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Response of Tax Credit Claims to Tax Enforcement: Evidence from a Quasi-Experiment in Chile*

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Abstract

Diesel in Chile receives different tax treatments depending on its use. If diesel is used in industrial activities, the diesel taxes paid can be fully used as a credit against VAT, but if it is used in freight or public transportation – basically trucks and buses – only a fraction of diesel taxes paid can be claimed as a tax credit for VAT payments. As a result of this different tax treatment, firms have incentives to use ‘tax-exempted’ diesel in activities requiring ‘non-tax-exempted’ diesel. This tax wedge therefore generates an opportunity for tax evasion, especially for firms with multiple economic activities, one of them being transport. In this paper, we analyse the impact of a tax enforcement programme implemented by the Chilean Internal Revenue Service (IRS), where letters requiring information about diesel purchases and use and vehicle ownership were sent to around 200 firms in 2003. Using different empirical strategies to consider the non-randomness of

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the selection of firms, the empirical results show consistently that firms receiving a letter decreased their diesel tax credits by around 10 per cent.

Policy points

- A differential tax treatment for diesel depending on its use creates opportunities for tax avoidance.
- Tax avoidance can be reduced, at least in the short run, with simple and not expensive enforcement mechanisms such as sending a letter to taxpayers. Receiving a letter from the tax authorities can have the potential impact of increasing the perceived detection risk for firms. This mechanism should therefore be considered as part of tax enforcement policies.
- In the case of Chile, this paper shows that a letter sent by the tax authorities asking for more information on diesel purchases had the impact of reducing claims by firms for diesel tax credits by 10 per cent.

I. Introduction

Gasoline and diesel are subject to specific taxes and VAT in Chile, but diesel is taxed at a much lower rate. Gasoline tax is equivalent to US\$1.93 a gallon while diesel tax is just US\$0.48 a gallon. Additionally, because diesel is used as a main input in several industrial activities, it receives special tax treatment depending on its use. Specifically: if diesel is used in industrial activities, the diesel tax paid can be used as a tax credit against VAT; and if diesel is used in freight or public transportation (basically trucks and buses), only a fraction of the diesel taxes paid can be used as a tax credit against VAT. As a result of this different tax treatment, firms have incentives to use 'tax-exempted' diesel in activities requiring 'non-tax-exempted' diesel. This might be easier to do for multi-product firms using diesel for several activities, allowing them to evade diesel taxes by claiming larger amounts of tax credits than is legally allowed. A similar practice was detected in the United States during the 1980s where firms were buying exempted fuel to be used for on-road tax activities, which were not exempted, and then creating several transactions among related firms to hide the tax evasion, a practice known as a 'daisy chain'.¹

In 2003, the Chilean Internal Revenue Service (IRS) implemented a special auditing plan to detect diesel tax evasion and improve tax enforcement. For this purpose, the IRS selected the firms that had the largest changes in diesel tax credits claimed between 2001 and 2002 and sent

¹Marion and Muehlegger, 2008. More specifically, firms purchased untaxed diesel fuel and resold it to affiliates to make it more difficult to audit the transaction. Then the affiliate resold the diesel to retail gas stations as diesel for which taxes had been collected.

them a letter asking them to voluntarily report more details of every diesel transaction during the last two-and-a-half years. In October 2003, 200 firms received the letter asking them to submit the required information within the next 30 days. The IRS received some information from 183 firms and, after checking this information, selected only 66 of them for an exhaustive and mandatory audit. This special enforcement plan was implemented only once, in October 2003. There were neither other enforcement actions nor tax changes during this period.

In this paper, we use monthly data from October 2002 to September 2004, for firms claiming diesel tax credits in all sample periods, to estimate the impact of receiving the IRS letter requesting information related to diesel purchases, vehicles owned and tax credits claimed. Firms receiving the letter could have perceived its message as an increase in the probability of any evasion activities being detected, which should have decreased such activities.² The data set used for the empirical analysis contains detailed information about many relevant dimensions for each firm – size based on sales (very small, small, medium, large), number of economic sectors in which the firm has activities, tax regime (accrual-based accounting, cash-flow accounting, presumptive tax regime) and the year the firm started its operations.

One of the main difficulties in identifying the effects of receiving the letter from the IRS is that firms were not randomly selected to receive it. As a matter of fact, the firms receiving the letter are quite different from the firms not receiving it in some observable dimensions that might potentially be correlated with tax evasion. For example, 66.0 per cent of the firms to which the IRS sent letters were large firms, while only 16.1 per cent of the ones not sent them were large; all those receiving the letter were under the accrual accounting tax reporting regime, compared with only 55.1 per cent among firms that did not receive it.³

Even though the firms were not randomly selected⁴ and the two groups actually differ in some relevant dimensions, we have the advantage of knowing the selection criterion used by the IRS to choose the firms that would receive the letter.⁵ The IRS ranked the firms based on the change in their annual tax credits claimed between 2001 and 2002 and sent a letter to

²Allingham and Sandmo, 1972; Sheffrin and Triest, 1992.

³In some other dimensions, the two groups of firms are not too different: for example, 36.6 per cent of the firms receiving the letter have only one economic activity and 55.0 per cent are more than 10 years old, compared with 39.9 per cent and 52.0 per cent respectively among the firms not receiving the letter.

⁴Given that the assignment to treatment conditions was not random, the identification strategy used in this paper is different from the one used in the literature of tax evasion based on experimental methods (Slemrod, Blumenthal and Christian, 2001; Wenzel and Taylor, 2004; Fellner, Sausgruber and Traxler, 2009; Kleven et al., 2011).

⁵Although the non-random selection creates a potential bias that needs to be controlled for, it avoids the problems of the Taxpayer Compliance Measurement Program (TCMP) studies in the US, where taxpayers were aware that selection was random (Long and Schwartz, 1987).

the 200 firms with the largest changes. Therefore, there are two steps to the empirical strategy we use to identify the effects of the letter on the firms' diesel tax credit claims. First, we balance the sample using a propensity score method such that notified and not notified firms are similar in observable characteristics. Considering the selection process, we cannot achieve total balance, but the matching allows us to compare across firms that are in the common support. Second, using this subsample, we estimate a difference-in-difference impact of the letter controlling for the selection process implemented by the IRS to choose the 'treated' firms. The selection equation is estimated using the change in the amount of tax credits claimed by each firm between 2001 and 2002. The results of the estimation indicate that receiving the letter reduced diesel tax claims by 10 per cent.

In general, the empirical results show a significant impact of the letter sent by the IRS – asking firms to voluntarily report some information on their diesel tax credits – in reducing the amount of tax credits claimed by firms. These results are consistent with other results in the literature showing that just receiving a letter from the IRS has an impact on tax compliance because it causes a substantial increase in the perceived detection risk.⁶ In that sense, the results show that the IRS in Chile can successfully reduce diesel tax evasion by affecting firms' perceived cost of non-compliance. However, it is important to interpret this result as a short-term impact of receiving a letter from the IRS once, which might or might not differ from either a long-run impact or the effect of receiving multiple IRS letters over time.

Most of the empirical evidence in the tax evasion literature has focused on individuals' income tax compliance in developed countries. This paper contributes to the empirical literature on tax evasion and enforcement, providing evidence about firms' diesel tax compliance in a developing country.

The paper continues as follows. Section II describes Chile's fuel taxes in detail and Section III explains the diesel tax enforcement programme implemented by the IRS. Section IV describes the data and the strategy used in the empirical analysis. Section V shows and discusses the empirical results, while Section VI presents a robustness analysis of the main results. Finally, Section VII concludes.

II. Fuel taxes in Chile

Fuel taxes were enacted in Chile in 1986, justified as an instrument to finance road construction, especially after a strong earthquake that struck the country in 1985. They are specific taxes collected by the seller at the first

⁶Fellner, Sausgruber and Traxler, 2009.

sale or import. The diesel tax rate is a quarter of the gasoline tax rate, with a rate of 1.5 UTM per cubic metre, equivalent to US\$0.48 per US gallon, as opposed to 6 UTM per cubic metre for gasoline.⁷ The gasoline tax is high relative to the United States, but not relative to Europe, while the diesel tax (for transportation) is relatively low.

Currently, there are two regimes establishing diesel tax credits. Initially, when the diesel tax was enacted in 1986, there was a unique regime establishing that firms could claim a tax credit for 100 per cent of diesel taxes paid if diesel were used in activities other than transportation on public roads. Under this regime, passenger transport and trucking firms were explicitly not allowed to claim diesel tax credits. Then, starting in October 2001, a second regime was created for the trucking industry, allowing firms to claim a tax credit for a share of their diesel purchases. More specifically, the new regime established that firms owning or leasing trucks with a gross weight of 3.86 tons or higher could claim 25 per cent of their diesel tax paid as a tax credit against VAT. However, the recovery rate of diesel taxes was increased to 80 per cent from July 2008 to June 2009, after hundreds of truckers blocked the main highway for three days requesting subsidies from the government to compensate the spike in oil prices.⁸ Then, in July 2009, Law No. 20.360 established a recovery rate based on annual sales. Firms with annual sales below 18,600 UTM can claim as a tax credit 80 per cent of their diesel tax paid, firms with sales of at least 18,600 UTM and below 42,500 UTM can claim 50 per cent and firms with sales of at least 42,500 UTM can claim 38 per cent.

To summarise, currently there is a general regime allowing firms a 100 per cent recovery rate for diesel taxes paid on diesel used as an input in all their economic activities except transportation on public roads, and there is a special regime for trucking firms allowing them a recovery rate between 38 and 80 per cent depending on their sales. Under both regimes, firms can claim diesel tax credits when they make their monthly VAT payments.

Tax revenue, credit claims and the number of firms claiming the tax credit have changed over time because of changes in diesel prices and regulation, even though the diesel tax rate has not changed since its enactment in 1986. Between 2000 and 2009, diesel tax revenue increased by 97.9 per cent and diesel VAT credits increased by 192.3 per cent. The percentage of diesel taxes paid that can be claimed as VAT credit was raised from 48.06 per cent to 70.9 per cent during the same period. Absent a diesel price change, the recovery rate (VAT credit / diesel tax revenue) of each

⁷The monthly tax unit (UTM) is an index used to maintain the value of taxes in constant money. In December 2012, one UTM was worth Ch\$40,206, around US\$85.

⁸Law No. 19.764 established a phase-in period of three years for the diesel tax credit. The share of the diesel tax paid that could be claimed as tax credit was 10 per cent in 2001–02, 20 per cent in 2003 and 25 per cent from January 2004. Then Law No. 20.278 increased the share to 80 per cent for the period between July 2008 and June 2009.

firm should be constant over time unless there is either a change in their productive process modifying the amount of diesel used or a normative change. For the firms analysed in this study, there are no relevant policy changes in regulation or in enforcement activities during the years of analysis, except for the IRS letter explicitly considered.

The recovery rate can also be affected by changes in consumer behaviour – namely, tax avoidance and evasion. The diesel tax credit creates a wedge in the price of diesel depending on its use: there is a price for diesel used in transportation, a lower price for diesel used in the trucking sector and a ‘tax-free’ price for diesel used in manufacturing. These different prices generate incentives to use ‘tax-exempted’ diesel in activities that should pay diesel tax. The fact that there is no third-party reporting associated with diesel taxes in Chile might exacerbate the incentives to evade or avoid the tax, as has been empirically shown in many studies for other countries.⁹

Evasion of diesel taxes can mostly occur through claiming more tax credits than firms are eligible for. There are at least four mechanisms for doing this that have been detected over time by the Chilean IRS. First, firms with multiple economic activities can buy diesel for their non-transport activities but use it for their transport operations. Second, non-transport firms can hire a transport firm – a trucking company, for example – and pay for the transport services with diesel instead of money. If the two firms have a common owner, these types of transaction are even easier. Third, transportation firms claim diesel tax credits for all their operations, national and international – not just for the diesel used in their national operations, which is what they are legally allowed to do. Fourth, diesel purchased by a firm for its operations is also used in diesel cars belonging to the firms’ owners and managers and tax credits are claimed for all diesel purchases made by the firm. The IRS suspected that some of these mechanisms were being used, which motivated the implementation of a special enforcement programme for diesel taxation with the main goal of reducing its evasion.

III. The diesel tax enforcement programme

In October 2003, exactly two years after the diesel tax credit system started, the Chilean IRS implemented a special auditing plan to detect diesel tax evasion and improve tax enforcement. The IRS selected the firms that had the largest changes in tax credits claimed between December 2001 and December 2002 and sent them a letter asking them to report more details on every diesel transaction. The letter said:

⁹Klepper and Nagin, 1989; Long and Swingden, 1990; Christian, 1994; Andreoni, Erard and Feinstein, 1998; Slemrod, 2007.

The IRS is going to start an auditing programme for taxpayers claiming diesel tax credits. For this reason you should send the following information to the IRS:

- Diesel purchases between January 2001 and August 2003
- Diesel tax paid
- Quantity and fraction of diesel used by vehicles
- List and registration number of vehicles owned by the firm, including year, maker, model, miles per gallon and monthly miles travelled.

The requirement to send this information does not imply you are going to be audited. If your firm is selected for a detailed auditing you will receive a new letter from the IRS.

During October 2003, 200 firms received the letter asking them to submit the requested information within the next 30 days. As mentioned above, firms were chosen according to their previous increase in diesel tax credits claimed. The reason for choosing firms based on the level change in tax credits – as opposed to the percentage change, for example – is related to the IRS's incentives for increasing revenue by its enforcement actions. The Ministry of Finance pays an annual bonus, to be distributed among IRS employees, based on tax revenue increases due to IRS enforcement. Therefore, enforcement actions implemented by the IRS usually have the goal of detecting large amounts of tax evasion rather than catching taxpayers evading a large fraction of the taxes they should pay. In other words, for the IRS, catching one taxpayer evading 10 per cent of a large amount of taxes owed is more attractive than catching one taxpayer evading 100 per cent of a small amount.

Using IRS data, we replicate its decision rule, ranking the firms according to their level change in tax credits claimed between December 2001 and December 2002. Although the IRS criterion was to send letters to the top 200 firms in this ranking, the data show that the letter was not sent to 21 of the top 200 firms¹⁰ but it was sent to 21 firms that were not in the top 200.¹¹ Apparently, the reason for the exclusion of 21 firms was an administrative problem with the mailing address and, as a result, the IRS decided to send the letter to the next 21 firms in the ranking.

The IRS received some type of information from 183 firms out of the 200 that received the letter and, after this information had been checked, 66 firms were selected for an exhaustive and mandatory audit. The small number of audited firms, as well as the lack of information on their selection, prevents a consistent econometric identification of the impact of the audit. Furthermore, we do not know the date on which each firm was audited. However, as a complementary analysis to that of the letter's impact, the empirical section of this paper also includes an estimation of the letter's impact on audited firms. It is important to highlight, for the purpose of identifying the effects of

¹⁰Firms ranked in places 2, 3, 6, 11, 29, 30, 34, 38, 62, 69, 77, 79, 100, 115, 123, 147, 150, 153, 175, 193 and 196.

¹¹Ranked 202 to 223, except 210.

the letter and the audits, that this special enforcement and auditing plan was implemented only once, in October 2003.

Theoretically, the letter sent by the IRS could potentially reduce the amount of tax credits claimed by firms after receiving it. Marion and Muehlegger (2008), using a simple model where firms choose the fraction of untaxed diesel purchases they use to produce output conditional on their evasion cost, show that an increase in the probability of auditing by the IRS reduces the fraction of untaxed diesel purchases by the firms. If the IRS letter had the effect of increasing firms' perceived probability of being audited, the amount of tax credits claimed should have decreased for evading firms. The empirical question then is whether and to what extent this happened.

IV. Empirical strategy

1. Data

We have access to IRS monthly data for 21,876 firms claiming diesel tax credits at least once from October 2002 to April 2004. After doing basic and minimum cleaning (dropping duplicate observations and also firms with missing diesel tax claims and missing economic sector), the number of firms is reduced to 17,071, of which 198 received the IRS letter. However, we decided to consider in the empirical analysis only those firms that claimed diesel tax credits every month during this period (19 months), which reduces the number of firms to 3,461, of which 105 received the IRS letter. The main reason for considering only firms that claimed diesel tax credits regularly is to focus on the intensive margin response to the letters sent by the IRS.¹²

The main activity listed by the firms in the enforcement programme covered four economic sectors: transportation (except passenger transportation firms because they cannot claim diesel tax credits), manufacturing, commerce and construction. The data include sales, VAT credits and debits, diesel credits, economic sector of the firm's main activity, accounting system / tax regime, number of different economic sectors in which the firm has activities, age and size.

Table 1 shows, separately for firms receiving and not receiving the IRS letter, summary statistics of the data we use in the empirical analysis. The first two columns report the mean and standard deviation of the 3,461 firms

¹²One possible reaction to the IRS letter from firms not claiming diesel tax credits regularly could have been for them to start claiming more often. If we include these firms in the analysis, there could be a spurious positive effect of the enforcement if the same tax credit amount is claimed but spread out across more months as a result of the letter. In such cases, the average monthly claim after the enforcement would be smaller; therefore, we are being conservative focusing only on firms claiming tax credits every month.

TABLE 1
Mean characteristics

	All (N=3,461)		Not notified (N=3,356)		Notified (N=105)		Difference (N=3,461)	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	t-test
<i>Firm characteristics</i>								
Number of economic sectors	2.140	1.584	2.120	1.555	2.781	2.232	-0.661	-4.219
Construction	0.059	0.236	0.051	0.220	0.324	0.470	-0.273	-11.896
Transport	0.769	0.421	0.782	0.413	0.352	0.480	0.430	10.462
Manufacturing	0.114	0.318	0.113	0.316	0.171	0.379	-0.059	-1.864
Commerce	0.057	0.232	0.054	0.226	0.152	0.361	-0.098	-4.298
Very small firm	0.294	0.456	0.303	0.460	0.000	0.000	0.303	6.755
Small firm	0.473	0.499	0.486	0.500	0.048	0.214	0.439	8.966
Medium firm	0.136	0.342	0.131	0.337	0.295	0.458	-0.165	-4.871
Large firm	0.098	0.297	0.080	0.272	0.657	0.477	-0.577	-20.796
Aged 0-2	0.025	0.155	0.025	0.157	0.000	0.000	0.025	1.652
Aged 2-4	0.163	0.370	0.163	0.369	0.171	0.379	-0.008	-0.229
Aged 4-6	0.125	0.330	0.125	0.331	0.095	0.295	0.030	0.924
Aged 6-10	0.143	0.350	0.145	0.352	0.105	0.308	0.040	1.146
Aged over 10	0.544	0.498	0.542	0.498	0.629	0.486	-0.087	-1.763
Accrual accounting	0.564	0.496	0.551	0.498	1.000	0.000	-0.449	-9.254
Cash reporting	0.099	0.034	0.101	0.035	0.000	0.000	0.001	0.354
Presumptive tax	0.337	0.473	0.348	0.476	0.000	0.000	0.348	7.485
<i>Monthly data</i>								
VAT reported (log)	10.436	5.569	10.463	5.474	9.577	7.998	0.886	5.328
Diesel tax credit (log)	11.234	1.809	11.119	1.700	14.920	1.197	-3.802	-75.418

included in the analysis. The average monthly diesel tax credit is CH\$635,526 with a standard deviation of CH\$4,842,650. The letter was sent to 3.0 per cent of all diesel tax credit claimers in the sample. The firms claiming diesel tax credits are mostly small firms (47.3 per cent); large firms represent only 9.8 per cent.¹³ The main economic sector claiming tax credits is, as expected, transportation (76.9 per cent), followed by manufacturing. Regarding the type of tax reporting, 56.4 per cent of the firms in the sample use accrual reporting and 33.7 per cent pay according to presumptive tax. The average number of economic sectors in which the firm has activities is 2.1, with a maximum of 19, and most of the firms are at least 10 years old.

Table 1 also shows firms' descriptive statistics by notification status – which is relevant for framing the empirical strategy – and the results of a t-test for the mean difference between notified and non-notified firms for each observable characteristic. Not surprisingly, because the letter was not sent to a random sample of firms, the t-tests of the difference in means show that notified and non-notified firms are statistically different in several dimensions. Notified firms tend to have activities in more economic sectors – which can give them more opportunities for evasion – are more likely to be in construction or commerce as their main economic activity and less likely to be in transport, are less likely to be small and, as expected, have larger diesel tax credits. Interestingly, none of them files taxes under a presumptive tax or under a cash-reporting regime. These large differences in firms' observable characteristics challenge the identification of the letter's effect on the amount of diesel tax credits claimed by the notified firms.

The most natural approach to estimating the effect of the letter is to use a difference-in-difference estimator, comparing the behaviour of non-notified firms (control group) with that of notified firms (treatment group) before and after the letter was sent. However, using observations in the control group that are not relevant comparisons can bias the results.¹⁴ For example, as previously noticed, there are no observations in the notified group under the presumptive tax regime, and therefore it is not relevant to have observations with this tax regime in the control group. This asymmetry in firms' characteristics also occurs in firm size and age, as there are no firms classified as 'very small' or aged between 0 and 2 in the notified group. As an objective statistical method to keep only relevant observations and have a comparable control group, we use the propensity score to define the control and treatment groups, as suggested and implemented by Dehejia and Wahba (1999 and 2002) and Imbens and Wooldridge (2009).

¹³The standard classification used by the government is based on annual sales: those with less than US\$100,000 are very small firms; between US\$100,000 and US\$1,000,000 are small firms; above US\$1,000,000 but below US\$4,200,000 are medium firms; and those with at least US\$4,200,000 are large firms.

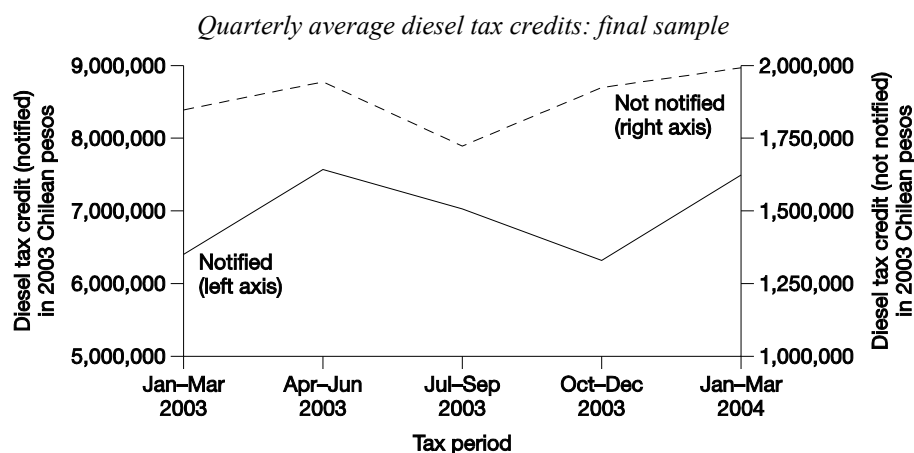
¹⁴Imbens, Rubin and Sacerdote, 2001.

The propensity score estimation has as dependent variable a dummy with the value 1 if the firm was notified and 0 if not. The regression is run using cross-sectional data for August 2003, before the letter was sent. The controls included are the logarithm of diesel tax credit, the number of economic sectors in which the firm has activities, economic sector dummies, the log of VAT and the firm's age. The balancing property of the propensity score is only satisfied when the sample is restricted to the top 1,401 firms in the ranking constructed by the Chilean IRS to select firms to be notified. After computing the propensity score, only observations in the common support are kept in the sample of analysis, in both the treatment and control groups. It is important to note that the propensity score is only used to select the sample of analysis; it is not used in the estimation.

The number of observations in the control group in the common support sample is 464 and in the treatment group is 105, slightly more than 50 per cent of the total number of firms notified. Figure 1 shows the quarterly average diesel tax credits claimed by notified and non-notified firms in the final sample of 569 firms used in the empirical analysis. As can be seen in the figure, there is a clear reduction in diesel tax credits claimed by the firms receiving the IRS letter just after receiving it in October 2003, which is something that did not occur among firms not receiving the letter.

Table 2 shows the descriptive statistics for all firms in the common support of the sample. Differences between the treatment and control groups are now reduced and even completely disappear for some variables. However, because some unobservable differences might still remain given the non-randomness of the treatment, the empirical strategy used to identify the effect of the IRS letter on the amount of diesel tax credits claimed should attempt to separate the effect of the letter from the potential effect of

FIGURE 1



Note: Data are real, not nominal.

TABLE 2
Mean characteristics by treatment status

	Control (1) N=464		Treatment (2) N=105		Difference (1)-(2) N=569	
	Mean	Standard deviation	Mean	Standard deviation	Mean	t-test
<i>Firm characteristics</i>						
Number of economic sectors in which firm has activities	2.526	1.672	2.781	2.232	-0.255	-1.321
Construction	0.123	0.329	0.324	0.470	-0.201	-5.183
Transport	0.612	0.488	0.352	0.480	0.260	4.941
Manufacturing	0.155	0.362	0.171	0.379	-0.016	-0.412
Commerce	0.110	0.313	0.152	0.361	-0.042	-1.219
Small firm	0.334	0.472	0.048	0.214	0.286	6.073
Medium firm	0.416	0.493	0.295	0.458	0.121	2.293
Large firm	0.250	0.433	0.657	0.477	-0.407	-8.528
Aged 2-4	0.175	0.380	0.171	0.379	0.003	0.077
Aged 4-6	0.116	0.321	0.095	0.295	0.021	0.618
Aged 6-10	0.144	0.352	0.105	0.308	0.040	1.066
Aged over 10	0.565	0.496	0.629	0.486	-0.064	-1.196
<i>Monthly data</i>						
VAT reported (log)	10.530	6.717	9.628	7.983	0.902	3.386
Diesel tax credit (log)	13.223	1.176	14.939	1.193	-1.717	-38.104

Note: Table shows descriptive statistics of firms that reported diesel tax credit every month and that are in the common support according to the propensity score. Very small firms, firms using presumptive tax or cash reporting, and firms between 0 and 2 years old are excluded from the propensity score since none of the notified firms with positive diesel tax credit every month has these characteristics.

different underlying characteristics between notified and non-notified firms. For this purpose, and based on this sample of 569 firms (each of them with 19 months of diesel tax credit information), we also use the selection criterion used by the IRS for notifying firms to estimate the impact of being notified.

2. Econometric specification

As previously mentioned, the notified firms in the sample might not be comparable to the non-notified firms even after considering only the observations in the common support. As a result, the difference in outcomes of treated and untreated firms might be biased as a measure of the effect of the enforcement programme. To avoid this potential bias, we consider two empirical strategies. First, we estimate the effect of the IRS letter with a difference-in-difference model using the following empirical specification:

$$(1) \quad TaxCredit_{it} = \beta_0 + \beta_1 T_i A_t + \beta_2 T_i + \beta_3 A_t + \beta_4 X_{it} + \varepsilon_{it}$$

where $T_i = 1,0$ indicates whether or not the firm was notified, $A_t = 0,1$ indicates whether the observation is before or after the letter was sent,¹⁵ $TaxCredit_{it}$ is the diesel tax credit (the outcome of interest) of firm i in period t and X_{it} is a set of firm i characteristics in period t : number of economic sectors in which the firm has activities, economic sector, VAT reported, firm age and firm size. This empirical strategy, which combines propensity score matching to obtain a comparable control group and a difference-in-difference estimator to estimate the average impact of the treatment on the treated group, follows Caliendo and Kopeinig (2008). Its identification assumption is that notified and non-notified firms have parallel trends in their diesel tax credits.

The second empirical strategy adds a selection. Even though the firms were not randomly selected and the two groups actually differ in some relevant dimensions, as was shown in Table 2, we know the selection criterion used by the IRS to choose which firms to send letters to. The unique criterion was to send letters to the 200 firms with the largest changes in tax credits used between 2001 and 2002. Therefore, we can identify the effect of the letter on these firms' diesel tax credit claims by estimating a difference-in-difference impact between control and treatment groups taking into account the selection process implemented by the IRS to choose the 'treated' firms.¹⁶ The estimation of the selection equation explicitly

¹⁵The period before is January to September 2003 and the period after is October 2003 to April 2004.

¹⁶In some studies using ordinary audits, the selection is also endogenous but is not known, which makes it difficult to control for the selection bias (Erard, 1992).

considers the change in the amount of tax credit claimed by each firm between 2001 and 2002. The empirical specification used is

$$(2) \quad TaxCredit_{it} = \beta_0 + \beta_1 T_i A_t + \beta_2 T_i + \beta_3 A_t + \beta_4 X_{it} + \beta_\lambda IMR + \varepsilon_{it}$$

$$(3) \quad Pr(T_i = 1) = \alpha_0 + \alpha_1 \Delta TaxCredit_{it} + \alpha_3 X_{it} + u_i$$

where $\Delta TaxCredit_{it}$ is the change in the total amount of diesel tax credits claimed between 2001 and 2002. Equation (3) is the selection equation and equation (2) is the difference-in-difference equation adding the inverse Mills ratio (*IMR*). The identification assumption is that notified and non-notified firms have parallel trends in their diesel tax credits conditional on the IRS selection process.

Finally, to explore the heterogeneous effects of the letter on different economic sectors, we estimate the following extension of equation (1):

$$(4) \quad TaxCredit_{it} = \beta_0 + \beta_1 T_i A_t + \beta_2 T_i + \beta_3 A_t + \sum_j A_t I_j + \sum_j T_i I_j + \sum_j T_i A_t I_j + \beta_4 X_{it} + \varepsilon_{it}$$

where I_j is industry j (transportation, construction, manufacturing). This equation is estimated using the same two previous empirical strategies (difference-in-difference estimation with and without selection).

V. Results

1. Main effects

Table 3 shows the results of estimating equation (1) using the panel of firms with random effects.¹⁷ The variable *Notification* is a dummy equal to 1 for firms receiving the IRS letter, the variable *After letter* is a dummy equal to 1 for all the months after the letter was sent and the variable *Letter* \times *After letter* is the interaction of the two variables, whose coefficient therefore represents a difference-in-difference estimator.

Column 1 shows the results without any controls, column 2 adds month and year dummies, and column 3 includes additional explanatory variables related to firm characteristics. The difference-in-difference estimator is statistically significant and shows that receiving the IRS letter decreased the amount of tax credits claimed by the firms by 9.9 per cent, a result that is robust across all specifications.

Table 4 shows the results of estimating equations (2) and (3), which eliminates the potential bias introduced by the non-random selection of firms. As in Table 3, the first column shows the results of the estimation

¹⁷The Wu–Hausman test does not reject random effects with respect to fixed effects. The point estimate using fixed effects is –9.9 per cent, statistically significant.

without any controls, the second column includes month and year dummies in the regression, and the last column includes some firm characteristics. The top part of the table shows the treatment effect, where the difference-in-difference estimator again shows a significant impact of the letter on diesel

TABLE 3
Diesel tax credit (random effects panel)

	(1)	(2)	(3)
Log diesel tax credit			
Notification	1.704** (0.117)	1.704** (0.117)	1.209** (0.112)
After letter	0.107** (0.0117)	0.160** (0.0250)	0.121** (0.0243)
Notification × After letter	-0.0993** (0.0272)	-0.0993** (0.0271)	-0.0993** (0.0272)
No. of economic sectors in which firm has activities			0.0309 (0.0226)
Transport			0.131 (0.129)
Manufacturing			0.178 (0.155)
Construction			-0.0113 (0.154)
Small firm			-1.469** (0.113)
Medium firm			-0.830** (0.101)
Aged 2–4			-0.119 (0.110)
Aged 4–6			0.0682 (0.131)
Aged 6–10			-0.0481 (0.120)
VAT reported (log)			0.00105 (0.00103)
Constant	13.22** (0.0504)	13.14** (0.0580)	13.88** (0.154)
Month dummies	No	Yes	Yes
Year dummies	No	Yes	Yes
Number of observations	9,104	9,104	9,104
Number of firms	569	569	569
R ²	0.230	0.231	0.395
Wald	286.7	402.8	667.2

Note: Table shows regressions for firms that reported diesel tax credit every month and that are in the common support according to the propensity score. The estimations are based on monthly data from January 2003 to April 2004. Standard errors are given in parentheses. * p<0.1, ** p<0.05.

tax credit claims. On average, the letter reduced the amount of credits reported by the treated firms by between 6.7 and 7.3 per cent. This result is quite robust across the different specifications and is only slightly lower in

TABLE 4
Diesel tax credit (Heckman selection)

	(1)	(2)	(3)
Log diesel tax credit			
After letter	0.101** (0.0118)	0.128** (0.0154)	0.129** (0.0150)
Notification × After letter	-0.0674** (0.0306)	-0.0676** (0.0308)	-0.0734** (0.0275)
No. of economic sectors in which firm has activities			-0.277** (0.00340)
Transport			1.698** (0.0223)
Manufacturing			1.802** (0.0267)
Construction			-2.067** (0.0304)
Small firm			9.413** (0.0995)
Medium firm			0.0832** (0.0158)
Aged 2–4			-0.0308* (0.0171)
Aged 4–6			0.319** (0.0164)
Aged 6–10			0.111** (0.0148)
VAT reported (log)			0.00118 (0.00107)
Inverse Mills ratio	-0.182** (0.00172)	-0.182** (0.00173)	-1.434** (0.0124)
Constant	14.49** (0.0107)	14.43** (0.0235)	18.05** (0.0403)
Letter			
Difference in diesel tax credit, 2002 – 2001	2.06e-08** (3.10e-09)	2.06e-08** (3.10e-09)	2.06e-08** (3.10e-09)
Number of observations	9,104	9,104	9,104
Number of firms	569	569	569
R ²	0.234	0.235	0.469
Wald	13,566.1	13,668.5	67,808.1

Note: Table shows regressions for firms that reported diesel tax credit every month and that are in the common support according to the propensity score. The estimations are based on monthly data from January 2003 to April 2004. Standard errors are given in parentheses. * p<0.1, ** p<0.05.

magnitude than the one estimated without a selection correction. The coefficient of the inverse Mills ratio is statistically significant, implying a sample selection bias,¹⁸ and negative, indicating a negative correlation between unobservable variables in the selection equation and the outcome equation.

The lower part of the table shows the estimated selection equation. It can be seen that the larger the level change in diesel tax credits claimed between 2001 and 2002, the more likely it is that a firm would be notified.¹⁹

Some other interesting patterns emerge from these results. Firms in manufacturing and transport claim more tax credits than firms in the services sector – the omitted category – and firms in construction claim less than firms in services. Small and medium-sized firms claim more diesel tax credits than large firms, which might be surprising but is consistent with similar patterns found by Kleven et al. (2011) and Pomeranz (2013). Finally, younger firms – aged between 2 and 4 years – claim less tax credits, while firms aged between 4 and 10 years claim significantly more, than the oldest firms (aged over 10).

We also consider the possibility that the letter would have reduced the amount of VAT credits claimed. For this purpose, we estimate the equivalent to equations (1) and (2), but replacing diesel tax credits by VAT credits. The results, which are presented in Tables A1 and A2 in the online appendix,²⁰ show that there is no impact of the IRS letter on the amount of VAT credits claimed by firms receiving the letter. This is an interesting and maybe surprising result because the tax form used to claim diesel tax credits is the same one used to report VAT debits and credits. A letter from the IRS asking for information about diesel tax credits claimed could have implied a potential audit of everything reported on the same tax form. If firms were over-reporting diesel tax credits, they could have been over-reporting VAT credits too, in which case a potential impact of the letter would have been to reduce both. The empirical results, however, show an impact only on diesel tax credits reported. One potential explanation is that VAT has a self-enforcement mechanism and it is more difficult for firms to over-report credits because other firms are reporting equivalent debits,²¹ which is consistent with the empirical results of Pomeranz (2013) for Chile. Another explanation is that firms believed that the IRS would potentially audit only the diesel tax credits, which is not unlikely as the IRS is organised in different auditing divisions for different taxes.

¹⁸Melino, 1982.

¹⁹The selection equation also includes the corresponding control variables considered in each specification, but the coefficients are not reported in the table.

²⁰Available at http://www.ifs.org.uk/docs/fsmar14_agostini&martinez_appendix.pdf.

²¹Agha and Haughton, 1996; Kopczuk and Slemrod, 2006.

2. Heterogeneous effects

Table 5 shows the results of considering heterogeneous treatment effects based on the main economic sector in which firms report activities: transport, manufacturing and construction (the default sector is services). All point estimates are positive, between 0.03 and 0.19; however, they are only significant for transport and construction. These positive coefficients imply that the letter had a smaller effect on services. The estimation for the total effect (at the bottom of Table 5) shows that the specific industry effect is only relevant for manufacturing and it is not significant when the selection process is considered. This might be a result of having a small number of treated firms in the sample, which prevents accurate identification of industry effects for all industries as standard errors increase when more interaction effects are included in the regressions.

We also tried to identify the letter's effect on single-industry firms separately from its effect on multi-industry firms. The coefficient on the number of economic sectors in which the firm has activities was large (31 per cent), negative and significant. However, the difference-in-difference estimator for multi-industry firms was not significant and was of small magnitude (around -3.0 per cent). Again, it is difficult to know whether the effect is truly zero or whether there are too few observations to identify the

TABLE 5
Heterogeneous effects by industry

	(1)	(2)
Log diesel tax credit		
Notification	1.242** (0.273)	
After letter	0.100** (0.0412)	0.115** (0.0445)
Notification × After letter	-0.223** (0.0721)	-0.188** (0.0570)
After letter × Transport	0.0283 (0.0383)	0.0366 (0.0436)
Notification × Transport	-0.288 (0.317)	0.765** (0.0262)
Notification × After letter × Transport	0.171** (0.0845)	0.137** (0.0667)
After letter × Manufacturing	-0.0359 (0.0461)	-0.0276 (0.0498)
Notification × Manufacturing	0.506 (0.370)	0.305** (0.0670)
Notification × After letter × Manufacturing	0.0654 (0.0980)	0.0307 (0.114)
After letter × Construction	-0.0105 (0.0485)	-0.00219 (0.0601)

Notification × Construction	-0.0446 (0.341)	1.040** (0.0315)
Notification × After letter × Construction	0.191** (0.0904)	0.156** (0.0781)
Number of economic sectors in which firm has activities	0.0356 (0.0227)	-0.265** (0.00428)
Transport	0.144 (0.145)	1.441** (0.0314)
Manufacturing	0.0926 (0.174)	1.662** (0.0345)
Construction	-0.0150 (0.183)	-2.332** (0.0404)
Small firm	-1.477** (0.113)	8.914** (0.0993)
Medium firm	-0.828** (0.101)	0.145** (0.0181)
Aged 2–4	-0.105 (0.110)	-0.0411** (0.0130)
Aged 4–6	0.0767 (0.131)	0.295** (0.0201)
Aged 6–10	-0.0315 (0.120)	0.123** (0.0156)
VAT reported (log)	0.00112 (0.00103)	0.00113 (0.00138)
Inverse Mills ratio		-1.443** (0.0150)
Constant	13.87** (0.163)	17.76** (0.0452)
Letter		
Difference in diesel tax credit, 2002 – 2001		2.06e-08** (3.10e-09)
Effect Notification × After letter × Transport	-0.0512 (0.0440)	-0.0512 (0.0349)
Effect Notification × After letter × Manufacturing	-0.157** (0.0663)	-0.157 (0.104)
Effect Notification × After letter × Construction	-0.0319 (0.0545)	-0.0318 (0.0547)
Month dummies	Yes	Yes
Year dummies	Yes	Yes
Number of observations	9,104	9,104
Number of firms	569	569
R ²	0.400	0.507
Wald	304.7	133,255.6

Note: Table shows regressions for firms that reported diesel tax credit every month and that are in the common support according to the propensity score. The estimations are based on monthly data from January 2003 to April 2004. Standard errors are given in parentheses. * p<0.1, ** p<0.05.

potential additional impact of the letter on firms active in more than one economic sector.²²

VI. Robustness

It is important to discuss the main identification assumption in the empirical strategy we used, which is the existence of similar trends among notified and non-notified firms. The estimated treatment effect of the IRS letter relies on the idea that in the absence of the letter, there would be no different trends in the diesel tax credits claimed by notified and non-notified firms. We test this assumption by doing a false experiment implemented with the data for the period before the notification. For this purpose, we estimate equations (1), (2) and (3) again but defining the dummy *Notification* as if the letter were sent in March 2003.²³ The results of this false experiment are reported in Table 6, which shows a non-significant treatment effect with a coefficient very close to zero for the difference-in-difference estimator.

In addition to the main identifying assumption, it is also important to consider robustness checks on the main empirical results related to the data used in the regressions and the decisions implemented to obtain the final sample used in the estimations.

Regarding the data, we used a sample of firms that claimed diesel tax credits every month during the period of analysis, with the goal of focusing on the intensive margin. Even though firms file VAT and diesel tax credits monthly, this decision might be considered arbitrary. To check the robustness of the results considering longer periods, we did the same empirical analysis using all firms claiming diesel tax credits every quarter instead of every month. The results show a larger impact of the IRS letter, of around –13 per cent, which is consistent with a potential additional impact on the extensive margin and firms spreading their diesel tax credit claims across more months as a result of the letter.

An additional restriction on the data was to use a sample of firms based on the results of the propensity score matching (PSM) to ensure

²²Additionally, the lack of data prevents us identifying the potential major effect of having economic activities in more than one sector, one of them being transport. A firm with activities in the transport sector and an additional economic sector could claim diesel tax credits in its other sector for diesel used in its transport activities. Therefore, the letter could have had a larger impact on firms having economic operations in the transport sector and also in another economic sector. However, the data report only the main economic activity of each firm and the total number of economic sectors in which the firm has activities. Therefore, the data allow us to identify only firms whose main economic sector is transport and also have economic activities in some other sector, but it is not possible to identify firms whose main economic activity is in a sector other than transport but that also have transport activities.

²³The period after treatment is therefore defined as March to August 2003. We also run false experiments choosing February or April as the month in which the letter was sent; the results do not change.

TABLE 6
False experiment

	(1)
Log diesel tax credit	
After letter	0.0630** (0.0288)
Notification × After letter	0.00115 (0.0314)
Inverse Mills ratio	-0.426** (0.00381)
Constant	-0.141** (0.0276)
Letter	
Difference in diesel tax credit, 2002 – 2001	2.24e-08** (1.83e-09)
Month dummies	Yes
Year dummies	Yes
Number of observations	6,259
Number of firms	569
R ²	0.334
Wald	20,884.7

Note: Table shows regressions for firms that reported diesel tax credit every month and that are in the common support according to the propensity score. The estimation is based on monthly data from October 2002 to August 2003. The false experiment considered March 2003 as the month of notification. Standard errors are given in parentheses. * p<0.1, ** p<0.05.

comparability. If the sample before the PSM is used instead, the empirical results show an impact of the IRS letter ranging between -12 and -15 per cent.

One final robustness check related to the data used is to completely drop the monthly variation in tax credits claimed and estimate the effect of the IRS letter considering only two periods. If we collapse the monthly observations into two periods, pre- and post-treatment, the estimated effect of the IRS letter is a 9.6 per cent reduction in tax credits claimed.

Finally, it could be informative to consider that 32 per cent of notified firms were also audited as part of the diesel tax enforcement programme. The small number of firms and the lack of information on the selection mechanism and the date of the audits prevent a robust estimation of the effect of audits on diesel tax claims. However, in Table 7, we present the results of estimating equation (1) restricting the sample to notified firms. In this case, the difference-in-difference estimator is based on considering the audited firms as the treatment group and the firms receiving the letter but not audited as the control group. The point estimates range between -2 and -5 per cent, but they are not statistically significant, which is not at all

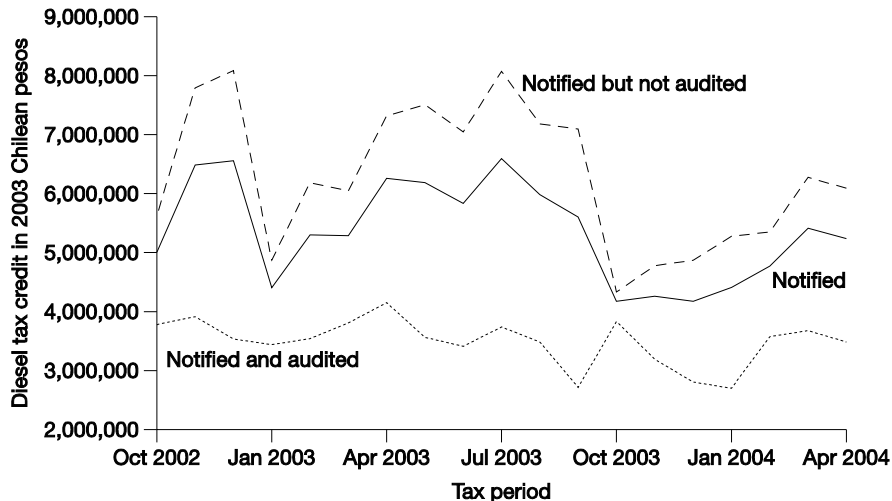
surprising considering the small number of firms included in this exercise ($N=198$). If we consider this result to be a consistent estimate of the effect of auditing on tax credits claimed, the effect of the letter found in the previous section could be interpreted as a combination of the effect of notification and the effect of an audit for a fraction of the notified firms. However, some

TABLE 7
Diesel tax credit: only notified firms (random effects panel)

	(1)	(2)	(3)
Log diesel tax credit			
After letter	-1.247** (0.153)	-1.543** (0.302)	-1.579** (0.302)
Audited	0.443 (0.590)	0.444 (0.582)	0.374 (0.631)
Audited × After letter	-0.0223 (0.265)	-0.0198 (0.264)	-0.0508 (0.264)
Number of economic sectors in which firm has activities			0.0803 (0.150)
Transport			1.654** (0.821)
Manufacturing			0.692 (0.978)
Construction			0.636 (0.779)
Small firm			-1.570* (0.927)
Medium firm			-1.037 (0.634)
Aged 2–4			-1.107 (0.688)
Aged 4–6			-1.266 (0.898)
Aged 6–10			-0.575 (0.966)
VAT reported (log)			0.0382** (0.0106)
Constant	13.01** (0.343)	13.14** (0.479)	12.74** (0.920)
Monthly dummies	No	Yes	Yes
Year dummies	No	Yes	Yes
Number of observations	3,101	3,101	3,101
Number of firms	198	198	198
R ²	0.0156	0.0195	0.0740
Wald	101.5	131.4	163.3

Note: Table shows regressions for only notified firms, of which 66 were audited. The estimations are based on monthly data from January 2003 to April 2004. Standard errors are given in parentheses. * $p < 0.1$, ** $p < 0.05$.

FIGURE 2
Monthly diesel tax credits: notified firms



Note: Data are real, not nominal.

caution is needed in interpreting this estimate. More specifically, it is not clear that it is a consistent estimator of the effect of the audit on firms, for two reasons. First, the selection criteria used for choosing the firms to be audited are not known and we do not have access to the information sent by the firms in response to the IRS letter. Second, it is not known when the firms were audited, which makes it impossible to determine the after-treatment period.

Figure 2 shows the monthly diesel tax credits claimed by notified firms, separating them between audited and not audited. This reinforces the previous conclusion in the sense that the effect of the letter on all treated firms is what is being identified in the regressions, even though an additional later effect from auditing cannot be ruled out.

VII. Conclusion

Differential diesel tax treatment in Chile creates incentives for firms to use 'tax-exempted' diesel in activities requiring 'non-tax-exempted' diesel. This might be particularly easy to do for multi-product firms using diesel for several activities, allowing them to evade diesel taxes by claiming a larger amount of tax credits than is legally allowed.

In an attempt to reduce the potential evasion of diesel taxes and to improve tax enforcement, the Chilean IRS sent a letter to some firms asking them to voluntarily report more details of every diesel transaction during the previous year. In this paper, we evaluate the impact of the letter on firms'

behaviour. The results show a significant impact of the letter sent by the IRS in reducing the amount of diesel tax credits claimed by firms. On average, treated firms reduce their tax credit claims by around 10 per cent after receiving the letter. The results are consistent with previous results in the literature showing that just receiving a letter from the IRS has an impact on tax compliance because it causes a substantial increase in the perceived detection risk. In that sense, the results show that the IRS in Chile can successfully reduce diesel tax evasion by affecting firms' perceived cost of non-compliance. It will be important in future research to consider what happens in the long run. It could be that future letters would not have the same effect or even that the effect of the letter fades out in time and firms go back to their over-claiming practice.

Furthermore, the reduction in tax credit claims shows indirectly the existence of evasion in the diesel tax in Chile. If there were no tax evasion, the diesel tax credit claims would not have been affected by the IRS notification letter. Therefore, the substantial impact the letter had on diesel tax credit claims can be interpreted as evidence of tax evasion through over-claiming diesel tax credits.

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