_d(e_d)(1+\theta) \geq \phi \geq (1+\theta)(a_d(e_d) - \alpha_d \frac{e_d}{e_u}). \tag{19}$$

This equation tells us that collusion is more likely if ρ is large, meaning a high paper trail effect on tax evasion detection, e_d is large compared to e_u, i.e. the downstream firm evasion is high compared to the upstream firm, or α_d, i.e. the increase in audit probability for reporting negative value added, is large.

B.3 Reverse charge

Let us now consider evasion under reverse charge, first the unilateral choice and then collusion. Under reverse charge the upstream firm has no tax base to evade, but they could face a penalty for misreporting their sales. The expected profit function for firm u is:

$$\pi_u = s_u - a_u(e_u)\theta^r|s_u - \overline{s}_u| - \rho a_d\theta^r|s_u - \overline{s}_u| \tag{20}$$

where $e_u = s_u - \overline{s}_u$ reflects misreporting rather than evasion. The firm reports $\overline{s}_u = s_u$ as the profit function is strictly decreasing in the difference.

The downstream firm has expected profit:

$$\pi_d = s_d + \tau e_d - (a_d(e_d) + \alpha_d I(\overline{s}_d < \overline{c}_d))((1+\theta)\tau e_d + \theta^r|\overline{c}_d - s_u|) - \rho a_u\theta^r|\overline{c}_d - s_u| \tag{21}$$

and here $e_d = s_d - \overline{s}_d$. Again, the firm d reports the true costs equal to s_u. The FOC for optimal level of evasion is given by:

$$FOC: 1 = (1+\theta)(a_d'(e_d)e_d + a_d(e_d) + \alpha_d I(\overline{s}_d < s_u)), \tag{22}$$

which is exactly the same as the FOC under conventional VAT in equation 18. Hence, without collusion firm d's evasion does not change between conventional or reverse charge mechanism. Since the tax evasion channel of the upstream firm is shut down, total evasion decreases. VAT collected from upstream firms but paid by the downstream firm increases. This result relies on RC retaining the paper trail of transactions between the firms, enforced by the misreporting penalty, allowing the tax authority to observe a lower bound of value added for firm d.

Now consider collusion such that firm d pays $1-\phi$ of its evasion to firm u to report $s_u^* < s_u$ in order to reduce the audit probability for reporting sales under s_u. The profit function of firm u is:

$$\pi_u = s_u + (1-\phi)\tau e_d - a_u\theta^r|s_u - \overline{s}_u| + \rho a_d\theta^r|s_u^* - \overline{s}_u|. \tag{23}$$

Collusion is profitable for the upstream firm when $(1-\phi)\tau e_d \geq a_u\theta^r|s_u - s_u^*| \Leftrightarrow 1 - a_u\theta^r\frac{|s_u - s_u^*|}{\tau e_d} \geq \phi$.

The profit function for firm d is:

$$\pi_d = s_d - \tau s_d + \phi\tau e_d - (a_d(e_d) + \alpha_d I(\overline{s}_d < s_u^*))((1+\theta)\tau e_d + \theta^r|\overline{c}_d - s_u^*|) - \rho a_u\theta^r|\overline{c}_d - s_u^*|. \tag{24}$$

Because firm d can choose a level of s_u^* such that $\overline{s}_d > s_u^*$ and naturally reports $\overline{c}_d = s_u^*$, the firm only faces the audit rate of $a_d(e_d)$. The first-order condition is:

$$FOC: \phi = (1+\theta)(a_d'(e_d)e_d + a_d(e_d)). \tag{25}$$

The downstream firm will not collude if it is an inner solution firm: the marginal benefit of evasion is lower if it needs to share it and it still faces the increase in the audit rate, given that the derivative of $a_d(e_d)$ is positive. Collusion is only feasible when firm d is a high evader either bunching close to zero value added or reporting negative value added in the baseline. Rearranging and adding 1 to each side gives a formula:

$$FOC : 1 = (1+\theta)(a_d'(e_d)e_d + a_d(e_d)) + 1 - \phi \tag{26}$$

that can now be compared to equation 26. Assuming conventional properties of $a_d(e_d)$ that it is twice differentiable and has positive first and second derivatives, this gives the following condition colluding to enable higher tax evasion:

$$1 - \phi < \alpha_d(1+\theta). \tag{27}$$

Buncher firms, however, have lower evasion under RC than in the conventional system if they participate in collusion. This is clear when comparing equations 18 and 27, because the marginal cost of tax evasion is higher under RC, as the firm needs to share part of evasion with firm u. For firms with the outer solution, i.e., negative value added in the baseline, collusive tax evasion is feasible under RC and thus they evade more. Consequently, RC can increase tax evasion when the downstream firms are high evaders and the firms collude to evade taxes. Collusion is feasible if there are ϕ and s_u^* such that:

$$1 - a_u\theta^r \frac{|s_u - s_u^*|}{\tau e_d} > \phi > 1 - \alpha_d(1+\theta) \tag{28}$$

depending on the evasion choice of d and tax audit policy. In particular, a small misreporting penalty θ^r and a large audit rate increase for negative value added α_d make collusion more attractive.

The sufficient condition for RC to increase tax revenue compared to the conventional system is that the downstream firm does not increase tax evasion under RC. The only possibility in our model for this is when the downstream firms are high evaders and collude with the upstream firms to evade taxes. In this case the effect on total tax evasion is ambiguous. Tax revenue could decrease if the increase in firm d's evasion would be greater than what u evaded in the conventional system.

B.4 Sales tax

In the sales tax regime, the upstream firm does not pay or report sales tax, and the downstream firm pays tax on the full value of sales. The downstream firm's expected profit is:

$$\pi_d = s_d + \tau e_d - a_d(e_d)(1+\theta)\tau e_d \tag{29}$$

implying a first-order condition for the optimal level of tax evasion of:

$$FOC : 1 = (1+\theta)(a_d'(e_d)e_d + a_d(e_d)). \tag{30}$$

The evasion level is the same for an inner solution under conventional and RC, i.e. when the firm is rather compliant. However, sales tax has higher evasion for firms that face relatively low tax audit rate or cost of evasion as they face lower costs of evading more than their value added. While the RC mechanism resembles sales tax, it still preserves the paper trail deterrence effect if punishment for misreporting is high enough.