UNIVERSITAT DE BARCELONA

Essays on Wealth Taxation, Aviodance and Evasion among the Rich

Mariona Mas Montserrat

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PhD in Economics | Mariona Mas Montserrat

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Thesis title:

Essays on Wealth Taxation, Avoidance and Evasion among the Rich

PhD student:
Mariona Mas Montserrat

Advisors:
José María Durán-Cabré
Alejandro Esteller-Moré

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A les meves àvies, la Roser i la Nuri.
Dues grans dones que, amb més de noranta anys, segueixen ensenyant com en són de fortes i valentes; amb més de noranta anys, segueixen desitjant viure en un món més lliure i més just; amb més de noranta anys, segueixen demostrant que no es rendeixen.
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Contents

Chapter 1

Introduction

Although the importance of wealth taxation within the tax systems has declined over time (OECD, 2018), its presence in the public debate has revived in recent years. The rise in income and wealth inequality (Piketty, 2014; Alvaredo et al., 2018) has motivated the emergence of proposals that advocate the introduction of wealth taxes on the wealthier as a redistributive instrument. These proposals are not only supported by researchers (Piketty, 2014; Saez and Zucman, 2019), but also by some policy-makers.[1]

However, the effectiveness of wealth taxes as a redistributive tool has usually been questioned and discussed (e.g. Boadway, Chamberlain and Emmerson, 2010; Adam et al., 2011). Besides the concerns about double taxation and the negative effects of wealth taxes on savings, other arguments given by detractors of this type of taxation relate to the inequities and inefficiencies arisen from the difficulties in levying particular forms of wealth, the differences in assets' valuation and exemptions and other tax relief commonly present in wealth tax structures. Additionally, it is believed that the richest are more capable to avoid/evade this type of taxes and this distorts the real incidence of the tax.

An important absence in this debate has been reliable empirical evidence. Due to data availability and identification issues, convincing empirical evidence on behavioural responses to wealth taxation is still limited (Kopczuk, 2017), although some recent studies are starting to fill this gap in the literature (Glogowsky, 2016; Seim, 2017; Brülhart et al., 2017, 2019; Escobar, 2017; Sommer, 2017; Goupille-Lebret and Infante, 2018; Erixson and Escobar, 2018; Zoutman, 2018; Londoño-Vélez and Ávila-Mahecha, 2019; Jakobsen et al., 2019). Understanding how taxpayers respond to wealth taxation is especially important when considering the implementation and design of this type of taxes, hence,

[1] A recent example is the wealth tax proposal made by a US senator.

empirical evidence about the behavioural responses associated with this form of taxation is indeed needed.

This PhD thesis contributes to this literature by studying behavioural responses to two different forms of wealth taxation: the inheritance tax and the annual net wealth tax. These responses are analysed in the second and third chapters of the Thesis, respectively.

The inheritance tax levies the transfer of wealth at death and is still present in 22 out of the 36 OECD countries.[2] Alternatively, the net wealth tax recurrently levies individual net wealth stocks. Although today it is only present in 3 OECD countries - Norway, Spain and Switzerland - (OECD, 2018), the interest in this type of taxation has surged due to the proposals referred above.

Opposite to the estate tax, which is levied on the deceased's estate, the inheritance tax is levied on the estate portion inherited by each recipient. Hence, the inheritance and the net wealth tax do not only differ in the timing of being levied but also in the definition of taxpayers. Consequently, these differences might also imply different behavioural responses arising from each tax. Therefore, to properly assess the implications of these taxes on individuals' behaviour, empirical evidence on both forms of wealth taxation is needed.

Another relevant factor in this debate, both when considering wealth inequality and when assessing the appropriateness of wealth taxation as a redistributive instrument, is wealth evasion among the rich. Indeed, estimates suggest that wealth held offshore is not trivial: Zucman (2013) calculates that the equivalent of 10% of world GDP is held in tax havens, although there is heterogeneity across countries (Alstadsæter, Johannesen and Zucman, 2018). Alstadsæter, Johannesen and Zucman (2019) show that, according to the existing evidence, most of the offshore wealth goes undeclared and, in the case of Scandinavian countries, it is very concentrated at the top of the wealth distribution. However, little is still known about tax evasion of richest individuals because it can hardly be detected through random tax audits (Alstadsæter, Johannesen and Zucman, 2019).

In this context, the fourth chapter of the Thesis contributes to this literature by studying wealth evasion disclosed by rich individuals and by analysing the detectability of wealth evaders.

All in all, this Thesis contributes to two main strands of the taxation

[2]EY 2019 Worldwide Estate and Inheritance Tax Guide: `https://www.ey.com/gl/en/services/tax/worldwide-estate-and-inheritance-tax-guide---country-list`; PWC Worldwide Tax Summaries: `taxsummaries.pwc.com/ID/tax-summaries-home`; KPMG Insights: `https://home.kpmg/xx/en/home/insights/2011/12/Slovenia-other-taxes-levies.html`

literature: that related to wealth taxation and that studying avoidance and evasion. The following paragraphs review the contributions and content of the Thesis more extensively.

The second chapter contributes to the literature on behavioural responses to inheritance taxation (Glogowsky, 2016; Escobar, 2017; Sommer, 2017; Erixson and Escobar, 2018; Goupille-Lebret and Infante, 2018) by studying the effect of the inheritance tax both on the apportionment of estates and on the reporting and assessment of inherited assets.

In particular, it presents a study that exploits two tax reforms that occurred during 2010 and 2011 in Catalonia. Using the universe of inheritance tax returns of Catalan tax residents from 2008 to 2015, first I study whether inheritance taxation influences estates' apportionment. The data suggests that, while the distribution of estates between close and distant heirs did not change throughout the period studied, it did change in relation to the portions inherited by spouses and descendants. To examine whether this change is motivated by inheritance tax cuts, I exploit the introduction of a tax deduction for heirs older than 74 and use this age cut to instrument inheritance tax rates. Results indicate that spouses are more likely to inherit the entire estate when there is no need to minimize tax payments. This can be explained by the fact that descendants are more likely to request the estate portion which corresponds to them by law when it helps to reduce the overall tax burden.

Second, I exploit a natural experiment resulting from the quasi-repeal of the inheritance tax for bequests given to close relatives (i.e. descendants, spouses and parents) to study changes in reported inheritances. In fact, it was not a proper abolishment of the tax, but the introduction of a 99% discount of the tax liability. Other heirs with a more distant relationship with the deceased were not affected by the reform. This measure, which was approved on June 1st, 2011, was applicable to all deceases occurred from January 1st, 2011. This retroactive effect ensures the absence of any behavioural response regarding the timing of death.

Focusing on estates placed at the top 5% of the distribution, I implement a difference-in-differences strategy and compare estates mostly inherited by close heirs, and hence, affected by the quasi-repeal of the tax, to estates mostly inherited by distant heirs, which were not affected by this reform. The main estimates indicate that reported estates increased significantly due to the 99% tax cut. This response is not driven by changes in wealth accumulation but from changes in heirs' reporting behaviour. In particular, it is primarily explained by real estate "over-assessment" and, to a lesser extent, by the reporting of assets that otherwise would have been evaded, such as cash, antiques,

jewellery, etc.

These responses can be easily adopted provided that such assets are self-reported and self-assessed by taxpayers. While the under-reporting of the latter type of assets does imply inheritance tax evasion, the real estate over-assessment does not. Nonetheless, this behaviour has implications for other taxes. It helps to reduce capital gains in the case of a sale and, therefore, it might imply the evasion of future personal income taxes.

Following with an alternative form of wealth taxation, the third chapter of this Thesis presents a study which focuses on the net wealth tax.[3] In particular, it contributes to the nascent literature on behavioural responses to net wealth taxes (Seim, 2017; Brülhart et al., 2017, 2019; Zoutman, 2018; Londoño-Vélez and Ávila-Mahecha, 2019; Jakobsen et al., 2019) by exploring different types of taxpayers' responses, not only in terms of wealth accumulation, but also of the potential avoidance strategies adopted.

It does so by studying how taxpayers reacted to the reintroduction of the Spanish Net Wealth Tax in 2011. Spain provides a good setting in which to study the wealth tax given that it is one of the few countries that continues to impose it. Although the tax was reintroduced in most of the regions, for questions of data availability this study focuses solely on Catalonia, which is, in fact, the region that collects the highest share of Spain's overall wealth tax revenues.

In particular, it uses a panel of tax return micro-data from the universe of Catalan wealth taxpayers between 2011 and 2015, which approximately accounts for the - known - wealthiest 1% of income tax filers. With this data, this chapter analyses whether the wealth tax affects wealth accumulation and taxable wealth. Additionally, it identifies potential avoidance strategies attributable to the design of the tax, related primarily to exemptions and the existence of a limit on tax liability. Specifically, it examines whether taxpayers reorganized their wealth composition and changed the realization of income to benefit from them. Moreover, it also looks at the effect of the wealth tax on (reported) gifts.

As there are no data for the period when the wealth tax was not being imposed, this study takes advantage of the unexpected reintroduction of the tax by the Catalan Government at the end of 2011. This serves as the control year. The variation in treatment exposure, measured through the average tax rates for 2011, is then used to identify the effects of the wealth tax. This variation occurs not only across different levels of wealth, but also within

[3]This study is co-authored with José María Durán-Cabré and Alejandro Esteller-Moré.

similar levels. Accordingly, different non-parametric controls are considered for taxpayers' 2011 wealth, income, asset portfolio, age and other relevant characteristics.

Results show that the taxpayers' response to the reintroduction of the wealth tax was significant. In this regard, the estimated effects reflect avoidance rather than real responses. While facing higher wealth taxes did not have a negative effect on savings, it did encourage taxpayers to change their asset and income composition to take advantage of wealth tax exemptions (mostly business-related) and the limit on wealth tax liability. The intensity of the responses varies depending on the initial importance of taxpayers' business shares, favouring the use of business exemptions over the limit on tax liability if initial business shares are high, and vice versa. Overall, these avoidance responses are large in terms of revenues and increasing over time.

Leaving aside the avoidance strategies just discussed, the fourth chapter of this Thesis takes a step forward and studies wealth evasion among the rich. In this context, it contributes to the literature on offshore tax evasion (e.g. Roine and Waldenström, 2009; Zucman, 2015; Alstadsæter, Johannesen and Zucman, 2018) and, in particular, to that studying voluntary disclosure programs (Johannesen et al., 2018; Alstadsæter, Johannesen and Zucman, 2019; Londoño-Vélez and Ávila-Mahecha, 2019), by providing new estimates of evaded wealth and evaded taxes among the rich. Moreover, it also contributes to the literature studying tax evasion prediction (e.g. Castellón González and Velásquez, 2013; Junqué de Fortuny et al., 2014; Tian et al., 2016; Shukla et al., 2018; Pérez López, Delgado Rodríguez and de Lucas Santos, 2019) by analysing wealth evasion detectability.

More specifically, this chapter presents a study which exploits a tax amnesty implemented by the Spanish government in 2012.[4] In particular, through belated wealth tax returns submitted after the voluntary period - by the end of the amnesty program -, it identifies taxpayers voluntarily disclosing hidden wealth and quantifies the levels of evasion. In this regard, the study intends to, first, describe the evasion voluntarily disclosed, not only in aggregate terms, but also across taxpayers' wealth distribution and, second, to learn whether tax evaders can be detected with the information they initially report - i.e. when evasion is still not disclosed -, and if so, how can they be detected.

The data indicates that most of the disclosed wealth relates to financial assets, which necessarily must reflect wealth held abroad (except for cash), since the Spanish Tax Agency automatically receives information on financial

[4]This study is joint work with Daniel Mas Montserrat.

assets held in Spanish entities. Other conclusions that can be extracted from the data relate to the probability of voluntarily disclosing hidden assets, which increases significantly with wealth. In this regard, taxpayers initially reporting lower levels of wealth are less likely to voluntarily disclose evaded wealth, but, in the case they do, the portion disclosed and the share of taxes evaded is higher, on average. Overall, wealth disclosers were evading an important share of their stock of wealth and their wealth taxes.

After this descriptive exercise, this study estimates the probability of a taxpayer being evader given the values reported in wealth tax returns filed during the voluntary period. For this matter, it frames tax evasion detection as a binary classification problem and trains and evaluates multiple classifiers commonly used in supervised machine learning methods. The accuracy rates obtained are very similar between linear and non-linear methods and approximate the upper bound of the estimated maximum achievable accuracy. Therefore, with the relatively little information available from wealth tax returns, which mostly relates to wealth composition and income levels, it is already possible to distinguish evaders from (presumably) non-evaders. Nonetheless, the provision of additional taxpayers' information might help to achieve a better detectability.

Finally, the fifth and last chapter summarizes the main results, discusses their policy implications and provides some proposals meant to overcome the avoidance and evasive practices identified throughout the Thesis.

Chapter 2

What Happens When Dying Gets Cheaper? Behavioural Responses to Inheritance Taxation

2.1 Introduction

Inheritance taxation takes an important place in the current debate about the use of wealth taxation as an instrument to deal with the rise in wealth inequality (Piketty, 2014; Alvaredo et al., 2018). First, because among the taxes that levy broad stocks of wealth, it is the form of taxation most common in the tax systems: the inheritance tax is still levied in 22 out of the 36 OECD countries.[1] Second, because empirical evidence suggests that inheritances affect wealth inequality (e.g. Boserup, Kopczuk and Kreiner, 2016; Elinder, Erixson and Waldenström, 2018).

In order to assess the desirability of such a tax, it is also relevant to understand how it affects individuals' behaviour. Because most of the studies have focused in the US[2] - where an estate tax is levied -, empirical evidence on behavioural responses to inheritance taxation is still limited.[3]

[1] EY 2019 Worldwide Estate and Inheritance Tax Guide: `https://www.ey.com/gl/en/services/tax/worldwide-estate-and-inheritance-tax-guide---country-list`; PWC Worldwide Tax Summaries: `taxsummaries.pwc.com/ID/tax-summaries-home`; KPMG Insights: `https://home.kpmg/xx/en/home/insights/2011/12/Slovenia-other-taxes-levies.html`

[2] See Kopczuk (2013, 2017) for a review.

[3] Some recent studies are: Glogowsky (2016); Escobar (2017); Sommer (2017); Goupille-Lebret and Infante (2018); Erixson and Escobar (2018). At the end of this section I will

Opposite to the estate tax, which is levied on the deceased's estate, the inheritance tax is commonly levied on the estate portion inherited by each recipient. Consequently, the tax burden is not only determined by the level of the estate but also by its distribution if the tax is progressive.

Considering these differences, this paper contributes to the literature on behavioural responses to inheritance taxation by studying the effect of the inheritance tax both on the apportionment of estates and on the reporting and assessment of inherited assets.

Using the universe of inheritance tax returns of Catalan tax residents from 2008 to 2015, the paper exploits two tax reforms that occurred during 2010 and 2011 in Catalonia. First, it studies whether inheritance taxation influences estates' apportionment. While the distribution of estates between close and distant heirs does not change throughout the period studied, it does change in relation to the portions inherited by spouses and descendants. To examine whether this change is motivated by inheritance tax cuts, the paper exploits the introduction of a tax deduction for heirs older than 74 and uses this age cutoff to instrument inheritance tax rates. Results indicate that as the net-of-marginal tax rate increases by 1%, the probability that spouses inherit the entire estate increases by approximately 4.2-6.6 percentage points. Put differently, spouses are between 2 and 3 times more likely to inherit the overall estate when there is no need to minimize tax payments. This can be explained by the fact that descendants are more likely to request the estate portion which corresponds to them by law when it helps to reduce the tax burden.

Second, the paper exploits a natural experiment resulting from the quasi-repeal of the inheritance tax for bequests given to close relatives (i.e. descendants, spouses and parents) to study changes in reported inheritances. In fact, it was not a proper abolishment of the tax, but the introduction of a 99% discount of the tax liability. Other heirs with a more distant relationship with the deceased were not affected by the reform. This measure, which was approved on June 1st, 2011, was applicable to all deceases occurred from January 1st, 2011. This retroactive effect ensures the absence of any behavioural response from the deceased during the first months of 2011.

Focusing on estates placed at the top of the distribution, the paper implements a difference-in-differences strategy and compares estates mostly inherited by close heirs, and hence, affected by the quasi-repeal of the tax, to estates mostly inherited by distant heirs, which were not affected by this reform. This comparison is possible given that around 99% of estates are entirely

review them in detail.

bequeathed either to close or to distant heirs. In particular, it compares estates inherited by close heirs placed at percentiles 95-99 and the top 1% of the estates' distribution to estates inherited by distant heirs from the top 30% of the distribution.[4]

The main estimates indicate that, on average, estates inherited by close heirs at the top 1% of the distribution increased by 39.56% between 2011 and 2013 due to the 99% tax cut. This increase was of 19.47% in the case of estates inherited by close heirs placed at percentiles 95-99. These responses imply an elasticity of reported estates with respect to the net-of-inheritance tax rates of about 2. This elasticity is not driven by changes in wealth accumulation but from changes in heirs' reporting behaviour. In particular, it is primarily explained by real estate "over-assessment" and, to a lesser extent, by the reporting of assets that otherwise would have been evaded, such as cash, antiques, jewellery, etc.

These responses can be easily adopted provided that such assets are self-reported and self-assessed by taxpayers. While the under-reporting of the latter type of assets does imply inheritance tax evasion, the real estate over-assessment does not. Nonetheless, this behaviour has implications for other taxes. It helps to reduce capital gains in the case of a sale and, therefore, it might imply the evasion of future personal income taxes.

The existing literature on behavioural responses to inheritance taxation can be divided according to whether these responses occur during the lifetime of the deceased or arise from heirs when inheriting. The study developed here fits better in the second group.

Others papers which might be placed in the latter group are Glogowsky (2016), Escobar (2017) and Sommer (2017). However, this classification might not be precise in the case of Glogowsky (2016) and Sommer (2017) since the methodology employed does not allow to distinguish between real, avoidance or evasive behaviour. In particular, these two studies implement a bunching analysis by exploiting large kinks present in the German inheritance and inter-vivos gifts tax schedule. Overall, both studies find bunching responses although they translate into very small inheritance elasticities.

Alternatively, Escobar (2017) implements a regression discontinuity design to estimate the impact of the repeal of the Swedish tax for spousal bequests on reported estates. Results reflect a significant increase in reported estates, which is attributed to previous under-reporting. However, the data employed does not allow to determine where the under-reporting comes from.

[4]Results are robust to alternative definitions of treated and control groups.

Therefore, I contribute to this literature by providing new estimates on heirs' responses to inheritance taxation, not only in terms of reported estates, but also of estates' apportionment, and by showing the mechanisms driving these responses.

Focusing on the first group, Goupille-Lebret and Infante (2018) study the impact of inheritance taxation on wealth accumulation during lifetime and Erixson and Escobar (2018) study estate planning strategies.

In particular, Goupille-Lebret and Infante (2018) use French Assurance-vie accounts data and take advantage of age and time discontinuities contemplated in the inheritance tax scheme. Authors first implement a bunching approach to estimate an inter-temporal shifting elasticity of Assurance-vie contributions in the medium term. Then they use a difference-in-difference setting to estimate elasticities of Assurance-vie contributions and balances which capture shifting among asset portfolio and real responses. Overall, authors find modest but significant elasticities which cannot be supported by the desire to retain control over wealth.

Extending the methodology in Kopczuk (2007), Erixson and Escobar (2018) exploit the repeal of the inheritance tax on bequests to spouses in Sweden to study estates' planning response to the onset of a terminal illness. Authors implement a difference-in-differences strategy and compare, before and after the reform, individuals who die from sudden death to those who decease from a lengthy terminal illness. Their findings suggest that long-term terminal illness triggers the use of some tax planning tools, although not enough to reduce average tax payments.

Although this is not the main objective of the paper developed here, it also contributes to the literature studying bequest motives and the adoption of estate planning strategies (e.g. Kopczuk, 2007; Erixson and Escobar, 2018; Niimi, 2019; Suari-Andreu et al., 2019)[5] by showing that transfers made before death reduced after the introduction of the 99% tax cut. Even though these transfers are not properly anticipated, and hence they need to be accumulated to the estate, the fact that they respond to the tax cut suggests that some individuals have a bequest motive and care about the net amount given to their beneficiaries.

The remaining of the paper proceeds as follows: Section 2.2 describes the institutional setting, explaining how the inheritance tax works and the reform that took place during the period under study. Section 2.3 presents the data. Section 2.4 studies the effect of inheritance tax cuts on estates' apportionment.

[5]See Kopczuk (2013) for a review.

Section 2.5 studies the effect of inheritance tax cuts on reported estates. Section 2.6 concludes.

2.2 Institutional setting

The Spanish Inheritance Tax is levied on heirs and depends on the degree of kinship with the deceased. Therefore, who inherits matters. In particular, the law distinguishes 4 groups of heirs: I) descendants younger than 21, II) other descendants, spouses and (grand)parents, III) siblings, stepchildren, nephews/nieces, uncles/aunts and IV) cousins, grand nephews/nieces, more distant relatives and non-relatives. From now on I will refer to groups I and II as "close heirs" and to groups III and IV as "distant heirs".

The estate of any deceased comprises their wealth holdings at the moment of death and also other assets transferred before death which are determined by Law as an anti-avoidance measure. One common example are gifts made by the deceased to heirs during the four years preceding the moment of death.[6] These assets have to be added either to the estate when they affect all heirs, or to inheritors individual portions when they only affect specific heirs. Heirs' tax base is defined as the sum of the individual portion inherited, the specific added assets and life insurance benefits derived from deceased's death. In the case of accumulated gifts, they are added to the tax base to compute an average tax rate, which is then applied to the remaining assets and rights (excluding these gifts). This is the case because gifts are already subject to the gift tax.

The Spanish Inheritance Tax is transferred to regional governments, who have some normative capacity to modify specific features of the tax and they also are in charge of its administration and control. Given this decentralization, the inheritance taxpayers required to file in Catalonia, at least during the period under study, were those heirs who, residing anywhere in Spain, inherited from a deceased who was living in Catalonia.[7,8] Heirs have up to 6 months after

[6] Other examples are: assets held during the last year of deceased's life but not possessed at the moment of death nor substituted for other assets, assets transferred during the last four years before death when the deceased kept its usufruct right, etc.

[7] In terms of inheritance taxation, a deceased will be considered a Catalan resident if he/she lived most of the time in Catalonia during the last 5 years before death. When it is not obvious where to fix the deceased residence, the Law contemplates specific rules that rely on personal income criteria.

[8] On January 1, 2015, came into force a legislation change that broadened this criterion as a result of a sentence from the EU Justice Tribunals (Case C-127/12), which condemned the existing discrimination between Spanish and other EU residents with respect to the Spanish Inheritance and Gifts Tax Law. From that time onwards, other taxpayers can apply the inheritance legislation foreseen in Catalonia: i) heirs residing in Catalonia that inherit from

the decease to file inheritance tax returns to the Catalan Tax Agency.

Whereas the tax base is defined according to the Inheritance Tax Law approved by the Central Government[9], regional governments have legislative power to regulate tax deductions and tax credits. Tax deductions depend on (a) heirs characteristics (age, degree of disability) and family relationship with the deceased, and (b) on the type of assets inherited[10]. In this regard, the first type of tax deductions (*type a*) was modified several times between 2009 and 2014 by the Catalan government. In particular, they were first increased between 2010 and 2011, and then reduced again in 2014 (see Table A2.1 for more detailed information). This increase in the tax deductions, which in turn translates in lower tax liabilities, will be employed in Section 2.4 to study the impact of inheritance taxation on estates apportionment.

If the net tax base, defined as the tax base minus the deductions exposed above, is positive, progressive tax rates are applied to compute the tax liability. Tax rates also depend on the family relationship with the deceased.[11] For close inheritors, tax rates ranged from 7.42% to 32.98% with 16 tax brackets until December 31, 2009. From January 1, 2010, onwards, tax rates were simplified and ranged from 7% to 32% with 5 tax brackets. In the case of heirs belonging to groups III and IV, the tax rates just exposed have to be multiplied by 1.5882 and 2, respectively.

The last step to compute the tax liability is to consider tax credits, if any. From 2011 onwards, the Catalan Inheritance Tax Law contemplated a 99% discount on the tax liability, which was applicable only to close heirs. The introduction of this 99% tax credit will be employed in Section 2.5 to study the effect of inheritance taxation on reported estates. Given the relevance of this reform throughout the paper, additional information about its introduction is provided in the next section. This tax credit was applicable until January 31st, 2014. From February onwards, it remained the same for spouses but it was reduced for other close inheritors.[12]

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a deceased who was an EU resident, and most of the assets are located either in Catalonia or elsewhere outside Spain; ii) heirs who are EU residents and inherit Spanish life insurance benefits or assets located in Spain from a deceased who was living in Catalonia; iii) heirs residing outside Spain who inherit Spanish life insurance benefits or assets located in Spain from a deceased who was an EU resident, and most of such inherited assets are located in Catalonia. For an EU resident, I refer to individuals living in EU countries other than Spain.

[9] Ley 29/1987, de 18 de diciembre, del Impuesto sobre Sucesiones y Donaciones.

[10] For some types of assets, such as life insurance, business assets or closely-held shares, descendant main dwelling, etc., the law contemplates a deduction of 95% of the net asset value.

[11] Until the end of 2009 tax rates depended on heirs' pre-existing wealth as well, but this aspect goes beyond the precision and details this paper intends to provide.

[12] From February 1, 2014, the tax credit rate applicable to close heirs other than spouses

As a clarifying example, imagine a taxpayer aged 52 who in 2012 inherited 400,000 euros in financial assets from her mother and received 40,000 euros as a life insurance benefit. The corresponding tax base amounted to 440,000 euros and the net tax base was of 165,000 euros, since descendants could apply a deduction of 275,000 euros. The amount resulting from applying the tax schedule to the net tax base was 17,050 euros. The 99% tax credit corresponded to 16,879.5 euros and hence the final tax liability was of 170.5 euros.

In relation to assessment rules, the Inheritance Tax Law foresees that all assets should be valued by its market price. In the case of financial assets such as bank accounts, bonds, quoted shares, etc., it is the bank or investment office who provides a certificate with this information. In turn, the inheritor will be requested to attach these certificates to the inheritance tax return when submitting it to the tax authorities. Therefore, in these cases, it is very straight forward for inheritors to value this type of assets and for the tax administration to check whether it has been done correctly. Nevertheless, there are other assets such as real estate, closely-held business, jewellery, art pieces, etc., whose valuation is not that straight forward. In most of these cases, market price assessments are not available, so heirs have to value them by themselves or hire an appraisal expert. With respect to closely-held businesses, taxpayers can use the assessment rules determined in the Spanish Wealth Tax Law[13], which mainly rely on balance sheets (and not necessarily reflect their market value).

In the case of real estate, the tax administration knows the ownership of all registered properties located in Spain and their administrative value (known as cadastral value), but it does not have their market price. Therefore, the tax agency needs to infer the market price somehow in order to validate the values reported by taxpayers, not only in relation to the inheritance tax, but also with respect to the transfer tax. It does so by adjusting the cadastral value with some coefficients that are determined at the municipal level and reviewed every year. The Catalan Tax Agency publishes these coefficients and the assessment instructions yearly[14], stating clearly that real estate properties assessed below this adjusted administrative value will be prioritized in terms of auditing procedures. It is also important to note that, in the case of inherited properties, the Tax Agency takes into consideration different factors that might negatively

decreases in a regressive way with the tax base, ranging from 99% for the first bracket (tax bases below €100,000) to 20% for the eleventh and last bracket (tax bases above €3,000,000).

[13]Ley 19/1991, de 6 de junio, del Impuesto sobre el Patrimonio.

[14]`https://atc.gencat.cat/ca/normativa-i-criteris/valoracions-immobiliaries/instruccions-comprovacio-valors/`

affect market values. For instance, taxpayers cannot choose the moment they have to assess the property. Consequently, the adjusted administrative value referred above is reduced by 20% in the case of inheritances. Therefore, heirs who need to asses real estate properties can use as a reference point the 80% of the cadastral value corrected with the corresponding multiplying coefficient.

2.2.1 The "repeal" of the inheritance tax

The abolishment of the inheritance tax in Catalonia had been requested from different spheres of society, both political and social[15]. The political coalition who won the Catalan Regional Elections in November 2010 contemplated the abolishment of the inheritance tax in its political program, however, the debate of such measure did not arise until the end of January 2011. It was an extremely controversial proposal given that the Catalan economy was severely harmed by the economic crisis and the government had to adopt rigorous austerity measures to reduce fiscal deficit. The majority of the opposition parties and part of the public opinion begged to postpone its implementation and threatened the government to vote against the Budgetary Laws if the reform was carried on. Given this situation, the potential inheritance tax amendment evolved with high uncertainty. Finally, on June 1, 2011, the Catalan Parliament approved the "repeal" of the inheritance tax for bequests given to descendants, (grand)parents and spouses. One week later the legislation was modified accordingly.

In fact, it was not a proper abolishment of the tax, but a significant reduction of the tax liability. The reform consisted of the introduction of a 99% discount of the tax liability for close inheritors (descendants, spouses and (grand)parents). Other heirs with a more distant family relationship with the deceased (including siblings) could not benefit from the reform. This new measure entered into force on June 15, 2011, but was applicable to all deceases occurred from January 1, 2011, onwards. This retroactive effect ensures the absence of any behavioural response regarding the timing of death.

[15]Just to provide some anecdotal evidence, by the end of 2008 a popular association was created to protest against inheritance taxation in Catalonia (see `http://www.nosuccessions.org`) and one year later they managed to carry out a bus advertisement campaign in the main Catalan cities (see `http://www.eleconomista.es/economia/noticias/1635571/10/09/Un-cadaver-con-una-etiqueta-de-cobrado-para-protestar-contra-el-ipuesto-de-sucesiones.html`).

2.3 Data

The data employed in this paper is the universe of anonymized inheritance tax returns filed in Catalonia between 2008 and 2015. This results in 789,320 different taxpayers. These data have been provided by the Catalan Tax Agency and contain most of the information reported in the tax returns. In particular, heirs are required to fill two different forms: 650 and 660 forms. The 650-form is specific to each taxpayer and collects information on the individual portion inherited, added assets, insurance benefits, heirs' age and family relationship with the deceased. This is the form used to compute the inheritance tax base and the tax liability. Alternatively, the 660-form, which should be common to all heirs, collects information on the composition and the overall value of the estate. However, the latter form is not always filed correctly when there is more than one heir. Instead of filing a single form, in many cases they file several and do not necessarily include all estate assets and debts, but only part of it.[16] This fact complicates the assessment of an estate's level and composition.

Consequently, the overall (initial) estate of deceased i is defined as the sum of the inheritances, including (excluding) added assets, reported individually by each heir j in the 650-form. Note that life insurance benefits are included by law in the tax base but not in the estate definition. Hence, the initial estate, $Iestate_i$, and the overall estate, $Estate_i$, of deceased i are computed as follows: $Iestate_i = \sum_j p_{ji}$; $\quad Estate_i = \sum_j inheritance_{ji}$; $\quad j = \{1, ..., n\}$, where p_{ji} is the individual portion of taxpayer j inherited from i and reported in the 650-form, excluding "added assets", $inheritance_{ji} = p_{ji} + added\ assets_{ji}$ and n is the number of heirs of deceased i. To avoid outliers, I will disregard the top 0.01% of the estates' distribution.

Since marginal tax rates are not directly observed in the database, I compute them with a self-constructed tax calculator which replicates all the inheritance tax features applicable in Catalonia between 2008 and 2015.

The marginal tax rate τ of taxpayer j inheriting from deceased i is computed as follows:

$$\tau_{ji} = \frac{L(b_{ji} + \Delta b_{ji}) - L(b_{ji})}{\Delta b_{ji}}$$

Where b_{ji} is the tax base of inheritor j related to deceased i, Δb_{ji} captures a marginal increase in the tax base and is defined as $\Delta b_{ji} = max(b_{ji} * 0.001, 1)$ and $L(\cdot)$ represents the tax liability resulting from b_{ji} or $(b_{ji} + \Delta b_{ji})$.

In relation to some general descriptive facts, 42,270 estates were reported

[16] Values misreported in the 660-form do not have an impact on the tax liability, since it is computed from the information reported in the 650-form.

to the tax authorities every year, on average, between 2008 and 2015, and the average number of inheritors for a given estate was 2.33. Spouses, descendants and (grand)parents represent 19.6%, 67% and 1% of all taxpayers, respectively. In the case of distant heirs, groups III and IV, defined in Section 2.2, represent 9.8% and 2.6% of all taxpayers, respectively. The average estate size is 207,875 euros and the average individual portion inherited is 89,078 euros (the last two figures are expressed in 2011 prices).

Table 2.1 provides additional descriptive statistics on tax bases and tax liabilities for different periods, distinguishing between close and distant heirs.

2.4 Estates' apportionment

Figure 2.1 shows the histogram of the portion inherited by distant heirs for the pooled period 2008-2015. The first thing to notice is that it is very unlikely that one estate is distributed to both distant and close heirs: either everything, or nothing, is bequeathed to close (distant) heirs. In this regard, the figure shows that around 90% (10%) of the estates are entirely inherited by close (distant) heirs. Indeed, only 1.12% of the estates are not accounted for when selecting those mainly inherited either by close or distant heirs.[17] Figure A2.1 provides the same information by year and shows that this assignment of the estates does not change over time.

Figure 2.2 focuses on estates entirely inherited by close heirs and shows the portion inherited by spouses. The top-figure of panel (a) provides the histogram of the portion inherited by spouses in 2008. The bottom-figure plots the differences between the histograms of subsequent years and that of 2008. According to the first figure, there were three predominant assignments in 2008: spouses inherited either nothing, the entire estate or around 75%. This last share is explained by the fact that descendants have the right to inherit 25% of the estate jointly and then distribute it equally among them. This right is provided for in the civil law and descendants have to request this portion to heirs in the case they want to exercise it. The figure in the bottom shows a clear decline of estates in which spouses inherit around 75% towards estates fully inherited by spouses. Panel (b) of Figure 2.2 provides the same information than panel (a) for the period 2012-2015. There seem to be no big changes in the portion inherited by spouses with respect to the distribution existing in 2012. Given that the tax cuts under study took place in 2010 and

[17] I consider that an estate is mainly inherited by close (distant) heirs when this heir group inherits more than 90% of the estate.

2011, I will focus on changes in estates' apportionment occurred during this period.

Figures A2.2 and A2.3 in Appendix 2.9 provide the same information than Figure 2.2 but focusing on descendants and parents. Figure A2.2 shows the portion inherited by descendants and complements the explanation given just above. There were three predominant assignments to descendants as well in 2008: they inherited either nothing, the entire estate or around 25%. In accordance with Figure 2.2, since 2010 there is a clear decline of estates in which descendants inherit around 25% towards estates in which descendants do not inherit. Figure A2.3 shows the portion inherited by parents. The fraction of estates in which parents inherit a portion is very low and this does not change during the period under consideration.

Figures A2.4 and A2.5 provide the same information than the figures just described but focusing on estates entirely inherited by distant heirs. Figure A2.4 shows the portion inherited by group III (i.e. siblings, stepchildren, nephews/nieces, uncles/aunts) and Figure A2.5 shows the portion inherited by group IV (i.e. cousins, grand nephews/nieces, more distant relatives and non-relatives). From both figures it can be seen that a particular estate is very unlikely to be distributed between the two groups; it is entirely inherited by one of them.

In the remaining of this section, I will explore whether the increase of estates fully inherited by spouses is (partially) motivated by the inheritance tax cuts.[18] A starting point is looking what happens at different estate levels. If the increase of the estates fully inherited by spouses is somehow driven by the tax cuts, we should observe this effect already taking place in 2010 for low estates, since they became exempt due to the increase of deductions. Alternatively, large estates were still taxed in 2010 (with marginal tax rates ranging from 7 to 32%), so we should expect this effect to take place in 2011, when the 99% tax credit was introduced, for this estates type.

Figure 2.3 provides the same information than Figure 2.2, panel (a), distinguishing between those estates placed at the bottom 50% and those placed at the top 5% of the distribution. Estates' distribution is defined yearly and by estate type (i.e. estates mainly inherited by close vs. distant heirs). Table A2.2 shows both distributions for different years. Estates inherited by close heirs

[18] Anecdotal evidence from newspapers articles with experts' opinions suggests this is in fact the case, since they believe descendants tend to demand the portion assigned by law only when there are family conflicts or due to tax reasons. See for instance: `https://www.lavanguardia.com/vida/20161010/41883819196/seniors-testamentos-a-favor-conyuge.html`.

placed at the bottom 50% of the distribution are lower than 110,000 euros, hence they could be entirely exempt since the beginning of 2010. According to the bottom panels of Figure 2.3, the apportionments in 2009 did not change with respect to 2008 for any of the two percentile groups. Conversely, the decrease of estates in which descendants inherit the portion attributable by law, and hence spouses inherit around 75% of the estate, already took place in 2010 for the bottom 50%, but it did not occur until 2011 for the top 5%. This timing in the responses points towards a potential link between tax cuts and changes in the assignment of estates. In the following subsection, I will exploit an additional tax feature introduced in 2010 to further explore any causal relation between tax rates and estates' apportionment.

2.4.1 Methodology

As explained in Section 2.2, tax deductions were increased in 2010. As part of this reform, it was introduced an additional 275,000 euros deduction for heirs older than 74.

The progressivity of the inheritance tax could motivate estates' fragmentation in order to minimize the tax burden. Indeed, this can be one of the reasons why descendants request the portion attributable by law, even if they are not designated as heirs. If this is the case, the existence of the additional deduction for inheritors older than 74 might make this request unnecessary. According to this hypothesis, spouses older than 74 should be more likely to inherit the entire estate, compared to spouses aged 74 or below. This age difference only mattered for heirs whose sum of tax bases (i.e. overall estate + life insurance payments) was above the personal deduction of 125,000 euros; spouses inheriting a lower sum were exempt from the tax in 2010, regardless of their age. Moreover, the "age" deduction became irrelevant in 2011 with the increase of the personal deductions and the introduction of the 99% tax credit.

As an illustration, Figure 2.4 shows the portion inherited by spouses belonging to two different groups: those aged between 72 and 74 and those aged between 75 and 77. This figure only considers spouses whose tax base could exceed 125,000 euros. The two distributions do not seem to be different for the periods 2008-2009 and 2011-2013; however, they are significantly different in 2010. In particular, spouses aged between 75 and 77 are around 6 percentage points more likely to inherit the entire estate.

Given that tax rates are endogenous to the portion inherited, they need to be instrumented and the age cut just described will be employed for this

purpose. Accordingly, I will estimate the following 2SLS specification:

$$First\ stage:\ Tax\ var_{ji} = \beta \cdot over74ji + \epsilon_{ji} \tag{2.1}$$

$$Second\ stage:\ Entire\ estate_{ji} = \alpha \cdot \widehat{Tax\ var}_{ji} + v_{ji} \tag{2.2}$$

Where $over74_{ji}$ is a dummy which equals 1 if a spouse j (inheriting from i) is aged between [75,75+y] and equals 0 when aged between [74−y,74]. Hence, different age bandwidths will be considered: $y = \{0, 1, 2, 3, 4\}$.[19] In the case of $Tax\ var_{ji}$, two different variables are defined: i) $Indifferent_{ji}$, a dummy which equals 1 when, according to the information reported and in terms of tax savings, heirs should be indifferent between the spouse inheriting 75% of the estate and descendants 25%, or the spouse inheriting the entire estate, since the tax liability would be zero in both cases, and it takes value 0 otherwise; ii) the log of the net-of-marginal tax rate, $ln(1 - \tau_{ji})$. Finally, $Entire\ estate_{ji}$ equals 1 if a spouse j inherits 99% of the estate or more and 0 if j inherits something but less than 99%.

2.4.2 Results

Table 2.2 provides the reduced form estimates from specification 2.1 and 2.2.[20] The $over74_{ji}$ coefficient estimate from the third column coincides with the positive difference from Figure 2.4, panel (b). Spouses aged between 75 and 77 are 6.27 percentage points - or 17.78% - more likely to inherit the entire estate in 2010 than those aged between 72 and 74. Coefficients do not change substantially when considering other age bandwidths. These estimations only consider spouses whose tax base could exceed 125,000 euros. As explained above, spouses with tax bases below 125,000 euros would be exempt from the tax in 2010, regardless of their age. Consequently, as placebo tests, the reduced form specification is also estimated for the periods 2008-2009 and 2011-2013, and for the period 2010 but considering only tax bases below 125,000 euros. In all these three situations, the age difference is irrelevant to determine the tax burden. And according to Table 2.2, it is also irrelevant to determine whether spouses inherit the entire estate. None of the $over74_{ji}$ coefficients provided in the three placebo tests are statistically significant. In sum, the age cut only matters to explain the probability of inheriting the entire estate when the age-

[19] Given that I do not observe spouses' characteristics other than age and the portion inherited, I opt to define narrow age groups to be able to compare similar taxpayers. Nonetheless, in the following subsection I will further examine whether the age dummy is an appropriate instrument for the tax variables.

[20] This is: $Entire\ estate_{ji} = \gamma \cdot over74_{ji} + u_{ji}$.

related deduction helps to reduce the tax liability. Therefore, the *exclusion restriction* required in the 2SLS estimation seems to be satisfied.

Table 2.3 provides the 2SLS estimates from specification 2.1 and 2.2. The F statistics from the first stage are above the generally accepted threshold of 10 to validate instrument relevance[21]. The second stage estimates related to $Indifferent_{ji}$ indicate that spouses who are indifferent, in terms of tax savings, between fully inheriting the estate, or giving the "legal quarter" to descendants, are between 21 and 30 percentage points - or between 2 and 3 times - more likely to inherit the entire estate, compared to the cases in which heirs minimize tax payments if descendants inherit the legal portion. The second stage estimates related to $ln(1-\tau_{ji})$ tell that, as the net-of-marginal tax rate increases by 1%, the probability that a spouse inherits the entire estate raises by approximately 4.2-6.6 percentage points.

To sum up, evidence confirms that the estate assignment is (partially) determined by tax reasons. Descendants are more likely to inherit the quarter that corresponds to them by law (and hence spouses inherit 75% of the estate) when it helps to minimize tax payments. This behaviour, however, does not necessarily imply a real response from the deceased. Even if a person designates the surviving spouse as the universal heir, the will still needs to preserve the right of descendants to inherit the quarter of the estate determined by law. Therefore, the final estate distribution will depend on descendants willingness to exercise their right. And results show that this willingness is influenced by tax saving motives.

2.5 Reported estates

This section will make use of the natural experiment resulting from the quasi-abolishment of the inheritance tax for close heirs to study the effect on reported estates and compute the corresponding elasticities.

2.5.1 Methodology

The findings reported in Section 2.4 rise the need to make some initial considerations. Given that the inheritance tax is levied on heirs, instead of the overall estate, one would ideally want to estimate the elasticity of heirs' tax bases with respect to the net-of-inheritance tax rates. However, taking into

[21]Except for column (1) when using $ln(1-\tau_{ji})$ as the instrumented variable, although the estimated coefficient is very similar to the first stages from other age groups.

account the results from the previous section, doing so might produce misleading estimates. The first concern relates to the unit of analysis (deceased vs. heirs). The fact that estates' apportionment changes during the period under study has a direct effect on reported inheritances, even if the overall estate's assessment does not change. As a higher portion of spouses inherit the entire estate (instead of the 75% share) and descendants stop inheriting the "legal quarter", spouses' tax bases will increase while the decrease in descendants' tax bases will not be accounted for since those who do not inherit do not appear in the database. This issue would translate into an unrealistic positive effect of the tax reform on inheritances. Consequently, the preferred unit of analysis will be deceased individuals, although estimations at heirs' level will be also provided to examine how the results change.

The second concern has to do with a potential miscalculation of the aggregate tax base at the deceased level. As explained in Section 2.2, the individual tax base is the sum of the estate portion inherited, including the assets that need to be added to the initial estate, and the amounts received from life insurances. Hence, the aggregate tax base corresponds to the overall estate (including "added assets") plus the sum of the life insurance payments received by each beneficiary. Life insurance payments only need to be included in the 650-form where estate portions are reported if the latter are inherited. Consequently, life insurance payments received by descendants who do not inherit will go unnoticed, and, as previously seen, the portion of this type of descendants increases over time. Therefore, using the aggregate tax base as the dependent variable could bias the estimates downwards if non-inheritors descendants are beneficiaries of life insurance contracts. To avoid this issue, the preferred dependent variable will be the overall reported estate, instead of the aggregate tax base. Nonetheless, robustness checks with the latter variable will be also carried out to evaluate the importance of the potential issue with life insurance payments.

Baseline specification

The empirical strategy employed in this section will exploit the fact that the 99% tax credit was only applicable to close heirs. Indeed, the tax reform only affected the largest inheritances (around the top 5% according to Table 2.1); lower portions were already exempt from the tax since 2010 due to the tax deductions mentioned in Section 2.2. As already shown in Figure 2.1 and Figure A2.1, estates are bequeathed entirely either to close or distant heirs. Therefore, estates inherited by distant heirs can be used as a control group.

The definition of the treated and control groups is made according to estates' percentile distributions, which are computed per year and per estate type (i.e. estates bequeathed to close vs. distant heirs). Table A2.2 shows the distribution of the two estate types for different years. Focusing on estates inherited by close heirs, two different treated groups are defined: i) the 1% largest estates, which were highly affected by the reform, and ii) the estates belonging to the percentiles 95-99, which were more modestly affected by the reform. These definitions include 2,975 and 11,913 observations, respectively. The control group would be ideally defined as the 5% largest estates bequeathed to distant heirs, however, this would result in a few observations. To have a more balanced number of observations between the control and the largest treated group, the former includes those estates inherited by distant heirs placed at the top 30% of the distribution. The control group involves 9,879 observations. Figure A2.6 shows that the evolution of reported estates inherited by distant heirs does not change when considering alternative control groups (i.e. the top 25%, 20% or 15%).

Once the treated and control groups are defined, a difference-in-differences (DID) strategy can be employed. Although the fulfilment of the parallel trends assumption should validate the identification strategy, one might still wonder about a potential manipulation of the date of death to benefit from the reform. Indeed, different studies provide evidence of death responses to tax changes (Kopczuk and Slemrod, 2003; Gans and Leigh, 2006; Eliason and Ohlsson, 2008, 2013). However, the reform under analysis offers a nice setting because it was approved in June 2011, but was applicable to all deceases occurred from January 1, 2011. This retroactive effect reinforces the assumption of no responses regarding the timing of death. In fact, together with the tax return, taxpayers have to provide a medical certificate of death, which cannot be modified once it has been registered.

Figure A2.7 provides the histogram of deaths reported to the tax authority two months before and after January 1, 2011. At first sight, it does not seem to be bunching of deaths during the first days of 2011. To confirm there is no manipulation at the cutoff, I ran a binomial test to check that the probability of dying just 2, 5, 10 or 15 days before or after January 1st is not different from 50%.[22] The test fails to reject the null hypothesis of no manipulation at

[22]Following the advice given in Cattaneo, Idrobo and Titiunik (2019*a*,*b*), I opt to perform the binomial test, rather than the Regression Discontinuity manipulation test proposed in Cattaneo, Jansson and Ma (2018) and firstly introduced by McCrary (2008), given that this manipulation test was designed for continuous running variables (see Cattaneo, Idrobo and Titiunik, 2019*a*,*b*) and the forcing variable under study is discrete.

the cutoff.[23]

Following with the DiD strategy, the specification employed is the following:

$$Dep.var_i = \alpha + \sum_{y \neq 2010} \gamma^y \cdot Year_i^y + \sum_{y \neq 2010} \beta^y \cdot Year_i^y \cdot Treat_i^g + \delta \cdot Treat_i^g + \nu_i \quad (2.3)$$

Where $Dep.var_i$ is one of the dependent variables associated to deceased i defined below and $Year_i^y$ is a year dummy that equals 1 when individual i deceases in year $y = \{2008, ..., 2015\}$. $Treat_i^g$ is a dummy which captures the treated and control groups defined above and, hence, it has two different definitions ($g = \{1, 2\}$). $Treat_i^1$ ($Treat_i^2$) equals 1 if an estate associated to deceased i is inherited by close heirs and belongs to the top 1% (percentiles 95-99) of the distribution. $Treat_i^g$ equals 0 if an estate associated to deceased i is inherited by distant heirs and belongs to the percentiles 70-100 of the distribution. Estimation results will be shown both for $Treat_i^1$ and $Treat_i^2$. γ^y capture time fixed effects and β^y capture the parameters of interest. Specification 2.3 defines 2010 as the base year since it was the year prior to the reform. Therefore, the estimation outputs will be expressed relative to 2010.

The main dependent variable $Dep.var_i$ employed is the log of the overall reported estate associated to deceased i. Additionally, alternative dependent variables defined in the following sections will be considered as well. All monetary variables will be expressed in 2011 prices.

Robustness checks and alternative specifications

Additional to the baseline specification described in the previous section, different robustness checks will be implemented, in accordance with the initial considerations discussed in Section 2.5.1.

In this regard, the estimations will be also carried out using as a dependent variable the log of the aggregate tax base and the probability that inheritors from deceased i report life insurance amounts[24]. These variables will help to assess how important is the miscalculation of life insurance payments. Additionally, alternative treated and control groups will be defined using the percentile distribution of aggregate tax bases instead of that resulting from reported estates.

Last, two variations of specification 2.3 will be carried out. One consists

[23]The two-sided p-value from the binomial test when considering 2/5/10/15 days before and after January 1st is 0.8673, 0.3585, 0.1568 and 0.2657, respectively.

[24]This variable is defined as a dummy which equals 1 if at least one heir reports the receipt of life insurance payments and equals 0 otherwise.

of defining the time variables as half-year (instead of calendar year) dummies. In this case, the base period will be the second half of 2010. The second variation consists of changing the unit of analysis from deceased i to inheritors j. The definition of treated and control groups, which is done at estates' level, does not change. Hence, treated (control) inheritors are those heirs associated with treated (control) estates. One precision needs to be made, though. Heirs inheriting very small portions were not affected by the reform because they would be exempt from the tax in any case due to the tax deductions. To avoid that small portions produce misleading results, those heirs inheriting less than 5% of the estate will be disregarded from the estimations. The dependent variables employed in this case will be the log of the individual inheritance and the estate share inherited by each heir. In relation to standard errors, they will be clustered by taxpayers who inherit from the same deceased in this specification.

When thinking of potential heterogeneous effects, two main reasons motivate the distinction between estates which are (partly) inherited by the surviving spouse and those which are not. The first reason relates to the fact that estates' apportionment changed for the first type of estates, but not necessarily for the second. The second reason has to do with the regulation of the 99% tax credit, given that it remained unchanged for spouses but it was reduced for other close relatives since February 2014. Therefore, when assessing heterogeneous effects, treated groups will be split according to whether spouses inherit or not.

Understanding the underlying mechanisms

The 99% tax cut could induce responses both from the deceased before dying and from heirs when inheriting. Before the reform, individuals with a *bequest motive* (Kopczuk, 2007) who care about the net amount given to their beneficiaries, had incentives to make inter-vivos gifts to deal with the progressivity of the inheritance and gift tax. Although, as explained in Section 2.2, gifts needed to be planned with time, since those made during the four years preceding the moment of death have to be included as part of the estate. After the reform, these individuals should have higher incentives to increase wealth accumulation until death or, said differently, they should have lower incentives to make inter-vivos gifts, given that, in general, gifts were taxed at the same rates than the inheritance tax without the 99% tax credit.

The data available does not allow to perform an accurate analysis of the universe of gifts made during the period under study to examine the response

just discussed.[25] However, the additional assets included in the estate (i.e. mostly gifts, but also other assets discussed in Section 2.2), might provide a hint on whether estate planning strategies play a role in wealth accumulation. This is the case because, in many occasions, the timing of death is uncertain and, moreover, the *bequest motive* referred above might coexist with the will to hold on to wealth while alive, also known as *capitalistic spirit* or *wealth in utility motive* (Kopczuk, 2007).[26] In fact, Kopczuk (2007) shows that this coexistence indeed takes place and explains estate planning "procrastination". All in all, if some of the gifts - or related transfers - added to the estate had been made due to tax planning purposes, although not properly anticipated, they should diminish after the reform. On the contrary, if gifts (or other assets) added to the estate did not pursue tax saving reasons, they should remain unaffected after the reform.

According to this reasoning, specification 2.3 will be estimated using the following variables as $Dep.var_i$: the probability of reporting assets which are required by law to be added to the estate[27], such as gifts, and the inverse hyperbolic sine (IHS) transformation of the overall value of these additional assets. Although the IHS transformation does not always provide a direct interpretation of the coefficients in percentage changes as logarithms do, the former is used instead of the latter because in very few cases additional assets are reported, and the IHS transformation allows to consider zeros in the dependent variable.[28]

Before proceeding, it is important to note that eventual changes in gifts (or other asset disposals) made before death should not have an impact on the overall reported estates' estimate obtained from the baseline specification, as long as they are reflected in deceased's wealth holdings. As explained in Section 2.2, the overall reported estate comprises wealth holdings of the deceased at the moment of death (i.e. the "initial estate") and other assets transferred before death which have to be added to the initial estate by law (e.g. gifts made to heirs during the last 4 years of deceased's life). Therefore, changes occurring between the two estate components should not matter in terms of the overall estate response: a decrease in "non-anticipated" gifts should translate into higher deceased's wealth holdings and vice versa. On the contrary,

[25] Future research on this matter will be developed if the information needed to accomplish a proper evaluation is available.

[26] See Kopczuk (2010) for a further discussion of different motives that might explain the existence of bequests.

[27] This variable is defined as a dummy that takes value 1 if additional assets are reported for a given estate and 0 otherwise.

[28] In this regard, I follow the approach adopted in Johannesen et al. (2018).

changes in "properly anticipated" gifts (i.e. those made earlier than 4 years before death) will have an impact on the overall estate response since they will not be accounted for as "added assets". Nonetheless, a decrease in this type of gifts motivated by the 2011 tax cut would not arise until 2015.

In line with the discussion above, specification 2.3 will be also implemented using the log of the "initial" estate as the dependent variable, since it will allow assessing how the estimates change when excluding the "added assets" from the estate definition.

Moving to heirs' side, the quasi-repeal of the tax could incentivize: (i) to report assets which otherwise would be undeclared, and (ii) to"overvalue" those assets that could generate capital gains in the future, given that capital gains are subject to personal income taxation in Spain. In this regard, over-assessing inherited assets might be useful for those willing to evade personal income taxes, since in the case of a potential sale, it will help to reduce the capital gains levied by the tax (computed as the difference between the selling price and the value reported in the inheritance tax return).[29] The first type of response is only possible for assets not captured in administrative registers such as jewellery, antiques, furs, art pieces, cash, offshore accounts, etc. The second type of response is only possible for assets which are self-assessed by heirs. Real estate properties clearly predominate in this category[30], although the assets listed above and unlisted companies or business assets are other examples. Therefore, looking at heterogeneous effects by asset types might help to learn more about these potential responses. In particular, I will distinguish between real estate, financial assets, unlisted companies and business assets, "unproductive" assets (which include jewellery, antiques, art pieces, vehicles, cash, etc.) and debts and deductible expenses.

One drawback of this approach is that information on estate composition is not completely accurate. As explained in Section 2.3, the 660-form, which collects information on estate composition, is not always filed correctly when there is more than one heir. Instead of filing a single form per deceased, in many cases heirs file several 660-forms and do not necessarily include all estate assets and debts, but only part of it. Consequently, the 660-form misreporting complicates the assessment of estates' composition.

To deal with this issue, I do two different things. First, I look at the probability of reporting each asset category $Z = \{$real estate, financial assets,

[29]The tax rates applicable to this type of capital gains were increased several times since 2007 and ranged between 18% and 27%, depending on the year.

[30]According to the data, financial assets and real estate properties are the assets most commonly inherited.

unlisted companies and business assets, "unproductive" assets, debts and deductible expenses}. More specifically, I define a dummy dZ_i which equals 1 if positive amounts of the asset category Z are reported in any 660-form related to deceased i, and takes value 0 otherwise. In this case, 660-form misreporting is less important because accurate values of Z are not needed.

Second, I compute two alternative asset shares from the information reported in 660-forms, $Share_i^{Z,1}$ and $Share_i^{Z,2}$, and then apply these shares to the initial estate of deceased i, $Iestate_i$, defined from heirs' 650-forms.[31] Consequently, for each asset category Z defined above, two different values will be obtained: $Z_i^1 = Iestate_i \cdot Share_i^{Z,1}$ and $Z_i^2 = Iestate_i \cdot Share_i^{Z,2}$.

The first type of asset shares, $Share_i^{Z,1}$, is computed as a weighted average of the shares reported in 660-form by each inheritor j, according to the importance of the portion inherited, p_{ij}, relative to the initial estate of deceased i, $\sum_j p_{ji}$:

$$Share_i^{Z,1} = \sum_j \left(\frac{asset660_{ji}^Z}{Iestate660_{ji}} \right) \cdot \left(\frac{p_{ji}}{\sum_j p_{ji}} \right), \qquad j = \{1, ..., n\}$$

Where $asset660_{ji}^Z$ is the total value of asset category Z reported in 660-form by taxpayer j, $Iestate660_{ji}$ is a computation of a hypothetical initial estate of deceased i according to the values reported in 660-form by taxpayer j, and n is the number of heirs of deceased i.

Alternatively, the second type of asset shares, $Share_i^{Z,2}$, is computed as a "global" asset share resulting from all 660-forms associated to deceased i:

$$Share_i^{Z,2} = \frac{\sum_f asset660_{fi}^Z}{\sum_f Iestate660_{fi}}, \qquad f = \{1, ..., F\} \tag{2.4}$$

Where $asset660_{fi}^Z$ is the total value of asset category Z reported in 660-form f associated to deceased i, $Iestate660_{fi}$ is a computation of a hypothetical initial estate of deceased i according to the values reported in 660-form f, and F is the total number of 660-forms filed in relation to deceased i.

I prefer the first asset value definition, Z_i^1, because the level of misreporting in 660-forms should be lower in relatively larger portions[32], and $Share_i^{Z,1}$ gives a higher weight to them. However, the second definition, Z_i^2, will be also con-

[31] The nature of "added assets" is not reported, this is why I will focus on assets composing the initial estate.

[32] With this hypothesis I assume that heirs report 660-form correctly with respect to the portion they inherit, hence the misreporting eventually occurs in relation to the remaining part of the estate that is not inherited by them.

sidered as a robustness check. Therefore, specification 2.3 will be implemented using the log of Z_i^1 and Z_i^2 as alternative dependent variables. In the case of asset categories which have few positive values, the IHS transformation will be also employed. To avoid potential outliers in the computed asset values, the higher 0.1% of Z_i^1 and Z_i^2 will be disregarded from the estimations.

Last, I define an additional variable in relation to real estate which might help to further assess whether heirs increase housing appraisals.

As explained in Section 2.2, since Tax Authorities do not have the market value of real estate properties, they define an adjusted administrative value[33] to determine those properties that should be audited. In fact, the Catalan Tax Agency makes clear in the real estate assessment instructions that properties valued below the adjusted administrative value will be prioritized with respect to auditing procedures. And the data shown below confirms that taxpayers are aware of this criterion.

To be able to compare real estate assessments with their adjusted administrative value, I compute the latter whenever the information is available. Hence, first I compile the municipal multipliers set yearly by the tax authorities. Then, for each (building) property reported in a 660-form, I compute its adjusted administrative value by applying the corresponding multiplier to the 80% of its cadastral value. This computation can only be done if the cadastral value and the zip code are provided. Next, I express the reported value of each property relative to its adjusted administrative value. I define this variable as "assessment ratio". Finally, if a deceased (heir) is related to more than one property, I calculate the mean of the corresponding assessment ratios to have a unified measure at deceased (heirs) level. This unified measure will be then employed as a dependent variable of specification 2.3.

Figure A2.8 shows the histogram of the averaged real estate assessment ratio at heirs' level. One can see there is a clear bunching at 1, meaning that real estate is valued exactly at its adjusted administrative value.[34] Hence, taxpayers seem to be aware of the assessment guidelines provided by the tax administration.

[33]The adjusted value corresponds to the 80% of the cadastral value corrected with a multiplying coefficient defined at the municipal level every year.

[34]The bunching at 1.25 reflects a misunderstanding of the assessment rules. As explained in Section 2.2, the adjusted administrative value defined by the Catalan Tax Agency is also used in the transfer tax, but with one difference: the cadastral value is not multiplied by 0.8. Therefore, some inheritance taxpayers take as a reference point the adjusted administrative value related to the transfer tax and not to the inheritance tax.

Computing elasticities with respect to the net-of-tax rates

A simple way to obtain estate (or estate portions) elasticities with respect to inheritance tax rates would be dividing the β^y coefficient estimates obtained from specification 2.3 by -0.99 (i.e. the 99% tax cut). Nonetheless, following the approach generally adopted in the taxation literature, I will also estimate these elasticities expressed with respect to the net-of-tax rates.

In this regard, if elasticities were estimated solely at inheritors level, using the computed individual marginal tax rates τ_{ji} defined in Section 2.3 would be enough. However, due to the reasons exposed at the beginning of Section 2.5.1, elasticities will be also computed at the estate level. Therefore, an "aggregate" marginal tax rate needs to be defined. In this regard, I will use two alternative measures of the "estate's marginal tax rate". One is a weighted average of the inheritors' marginal tax rates according to their tax base contribution to the aggregate tax base:

$$\tau_i^A = \sum_j \tau_{ji} \cdot \left(\frac{b_{ji}}{\sum_j b_{ji}} \right), \qquad j = \{1, ..., n\}$$

Where n is the number of heirs of deceased i and τ_{ji} and b_{ji} are the marginal tax rate and the tax base of taxpayer j inheriting from i, respectively.

The second measure captures the highest marginal tax rate among the n taxpayers inheriting from deceased i: $\tau_i^M = max(\tau_{ji})$.

Figure 2.5 shows yearly averages of the two measures of "aggregate" marginal tax rates just defined, τ_i^A and τ_i^M, by treated and control groups. As expected, τ_i^M presents slightly higher levels than τ_i^A, but they follow very similar trends. Figure A2.9 provides the same information expressed in logarithms of the net-of-tax rates[35] and normalized with respect to 2010 levels.

Given the progressive nature of the inheritance tax, marginal tax rates are endogenous to the tax base and, therefore, the tax elasticity needs to be estimated using instrumental variables. Accordingly, the following 2SLS procedure will be implemented:

$$First\ stage: \ ln(1-\tau_i) = \alpha \cdot Time_i \cdot Treat_i^g + \gamma_1 \cdot Time_i + \gamma_2 \cdot Treat_i^g + u_i \quad (2.5)$$

$$Second\ stage: \ ln(estate_i) = \varepsilon \cdot \widehat{ln(1-\tau_i)} + \beta_1 \cdot Time_i + \beta_2 \cdot Treat_i^g + v_i \quad (2.6)$$

Where τ_i can either be τ_i^A or τ_i^M and $Time_i$ is a time dummy which equals 0 if individual i deceases between 2008 and 2010 and takes value 1 if deceases

[35] This is, $ln(1-\tau_i^A)$ and $ln(1-\tau_i^M)$.

between 2011 and 2013.[36] $Treat_i^g$ are the two treatment dummies (g={1,2}) defined with the baseline specification, $ln(estate_i)$ is the overall reported estate associated to deceased i and the interaction between $Time_i$ and $Treat_i^g$ is used to instrument $ln(1-\tau_i)$. ε is the parameter of interest.

Although the preferred elasticity estimation is the one just described, specifications 2.5 and 2.6 will be also estimated using taxpayer j - inheriting from deceased i - as the unit of analysis.[37] In this case, the marginal tax rate employed will be τ_{ji} and the dependent variable the log of the individual inheritance, $ln(inheritance_{ji})$.

Considering all inheritors from deceased i might produce "unrealistic" elasticities estimates, because individuals inheriting small portions and hence, less affected by the inheritance tax, might still respond to tax changes influenced by heirs who inherit larger portions. This could be the case if estates' assessment and reporting is a joint decision among heirs who inherit shared assets - taking into account that assets are self-reported by heirs -.[38] If the influence in this decision is somehow proportional to the portion inherited or, put differently, if heirs are willing to cooperate to minimize the overall tax payments, then the amounts reported by heirs who inherit small portions would be highly determined by those who inherit larger portions and are more exposed to the tax. Consequently, large and small portions would respond similarly to the inheritance tax, although they are taxed differently, because the tax rate which mostly matters in this decision is that faced by heirs inheriting large portions. Accordingly, specifications 2.5 and 2.6 will be also estimated focusing on any taxpayer j who inherits the largest estate portion from i.

Similar to Figure A2.9, Figure A2.10 shows the evolution of the net-of-individual marginal tax rates, expressed in logarithms and normalized with respect to 2010. The left-panel includes all taxpayers who belong to treated and control groups. The right-panel considers only those heirs who inherit the largest portion of a given estate. Not surprisingly, it looks very similar to the right-panel from Figure A2.9.

[36] The 99% tax credit under study was introduced in 2011 and remained unchanged until 2013. This is the reason why these three years are considered.

[37] Hence, the subscript j should be incorporated in the variables used in each specification.

[38] Hence, this situation would not arise if all assets owned by deceased i were third-party reported.

2.5.2 Results

Baseline estimates

Figure 2.6 provides the DiD estimates (β^y) resulting from specification 2.3 when the log of the overall reported estate is used as the dependent variable. The first point that needs to be made is that coefficient estimates from the pre-reform period (2008 to 2010) confirm the parallel trends assumption and, hence, validate the identification strategy of this methodology. Looking at the post-reform coefficients, results reflect an immediate response in 2011, with an increase in reported estates of 40% for the top 1% and around 20% for percentiles 95-99. The effect remains statistically significant throughout the post-reform period, although in 2014 the coefficient estimates get reduced to 20% and 7% for the top 1% and percentiles 95-99, respectively. According to 95% confidence intervals, the 2014 estimates are statistically different than 2013 estimates for both treated groups. Interestingly, the decrease in the coefficient estimates coincides with the reduction of the 99% tax credit in 2014 (for other heirs than spouses).

In this regard, Figure 2.7 considers different types of treated estates according to whether spouses inherit or not. Until 2013 they provide similar coefficient estimates, hence, they did not react differently to the 99% tax cut. However, in the case of treated top 1% estates, estimates for 2014 and 2015 remain statistically significant and range around 40% when estates are mostly inherited by spouses, while the coefficients from estates not inherited by spouses get significantly lower. This divergence in the estimates further suggests that the decrease in the baseline coefficients observed for 2014 and 2015 is motivated by the tax increase implemented at that time.

As a comparison, Escobar (2017) estimates an increase in reported estates of 17% due to the repeal of the inheritance tax for spousal bequests in Sweden. The author also presents descriptive evidence suggesting that estates in the top 1% and 0.1% were 25% and 45% larger, respectively, in the year that the tax was repealed, compared to the previous year when the tax was still levied.

Robustness checks

Figures A2.11 and A2.12 try to assess how important is the potential miscalculation of life insurance payments discussed in Section 2.5.1. Figure A2.11 shows that, in the case of estates (partially) inherited by spouses, heirs are less likely to report life insurance benefits in 2014 and 2015, especially for the per-

centiles 95-99.[39] Nonetheless, this decrease in reported life insurance benefits has a negligible impact on aggregate tax bases, as shown in Figure A2.12. This Figure shows that estimates do not significantly change when including life insurance benefits in the dependent variable (this is, when considering the log of aggregate tax bases instead of the log of reported estates as $Dep.var_i$). Figure A2.13 shows that results do not change either when treatment groups are defined according to the aggregate tax base percentiles instead of the reported estates' distribution.

Individual portions

Figure 2.8 compares the coefficient estimates obtained when considering different units of analysis (deceased i vs. heirs j). In particular, it compares the baseline estimates to those obtained when estimating specification 2.3 at heirs' level and using the log of the individual portion inherited by each heir as the dependent variable. The right-panel of Figure 2.8 shows that, in the case of percentiles 95-99, coefficient estimates associated with heirs' individual portions are higher than those associated with reported estates. As already discussed at the beginning of Section 2.5.1, this is not surprising when considering the findings from Section 2.4. Even when estates levels remain constant, individual portions reported by spouses will necessarily increase if the share of the estate inherited by them rises. On the other hand, the decrease in the portions inherited by descendants cannot be accounted for, since non-inheritors are not observed. Consequently, this results in "unrealistically" high estimates. Figures A2.14 and A2.15 help to validate the reasoning just exposed.

Figure A2.14 shows heterogeneous effects on (the log of) reported individual portions according to the different treated groups defined in Section 2.5.1. The coefficient estimates are significantly higher in the case of estates from percentiles 95-99 in which spouses inherit more than 50%.

In turn, Figure A2.15 shows heterogeneous effects of the 2011 tax cut on the estate share inherited by each heir. The coefficient estimates reflect that, in the case of estates in which spouses inherit more than 50% and especially for the percentiles 95-99, the average share inherited by each heir increases significantly since 2011. This result goes in line with the increase in the portion

[39] As discussed at the beginning of Section 2.5.1, this decrease could be explained by the fact that descendants who do not inherit might still be life insurance beneficiaries, but they stop reporting life insurance benefits in the 650-form, since they are not required to. Life insurance benefits can be reported in an alternative form and there is no obligation to file a 650-form when no assets are inherited. However, further information on this alternative form would be required to confirm the hypothesis just exposed.

of spouses who inherit the entire estate, instead of 75%, plotted in panel (b) of Figure 2.3.

When considering Figures A2.14 and A2.15 together, two different observations can be derived. Coefficient estimates from Figure A2.14 are more similar to the baseline estimates (Figure 2.6) when the share inherited by each heir does not substantially change (Figure A2.15). This is the case of estates in which spouses do not inherit or inherit less than 50%. On the contrary, and according to the reasoning exposed above, coefficient estimates from Figure A2.14 are significantly higher than the baseline estimates when the share inherited by each heir increases. This is the case of estates in which spouses inherit more than 50%, especially for percentiles 95-99. Consequently, the estimates on inheritance levels resulting from this group of taxpayers need to be interpreted with caution, in the sense that they do not only capture changes in estates' levels, but also changes in estates' apportionment.

Underlying mechanisms I: Changes in wealth accumulation?

Figure A2.16 shows the coefficient estimates on the log of reported estates resulting from implementing specification 2.3 with half-year dummies. The immediate response in the first half of 2011 can hardly reflect changes in wealth accumulation, given that deceased passing away during this semester could not learn about the approval of the tax cut, which took place in June 2011 - although it was implemented with retroactive effects -. Moreover, as explained in Section 2.2, assets disposed or transferred before death need to be accumulated to the estate. Consequently, changes in these disposals/transfers are not driving the response.[40] The immediate effect cannot be driven either by mobility responses, this is, by individuals who otherwise would have died in other regions with lower inheritance taxation (such as Madrid). The inheritance tax residence is determined by the place most frequently resided during the last 5 years before death.

Focusing on longer term responses, we should observe an increasing effect over time if the tax cut had incentivized individuals to save more. However, this is not the case. Moreover, the fact that coefficient estimates get significantly lower in 2014, when the 99% tax credit was reduced, further suggest that the estimated response is not predominantly driven by changes in savings behaviour; wealth holdings can hardly be adjusted instantaneously and substantially through changes in savings behaviour. By this, I refer to alterations in the consumption-savings ratio, rather than changes in gifts or transfers made

[40] See Section 2.5.1 for a further discussion about this matter.

before death (which are added to the estate). As already mentioned above and discussed in Section 2.5.1, the latter changes should not have an impact on the overall estate level, as long as lower "added assets" get reflected in higher deceased's wealth holdings - this is, the "initial estate" -, and vice versa.

Nonetheless, even if these "added assets" are not driving the estimated effect, it is still interesting to see whether changes in gifts and other transferred assets do occur. In this regard, panel (a) of Figure 2.9 reflects the effect of the 2011 tax cut on the probability of accumulating gifts or other transferred assets to the initial estate. Since 2012, this probability decreased by around 7 (1.5) percentage points for treated estates placed in the top 1% (percentiles 95-99) of the distribution. For both treated groups, this decrease represents about 60% of the 2010 treated difference. Given that transferring assets before death is a decision which involves the future decedent, and considering that the tax cut was approved in mid-2011, it is not surprising that the effect is not statistically significant in 2011.

Panel (b) of Figure 2.9 shows the β^y coefficient estimates resulting from specification 2.3 when using the IHS transformation of the overall accumulated assets as the dependent variable. In the case of treated estates in the top 1%, the value of the assets added to the initial estate decreased up to 65.6% $(= (e^{-1.07} - 1) * 100)$ in 2013. This reduction was smaller in the case of treated estates from percentiles 95-99, ranging around 18% $(= (e^{-0.2} - 1) * 100)$.

All in all, Figure 2.9 reflects the existence of the *bequest motive* discussed in Section 2.5.1, which induces some individuals to adopt estate planning strategies and transfer assets before death (although not properly anticipated) to minimize inheritance tax payments. More precisely, the introduction of the 99% tax credit in the inheritance tax discouraged the use of these tax planning strategies.

Figure A2.17 compares the baseline estimates to those obtained when using the log of the initial estate as the dependent variable. Although the latter coefficients are higher, they are not statistically different from the baseline estimates. This is the case because, on average, accumulated assets represent a very small fraction of the overall estate (4.5% and 1% in 2010 for treated estates placed in the top 1% and percentiles 95-99, respectively). Hence, even if the transfer of assets before death does indeed occur, overall it has a relatively small impact on estates' level.

Underlying mechanisms II: Changes in reported assets?

Figure 2.10 shows the β^y estimates resulting from specification 2.3 when using as the dependent variable the probability of reporting different asset categories (i.e. real estate, financial assets, unlisted companies and "unproductive" assets). This probability only increases significantly in the case of "other" assets, which mainly reflect cash, jewellery, antiques, art pieces, vehicles, etc. In the case of treated top 1% estates, the probability of reporting this type of assets increases since 2011 by 13-14 percentage points, or around 56% relative to the 2010 treated difference. In the case of treated estates from percentiles 95-99, the increase in this probability is lower (around 6 percentage points in 2012 and 2013, or about 41% relative to the 2010 treated difference) and becomes statistically insignificant in 2014.

Figure 2.11 provides the same information than Figure 2.10 with respect to the probability of reporting debts and deductible expenses. This probability gets lower between 2011 and 2013 for treated estates in the percentiles 95-99. In particular, the probability of reporting debts and deductible expenses decreased by 7 percentage points in 2011 and 2012, or around 37% of the 2010 treated difference.

Focusing now on values reported for different asset categories, Figures A2.18 and A2.19 provide β^y coefficient estimates resulting from specification 2.3 when using the log of Z_i^1 and Z_i^2 as dependent variables.[41] Figure A2.18 relates to top 1% treated estates and Figure A2.19 relates to treated estates from percentiles 95-99. Figure A2.20 provides the same information with respect to debts and deductible expenses. The first thing to notice from these three figures is that both measures Z_i^1 (baseline) and Z_i^2 (alternative) provide very similar estimates. The second thing to notice is that, except for real estate and financial assets, the number of observations in the remaining categories decreases substantially when using logarithms and no clear conclusions can be extracted.

Figure 2.12 considers the two asset categories most commonly reported, real estate and financial assets, and compares the estimates shown in Figures A2.18 and A2.19 with the baseline estimates from Figure 2.6. In the case of real estate, coefficient estimates are statistically significant and similar to the baseline estimates (except for years 2014-2015 in percentiles 95-99). In the case of financial assets, coefficient estimates are not statistically significant, except for the year 2012 in the top 1%. The significant increase in 2012 could be related to the tax amnesty implemented by the Spanish government during

[41] The definition of these variables can be found in Section 2.5.1.

that year. Indeed, heirs could participate in the tax amnesty on behalf of the deceased.[42] However, further information would be needed to properly assess this hypothesis. All in all, real estate valuations clearly seem to be driving (part) of the estimated response, while results are inconclusive with respect to financial assets.

Figure 2.13 considers the asset categories less commonly reported (i.e. unlisted companies, "unproductive" assets and debts) and provides β^y coefficient estimates from specification 2.3 when using the IHS transformation of the asset values as dependent variables. According to the results shown in Figures 2.10 and 2.11, coefficient estimates are statistically significant in the case of "unproductive" assets and in the case of debts and deductible expenses (for percentiles 95-99). Below I will summarize the results and express the average effect of each category in percent changes. In the case of business assets and unlisted shares, coefficient estimates are not statistically significant (except for the year 2011 in percentiles 95-99). Hence, this category does not seem to be an important factor in explaining the estimated effect on reported estates.

Last, Figure 2.14 provides β^y coefficient estimates from specification 2.3 when using the "assessment ratio" defined in Section 2.5.1 as the dependent variable. Although these results do not consider all the observations from treatment groups because the information needed to compute the assessment ratio was not always reported, they help to confirm that real estate assessments increased with the 2011 tax cut. In particular, between 2011 and 2013 the assessment ratio remained unchanged at an average value of 1.18 for the control group, but it increased up to 1.4 for both treated groups.

Elasticities estimates

As explained in Section 2.5.1, a simple way to obtain estate elasticities with respect to inheritance tax rates would be dividing the coefficient estimates presented in Figure 2.6 by -99%. Additionally, in this section I will present elasticity estimates expressed with respect to the net-of-tax rates, which is the approach generally adopted in the taxation literature.

In this regard, Table 2.4 provides the estate elasticity estimates resulting from specifications 2.5 and 2.6. The F statistics from the first stage are significantly higher than the generally accepted threshold of 10 to validate instrument relevance. In relation to the second stage, a relevant point to make is that both treated groups have very similar elasticities. Using τ_i^M as a measure of the "aggregate" marginal tax rate provides slightly lower elasticities, al-

[42] Chapter 4 provides more detailed information on this tax amnesty.

though they lie within the 95% confidence intervals of the estimates associated to τ_i^A. As described in Section 2.5.1, the former measure reflects the higher marginal tax rate at which an estate is (partially) taxed, whereas the latter is a weighted average of heirs' marginal tax rates according to their contribution to the aggregate tax base.

All in all, elasticity estimates range around 2 (being 1.88 the lowest coefficient and 2.51 the highest). This indicates that, as the net-of-"aggregate" marginal tax rates increases by 1%, reported estates increase, on average, by 2%.

Table A2.3 provides inheritance elasticity estimates resulting from implementing specifications 2.5 and 2.6 at heirs' level. When considering all heirs from treated and control groups, the coefficient estimates are significantly larger than those reported in Table 2.4. This difference can be explained by two different reasons. First, because individual portions of treated heirs increase more than the overall estate due to changes in estates' apportionment. As shown before, this is the case of estates in which spouses inherit more than 50%, and this is indeed the group which presents the largest elasticities. Second, because as discussed in Section 2.5.1, heirs inheriting smaller portions, which are not directly affected by the reform, might also react to the tax cut influenced by heirs who inherit larger portions. Hence, the estimates suggest that the reporting and assessment of inherited assets is not an individual decision, but rather a shared decision among heirs. In this regard, the relevant tax rate is not that faced by each heir individually, but that related to the largest portions, which are the ones more directly affected by the reform.

Accordingly, when focusing on heirs inheriting the largest portions, inheritance elasticity estimates diminish and range around 2, similar to the estate elasticities reported in Table 2.4.

This inheritance elasticity is substantially larger than estimates obtained in other studies (potentially) capturing heirs' reporting behaviour (Glogowsky, 2016; Sommer, 2017). These studies implement bunching techniques and estimate inheritance elasticities that do not exceed 0.03.[43]

Summary and discussion of the main results

Table A2.4 provides average DiD estimates associated with the results presented in Figures 2.12 and 2.13. In particular, it shows the average DiD coeffi-

[43]Glogowsky (2016) estimates an inheritance elasticity of 0.11 when focusing on predefined inheritances. On the other hand, Escobar (2017), which also focuses on heirs' reporting behaviour, does not provide elasticity estimates.

cients for the period 2011-2013, relative to the pre-reform period 2008-2010.[44] I compute the average effect for the years 2011-2013 given that this was the period in which the 99% tax credit remained unchanged.

Column (1) of Table 2.5 collects the DiD coefficients which are statistically significant from Table A2.4 and expresses them in percent changes. The percent change is directly reflected in the DiD coefficient when the dependent variable is expressed in logarithms (this is the case of real estate, financial assets and the overall reported estate). However, in the case of the asset categories shown in Figure 2.13, which are transformed with the IHS function, the percent change p is obtained from exponentiating the DiD coefficient as follows: $p = (e^{DiD} - 1) * 100$.[45]

Column (1) of Table 2.5 indicates that, on average, estates inherited by close heirs in the top 1% of the distribution increased by 39.56% between 2011 and 2013 due to the 99% tax cut. This increase was of 19.47% in the case of estates inherited by close heirs placed in percentiles 95-99. As shown in the previous section, these responses imply an elasticity of reported estates with respect to the net-of-inheritance tax rates of about 2.

Additionally, column (1) also provides this information for specific asset categories. In the case of top 1% treated estates, real estate increased by 46.50%, financial assets by 25.96%, "unproductive" assets by 335.74% and reported debts and deductible expenses decreased by 30.04%. In the case of treated estates from percentiles 95-99, real estate increased by 21.40%, "unproductive" assets by 116.03% and reported debts and deductible expenses decreased by 63.04%.

Column (2) shows the relative importance of each asset category in the overall estate for the pre-reform period. Column (3) expresses the percent changes of column (1) weighted by the asset shares provided in column (2). When adding up these weighted percent changes, they result in 35.31% and 19.7% for top 1% and percentiles 95-99, respectively. In both cases, this aggregate coefficient lies within the 95% confidence interval of the estimated effect on reported estates. Hence, the asset categories considered are able to explain most of the overall estates' response. Column (4) shows the contribution of each asset category to the overall effect in percentage terms. For both treated groups, the asset category which drives most of the response is real estate,

[44] The average DiD estimate results from the β coefficient of this specification: $Dep.var_i = \beta \cdot Time_i \cdot Treat_i^g + \gamma \cdot Time_i + \delta \cdot Treat_i^g + v_i$, where $Time_i$ is a dummy which equals 1 if individual i deceased between 2011 and 2013, and equals 0 if i deceased between 2008 and 2010. $Treat_i^g$ are the two treatment dummies defined in Section 2.5.1.

[45] This is the approach adopted in Johannesen et al. (2018) and discussed in Bellemare and Wichman (2019).

followed by "unproductive" assets. More specifically, in the case of estates in the top 1% (percentiles 95-99), real estate and "unproductive" assets explain around 58% (76%) and 25% (14%) of the overall effect, respectively.

To sum up, the 2011 tax cut primarily incentivized inheritors to increase real estate assessments. This response can be easily adopted given that real estate properties are self-assessed by taxpayers and, moreover, if a tax audit takes place, the reported value prevails over that proposed by the tax administration when the former is higher.

As already discussed in Section 2.5.1, this practice might help to reduce capital gains taxation in the case of a potential sale.[46] It is important to notice that this practice does not reflect inheritance tax avoidance or evasion, given that, in any case, taxpayers were, on average, assessing real estate properties above their adjusted administrative values throughout the period, and assessments made according to these adjusted values are accepted by the tax administration.

On the contrary, this "over-assessment" practice could reflect income tax evasion. However, given the impossibility to compare real estate reported values to true market prices, it is difficult to conclude whether this is indeed the case. If we assume that the tax administration manages to approximate market prices well through the multiplying coefficients, then we can use the (adjusted administrative value)*1.25 as a reference point.[47] Or put differently, multiplying the real estate "assessment ratio" by 0.8 would reflect reported values relative to "approximate market prices".

As explained above, the real estate assessment ratio of the treated groups increased, on average, up to 1.4 with the 2011 tax cut. According to the reasoning just exposed, this ratio could suggest that real estate properties were assessed, on average, 12% above their "market price". Consequently, in the case of a property sale, this 12% "over-assessment" would go untaxed and, hence, it would imply income tax evasion. Nonetheless, more precise market price estimations would be needed to extract a definite conclusion about the level of real estate over-assessment and its consequences on the income tax.

While real estate over-assessment does not imply inheritance tax evasion,

[46] Moreover, this practice did not affect other local taxes that need to be paid when inheriting real estate. A capital gains tax (known as *plusvalía municipal*) is levied at the municipal level when real estate is transferred. Nonetheless, during the period under study this tax was levied on cadastral values, so market prices or other assessments did not have any impact on it.

[47] As explained in Section 2.2, the Catalan Tax Agency defines the multiplying coefficients to approximate market values for the transfer tax, and then allows to reduce them by 20% in the case of the inheritance tax. Hence, the adjusted administrative value considered in this paper is defined as the cadastral value*0.8*multiplying coefficient.

the under-reporting of "unproductive" assets it does. As explained in Section 2.5.1, this category includes assets such as cash, jewellery, antiques, furs, art pieces, etc., which are not captured in administrative registers and, hence, they can be easily evaded. In this regard, the estimates suggest that the inheritance tax cut incentivized to report this type of assets that otherwise would have been undeclared. According to column (3) of Table 2.5, reported estates increased by 8.7% and 2.7% for the top 1% and percentiles 95-99, respectively, due to the reporting of "unproductive" assets.

Additionally, the amounts reported as debts or deductible expenses got lower with the 2011 tax cut, especially for the percentiles 95-99. This could suggest that taxpayers inflate this type of expenses when taxes are high, as they reduce the tax base, but it could also reflect that they do not bother to report these amounts correctly when taxes are almost zero. In any case, the coefficient estimate on reported estates would not change substantially if debts were disregarded: according to column (3) of Table 2.5, it would get about 2 and 1 percentage points lower for percentiles 95-99 and the top 1%, respectively.

As a final consideration, the nature of all the responses just described point towards changes in heirs' reporting behaviour, rather than changes in the deceased's behaviour.

2.6 Conclusions

This paper contributes to the literature on inheritance taxation by studying the effect of the inheritance tax both on the apportionment of estates and on the reporting and assessment of inherited assets.

It does so by exploiting significant inheritance tax cuts that occurred between 2010 and 2011 in Catalonia. Results provide two main findings. First, the inheritance tax distorts the allocation of estates. In this regard, the paper shows that spouses are more likely to inherit the entire estate when there is no need to minimize tax payments. In terms of efficiency, this finding would support the measure adopted by some governments of exempting spouses from the inheritance tax, as it is - or used to be - the case in France or the Scandinavian countries.[48]

[48] According to the "2019 Worldwide Estate and Inheritance Tax Guide" published yearly by EY, spouses are still exempt from the inheritance tax in the case of France and Denmark. In the case of Sweden and Norway, the inheritance tax was abolished in 2004 and 2014, respectively.

Second, reported estates increase up to 40% (20%) for the top 1% (percentiles 95-99) of the distribution due to a 99% tax cut. These responses translate into an elasticity of reported estates with respect to the net-of-inheritance tax rates of about 2. This elasticity is not driven by changes in wealth accumulation but from changes in heirs' reporting behaviour. In particular, it is primarily explained by real estate "over-assessment" and, to a lesser extent, by the reporting of assets that otherwise would have been evaded, such as cash, antiques, jewellery, etc.

The first practice, which helps to reduce capital gains in the case of a potential sale, cannot be associated with inheritance tax evasion, but it could imply the evasion of future personal income taxes. This strategy can be easily adopted provided that real estate properties, and also other assets, are self-assessed by taxpayers.

Therefore, this type of response could also arise in other countries where real estate properties - or other inherited assets - are not directly assessed by the tax administration and the assessment given in the inheritance tax has implications for other taxes.[49]

This practice could be prevented by replacing the real estate self-assessment from taxpayers with the provision of accurate market price estimations from the tax administration. With an extensive use of information beyond administrative records and the employment of big data techniques, this should be a feasible solution. In fact, it is a desirable solution, because it would facilitate filing and control tasks to taxpayers and the tax administration, respectively, and it would increase the equity and fairness in the tax system, not only in the inheritance tax, but also in others such as transfer, wealth or personal income taxes which rely on cadastral values.

[49] An example is, again, France. See: `https://www.notaires.fr/en/capital-gains-tax-property-0`

2.7 Tables

Table 2.1: Descriptive statistics on tax bases and tax liabilities by heir types and time periods

Period		% taxpayers with tax liability>0		Taxpayers with tax liability>0					
				Tax base (€)		Tax liability (€)		Average tax rate	
		Close	Distant	Close	Distant	Close	Distant	Close	Distant
1	Mean	40.68	75.90	152,845	96,933	14,201	23,589	0.0510	0.1423
	Std. Dev.			*331,379*	*215,779*	*65,701*	*94,475*	*0.0471*	*0.0841*
2	Mean	14.60	58.87	300,767	124,586	17,267	20,203	0.0293	0.1125
	Std. Dev.			*493,377*	*439,307*	*66,643*	*67,487*	*0.0385*	*0.0657*
3	Mean	5.75	46.48	576,103	129,719	38,681	21,214	0.0298	0.1109
	Std. Dev.			*836,304*	*268,450*	*163,731*	*93,598*	*0.0452*	*0.0685*
4	Mean	4.47	37.58	914,820	154,779	920	26,743	0.0004	0.1168
	Std. Dev.			*1,452,431*	*360,063*	*3,382*	*97,088*	*0.0006*	*0.0772*
5	Mean	15.09	76.93	360,594	89,615	6,141	17,871	0.0036	0.1145
	Std. Dev.			*828,523*	*219,916*	*63,527*	*82,280*	*0.0124*	*0.0631*

Notes: Period 1: 2008-2009; period 2: 1st half 2010; period 3: 2nd half 2010; period 4: 2011-Jan2014; period 5: Feb2014-2015. Close heirs refer to spouses, all descendants and (grand)parents. Distant heirs refer to siblings, more distant relatives such as uncles, cousins and others with 3rd or higher degree of kinship, or inheritors with no family relationship with the deceased. The average tax rate is expressed as a ratio of the tax liability over the tax base. Monetary variables are expressed in 2011 prices.

Table 2.2: Probability that spouses inherit the entire estate: reduced form estimates

	(1)	(2)	(3)	(4)	(5)
Age bandwidth	74-75	73-76	72-77	71-78	70-79
Main estimates. *Year 2010 and aggregate tax base>125,000*					
1.over74	0.0825**	0.0757***	0.0627***	0.0606***	0.0554***
	(0.0400)	(0.0281)	(0.0236)	(0.0212)	(0.0191)
Constant	0.3533***	0.3469***	0.3526***	0.3607***	0.3571***
	(0.0276)	(0.0200)	(0.0171)	(0.0159)	(0.0142)
Observations	596	1,192	1,700	2,140	2,644
Placebos:					
Placebo 1: Years 2008-2009 and aggregate tax base>125,000					
1.over74	-0.0121	-0.0009	-0.0042	-0.0014	0.0081
	(0.0254)	(0.0180)	(0.0148)	(0.0130)	(0.0118)
Constant	0.2104***	0.2029***	0.2041***	0.2041***	0.1991***
	(0.0179)	(0.0129)	(0.0107)	(0.0095)	(0.0087)
Observations	1,007	1,996	2,952	3,865	4,739
Placebo 2: Years 2011-2013 and aggregate tax base>125,000					
1.over74	0.0028	-0.0084	-0.0148	-0.0144	-0.0164
	(0.0247)	(0.0176)	(0.0143)	(0.0124)	(0.0111)
Constant	0.5173***	0.5180***	0.5198***	0.5188***	0.5184***
	(0.0182)	(0.0132)	(0.0108)	(0.0093)	(0.0084)
Observations	1,646	3,271	4,951	6,671	8,336
Placebo 3: Year 2010 and aggregate tax base<125,000					
1.over74	-0.0350	-0.0273	-0.0150	-0.0227	-0.0095
	(0.0397)	(0.0280)	(0.0231)	(0.0205)	(0.0183)
Constant	0.5940***	0.6031***	0.5925***	0.6014***	0.5976***
	(0.0285)	(0.0203)	(0.0171)	(0.0156)	(0.0140)
Observations	620	1,242	1,840	2,365	2,968

Notes: This table provides reduced form estimates from specifications 2.1 and 2.2 for different age bandwidths. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 2.3: Probability that spouses inherit the entire estate: 2SLS estimates

	(1)	(2)	(3)	(4)	(5)
Age bandwidth	74-75	73-76	72-77	71-78	70-79
Instrumented variable: $Indifferent_{ji}$					
First stage estimates					
1.over74	0.2417***	0.2498***	0.2654***	0.2650***	0.2589***
	(0.0337)	(0.0239)	(0.0203)	(0.0186)	(0.0167)
F-stat	51.44	108.85	170.79	202.92	239
Second stage estimates					
$Indifferent_{ji}$	0.3412**	0.3033***	0.2361***	0.2286***	0.2142***
	(0.1582)	(0.1080)	(0.0854)	(0.0770)	(0.0709)
Constant	0.1361	0.1542*	0.2061***	0.2203***	0.2249***
	(0.1202)	(0.0832)	(0.0656)	(0.0593)	(0.0545)
Instrumented variable: $ln(1-\tau_{ji})$					
First stage estimates					
1.over74	0.0082**	0.0115***	0.0130***	0.0120***	0.0133***
	(0.0035)	(0.0027)	(0.0023)	(0.0021)	(0.0019)
F-stat	5.44	17.97	31.78	32.31	49.76
Second stage estimates					
$ln(1-\tau_{ji})$	10.0776	6.5925**	4.8139**	5.0444***	4.1552***
	(6.2304)	(2.8225)	(1.9488)	(1.9257)	(1.5125)
Observations	596	1,192	1,700	2,140	2,644

Notes: This table provides 2SLS estimates from specifications 2.1 and 2.2 for different age bandwidths. See section 2.4.1 for a definition of the instrumented variables. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 2.4: Estate elasticities with respect to the net-of-inheritance aggregate tax rates

	(1)	(2)	(3)	(4)
τ_i definition:	τ_i^A	τ_i^M	τ_i^A	τ_i^M
First stage estimates				
$Time_i \cdot Treat_i^g$	0.1675***	0.2013***	0.0775***	0.1035***
	(0.0058)	(0.0059)	(0.0050)	(0.0051)
F-stat	6436.28	6692.91	8233.02	9888.9
Second stage estimates				
$ln(1-\tau_i)$	2.3620***	1.9658***	2.5132***	1.8811***
	(0.2171)	(0.1763)	(0.3278)	(0.2283)
	[1.936,2.788]	[1.62,2.311]	[1.871,3.156]	[1.434,2.329]
Treated group	top 1%	top 1%	p.95-99	p.95-99
Observations	9,525	9,525	16,072	16,072

Notes: This table provides 2SLS estimates from specifications 2.5 and 2.6 using different definitions of inheritance "aggregate" marginal tax rates (τ_i): τ_i^A and τ_i^M. See section 2.5.1 for a definition of these variables. Robust standard errors in parentheses and 95% confidence intervals in brackets. *** p<0.01, ** p<0.05, * p<0.1

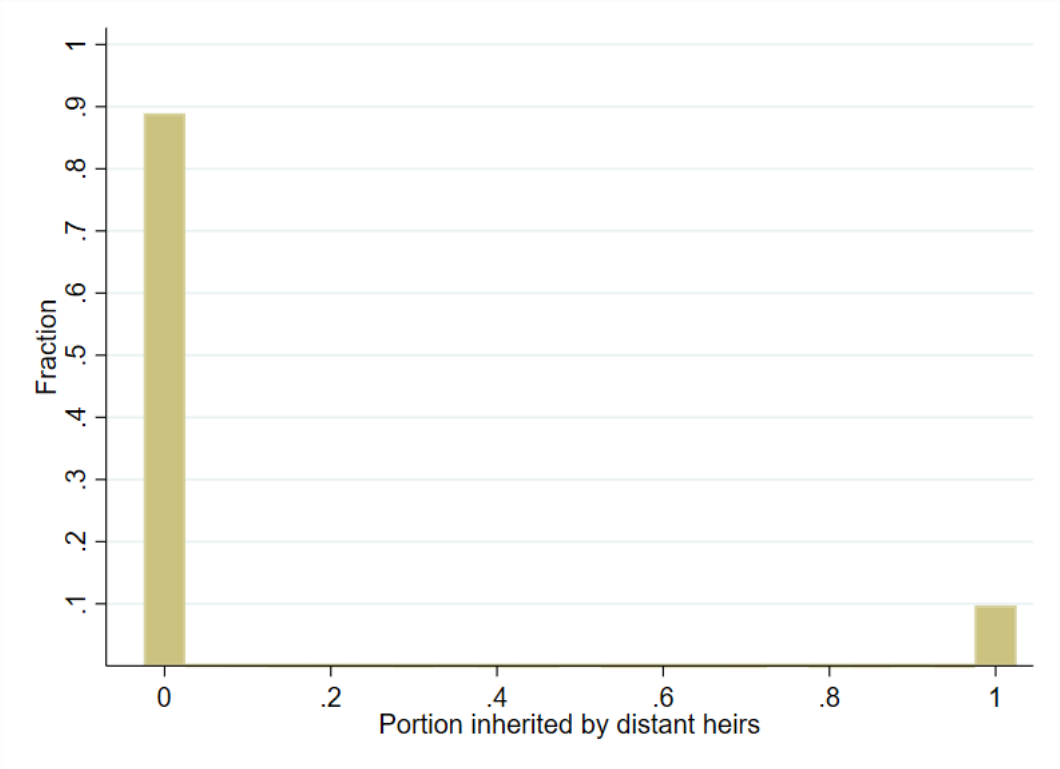
Table 2.5: Summary of the coefficient estimates

	(1) DiD percent change in post-reform period 2011-2013 *(%)*	(2) Average asset share in pre-reform period 2008-2010 *(%)*	(3) DiD percent change weighted by the asset share: (1)%*(2)%	(4) % contribution in the total effect: (3)/*total*
Top 1%				
Overall reported estate	39.56			
95% confidence interval	[33.68,45.45]			
Asset categories:				
Real estate	46.50	44.16	20.53	58.14
Financial assets	25.96	20.34	5.28	14.95
Unproductive assets	335.74	2.58	8.66	24.52
Debts	-30.04	-2.80	0.84	2.38
total			*35.31*	
Percentiles 95-99				
Overall reported estate	19.47			
95% confidence interval	[16.14,22.80]			
Asset categories:				
Real estate	21.40	69.57	14.89	75.58
Unproductive assets	116.03	2.30	2.67	13.53
Debts	-63.04	-3.40	2.14	10.88
total			*19.70*	

Notes: Column (1) of this table collects the average DiD coefficient estimates which are statistically significant from Table A2.4. Column (2) shows the average importance of each asset category relative to the overall estate for the pre-reform period 2008-2010. Debts have a negative sign given its negative impact on estate levels.

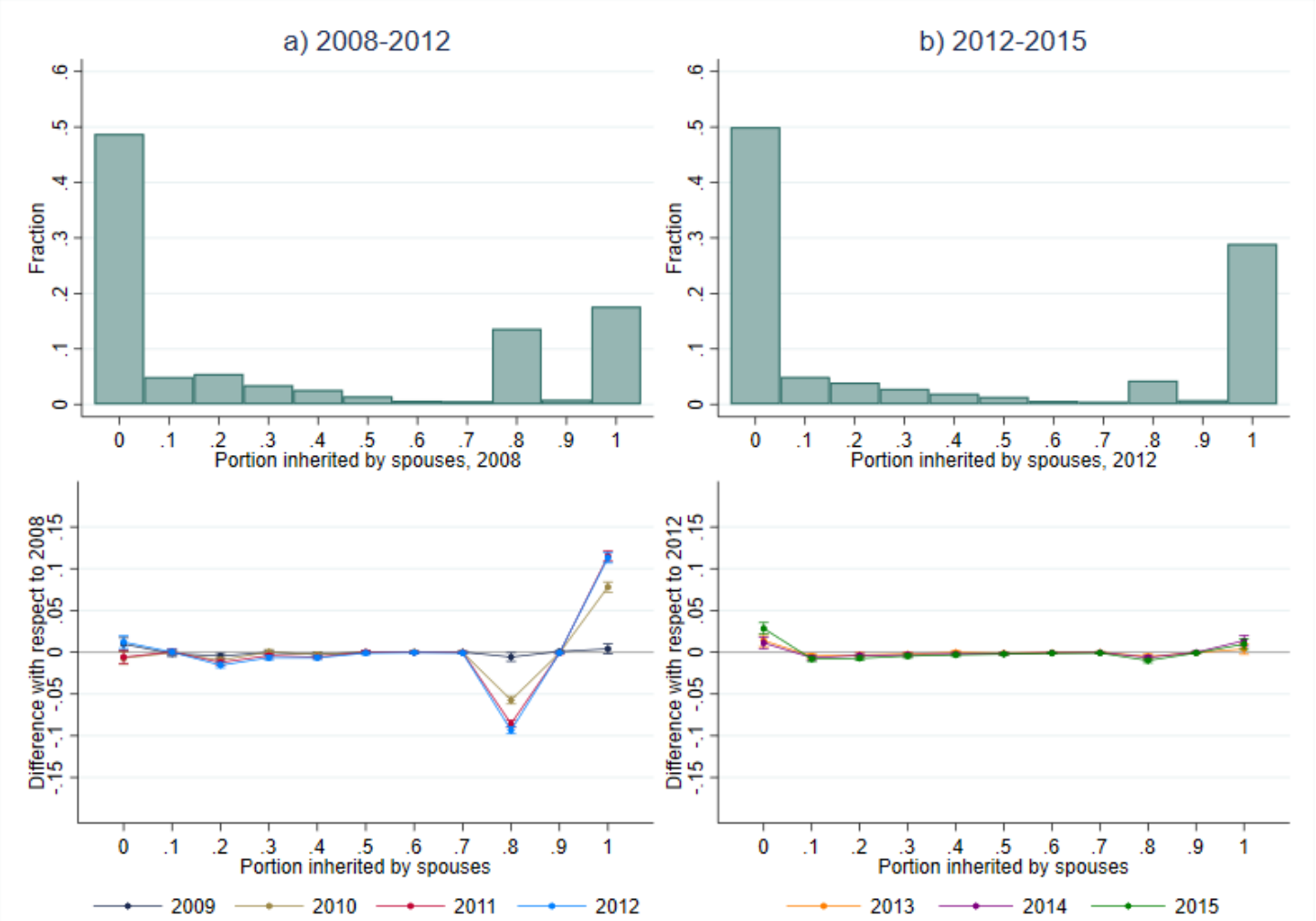
2.8 Figures

Figure 2.1: Portion inherited by distant heirs, 2008-2015



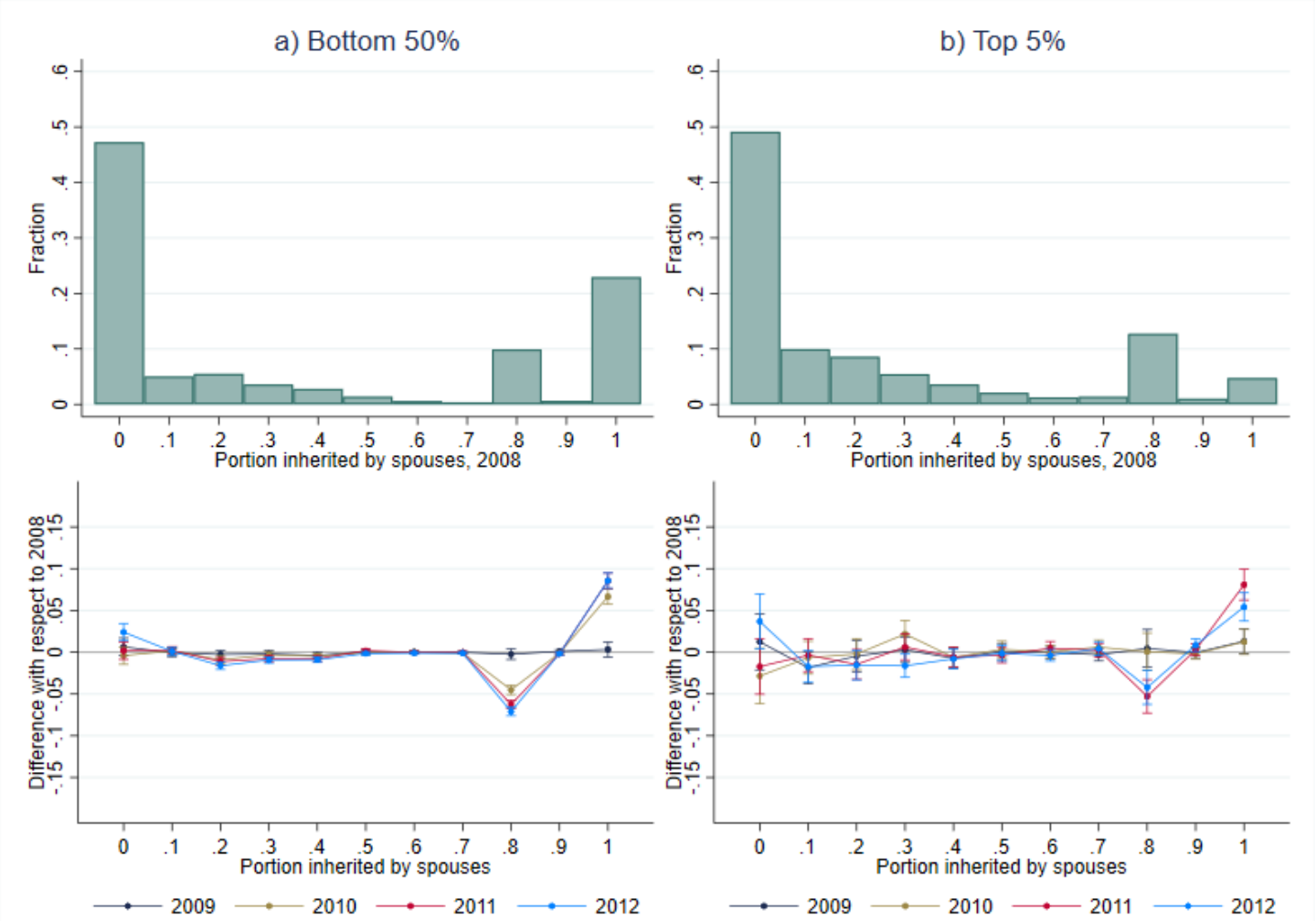
Notes: This figure shows the distribution of estates according to the overall portion inherited by distant heirs as a group (not individually). All positive estates are considered.

Figure 2.2: Portion inherited by spouses, 2008-2015



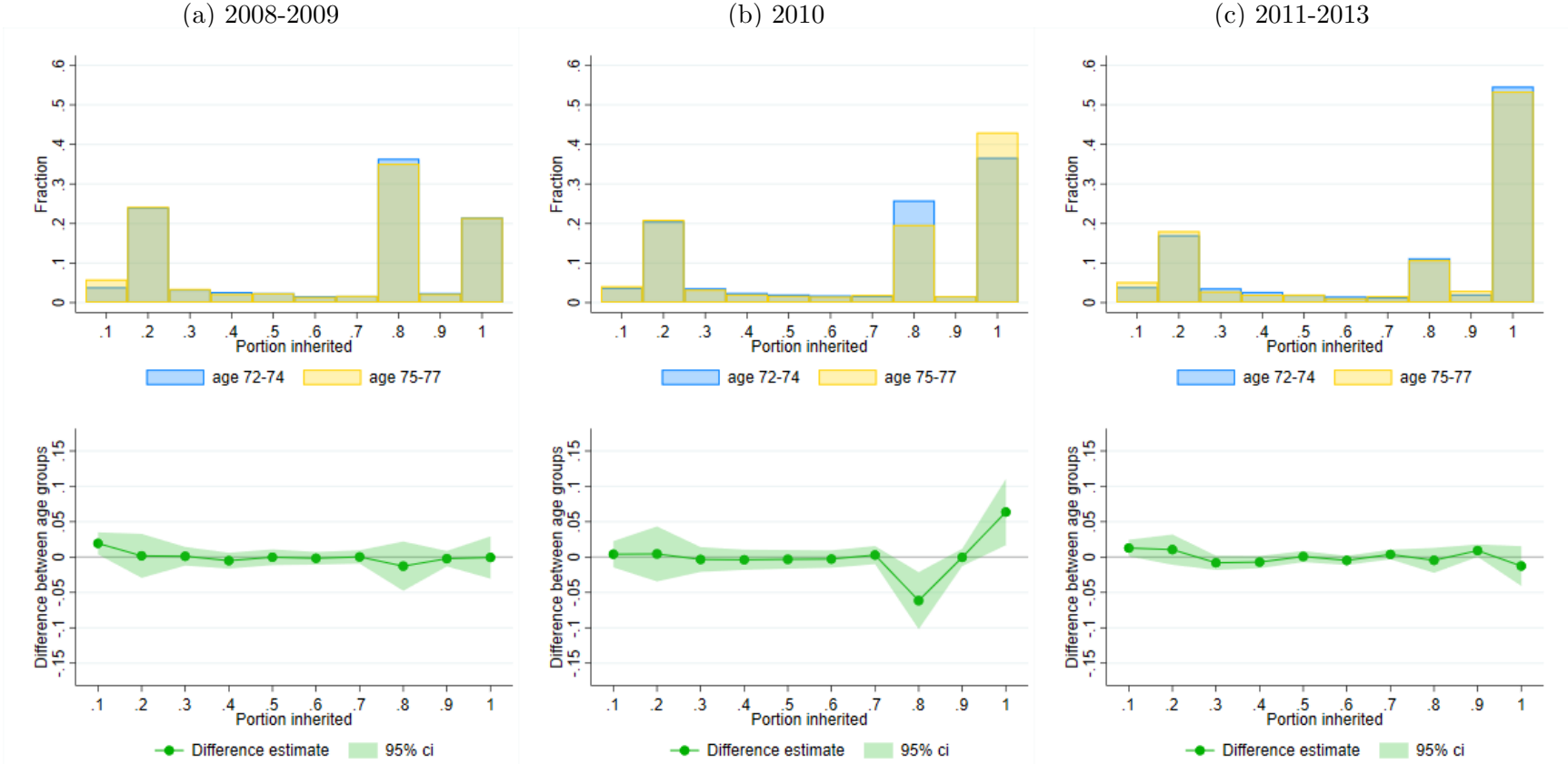
Notes: The top figures of panels (a) and (b) show the histogram of estates bequeathed to close heirs in 2008 and 2012, respectively, according to the portion inherited by spouses. The first bar of each panel includes only 0 values. Each of the other ten bars comprises an interval of 10 percentage points, being its x value the upper bound. The bottom figures of panels (a) and (b) plot the differences between the histograms of subsequent years and that presented in the top panel.

Figure 2.3: Portion inherited by spouses: bottom 50% vs. top 5%



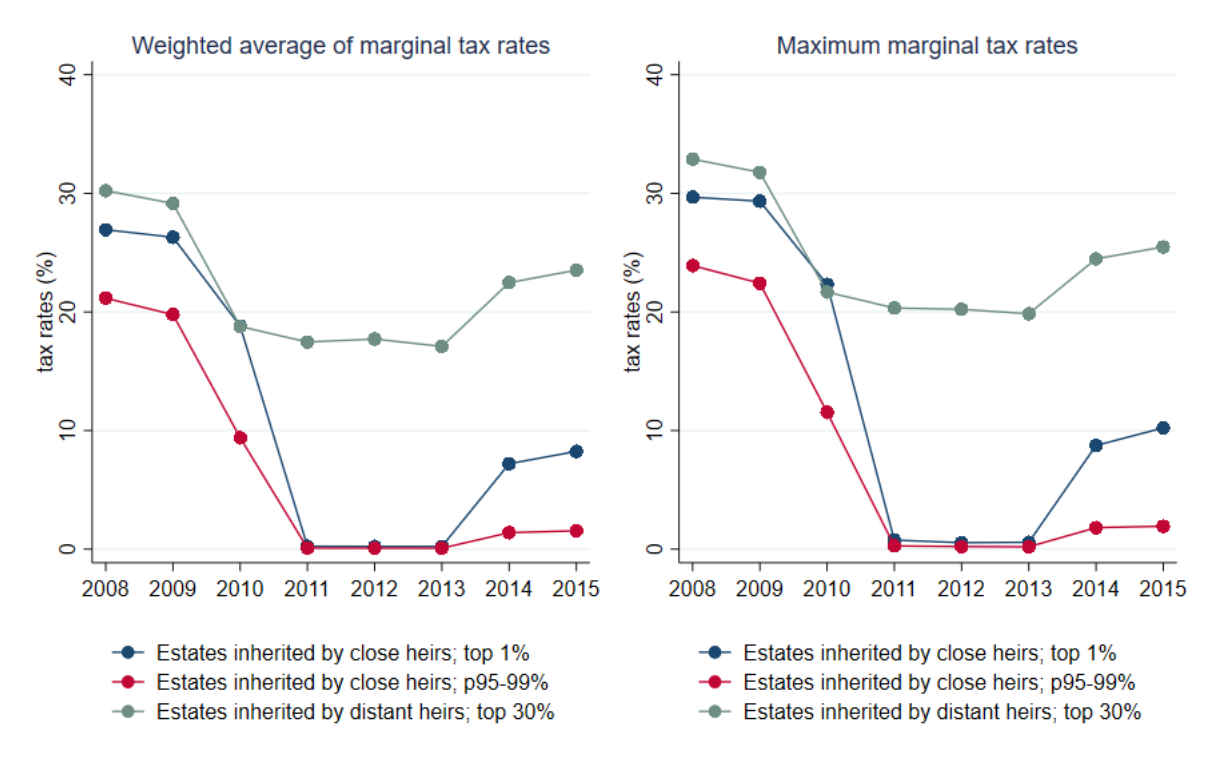
Notes: The top figures of panels (a) and (b) show the histogram of estates bequeathed to close heirs in 2008, according to the portion inherited by spouses. Panel (a) considers the bottom 50% of the estates' distribution and panel (b) considers the top 5%. The first bar of each panel includes only 0 values. Each of the other ten bars comprises an interval of 10 percentage points, being its x value the upper bound. The bottom figures of panels (a) and (b) plot the differences between the histograms of subsequent years and that presented in the top panel.

Figure 2.4: Portion inherited by spouses: difference between age groups



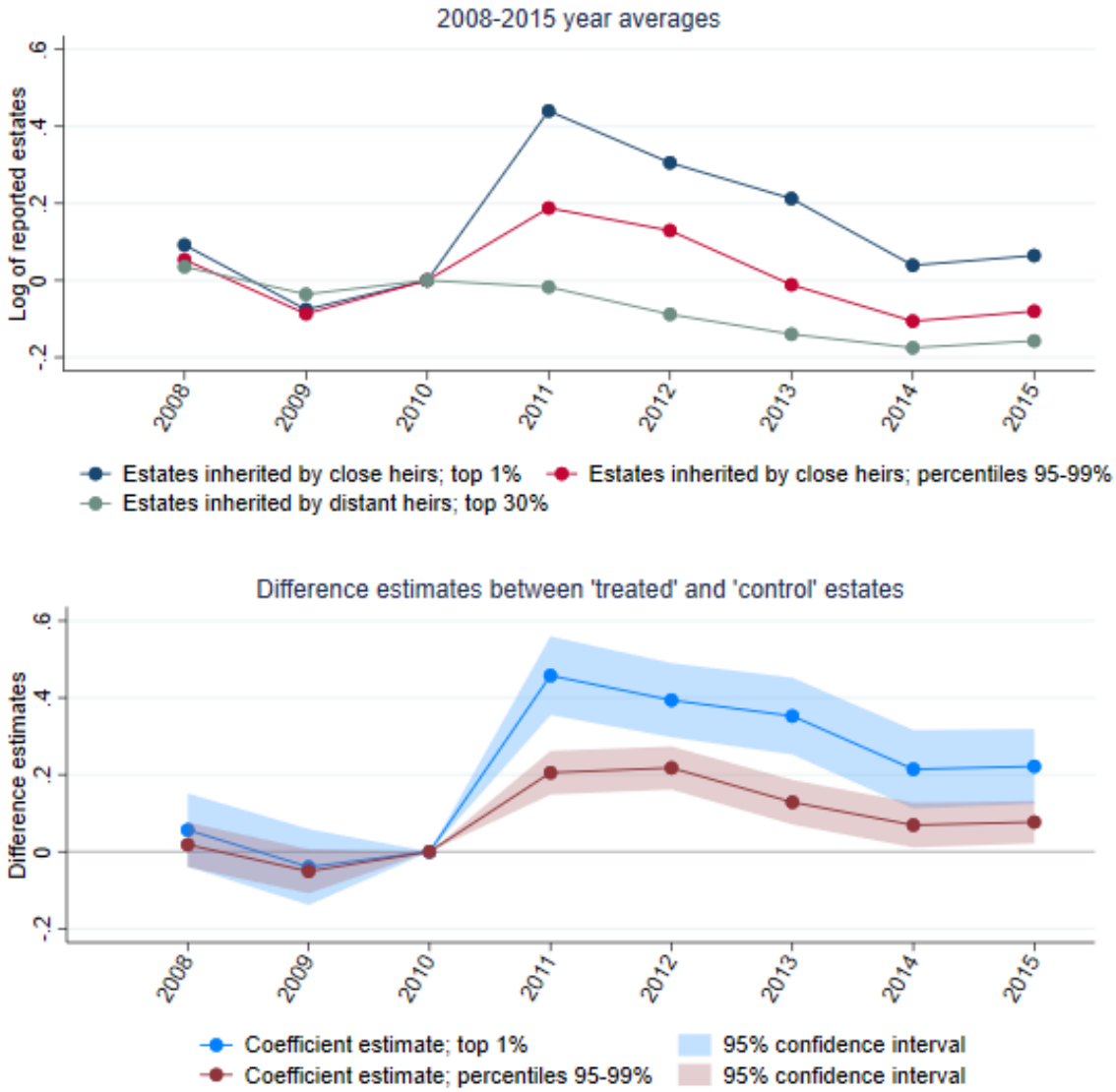
Notes: The top figures of panels (a), (b) and (c) show, for different periods, the histogram of spouses according to the portion inherited and distinguishing between different age groups. Each bar of each panel comprises an interval of 10 percentage points, being its x value the upper bound. The bottom figure of panel (a), (b) and (c) shows the estimated difference between the two histograms presented just above and the corresponding 95% confidence intervals.

Figure 2.5: "Aggregate" marginal tax rates



Notes: This figure shows the year-average of "aggregate" marginal tax rates for treated and control groups. Two different measures are used: the panel on the left reflects the yearly average of τ_i^A, which is a weighted average of heirs' marginal tax rates according to their contribution to the aggregate tax base. The right-panel shows the yearly average of τ_i^M, which reflects the higher marginal tax rate at which an estate is (partially) taxed. Section 2.5.1 provides a more detailed definition of these measures.

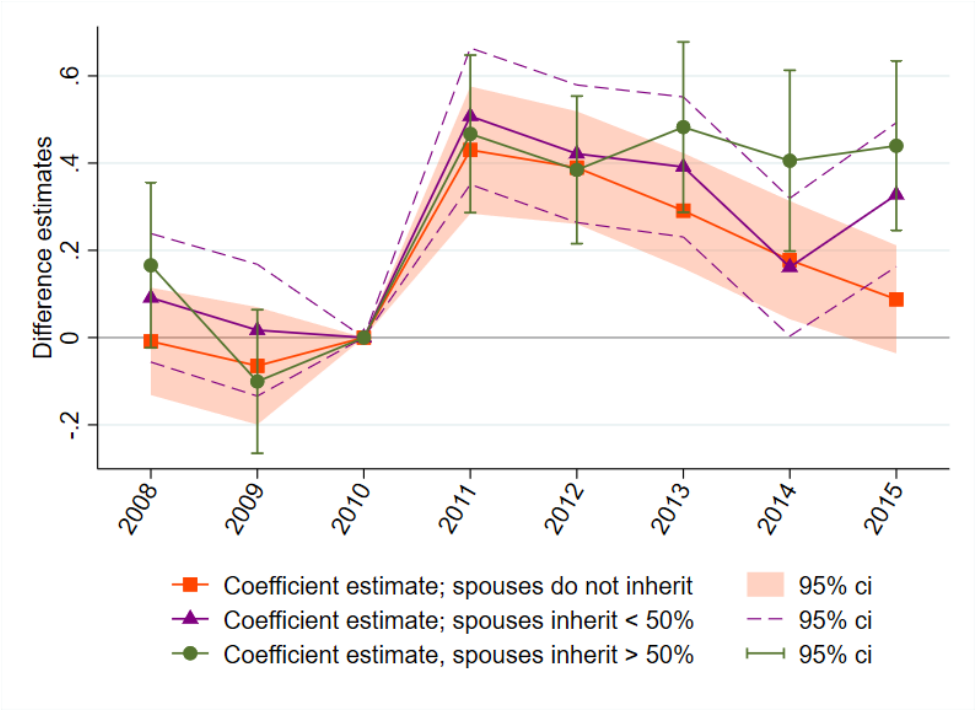
Figure 2.6: Effect of 2011 tax cut on reported estates



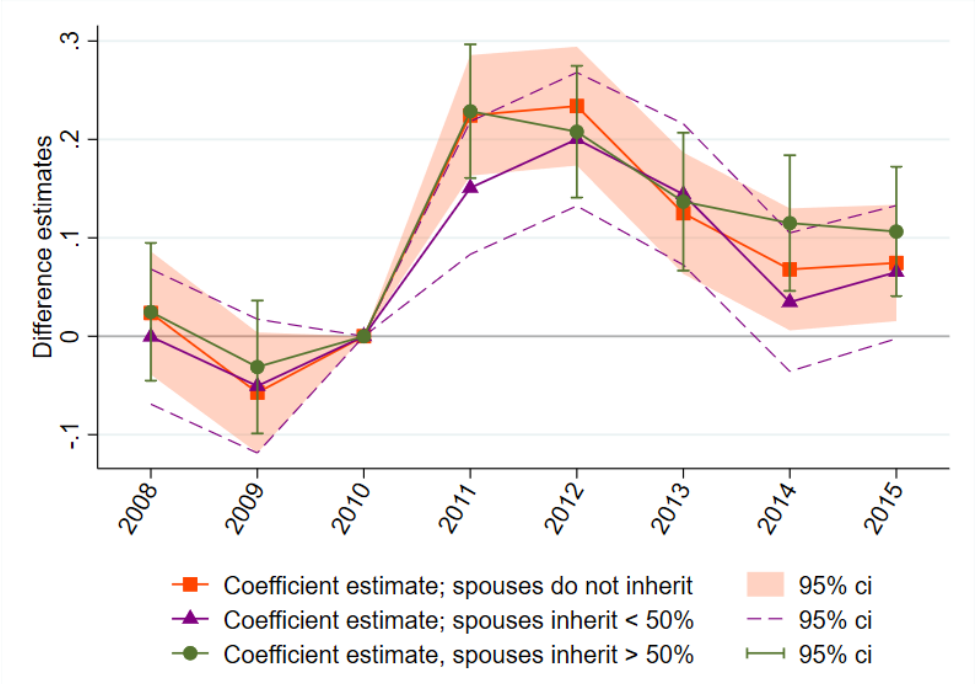
Notes: The figure in the top panel shows the evolution of the year-average of the (log of) reported estates, relative to 2010, for treated and control groups. Treated groups are estates inherited by close heirs placed at the percentiles 95-99 or the top 1% of the estates' distribution. The control group includes estates inherited by distant heirs placed at the top 30% of the estates' distribution. The figure in the bottom panel provides β^y coefficient estimates and 95% confidence intervals resulting from implementing specification 2.3 for both treated groups and using the log of reported estates as the dependent variable. The number of observations for each group is: 9,879 for the control group and 11,913 (2,975) for the treated group in percentiles 95-99 (top 1%).

Figure 2.7: Effect of 2011 tax cut on reported estates; distinction between estates inherited by spouses and estates which are not

(a) Top 1%

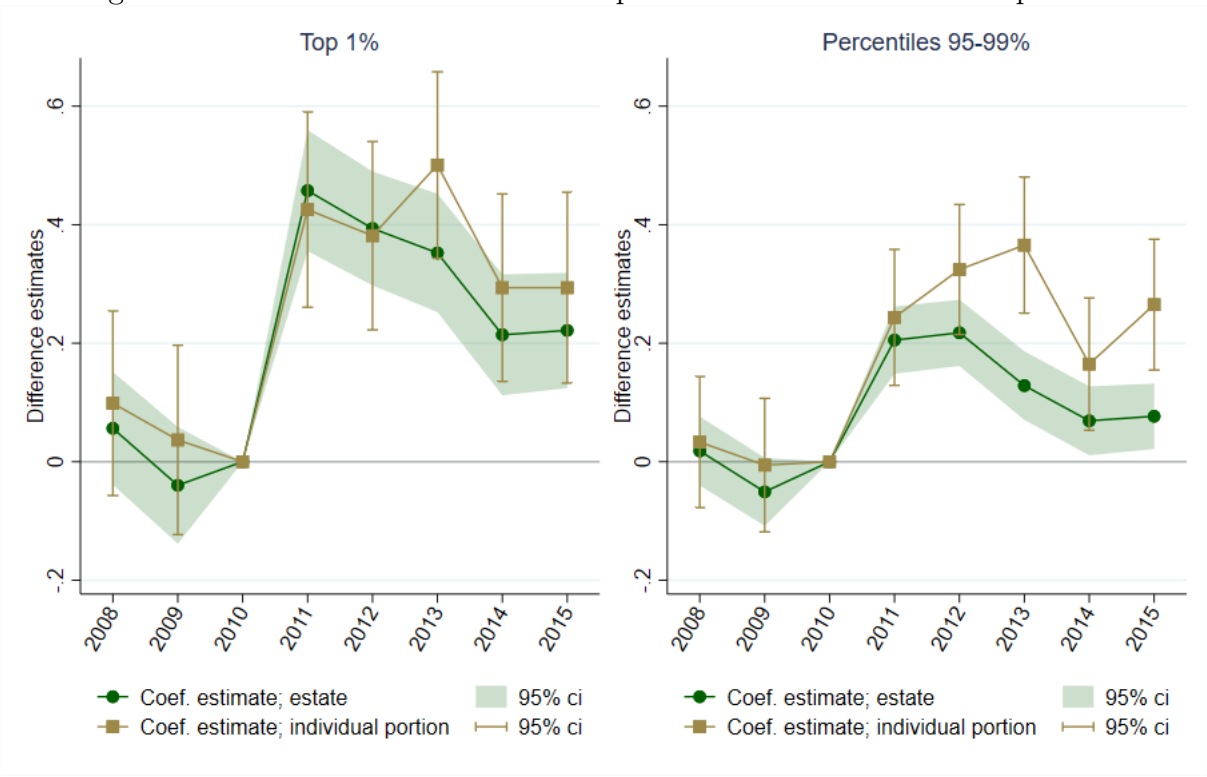


(b) Percentiles 95-99%



Notes: Figures in panel (a) and (b) provide β^y coefficient estimates and 95% confidence intervals resulting from implementing specification 2.3 for different treated groups and using the log of reported estates as the dependent variable. The number of observations of each type of estate in the percentiles 95-99 (top 1%) is: 6,112 (1,436) for estates in which spouses do not inherit, 2,832 (994) for estates in which spouses inherit less than 50% and 2,969 (545) for estates in which spouses inherit more than 50%.

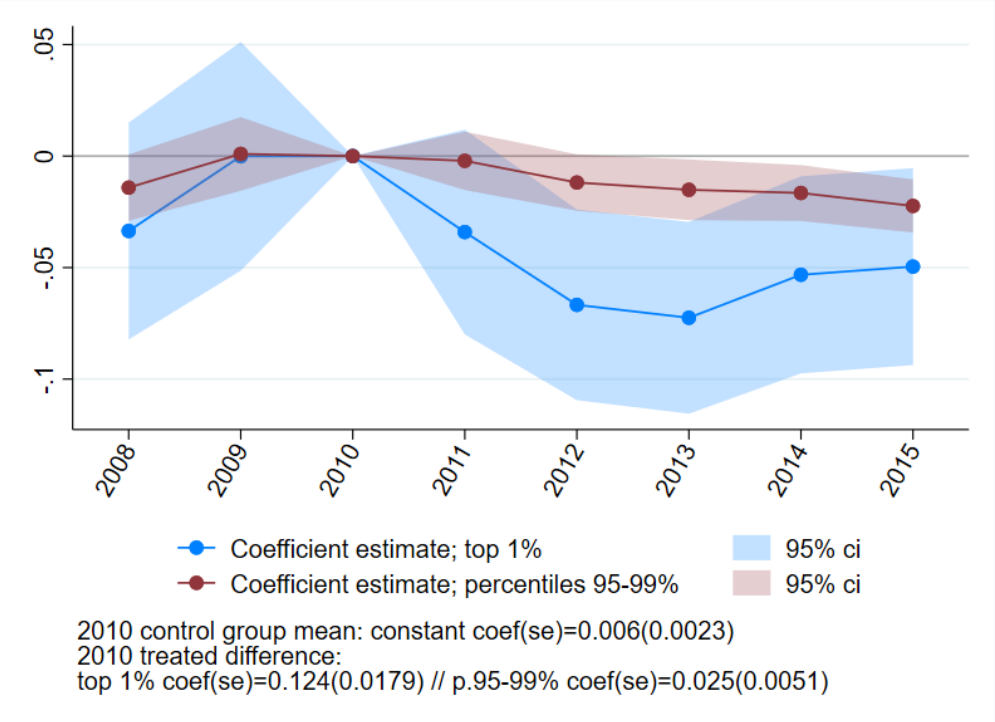
Figure 2.8: Effect of 2011 tax cut on reported estates vs. individual portions



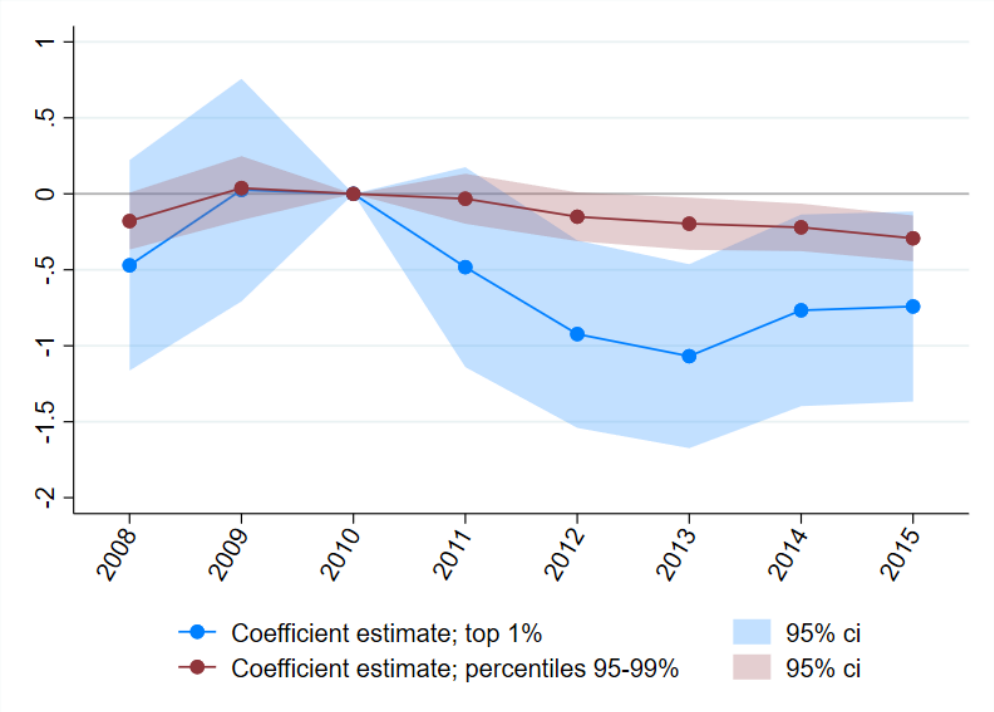
Notes: These figures provide β^y coefficient estimates and 95% confidence intervals resulting from implementing specification 2.3 for both treated groups (top 1% and percentiles 95-99). It compares the baseline coefficient estimates presented in Figure 2.6 with those obtained when implementing specification 2.3 at heirs' level and using the log of individual inherited portions as the dependent variable. The number of observations for each group at estates (heirs) level is: 9,879 (28,117) for the control group, 11,913 (32,960) for the treated group in percentiles 95-99 and 2,975 (9,640) for the top 1% treated group.

Figure 2.9: Effect of 2011 tax cut on "added assets"

(a) Dep. var: Probability of reporting "added assets"

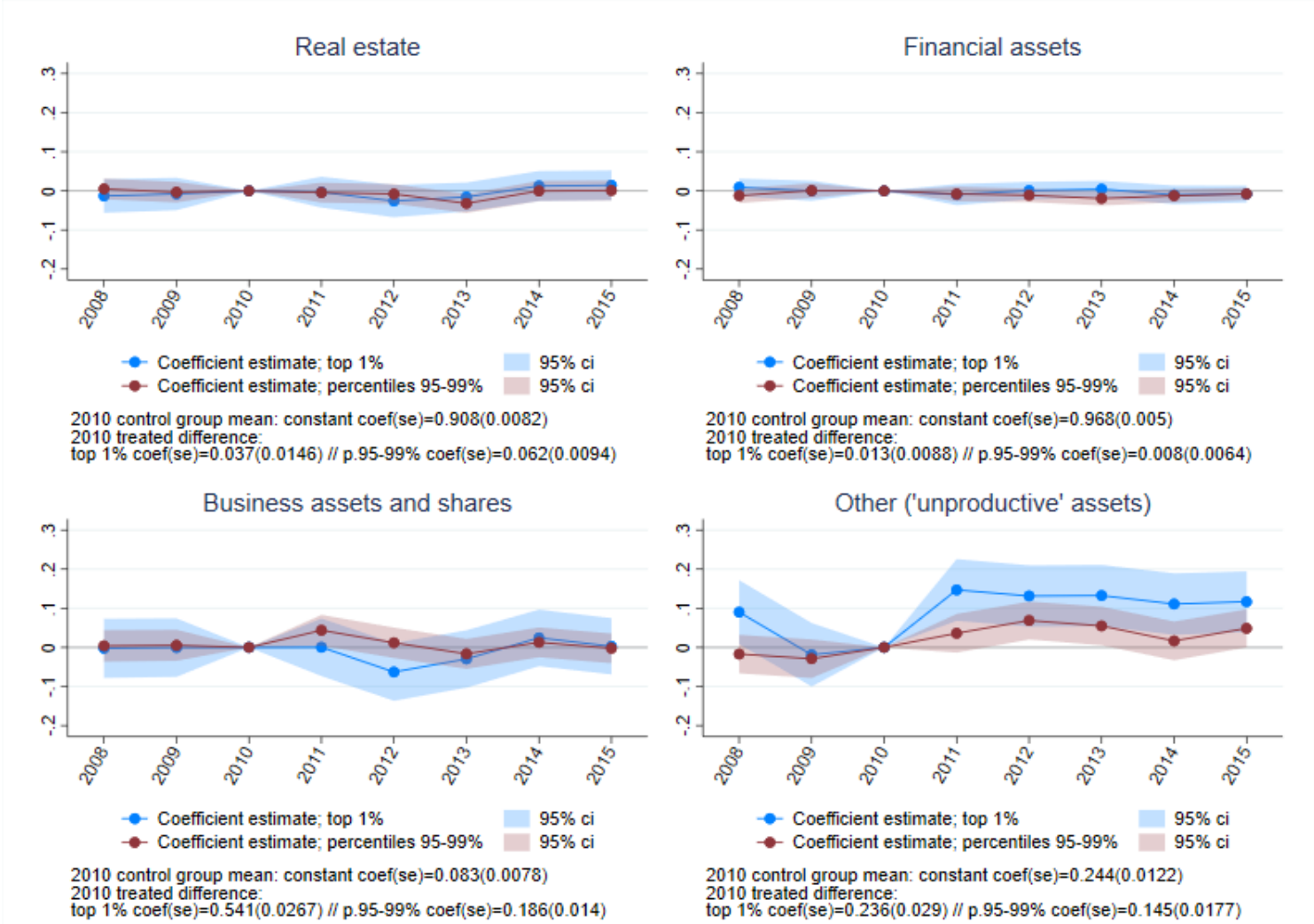


(b) Dep. var: IHS transformation of "added assets"



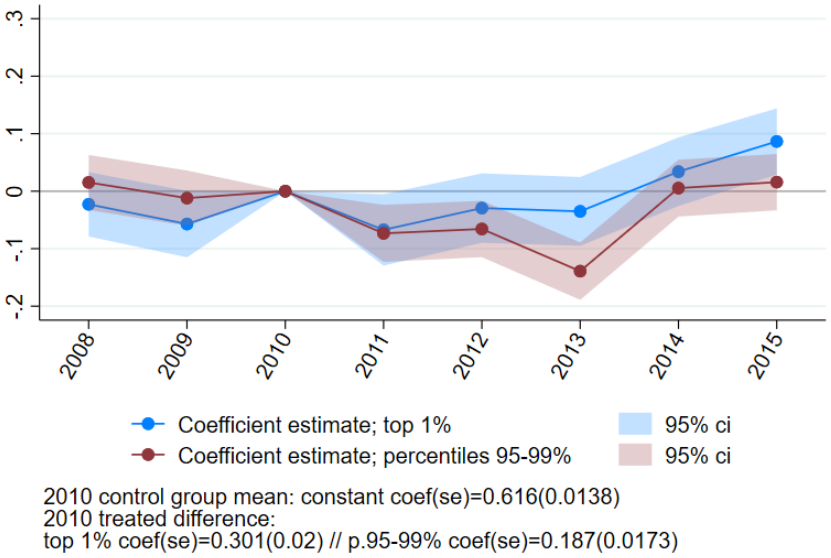
Notes: The figures provide β^y coefficient estimates and 95% confidence intervals resulting from implementing specification 2.3 for both treated groups (top 1% and percentiles 95-99) and using one of the dependent variables specified in panels (a) and (b).

Figure 2.10: Effect of 2011 tax cut on the probability of reporting different asset categories



Notes: Each panel provides β^y coefficient estimates and 95% confidence intervals resulting from implementing specification 2.3 for both treated groups (top 1% and percentiles 95-99) and using the probability of reporting an asset category Z as the dependent variable. $Z = \{$real estate, financial assets, unlisted companies holdings and business assets, "unproductive" assets$\}$.

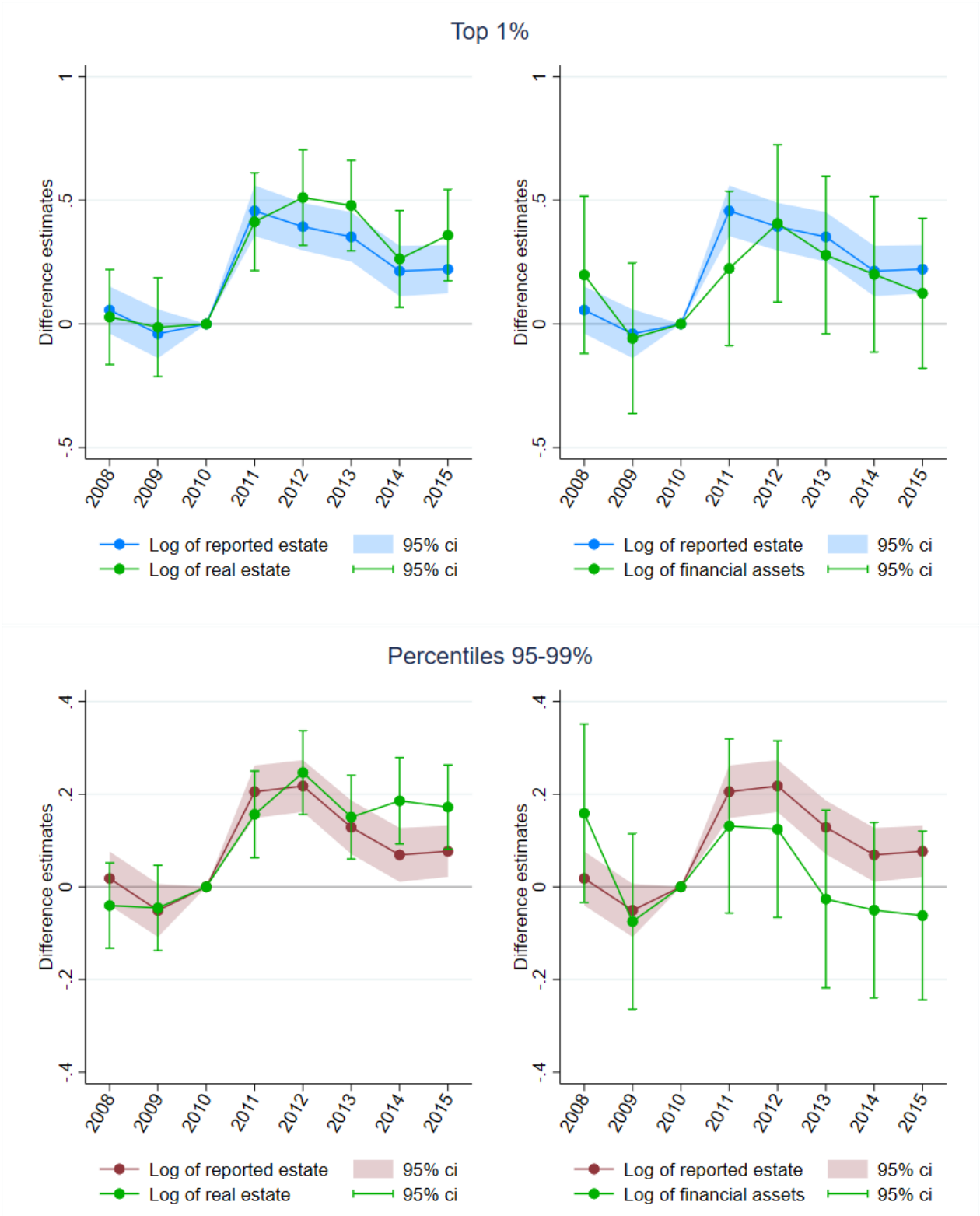
Figure 2.11: Effect of 2011 tax cut on the probability of reporting debts and deductible expenses



2010 control group mean: constant coef(se)=0.616(0.0138)
2010 treated difference:
top 1% coef(se)=0.301(0.02) // p.95-99% coef(se)=0.187(0.0173)

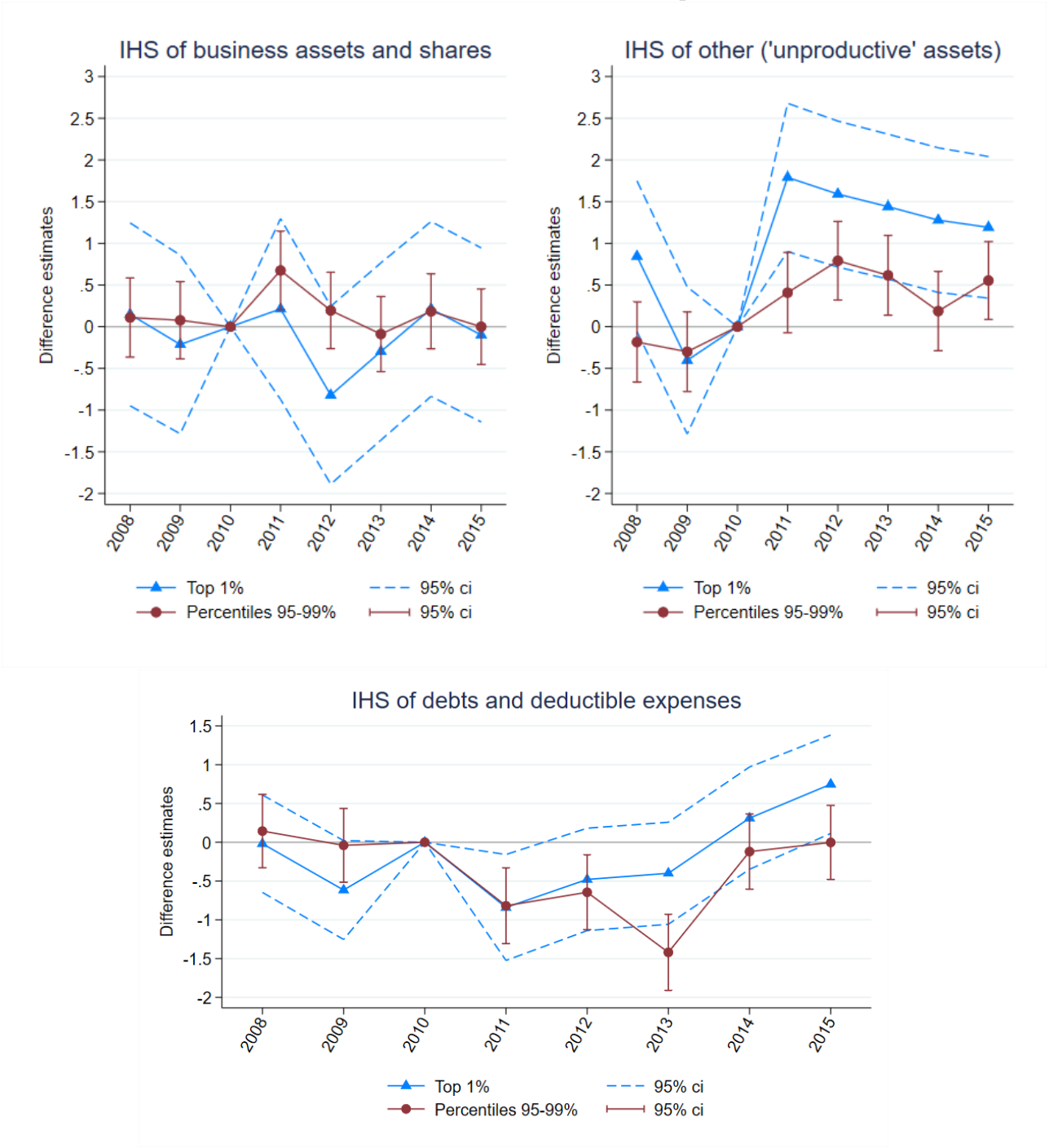
Notes: This Figure provides β^y coefficient estimates and 95% confidence intervals resulting from implementing specification 2.3 for both treated groups (top 1% and percentiles 95-99) and using the probability of reporting debts and deductible expenses as the dependent variable.

Figure 2.12: Effect of 2011 tax cut on real estate and financial assets



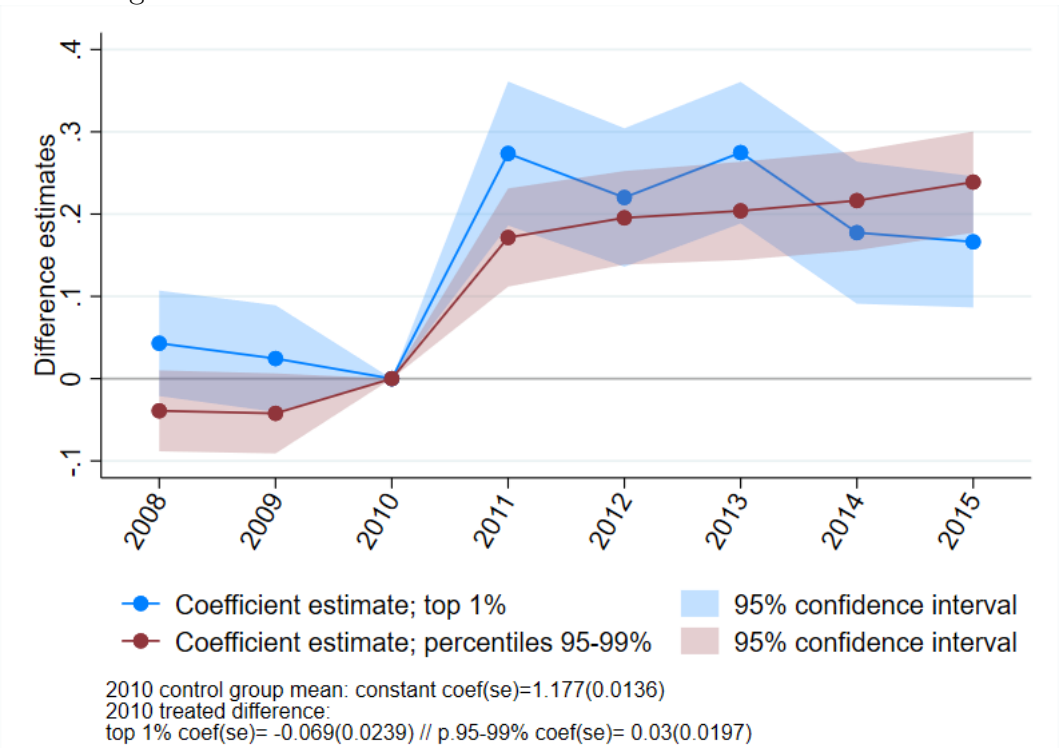
Notes: The panel in the top (bottom) provides β^y coefficient estimates and 95% confidence intervals resulting from implementing specification 2.3 for the treated group in the top 1% (percentiles 95-99) of the distribution. Both panels compare the baseline coefficient estimates presented in Figure 2.6 with those obtained when using the log of real estate (left) or the log of financial assets (right) as the dependent variable. These dependent variables are computed according to the asset value definition Z_i^1, which is defined in section 2.5.1.

Figure 2.13: Effect of 2011 tax cut on unlisted companies, "unproductive" assets and debts and deductible expenses



Notes: Each panel provides β^y coefficient estimates and 95% confidence intervals resulting from implementing specification 2.3 for both treated groups (top 1% and percentiles 95-99) and using the IHS transformation of the asset category Z as the dependent variable. The dependent variables are computed according to the asset value definition Z_i^1, which is defined in section 2.5.1. $Z = \{$unlisted companies holdings and business assets, "unproductive" assets, debts and deductible expenses$\}$.

Figure 2.14: Effect of 2011 tax cut on real estate assessment ratio



Notes: This Figure provides β^y coefficient estimates and 95% confidence intervals resulting from implementing specification 2.3 for both treated groups (top 1% and percentiles 95-99) and using the real estate "assessment ratio" defined in section 2.5.1 as the dependent variable. The number of observations used in the estimations is lower when considering this dependent variable since it cannot be computed for all individuals: the control group includes 6,702 observations and the treated groups in percentiles 95-99 and top 1% include 8,931 and 2,157 observations, respectively.

2.9 Appendix

Table A2.1: *Type-a* tax base deductions, 2008-2015

Type-a deductions	**2008-2009**	**Jan-Jun2010**	**Jul-Dec2010**	**2011-Jan2014**	**Feb2014-2015**
Family relationship:					
Descendants<21	[18,000 + 12,000*(21-age)] Max: 114,000	[68,750 + 8,250*(21-age)] Max: 134,750	[171,875 + 20,625*(21-age)] Max: 336,875	[275,000 + 33,000*(21-age)] Max: 539,000	[100,000 + 12,000*(21-age)] Max: 196,000
Spouse	18,000	125,000	312,500	500,000	100,000
Direct descendant	18,000	68,750	171,875	275,000	100,000
Other descendants	18,000	37,500	93,750	150,000	50,000
(Grand)parents	18,000	25,000	62,500	100,000	30,000
Group III	9,000	12,500	31,250	50,000	8,000
Degree of disability:					
33-64%	245,000	275,000			
$\geqslant$ 65%	570,000	650,000			
Heirs older than 74:	N/A	275,000			

Notes: Group III includes siblings, stepchildren, nephews/nieces, uncles/aunts.

Table A2.2: Percentile distribution of estates inherited by close heirs and estates inherited by distant heirs

Percentiles	Estates inherited by close heirs				Estates inherited by distant heirs			
	2008	2010	2012	2014	2008	2010	2012	2014
25	50,432	51,601	46,949	43,349	44,053	43,754	42,810	39,098
50	104,191	107,727	101,571	90,609	108,446	108,137	101,230	89,743
70	172,294	178,994	172,351	150,118	194,709	183,953	177,435	155,638
80	237,285	243,637	240,629	203,854	267,247	261,835	239,977	219,231
90	387,256	390,367	403,283	330,871	458,258	420,940	397,133	354,212
95	626,228	608,463	673,696	533,170	685,293	654,599	568,214	554,311
99	1,962,070	1,775,462	2,291,382	1,717,704	1,927,762	2,090,195	1,533,716	1,739,198

Notes: values expressed in 2011 prices.

Table A2.3: Inheritance elasticities with respect to the net-of-marginal tax rates

	Top 1%				Percentiles 95-99			
	All	Spouses do not inherit	Spouses inherit<50%	Spouses inherit>50%	All	Spouses do not inherit	Spouses inherit<50%	Spouses inherit>50%
All heirs included in treated and control groups								
First stage estimates								
$Time_{ji} \cdot Treat^g_{ji}$	0.1320***	0.1523***	0.1183***	0.1169***	0.0377***	0.0511***	0.0268***	0.0270***
	(0.0058)	(0.0072)	(0.0071)	(0.0097)	(0.0048)	(0.0051)	(0.0053)	(0.0054)
F-stat	4502.18	3724.96	3598.05	3254.24	6037.26	4521.16	3891.55	3742.69
Second stage estimates								
$ln(1-\tau_{ji})$	3.0124***	2.5030***	3.0467***	4.4064***	8.1085***	4.6712***	9.3273***	18.1816***
	(0.4533)	(0.5075)	(0.6571)	(0.9681)	(1.7862)	(1.1213)	(2.9477)	(4.8275)
	[2.124,3.901]	[1.508,3.498]	[1.759,4.335]	[2.509,6.304]	[4.607,11.609]	[2.473, 6.869]	[3.55,15.105]	[8.72,27.643]
Observations	27,905	23,897	23,828	21,858	45,312	32,483	28,568	25,939
Heirs inheriting the largest portion of the estate								
First stage estimates								
$Time_{ji} \cdot Treat^g_{ji}$	0.1859***	0.1913***	0.1674***	0.2171***	0.0896***	0.0926***	0.0764***	0.0979***
	(0.0062)	(0.0074)	(0.0077)	(0.0104)	(0.0054)	(0.0057)	(0.0061)	(0.0066)
F-stat	6346.95	5186.53	4929.66	4565.26	7969.89	6190.09	5202.99	5016.79
Second stage estimates								
$ln(1-\tau_{ji})$	1.9724***	1.6343***	1.8099***	2.2171***	2.4125***	2.1817***	2.4384***	2.6489***
	(0.2410)	(0.2984)	(0.3828)	(0.3485)	(0.3662)	(0.3821)	(0.5217)	(0.3795)
	[1.50,2.445]	[1.049, 2.219]	[1.06,2.56]	[1.534,2.9]	[1.695,3.13]	[1.433,2.931]	[1.416,3.461]	[1.905,3.393]
Observations	9,428	8,282	8,041	7,667	15,973	11,645	9,455	9,435

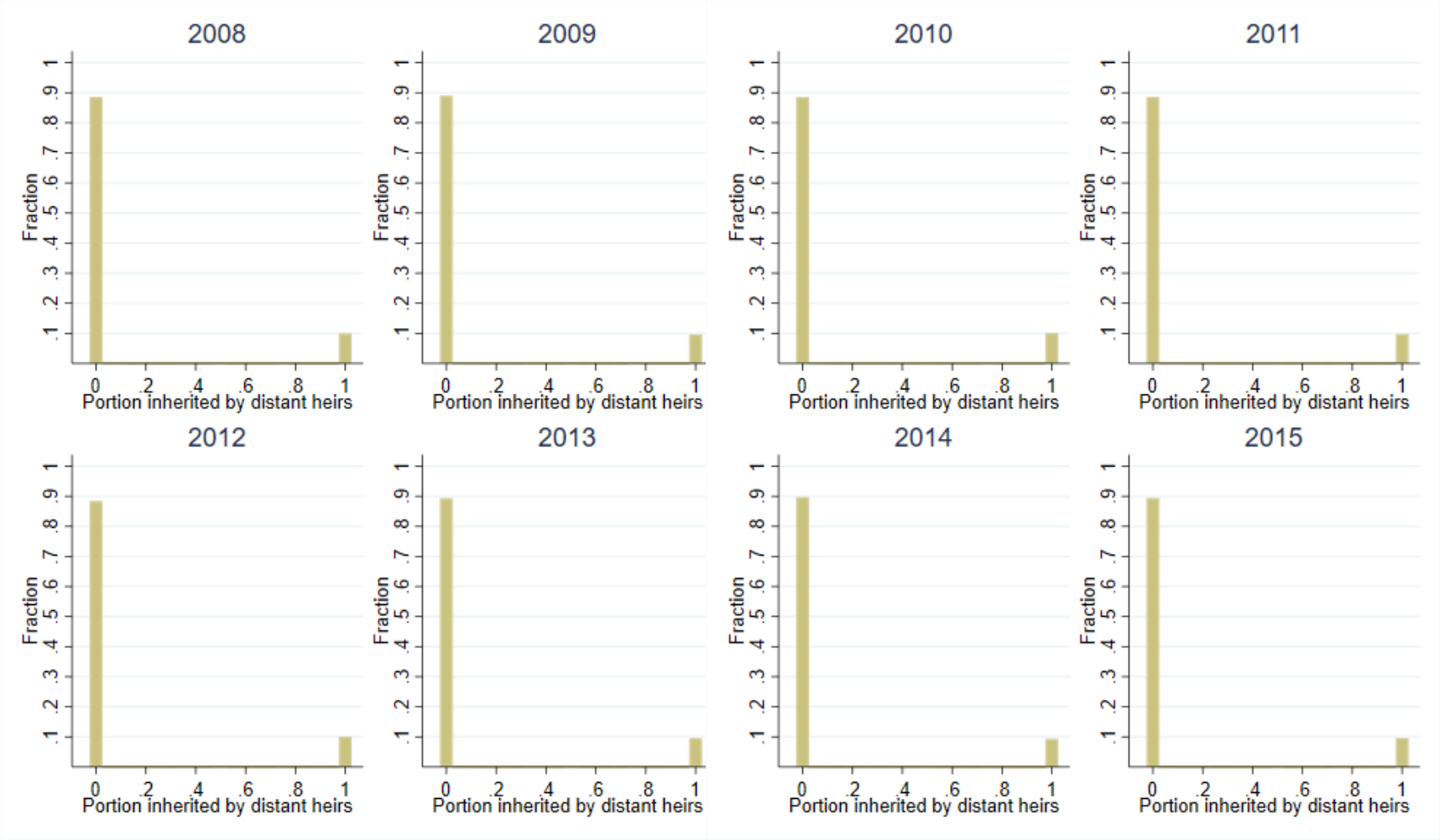
Notes: This table provides 2SLS estimates resulting from specifications 2.5 and 2.6 implemented at heirs' level. The dependent variable of the second stage is the log of reported inheritances. Standard errors are clustered by taxpayers who inherit from the same deceased. 95% confidence intervals in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table A2.4: Average DiD estimates for the period 2008-2013

$Dep.var_i$	Average DiD estimates Treated estates: Top 1%		Average DiD estimates Treated estates: p.95-99	
	Coefficient	Standard errors	Coefficient	Standard errors
log of overall reported estate	0.3956***	(0.0300)	0.1947***	(0.0170)
log of real estate	0.4650***	(0.0563)	0.2140***	(0.0266)
log of financial assets	0.2596***	(0.0952)	0.0495	(0.0570)
IHS of business assets	-0.2880	(0.3177)	0.1932	(0.1377)
IHS of unproductive assets	1.4719***	(0.2604)	0.7703***	(0.1412)
IHS of debts	-0.3573*	(0.1991)	-0.9952***	(0.1437)

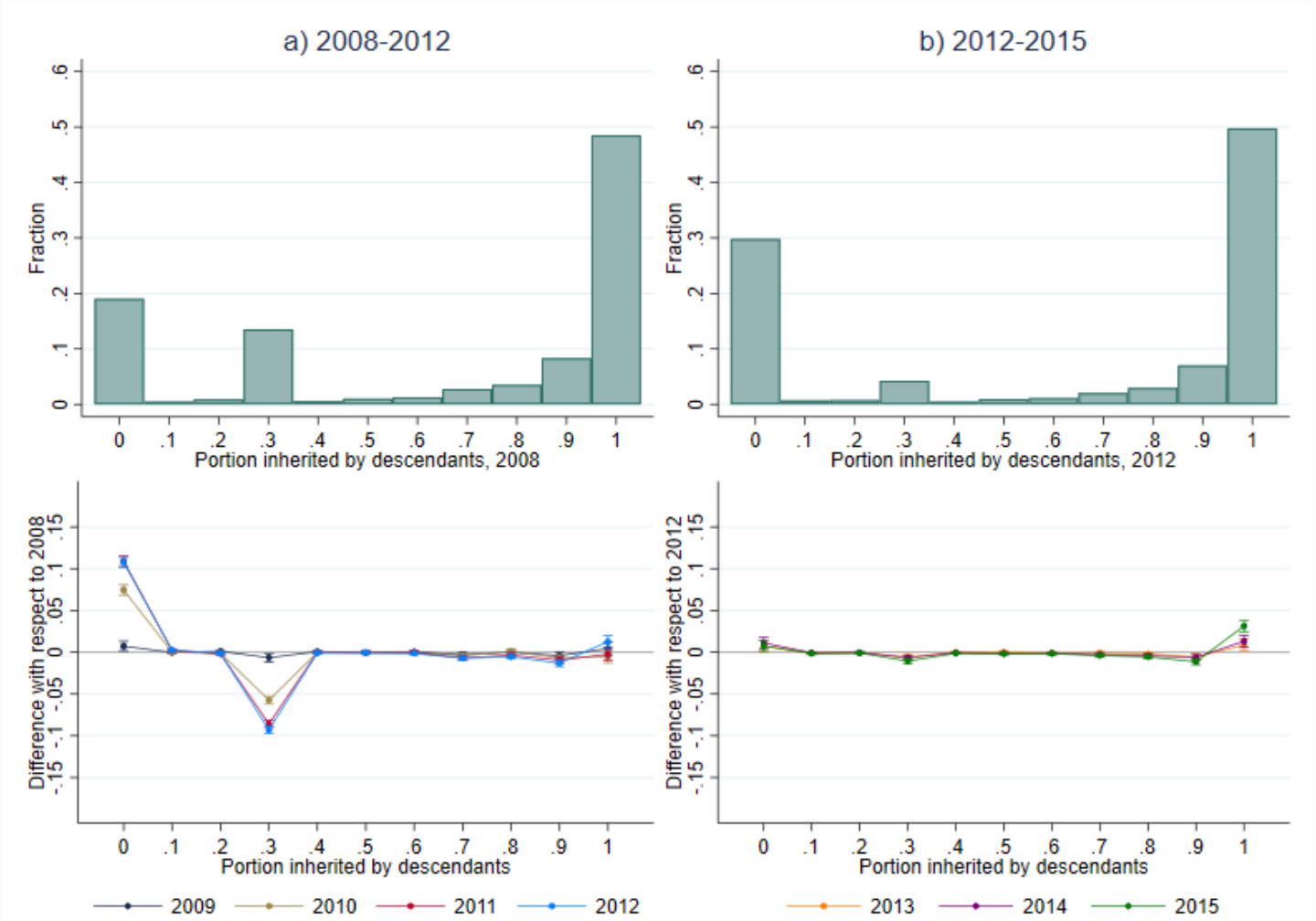
Notes: This table provides average DiD estimates for the period 2011-2013, relative to the pre-reform period 2008-2010. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Figure A2.1: Portion inherited by distant heirs and year



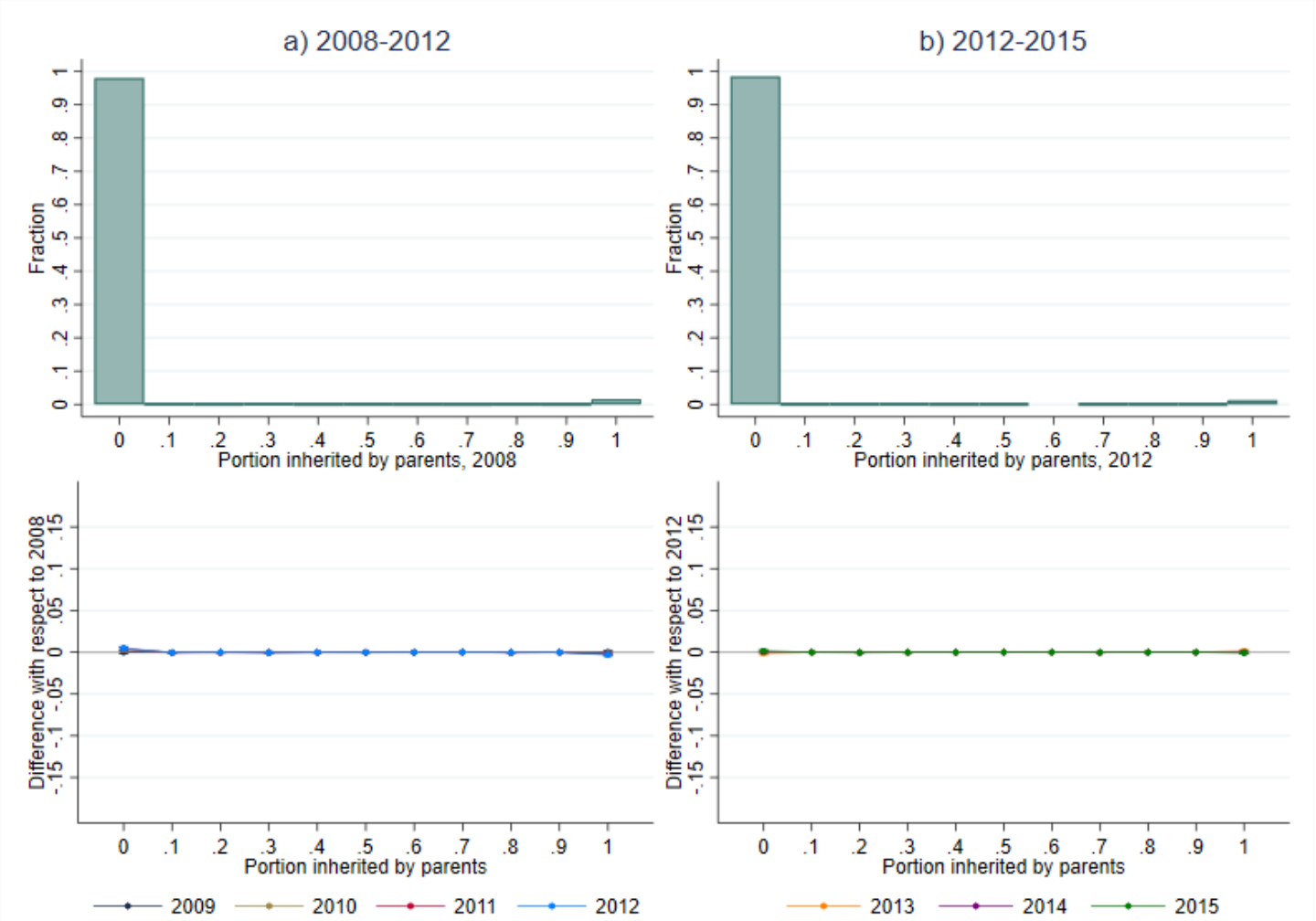
Notes: Each figure shows the yearly distribution of estates according to the overall portion inherited by distant heirs as a group (not individually). All positive estates are considered.

Figure A2.2: Portion inherited by descendants, 2008-2015



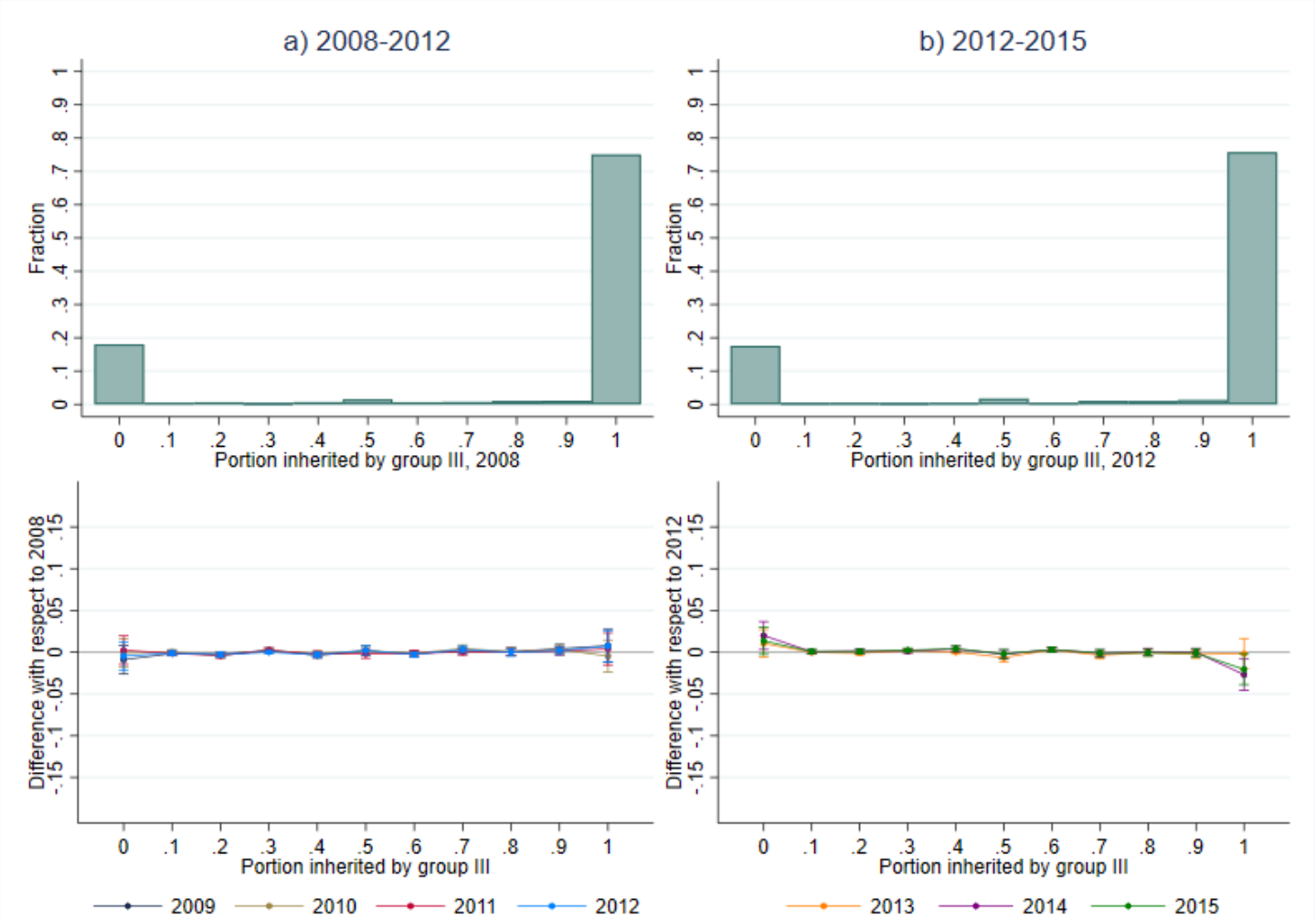
Notes: The top figures of panels (a) and (b) show the histogram of estates bequeathed to close heirs in 2008 and 2012, respectively, according to the portion inherited by descendants. The first bar of each panel includes only 0 values. Each of the other ten bars comprises an interval of 10 percentage points, being its x value the upper bound. The bottom figures of panels (a) and (b) plot the differences between the histograms of subsequent years and that presented in the top panel.

Figure A2.3: Portion inherited by parents, 2008-2015



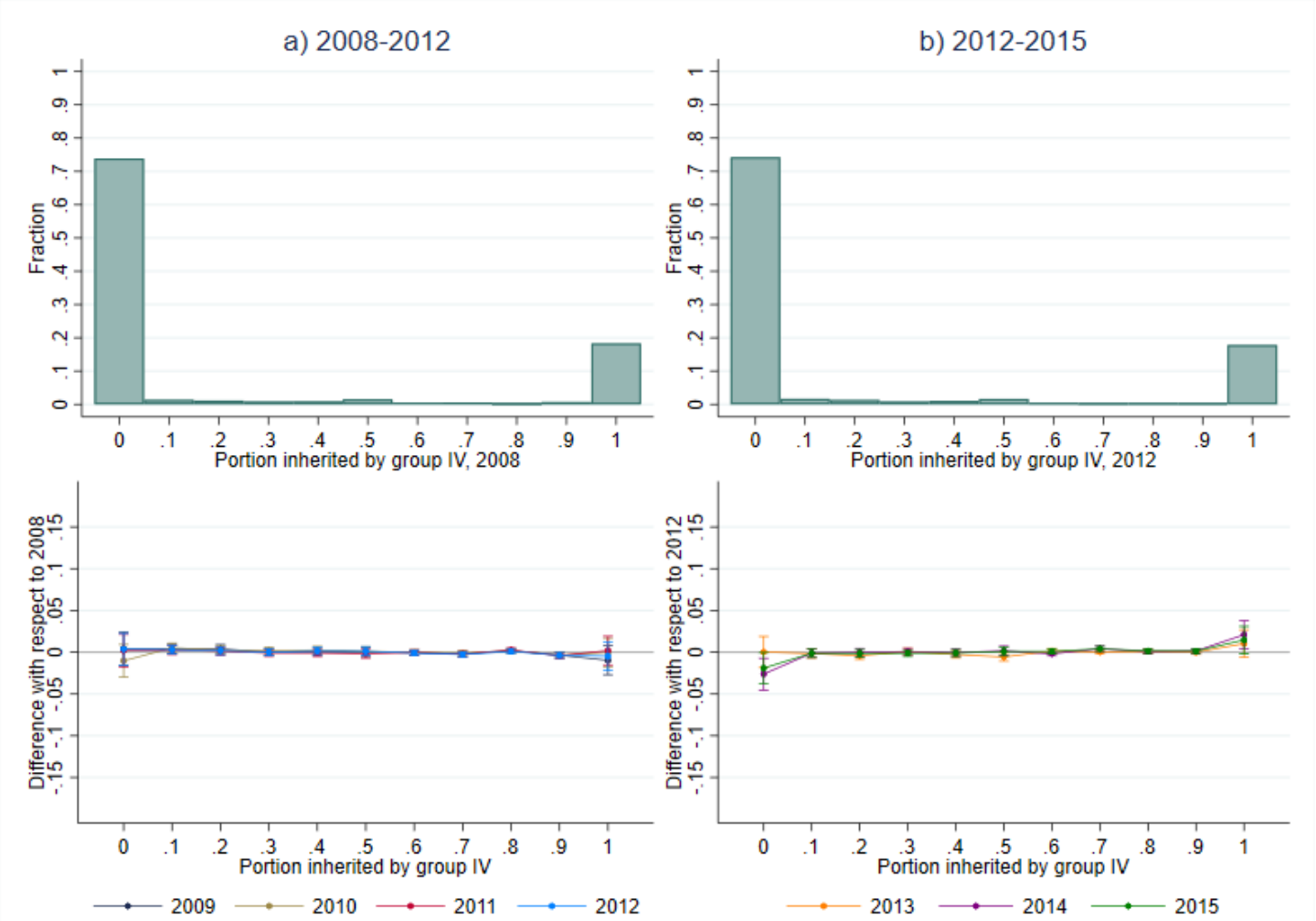
Notes: The top figures of panels (a) and (b) show the histogram of estates bequeathed to close heirs in 2008 and 2012, respectively, according to the portion inherited by parents. The first bar of each panel includes only 0 values. Each of the other ten bars comprises an interval of 10 percentage points, being its x value the upper bound. The bottom figures of panels (a) and (b) plot the differences between the histograms of subsequent years and that presented in the top panel.

Figure A2.4: Portion inherited by group III, 2008-2015



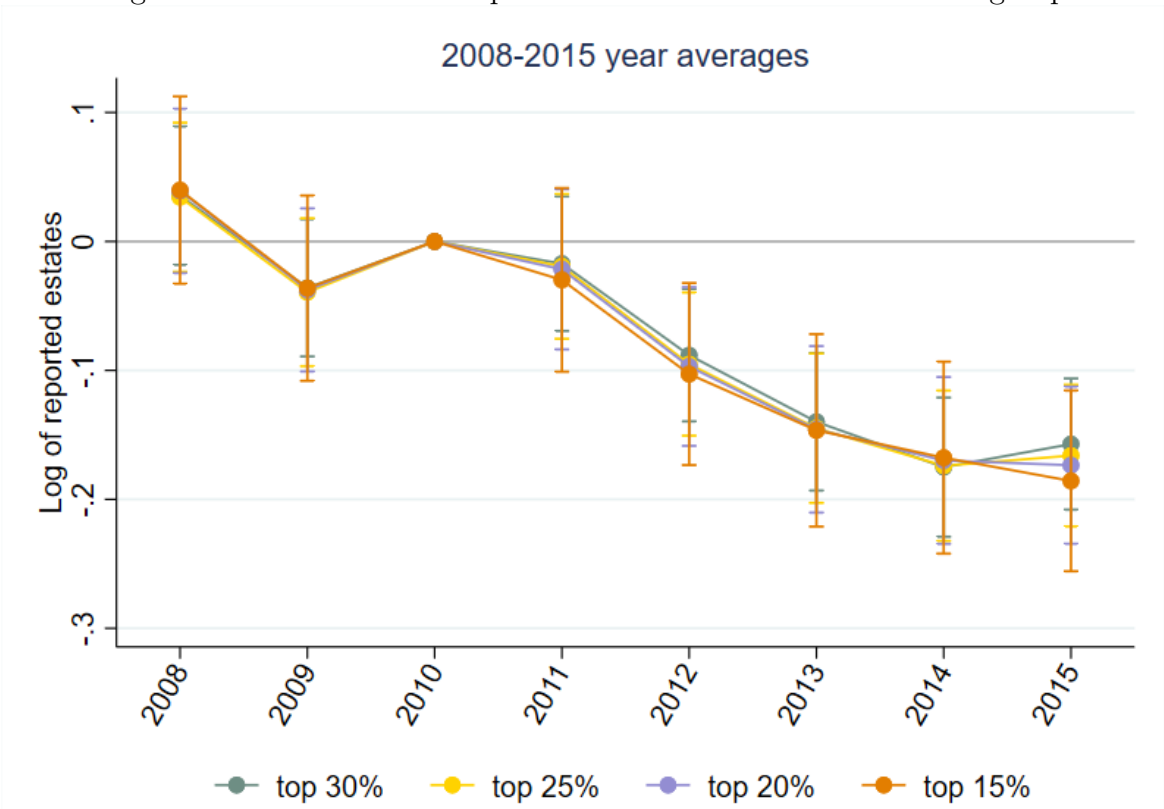
Notes: The top figures of panels (a) and (b) show the histogram of estates bequeathed to distant heirs in 2008 and 2012, respectively, according to the portion inherited by heirs in group III. The first bar of each panel includes only 0 values. Each of the other ten bars comprises an interval of 10 percentage points, being its x value the upper bound. The bottom figures of panels (a) and (b) plot the differences between the histograms of subsequent years and that presented in the top panel.

Figure A2.5: Portion inherited by group IV, 2008-2015



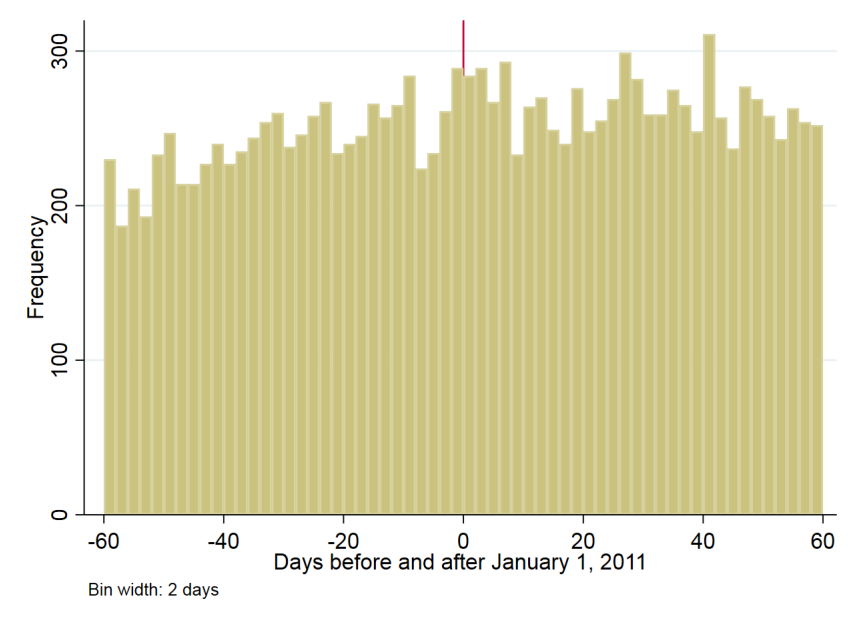
Notes: The top figures of panels (a) and (b) show the histogram of estates bequeathed to distant heirs in 2008 and 2012, respectively, according to the portion inherited by heirs in group IV. The first bar of each panel includes only 0 values. Each of the other ten bars comprises an interval of 10 percentage points, being its x value the upper bound. The bottom figures of panels (a) and (b) plot the differences between the histograms of subsequent years and that presented in the top panel.

Figure A2.6: Evolution of reported estates in alternative control groups



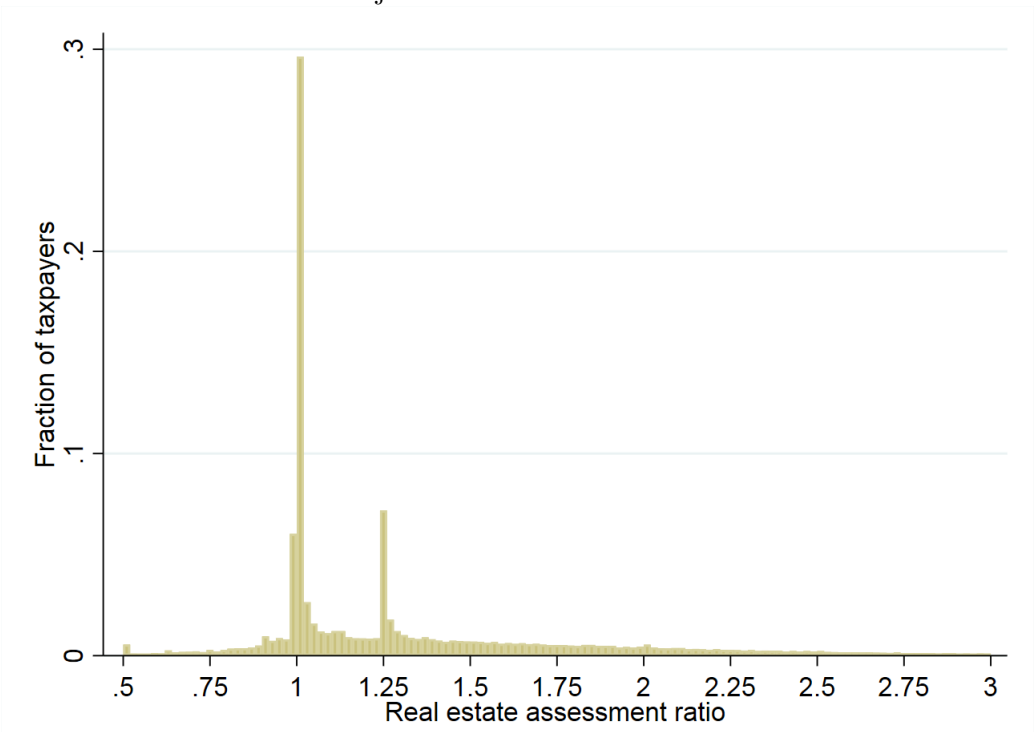
Notes: This figure shows the evolution of the log of reported estates, relative to 2010, for different control group definitions. It considers estates inherited by distant heirs placed in the top 30%, 25%, 20% or 15% of the estates' distribution.

Figure A2.7: Histogram of deceases reported to the tax authority



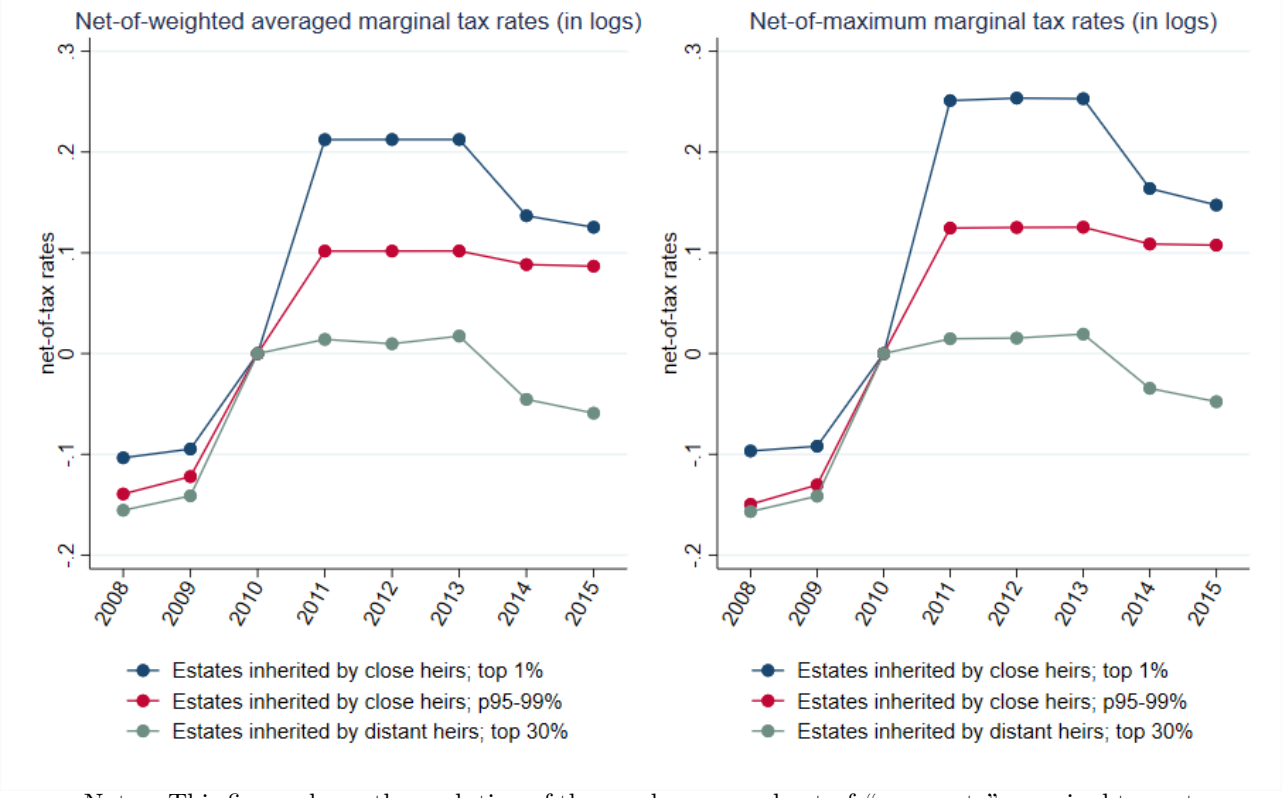
Notes: This figure shows the histogram of deceases reported to the tax authority before and after January 1, 2011.

Figure A2.8: Histogram of real estate assessment over its adjusted administrative value



Notes: This figure shows the histogram of the taxpayer average of the real estate assessment ratios resulting from the properties inherited. Section 2.5.1 describes how this variable is constructed. All taxpayers inheriting between 2008 and 2015 who are related to an assessment ratio are considered.

Figure A2.9: Net-of-"aggregate" marginal tax rates

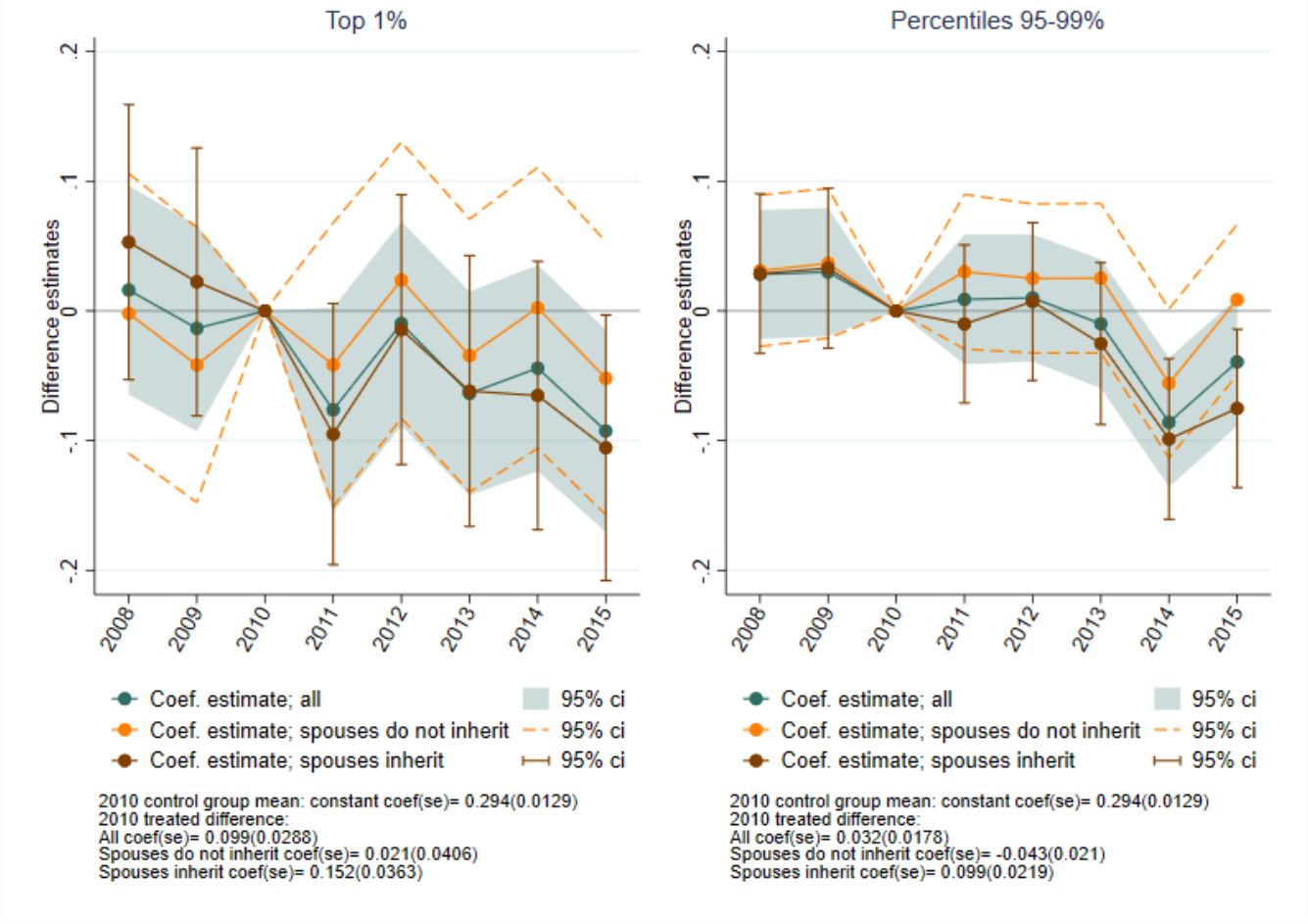


Notes: This figure shows the evolution of the yearly averaged net-of-"aggregate" marginal tax rates (in logs) for treated and control groups, relative to 2010. Two different measures are used as the "aggregate" marginal tax rates: the panel on the left uses τ_i^A, which is a weighted average of heirs' marginal tax rates according to their contribution to the aggregate tax base. The right-panel uses τ_i^M, which reflects the higher marginal tax rate at which an estate is (partially) taxed. Section 2.5.1 provides a more detailed definition of these measures.

Figure A2.10: Net-of-marginal tax rates

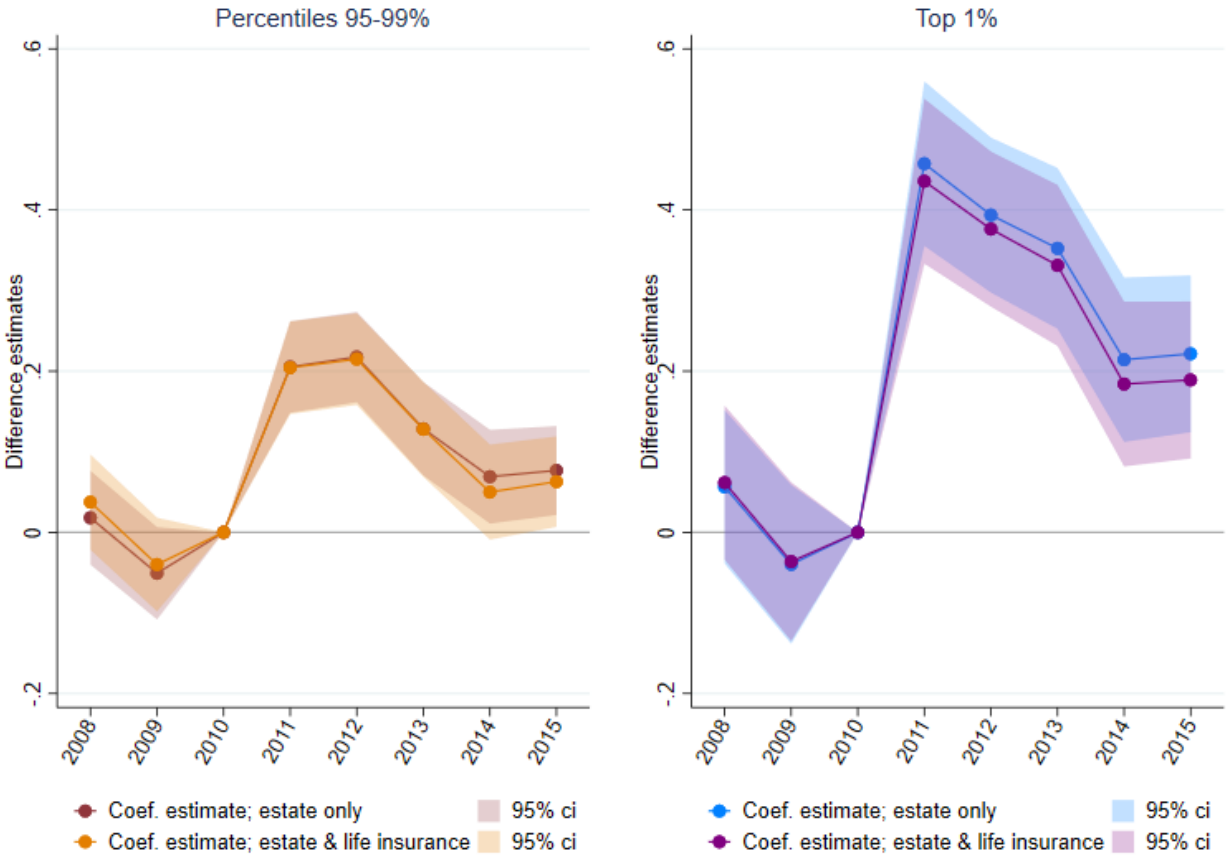
Notes: This figure shows the evolution of the yearly averaged net-of-marginal tax rates (in logs) for treated and control groups, relative to 2010. The left-panel considers all heirs included in the treated and control groups. The right-panel only considers those heirs inheriting the largest portion of the estate.

Figure A2.11: Probability of reporting life insurance benefits



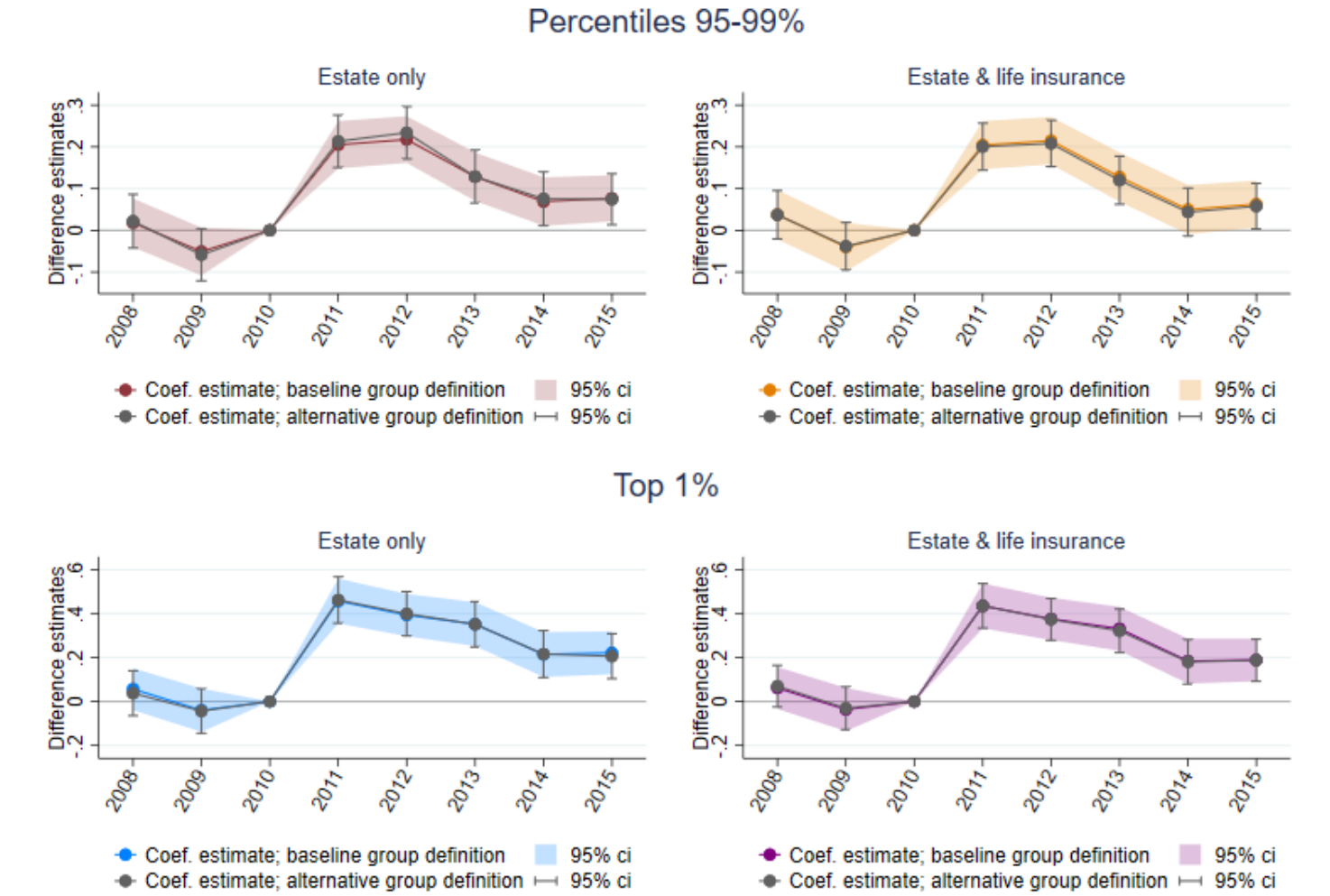
Notes: Both panels provide β^y coefficient estimates and 95% confidence intervals resulting from implementing specification 2.3 for different treated groups. The dependent variable employed is a dummy which equals 1 if at least one heir reports life insurance benefits and 0 otherwise. The number of observations of each type of estate in the percentiles 95-99 (top 1%) is: 11,913 (2,975) for all estates, 6,112 (1,436) for estates in which spouses do not inherit and 5,801 (1,539) for estates in which spouses inherit.

Figure A2.12: Comparison of the baseline estimates with those obtained when life insurance benefits are included in the dependent variable



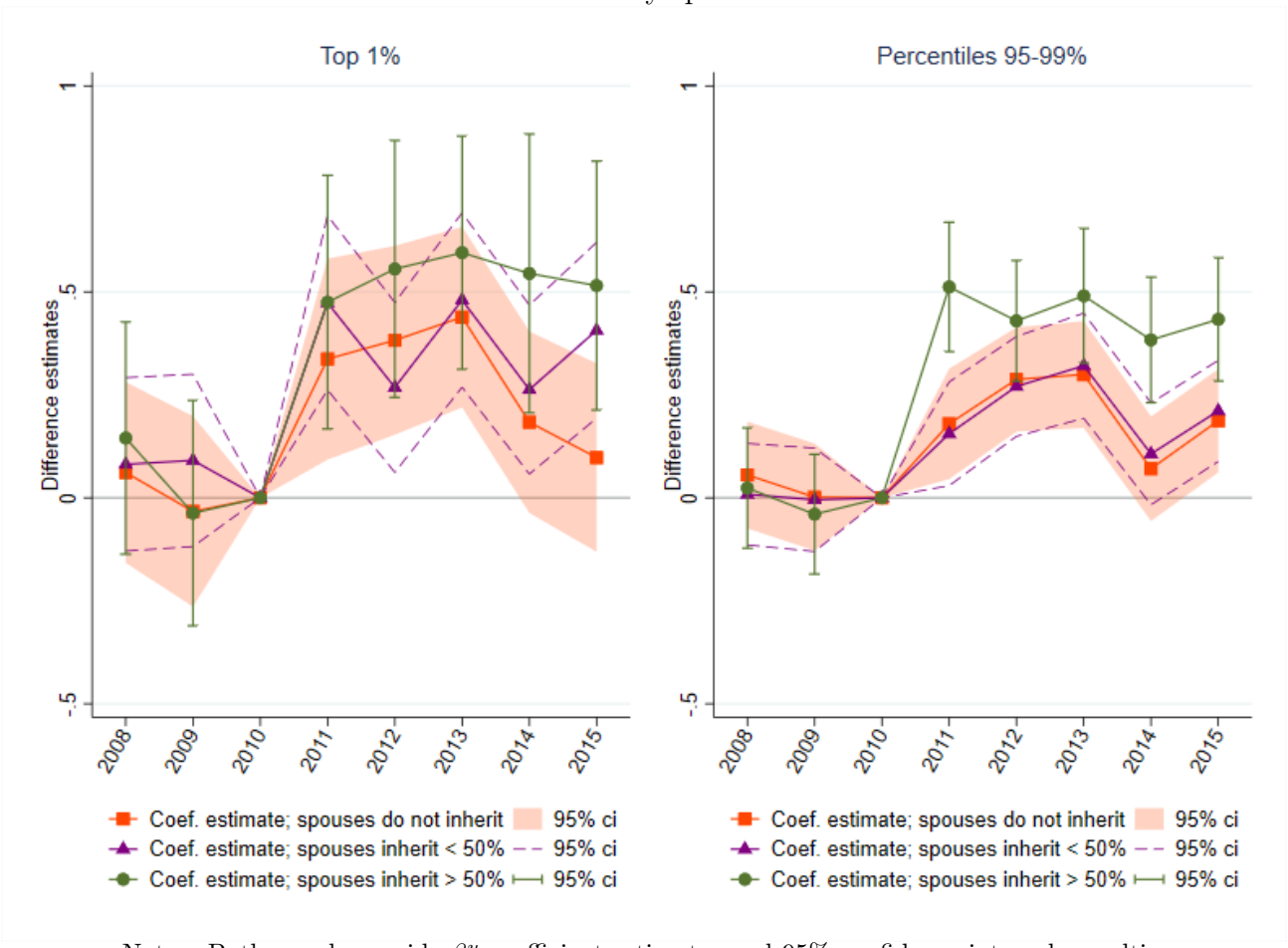
Notes: The panel in the left (right) provides β^y coefficient estimates and 95% confidence intervals resulting from implementing specification 2.3 for the treated group in the percentiles 95-99 (top 1%) of the distribution. Both panels compare the baseline coefficient estimates presented in Figure 2.6 with those obtained when using the log of the aggregate tax base (i.e. estate + life insurance benefits) as the dependent variable.

Figure A2.13: Comparison of the coefficient estimates obtained with the baseline vs. an alternative treatment definition



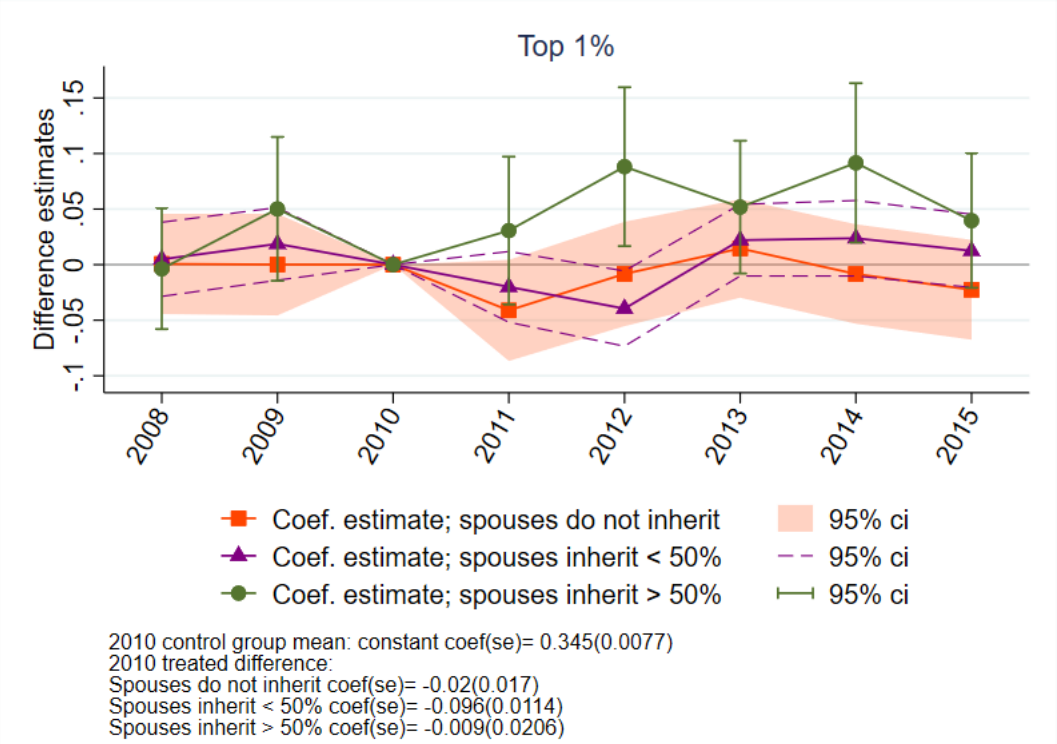
Notes: Each panel provides β^y coefficient estimates and 95% confidence intervals resulting from implementing specification 2.3 for two alternative definitions of treated and control groups. The baseline group definition is based on estates' distribution. The alternative group definition is based on the distribution of aggregate tax bases.

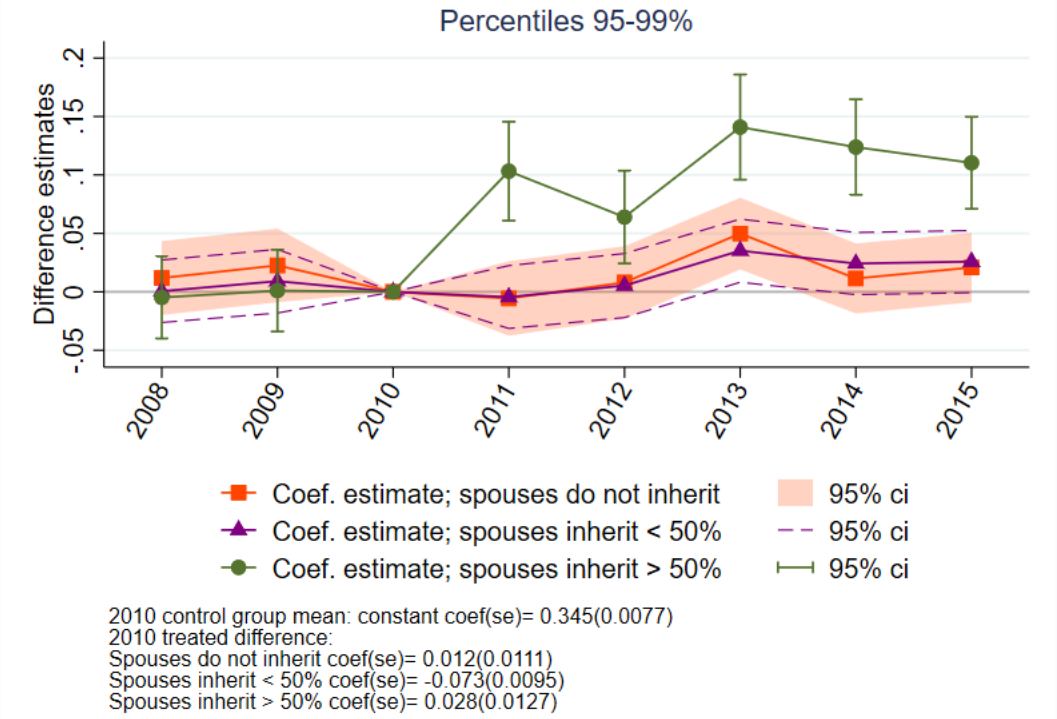
Figure A2.14: Effect of the 2011 tax cut on reported individual portions; distinction between estates inherited by spouses and estates which are not



Notes: Both panels provide β^y coefficient estimates and 95% confidence intervals resulting from implementing specification 2.3 at heirs' level for different treated groups. The dependent variable employed is the log of the individual portion inherited by each heir. The number of observations of each treated group in the percentiles 95-99 (top 1%) is: 16,266 (4,367) for estates in which spouses do not inherit, 9,929 (3,860) for estates in which spouses inherit less than 50% and 6,765 (1,413) for estates in which spouses inherit more than 50%.

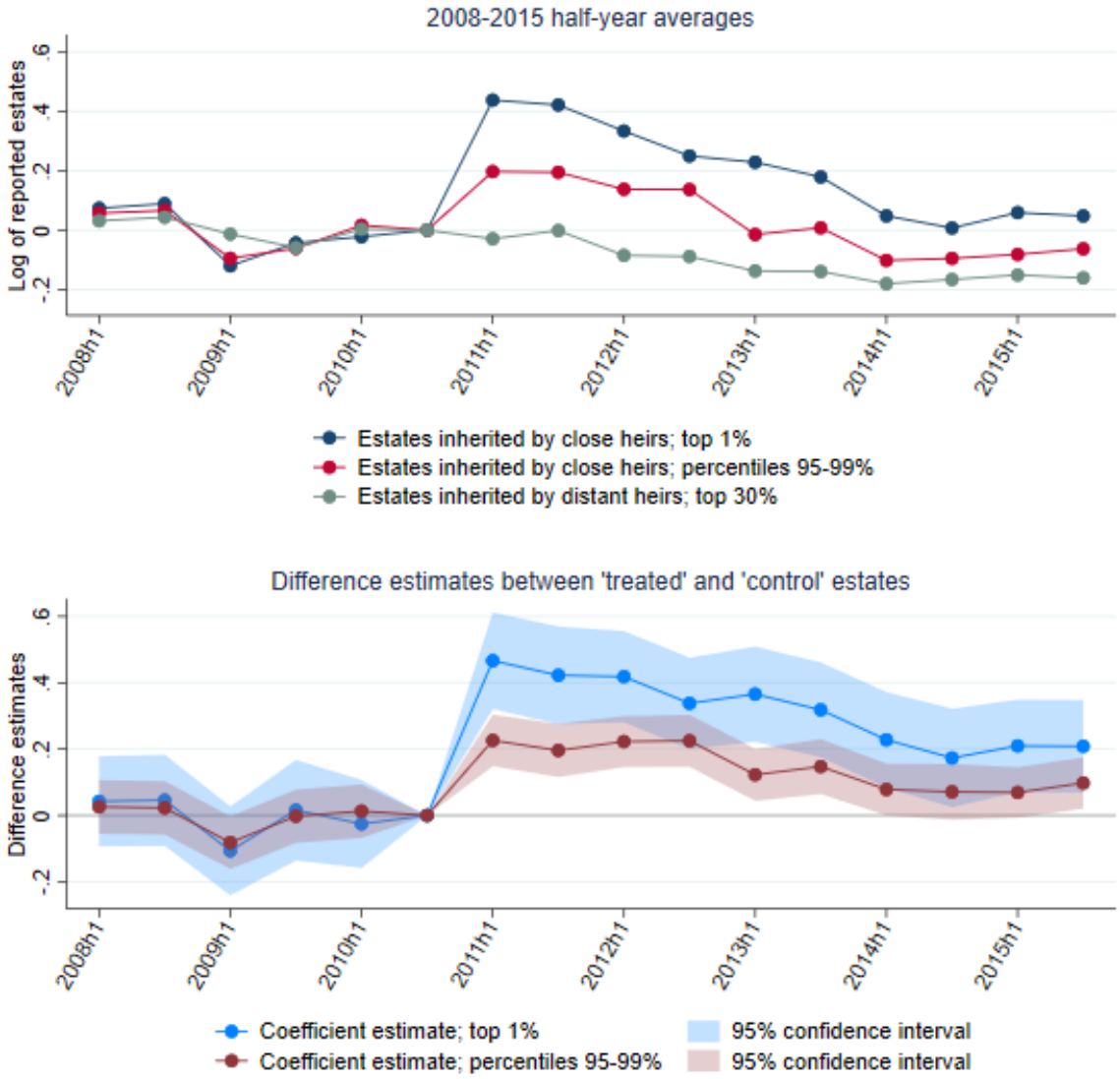
Figure A2.15: Effect of the 2011 tax cut on the share inherited by each heir; distinction between estates inherited by spouses and estates which are not





Notes: Both panels provide β^y coefficient estimates and 95% confidence intervals resulting from implementing specification 2.3 at heirs' level for different treated groups. The dependent variable employed is the estate share inherited by each heir. The number of observations of each treated group in the percentiles 95-99 (top 1%) is: 16,266 (4,367) for estates in which spouses do not inherit, 9,929 (3,860) for estates in which spouses inherit less than 50% and 6,765 (1,413) for estates in which spouses inherit more than 50%.

Figure A2.16: Effect of 2011 tax cut on reported estates; half-year estimates

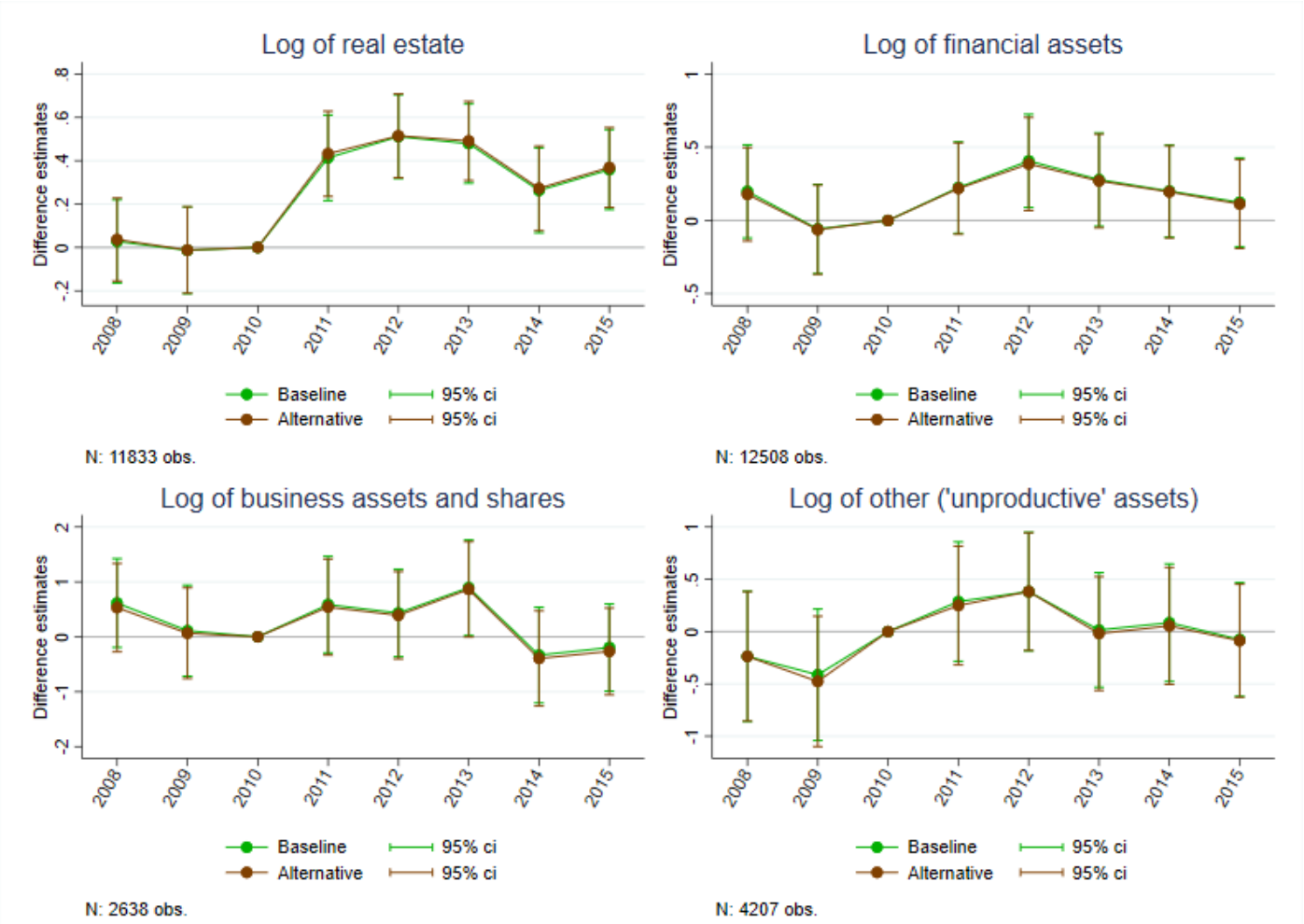


Notes: The figure in the top panel shows the evolution of the half-year average of the (log of) reported estates, relative to the second half of 2010, for treated and control groups. The figure in the bottom panel provides β^y coefficient estimates and 95% confidence intervals resulting from implementing specification 2.3 with half-year dummies for both treated groups and using the log of reported estates as the dependent variable. The number of observations for each group is: 9,879 for the control group and 11,913 (2,975) for the treated group in percentiles 95-99 (top 1%).

Figure A2.17: Effect of 2011 tax cut on reported estates vs. "initial" estates

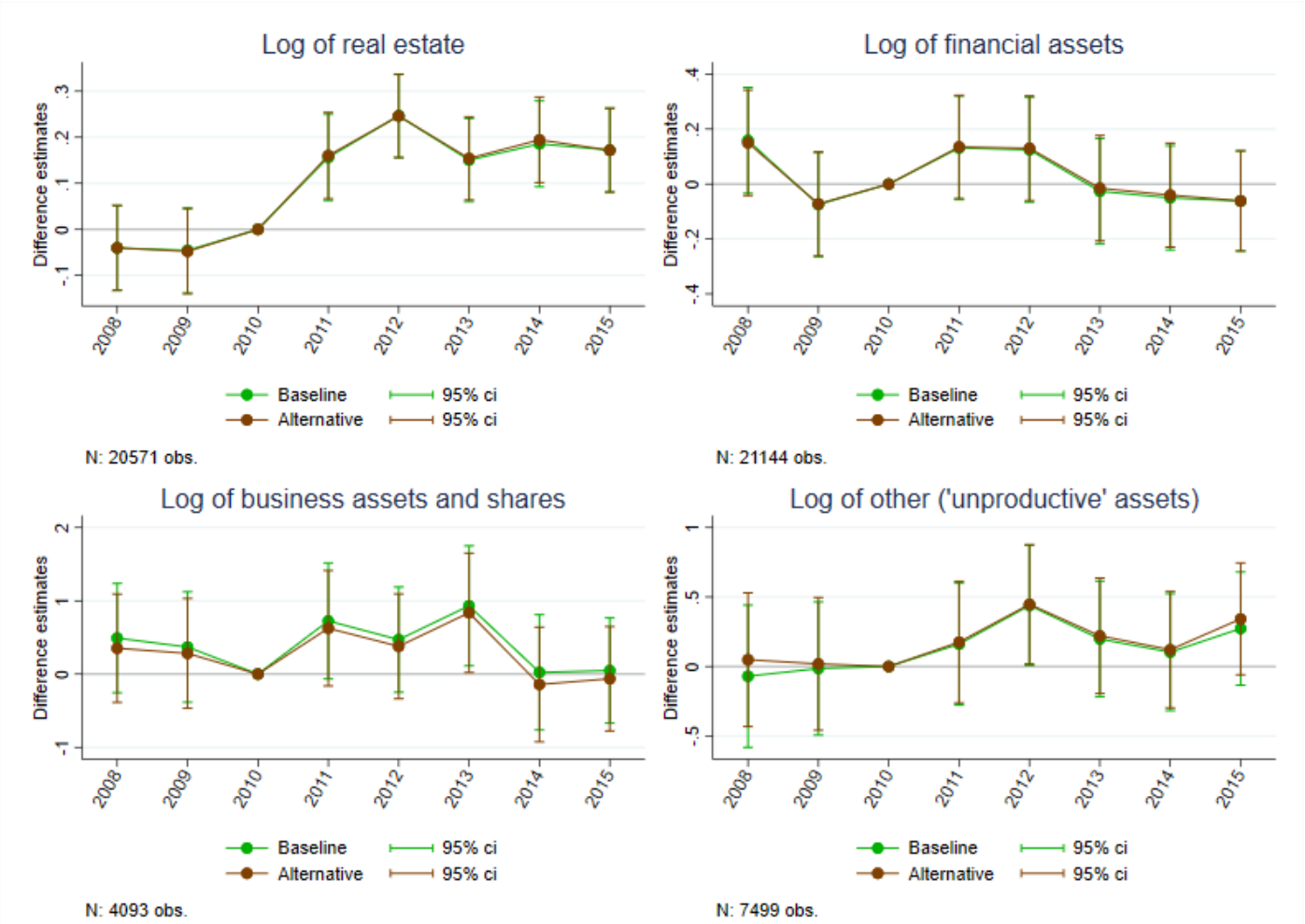
Notes: Both panels compare the baseline coefficient estimates presented in Figure 2.6 with those obtained when using the log of the initial estate (i.e. excluding the "added assets") as the dependent variable.

Figure A2.18: Comparison of the coefficient estimates obtained with the baseline vs. an alternative measure of reported assets; Top 1%



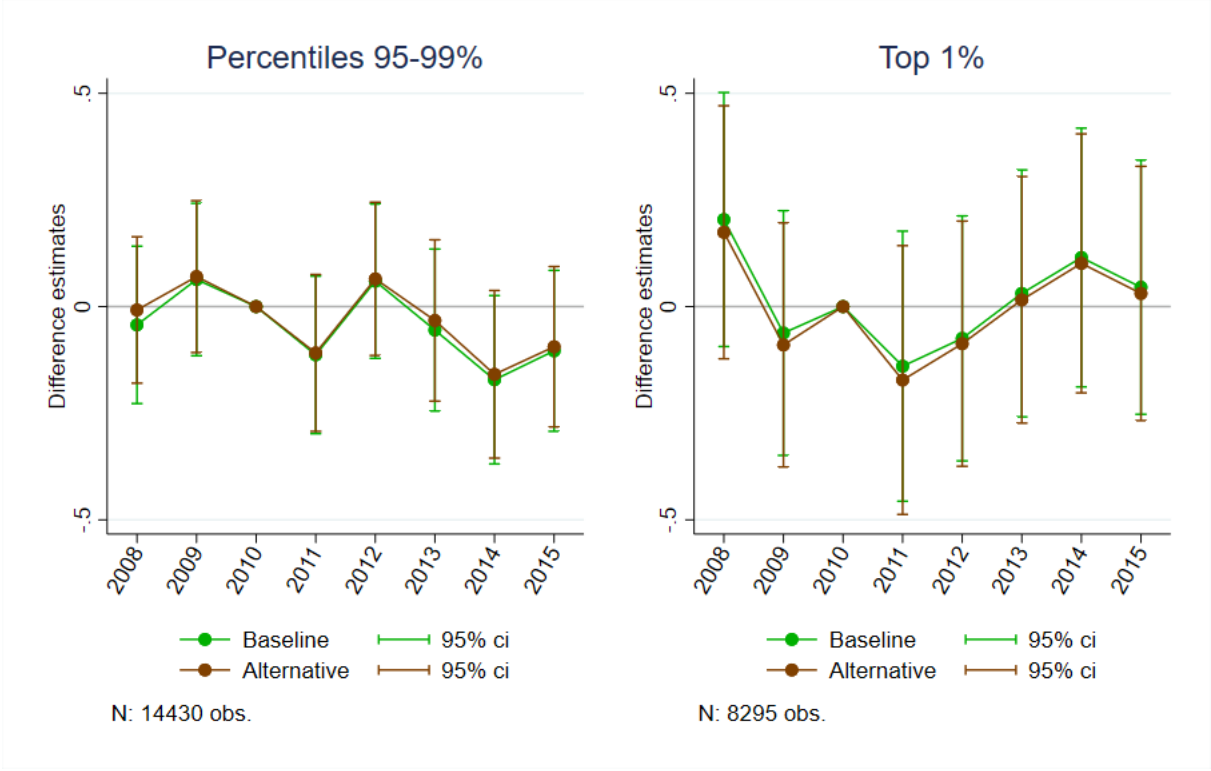
Notes: Each panel provides β^y coefficient estimates and 95% confidence intervals resulting from implementing specification 2.3 with the top 1% treated group. Two different measures of reported assets are used as the dependent variable: the log of Z_i^1 (baseline) and the log of Z_i^2 (alternative). Section 2.5.1 defines how these measures are constructed. Z = {real estate, financial assets, unlisted companies holdings and business assets, "unproductive" assets}.

Figure A2.19: Comparison of the coefficient estimates obtained with the baseline vs. an alternative measure of reported assets; Percentiles 95-99%



Notes: Each panel provides β^y coefficient estimates and 95% confidence intervals resulting from implementing specification 2.3 with the treated group placed at the percentiles 95-99. Two different measures of reported assets are used as the dependent variable: the log of Z_i^1 (baseline) and the log of Z_i^2 (alternative). Section 2.5.1 defines how these measures are constructed. $Z = \{$real estate, financial assets, unlisted companies holdings and business assets, "unproductive" assets$\}$.

Figure A2.20: Comparison of the coefficient estimates obtained with the baseline vs. an alternative measure of debts and deductible expenses



Notes: The left (right) panel provides β^y coefficient estimates and 95% confidence intervals resulting from implementing specification 2.3 with the treated group placed at the percentiles 95-99 (top 1%). Two different measures of reported debts are used as the dependent variable: the log of Z_i^1 (baseline) and the log of Z_i^2 (alternative). Section 2.5.1 defines how these measures are constructed. $Z = \{\text{debts and deductible expenses}\}$.

Chapter 3

Avoidance Responses to the Wealth Tax

3.1 Introduction

In the mid-eighties, about half the OECD countries imposed an annual net wealth tax, but today it is maintained solely by Spain, Norway and Switzerland (OECD, 2018). However, rising wealth inequality[1] has revived the debate about the desirability of wealth taxes, not only in academic but also in political and public circles.[2] To date, though, the empirical evidence about the behavioural responses associated with wealth taxation, which might help analysts form a well-grounded position on the need to implement such a tax and on its appropriate design, is still limited (Seim, 2017; Brülhart et al., 2017, 2019; Zoutman, 2018; Londoño-Vélez and Ávila-Mahecha, 2019; Jakobsen et al., 2019).

The aim of this paper[3], therefore, is to contribute to this nascent literature by studying how taxpayers reacted to the reintroduction of the Spanish Net Wealth Tax in 2011. We examine taxpayers' responses in terms not only of

[1]Following Piketty (2014), several studies have attempted to estimate the evolution of wealth concentration. Zucman (2019) provides a review.

[2]Clear evidence of this is the recent wealth tax proposal made by a US senator, Elizabeth Warren: `https://www.warren.senate.gov/newsroom/press-releases/senator-warren-unveils-proposal-to-tax-wealth-of-ultra-rich-americans`.

Evidence from the opposite camp comes from France, where the abolition of the net wealth tax in January 2018 led to social unrest, its reinstatement being one of the key demands of yellow vest protesters. See, for instance `https://www.wsj.com/articles/france-could-keep-wealth-tax-in-bid-to-placate-yellow-vests-1544025588`; `http://lavdn.lavoixdunord.fr/518614/article/2019-01-09/le-ps-lance-une-plateforme-numerique-pour-pousser-son-retablissement` or `http://piketty.blog.lemonde.fr/2018/12/11/yellow-vests-and-tax-justice/`.

[3]This paper is co-authored with José María Durán-Cabré and Alejandro Esteller-Moré.

wealth accumulation, but also of the potential avoidance strategies adopted. Spain provides a good setting in which to study the wealth tax given that it is one of the few countries that continues to impose it. Moreover, behavioural responses to wealth taxes in the country have not been previously examined.[4]

In Spain, wealth taxation has been transferred to sub-central governments, who have the legislative power to determine certain aspects of its structure. This is particularly relevant when we consider the reintroduction of the tax and its implementation. For this reason, in this study we have opted to focus on one of these sub-central governments (also for questions of data availability), that of Catalonia, which is in fact the region that collects the highest share of Spain's overall wealth tax revenues (about 52% in 2011[5] and 46% in 2015[6]).

Using a panel of tax return micro-data from the universe of Catalan wealth taxpayers between 2011 and 2015, we analyse whether the wealth tax affects wealth accumulation and taxable wealth. Additionally, we identify potential avoidance strategies attributable to the design of the wealth tax, related primarily to exemptions and the existence of a limit on tax liability. Specifically, we examine whether taxpayers reorganize their wealth composition and change the realization of income to benefit from them. Moreover, we also look at the effect of the wealth tax on (reported) gifts. Finally, we seek to verify whether there is a positive relation between wealth tax rates and the probability of a taxpayer not filing wealth tax returns in subsequent years.

As there are no data for the period when the wealth tax was not being imposed, we take advantage of the unexpected reintroduction of the tax by the Catalan Government at the end of 2011. This serves as our control year. We use the variation in treatment exposure, measured through the average tax rates for 2011, to identify the effects of the wealth tax. This variation, driven mainly by different ratios of taxable wealth over total reported wealth and different shares of realized long-term capital gains over taxable income, occurs not only across different levels of wealth, but also within similar levels. Hence, we control non-parametrically for taxpayers' 2011 wealth, income, asset portfolio, age and other relevant characteristics.

[4]There exist other studies analysing the Spanish wealth tax (e.g. Alvaredo and Saez, 2009; Durán-Cabré and Esteller-Moré, 2010) but they focus mainly on the evolution of wealth concentration. Alvaredo and Saez (2009) also assess, at an aggregate level, the effects of the introduction of business exemption.

[5]`https://www.agenciatributaria.es/AEAT/Contenidos_Comunes/La_Agencia_Tributaria/Estadisticas/Publicaciones/sites/patrimonio/2011/jrubikf3a8b3676ae1f33ed00f20cdccba2a93cbf97232f.html`

[6]`https://www.agenciatributaria.es/AEAT/Contenidos_Comunes/La_Agencia_Tributaria/Estadisticas/Publicaciones/sites/patrimonio/2015/jrubik53b6039ed4d69b32b967df1627a59aab8da95302.html`

When focusing on a balanced panel of the top 50% richest taxpayers, our results show that the taxpayers' response to the reintroduction of the wealth tax was significant. This translates into an elasticity of taxable wealth with respect to the net-of-tax rate of return of 0.64, or, put differently, a 0.1 percentage point increase in the average wealth tax rate leads to a reduction in taxable wealth of 3.24% over 4 years. This effect reflects avoidance rather than real responses. Indeed, while facing higher wealth taxes does not have a negative effect on savings, it does encourage taxpayers to change their asset and income composition to take advantage of wealth tax exemptions (mostly business-related) and the limit on wealth tax liability. The intensity of the responses varies depending on the initial importance of taxpayers' business shares, favouring the use of business exemptions over the limit on tax liability if initial business shares are high, and vice versa. Overall, these avoidance responses are high in terms of revenues and increasing over time: in 2015 they account for 74.5% of 2011 estimated wealth tax revenues. Put differently, the 4-year accumulated revenue loss amounts to 2.6 times the 2011 estimated wealth tax revenues.

As such, this paper provides new empirical evidence to the nascent literature studying behavioural responses to wealth taxation. According to the specific methodology applied, the existing literature can be divided into two main groups: one employs bunching strategies (Seim, 2017; Londoño-Vélez and Ávila-Mahecha, 2019) while the other undertakes difference-in-differences and cross-sectional analyses (Brülhart et al., 2017, 2019; Zoutman, 2018; Jakobsen et al., 2019).[7] The former report much smaller taxable wealth responses to wealth taxes than the latter, primarily reflecting tax evasion.[8] The mechanisms driving such large responses in the latter studies are unclear.

Seim (2017) uses Swedish administrative data and exploits the variation across wealth tax brackets, while Brülhart et al. (2019) use both aggregate data at Swiss Cantons level and individual tax records for specific Cantons and exploit the inter-cantonal time variation in wealth tax rates. Jakobsen et al. (2019) employ Danish administrative data and consider two different sources of variation: first, changes in the exemption threshold for couples and, second, changes in marginal tax rates for taxpayers unbound by a tax ceiling. Zoutman (2018) uses a Dutch capital-income and wealth tax reform that created variation in the rate-of-return after taxation at each level of income and

[7]Note, however, that Brülhart et al. (2017, 2019) and Jakobsen et al. (2019) complement their main findings with bunching evidence.

[8]The specific magnitudes as reported in individual studies are detailed below in the Results section.

wealth and, finally, Londoño-Vélez and Ávila-Mahecha (2019) draw on Colombian administrative data and exploit the time variation derived from several wealth tax reforms and discontinuities in the wealth tax schedule.

The main contribution of our paper - which by methodology belongs to the second group of studies identified above - is that it provides both an assessment of the effect of wealth taxes on taxable wealth and an analysis of other types of response, focused above all on tax avoidance strategies, which allows us to provide evidence of the mechanisms driving the results. Thus, the paper also contributes to the literature on capital taxation and portfolio choice.[9] While most earlier studies have sought to analyse the effect of personal income taxes on investment in financial assets[10], this paper provides evidence on asset portfolio responses to wealth taxation, not only in terms of financial assets, but also that of housing and businesses. On the one hand, higher tax rates lead taxpayers to increase the importance of their exempt assets - in the main their company holdings - although we also find a statistically significant (albeit small) effect on their main dwelling exemption. This finding is in accordance with the empirically documented use of closely-held businesses as tax shelters (Alstadsæter, Kopczuk and Telle, 2014). On the other hand, higher tax rates lead taxpayers to increase the importance they attach to listed equity and investment funds, which enables them to exploit the tax liability limit.

Likewise, in relation to the application of this limit, our paper documents that facing higher tax rates results in taxpayers reducing their taxable income and increasing the importance of their long-term capital gains within realized income. In this regard, our study contributes to the extant literature on the responses of taxable income to personal income taxes (see Saez, Slemrod and Giertz (2012) for a general review and Neisser (2018) for an empirical review) and to the literature studying the effect of taxes on capital gains realizations[11]. Finally, we provide evidence of gift responses to wealth taxes, which in turn can be related to the literature studying the effect of gifts and estate taxation

[9] See Schalck (2017), Bergstresser and Pontiff (2013), Desai and Dharmapala (2011), Alan et al. (2010), Poterba and Samwick (2002). For a review of the earlier literature, see Poterba (2002).

[10] One exception is Bergstresser and Pontiff (2013), who also consider corporate income taxation.

[11] Some recent empirical studies include Jacob (2018, 2016, 2013), Díaz-Caro and Crespo-Cebada (2016) and Daunfeldt, Praski-Ståhlgren and Rudholm (2010). In general, they study the effect of capital gains taxation on their realization (also known as the lock-in effect) with the exception of Jacob (2016), who studies the effect of labour income taxes on capital gains realizations. For a broad review of capital gains responses to taxes, see Hanlon and Heitzman (2010). With a particular focus on the wealthiest individuals, Auerbach, Burman and Siegel (2000) show that it is in fact the high-income, high-wealth and more sophisticated taxpayers that are most likely to avoid capital gains taxation.

on inter-vivos transfers (see Kopczuk, 2017, for a review)[12]. Unlike the former responses, the increase in - reported - gifts does not persist over time, only being documented during the first two years after the reintroduction of the tax.

The main conclusion we draw from this study is that the Spanish wealth tax did not reduce wealth accumulation, and that the taxpayers most affected by the reintroduction of the tax managed to reduce their tax liability significantly by employing avoidance strategies. In addition, we find a positive relation between the 2011 wealth tax rates and subsequent non-tax filing. Thus, in broad terms, this paper contributes to the literature on capital and estate taxation (see Kopczuk, 2017, for a review) and to that on tax avoidance and evasion (Slemrod and Yitzhaki, 2002; Slemrod, 2018).

The rest of the paper proceeds as follows. Section 3.2 describes the specific characteristics of the Spanish wealth tax and the circumstances surrounding its reintroduction in 2011. Section 3.3 presents the data and descriptive statistics. Section 3.4 outlines the methodology employed. Section 3.5 shows the estimation results; and Section 3.6 concludes.

3.2 Spanish wealth tax: Evolution and characteristics

The Spanish wealth tax was first introduced in 1977 as an extraordinary and temporary measure, but after more than fifteen years the temporary nature of the tax was revoked by Act 19/1991. Until that moment, the wealth tax had mainly been used as an instrument for census and control purposes. However, four additional objectives were pursued with the wealth tax reform: taxing the additional ability to pay derived from wealth holdings; achieving a better allocation of resources; serving as a redistributive tool and complementing personal income tax and inheritance and gift tax.[13]

The wealth tax is levied annually on December 31 and applies to all forms of wealth: real estate, bank accounts, bonds, shares, investment funds, life insurance, vehicles, boats, aircrafts, jewellery, art and antiques, intellectual or industrial property rights, etc. However, the legislation has incorporated a number of exemptions: starting in 1991 with elements of historical heritage,

[12]In addition to studying the effect of estate and gift taxation on transfers, Joulfaian (2005) also considers the impact of capital gains taxation.

[13]Memorandum of Act 19/1991, June 6.

art treasures, pension plans and other financial rights[14], wealth tax exemptions were extended to business assets in 1994 and "closely-held" companies (both unlisted - in 1994 - and listed - in 1998 -)[15]. Finally, main residences have been exempt from the tax (up to a limit) since 2000.

The Spanish wealth tax is only levied on taxable wealth exceeding a minimum threshold, a limit that has been modified over time. Wealth tax returns have to be submitted in two different situations: (i) when taxpayers face a positive tax liability, or (ii) when, although their tax liability is zero because their taxable wealth is below the threshold, their gross wealth (including both taxable and non-taxable assets) is above a certain level[16]. Tax liability is obtained by applying progressive tax rates to the net tax base, i.e. taxable wealth minus the minimum threshold. The wealth tax rates set by the Central government range from 0.2 to 2.5%. Moreover, a limit exists on wealth tax liability; specifically, the law sets a ceiling on wealth tax liability when taxable income is relatively low compared to taxable wealth.[17] It should be noted that, although forming part of the legal definition of taxable income, long-term capital gains (i.e. those derived from assets owned for longer than twelve months) are excluded from the ceiling computations.[18]

Although the main structure of the tax continues to be regulated by Spain's Central government, since the mid-1980s, wealth tax revenues have been transferred to the regional governments. Some years later, they were also given some limited legislative powers; thus, they can regulate the minimum threshold, tax rates and tax credits. Additionally, they are also responsible for the administration and control of the tax. This responsibility has been criticized

[14]Limited up to a certain amount. For further information, see Article 4, Act 19/1991.

[15]Certain conditions must be satisfied for business assets and companies to be exempt from the wealth tax. These requirements are not related to a firm's size, but rather to a minimum ownership share (5% individually or 20% within the family group), a minimum remuneration for the performance of managerial duties (by at least one member of the family group) and the fact that the company carries out an economic activity. See Appendix 3.9.1 for further information.

[16]Two million euros in 2011 and 601,012.10 euros in 2007.

[17]This limit on wealth tax liability is not unique to the Spanish wealth tax. For instance, in France, some Swiss Cantons (OECD, 2018) and Denmark (Jakobsen et al., 2019) have operated similar ceiling provisions. Indeed, Jakobsen et al. (2019) also exploit this tax feature.

[18]Specifically, overall wealth and income tax liabilities cannot exceed 60% of taxable income. The excess, if any, is deducted from the initial wealth tax liability. However, this reduction cannot exceed 80% of the initial wealth tax liability. In short: Limited wealth tax liability=MAX(60% taxable income-income tax liability, 20% initial wealth tax liability), if [initial wealth tax liability + income tax liability]> 60% taxable income. Note that in these computations, the sum of long-term capital gains and losses, if positive, is excluded from taxable income and the income tax liability needs to be adjusted accordingly.

for undermining the "control" function of the tax, given the difficulties encountered by the central and regional tax administrations to work together (Durán-Cabré and Esteller-Moré, 2007).

In addition to the greater fraud risk associated with low rates of tax control (Durán-Cabré and Esteller-Moré, 2010), many experts have stressed the inefficiencies and inequities derived from the design of this tax (i.e. assessment rules that differ from market prices, tax exemptions, etc.).[19] Apart from giving rise to horizontal inequities among taxpayers with different asset portfolios but with similar levels of wealth, its specific characteristics significantly distort the incidence and redistributive role of the tax given that it is primarily the richest taxpayers who benefit from them (e.g. Arcarons and Calonge, 2007; Alvaredo and Saez, 2009).

Taking into account these limitations, at the end of 2008 the Central government decided to abolish the tax given its inability to meet the objectives that justified its introduction in the first place.[20]

3.2.1 The reintroduction of the Spanish wealth tax

Surprisingly, the same Central government who suppressed the tax at the end of 2008 decided to reintroduce it in 2011. The political party in power at that time - the PSOE, occupying the centre-left of the political spectrum - opted to implement the reform as a means of addressing the economic crisis. Its argument was that those with more resources should be made to contribute more to the economic recovery, and by so doing this would reinforce equity and allow a better redistribution of income and wealth.

Thus, the tax was reintroduced in mid-September of 2011 as a transitory measure and, a priori, it was only to be imposed in 2011 and 2012. However, the Budgetary Laws passed in subsequent years have each extended this "transitory" measure and the Spanish wealth tax remains in force. Two main changes were made with respect to the regulation applicable in 2007: (i) the minimum threshold providing exemption from tax liability was raised from 108,182.18[21] to 700,000 euros and (ii) the main residence exemption raised

[19] Enciso (2006), Durán-Cabré and Esteller-Moré (2007, 2014), Fernández de Beaumont and Martín (2010), Carbajo (2015), among others.

[20] Memorandum IV of Act 4/2008, December 23. Due to legal constrains, the Wealth Tax Law remained officially in force and Act 4/2008 simply introduced a 100% tax credit to the wealth tax liability.

[21] Regional governments have legislative capacity to fix a different minimum threshold. Before the abolishment of the tax, this ranged from 108,182.18 to 150,000 euros depending on the region, where larger values were applied for specific situations.

from 150,253.03 to 300,000 euros. These changes sought to exempt the middle-classes from paying the tax.

The reintroduction of the tax was characterised by the confusion to which it gave rise right up to the very last moment. In July 2011, a prominent member of the PSOE party - standing for election at the November polls but not a member of the existing cabinet - proposed the introduction of a wealth tax on the richest Spaniards as part of its manifesto. The proposal came under heavy criticism from many sides, but above all from that of the centre-right opposition party (PP), who expressed its dismay at the fact that it had been the PSOE who had originally abolished the tax at the beginning of its mandate. However, according to the opinion polls, the PSOE had lost support during its second term in office to the PP[22], who adopted a clear position against the wealth tax. Thus, in summer 2011, the proposal to reintroduce the wealth tax remained just that, a proposal.

Although the government ruled out any new tax reforms before the general election[23], rumours about an imminent reintroduction of the wealth tax emerged in August 2011[24]. The possibility was mentioned in various sources, even making the front pages of several newspapers at the end of August[25,26]. However, the Central government remained equivocal on the matter[27]. On September 11, PSOE's general election candidate called on the government to reinstate the wealth tax, generating criticism across the board: Right-wing parties condemned government inconsistency in relation to the wealth tax, left-wing parties and organizations considered it an insufficient and belated measure, and various groups of experts stressed the inefficiencies and limitations of the tax.

The government failed to provide any specific details about the "new" wealth tax until one day before its reintroduction[28]. On September 16, the

[22]In particular, according to voter intention surveys carried out by CIS (*Centro de Investigaciones Sociológicas*), PP became the most preferred political party to run the central government from mid-2010 onwards.

[23]http://www.europapress.es/economia/noticia-campa-descarta-nuevas-reformas-fiscales-20110811104212.html

[24]http://www.europapress.es/economia/fiscal-00347/noticia-economia-gobierno-estudia-subir-irpf-antes-recuperara-patrimonio-consejo-general-economistas-20110819183751.html

[25]http://www.europapress.es/nacional/noticia-primeras-paginas-diarios-llegados-noche-redaccion-20110823001848.html

[26]http://www.europapress.es/nacional/noticia-primeras-paginas-diarios-llegados-noche-redaccion-20110826002711.html

[27]http://www.europapress.es/economia/noticia-salgado-no-aclara-si-piensa-recuperar-patrimonio-20110823150753.html

[28]http://www.europapress.es/economia/fiscal-00347/noticia-economia-ampl-

Council of Ministers agreed to its reinstatement and the legislation was modified accordingly[29].

As discussed above, the wealth tax had been transferred to the Autonomous Communities so it was they who would have the legislative power to decide whether to levy it or not. Thus, even though the Central government had approved its reintroduction, in the end it fell on the regional governments to implement it or not. And, indeed, from the very outset, some of these governments, including those of the Madrid Community and Catalonia, expressed their disagreement with the measure.

Thus, the centre-right regional government in Madrid gave guarantees that it would maintain the 100% tax credit introduced with the suppression of the tax, while the centre-right nationalist Catalan government also expressed its opposition to reintroducing the wealth tax, in line with the significant cuts to the Catalan inheritance tax made earlier in June that same year. However, with the reform passed, the Catalan government failed to legislate on the actual implementation of the tax. Indeed, the Catalan government saw the reform as a short-lived measure, given that the November General Elections were close and all the indications were that the PP, who had come out against the reintroduction of the tax, would be swept into power. This explains why the Catalan government postponed its decision on the wealth tax until the new Central government was formed.[30]

At the end of November 2011, the Catalan government announced that it would, after all, levy the wealth tax, if the newly elected Central government decided to retain it[31], which turned out to be the case. It was not until mid-December that the Catalan government confirmed that it would reintroduce the tax in Catalonia, applying the same conditions foreseen in the state legislation[32], and it was not until March 2012 (with effect from December 31, 2011) that it approved the corresponding legislative changes to implement the tax. Consequently, Catalan taxpayers did not learn that they would have to pay the wealth tax corresponding to 2011 until the end of that year, limiting their

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recuperacion-patrimonio-sera-temporal-afectara-160000-contribuyentes-aportara-1080-20110915132138.html

[29] *Real Decreto-ley 13/2011, de 16 de septiembre, por el que se restablece el Impuesto sobre el Patrimonio, con carácter temporal.*

[30] http://www.europapress.es/catalunya/noticia-catalunya-aparca-decision-impuesto-patrimonio-dudas-aplicacion-20110920154146.htm

[31] http://www.europapress.es/catalunya/noticia-catalunya-no-subira-impuestos-aplicara-patrimonio-si-pp-mantiene-20111122171408.html

[32] http://www.europapress.es/economia/macroeconomia-00338/noticia-economia-ampcataluna-estudiara-medidas-legales-reclamar-gobierno-759-millones-disposicion-estatut-20111207103034.html

possibilities of responding to its reintroduction.[33]

Some months later, towards the end of September 2012, the Central government announced the extension of the wealth tax to 2013.[34] Similarly, at the end of September 2013, the government prolonged the tax again to 2014, and so on, down to the present day. In Catalonia, at the end of 2012, the Catalan government actually agreed to a slight increase in the wealth tax rates and lowered the minimum threshold to 500,000 euros from 2012 onwards.[35]

3.2.2 How to avoid the Spanish wealth tax

Given the specific characteristics of the Spanish wealth tax, we need to comment on the mechanisms that allow the tax liability to be reduced as this helps explain the outcomes we present in our empirical analysis.

An obvious way to overcome the tax burden attributable to the progressivity of the tax is by decreasing wealth. This can be achieved by making gifts, although they are subject to gift taxes[36]. However, the design of the tax allows taxpayers to adopt other strategies to reduce, or even eliminate, their tax liability without decreasing their stock of wealth. Taxpayers do not even need to hire a tax advisor - although many do - nor have a detailed knowledge of Tax Law to learn about these strategies, as there are many explanations and suggestions available on the internet.[37]

These strategies are related to reducing taxable wealth in favour of exempt

[33]There is anecdotal evidence in the form of readers' letters to one of Catalonia's leading newspapers complaining about the impossibility of making plans with respect to the wealth tax due to the lack of information and time constraints (see, for instance, La Vanguardia newspaper, November 28, 2011, p. 22, article *'Hay que planificar'*).

[34]`http://www.europapress.es/economia/macroeconomia-00338/noticia-economia-gobierno-crea-impuesto-loterias-prorroga-patrimonio-elimina-deducciones-sociedades-20120927175205.htm`

[35]Statutory wealth tax rates were increased by 5%, except for the last tax bracket (net tax base above 10.7 million euros) were the increase was 10%.

[36]Gifts taxes depend on the family relationship between donor and recipient and on the recipient's region of residence. In Catalonia, for instance, tax rates range between 5-9% and 11.12-64% for gifts to close and distant relatives, respectively. Additionally, in the case of giving real estate, the donor would face two taxes on capital gains (personal income tax and a local tax on urban land transmissions).

[37]Google provides 16.5M entries (April 10, 2019) when searching *Como pagar menos impuesto patrimonio* (How to pay less wealth tax). Some examples are (websites in Spanish):
`https://www.consultingdms.com/impuesto-patrimonio-en-espana-10-formulas-legales-para-evitarlo-o-reducirlo/`;
`https://www.impuestosparaandarporcasa.es/2011/09/cuidado-con-lo-que-haceis-para-no-pagar-impuesto-del-patrimonio`;
`https://cincodias.elpais.com/cincodias/2016/10/13/abante_asesores/1476347818_147634.html`.

assets, making use of the limit on wealth tax liability or changing tax residence to another region where the wealth tax is not levied (e.g. Madrid). Examples for implementing the first option include: i) changing fiscal residence to that of the dwelling with the highest assessment so as to take advantage of the main-residence exemption[38]; ii) saving through pension plans; iii) investing in art treasures; or iv) increasing business exemptions. The taxpayer can achieve the latter by arranging their own businesses/shares in such a way that they satisfy the exemption requirements foreseen in the Law (see Appendix 3.9.1). If these conditions are already satisfied, the exemption value can be increased by capitalizing the company, for instance. In the case of the first three examples above, it should be stressed that their effectiveness for reducing taxable wealth is limited, as exemptions are bounded[39].

The alternatives for exploiting the limit on wealth tax liability are also diverse. They require the taxpayer to reduce realized income and to invest in assets that can generate long-term capital gains[40]. Both options can be achieved by investing in investment funds, since these assets do not generate regular income - such as dividends or interest - but only capital gains (or losses) when sold. Shares are another type of asset that can help the taxpayer benefit from the limit on tax liability.

Finally, the most radical strategy would be to move to Madrid. However, if a tax audit were to be conducted the taxpayer would have to demonstrate that this change of fiscal residence was neither fictitious nor motivated by reasons of tax avoidance.

The most convenient strategy depends on the income-wealth ratio and the asset portfolio of each taxpayer. For instance, for those who already own a business it might be easier and less costly to take advantage of the business exemption. Alternatively, those who have lower income and significant investments in financial assets might find it easier to benefit from the limit on tax liability. Taxpayers with high income and high job mobility might consider relocating to Madrid.

[38]This can only be done if the taxpayer owns several housing properties. According to the Spanish Survey of Household Finances (wave 2011), 89% of individuals in the last decile of wealth distribution - that is, those most comparable to the population under study - own other real estate properties besides their main dwelling (Banco de España, 2014).

[39]Main residence exemption is limited up to 300,000 euros. The yearly contribution to pension plans was limited to 10,000 euros (12,500 euros for those older than 50). The exemption on art treasures depends on the type of asset and ranges from 2,404.05 to 90,151.82 euros.

[40]As explained at the beginning of Section 3.2, long-term capital gains are excluded from the computation of the limit on wealth tax liability.

3.3 The data

The main data source used in this paper is the universe of anonymized wealth tax returns filed by Catalan tax residents for the years 2011 to 2015. We have complemented this database with an indicator of the taxpayer's age and information from inheritance and gift tax returns.[41] All the data have been provided by the Catalan Tax Agency.

The main database contains, at the micro level, all the information reported in the wealth tax returns aggregated by types of asset. That is, the total stock of wealth classified into real estate and main residence exemption, bank accounts, business assets, bonds, investment funds, non-exempted quoted shares and unlisted companies, exempted quoted shares and unlisted companies, life insurance, vehicles, jewellery, artwork, property rights and "other", including all taxable wealth not previously categorized. Unfortunately, some exempt assets such as historical heritage, art treasures and pension plans do not have to be reported, which might underestimate the overall stock of taxpayers' wealth. Nevertheless, according to the Spanish Survey of Household Finances (SHF) - wave 2011 - conducted by the Bank of Spain, assets of this type represent a small fraction (around 4%) of households' net wealth.[42] Apart from wealth portfolio, tax returns also include information on total taxable income and personal income tax liability. Regarding personal characteristics, little information is reported: just marital status and place of residence. As previously mentioned, though, we are also able to consider age.

Table 3.1 provides descriptive statistics for 2011 wealth tax returns.[43] Statistics are provided by wealth deciles and total number of observations. Here, certain features should be stressed: i) as total reported wealth increases, the difference between taxable wealth and total wealth also increases; and ii) there is significant variation in the average tax rate within the same wealth decile. We return to this last point in the following section. Figure 3.1 shows the average asset portfolio, including all reported assets (both taxable and exempt), by wealth deciles. The importance of unlisted companies increases with wealth, while the reverse occurs with real estate properties and bank accounts or bonds.

The data from the 2011 tax returns submitted to the Catalan Tax Agency

[41] We are able to know whether a taxpayer dies after 2011 or has declared a gift from 2008 onwards.

[42] This figure can be extracted from Table 2(cont.) and Table 4(cont.) from Banco de España (2014). We focus on the statistics for the last decile of the wealth distribution because it is the most comparable to the population under study.

[43] All wealth tax filers are considered, that is, those who face a positive tax liability and those who must submit the tax return because their overall gross wealth exceeds 2 million euros, although their taxable base is below the minimum threshold.

show there were 42,294 tax filers facing a positive tax liability and 1,942 tax filers with zero tax liability but gross wealth exceeding 2 million euros. Putting the total number of tax filers - 44,236 - in perspective, they represent about 1.27% of personal income tax filers[44] and about 0.59% of individuals residing in Catalonia in 2011[45]. Of these 2011 wealth tax filers, 36,373 (82.22%) continued to submit a wealth tax return in 2015. Of the taxpayers who disappeared from the sample (17.78%), 6.42% died and the remaining 11.36% disappeared for other reasons (wealth losses, mobility, evasion, etc.). In our empirical analysis we exclude those taxpayers that died. Additionally, we only consider those tax filers who submitted the 2011 tax return, which means those taxpayers who began to submit wealth tax returns later (from year 2012 onwards) are not included in our study. In fact, most of our estimations use a balanced panel of tax filers from the top 50% of the observed wealth distribution[46], according to the stock of wealth reported in 2011, who submitted wealth tax returns consecutively between 2011 and 2015. We provide further details about this in Section 3.4.

Finally, when a taxpayer voluntarily submits a supplementary return to declare additional wealth, we consider this last return in our analysis. This was a quite common occurrence among 2011 tax returns due to a tax amnesty issued by the Central government in November 2012.[47]

3.3.1 Some descriptive facts on outcomes of interest

Table 3.2 shows the evolution taken by wealth tax revenues between 2011 and 2015. Values are expressed in 2011 prices. The figures shown in Table 3.2 only consider those tax filers who submitted, at least, a 2011 tax return. In the case of the 2011 wealth tax revenues, two different indicators are given: a) the amount of revenues actually collected; and b) an estimation of the revenues

[44]Information obtained from the statistics published by the Spanish Tax Administration: `https://www.agenciatributaria.es/AEAT/Contenidos_Comunes/La_Agencia_Tributaria/Estadisticas/Publicaciones/sites/irpf/2011/jrubik6ae6ffddfab109478ffa0128999b8085fe3b9c97.html`.

[45]Information obtained from the Catalan Statistical Institute: `https://www.idescat.cat/pub/?id=pmh&n=446`.

[46]We focus on the top 50% of the wealth distribution derived from the population under study (i.e. wealth tax filers) not from the entire population.

[47]The tax amnesty offered the possibility to regularize evaded income by paying a 10% tax rate on the gross revenues generated during the non-prescribed years. Regularization of income implied the declaration of wealth generating such income, and this is why many taxpayers presented a supplementary wealth tax return. Indeed, 15.21% of 2011 tax filers submitted a supplementary 2011 wealth tax return around November 2012. See Chapter 4 for further information on this tax amnesty.

that would have been collected if the tax changes approved in 2012 had already been applied to 2011 wealth[48]. This estimation is provided to enable comparability across years. A notable trend emerging from Table 3.2 is that wealth tax revenues decreased by 19.23% between 2011 and 2015. When considering just those taxpayers who submitted the tax return every year between 2011 and 2015, there was a fall of 3.64%. Revenues fell by 8.37% when considering that group of taxpayers included in most of our estimations, i.e. those placed among the top 50% of the observed wealth distribution filing wealth tax returns every year. Another point that can be extracted from Table 3.2 is the importance, in terms of revenues, of taxpayers who stop filing wealth tax returns. If we sum all collected revenues (2011.a to 2015) for rows [1] and [2] we obtain 1,854M and 1,680M euros, respectively. This translates into a wealth tax revenue loss of almost 174M euros (expressed in 2011 prices) attributable to taxpayers who no longer submitted wealth tax returns during the 2012-2015 period. Recall, of these 174M euros, only 17.88% can be explained by taxpayers who died.

Table 3.3 provides some descriptive figures for the evolution of reported wealth and tax avoidance strategies described in Section 3.2.2. All figures refer to taxpayers placed at the top 50% of observed wealth distribution who filed wealth tax returns every year between 2011 and 2015. Contrary to the evolution of wealth tax revenues shown in row [3] of Table 3.2, overall reported wealth increased during this period and, so, the latter does not seem to explain the former. This in turn suggests there might be other factors, other than a fall in the stock of wealth (such as the adoption of avoidance strategies), that are driving the reduction in tax revenues. Indeed, a comparison of the 2011-2015 figures in Table 3.3 shows that the relevance of wealth exemptions, assets that allow an investor to obtain long-term capital gains and the limit on wealth tax liability have increased substantially over time.

In the case of the strategy of changing tax residence to another region, the only information available to us thus far is that 11.36% of 2011 tax filers disappeared from the sample in subsequent years for reasons other than death. If we focus on the 50% richest, the share is similar, at 10.15%. When looking at gifts reported to the Catalan Tax Agency, 5.92% of 2011 wealth taxpayers (7.70% for those in the top 50%) made a gift between 2008 and 2011, when the wealth tax was not in force. This share rose to 9.98% (14.26% for top 50%) for gifts made between 2012 and 2015.

These are, nevertheless, merely descriptive facts. In the following sections we consider the tax planning strategies explained above and examine the effect

[48]See Section 3.2.1 for further information regarding wealth tax changes.

of wealth taxes on wealth accumulation, on asset portfolio, on the probability of making a gift, on taxable income and on other relevant outcomes.

3.4 Methodology

3.4.1 Measuring the impact of the reintroduction of the wealth tax

As discussed, the objective of this paper is to study how taxpayers responded to the reintroduction of the wealth tax in terms of wealth accumulation, wealth composition and other outcomes we describe below. The ideal setting to carry out this study would be that in which it was possible to compare - before and after the reform - wealth taxpayers to similar individuals not subject to the tax. However, this ideal control group does not exist. Therefore, instead, we use as our identification strategy the variation in exposure to the treatment (i.e. the reintroduction of the tax).

Figure 3.2, panel (a), shows the 2011 average tax rates, defined as the wealth tax liability over total reported wealth, for different levels of wealth. Additionally, it shows the highest average tax rate a taxpayer would face for a given level of wealth, assuming all reported wealth is taxed (i.e. there are no exemptions other than the minimum threshold of 700,000 euros that applies to everyone) and the limit on tax liability is not operative.

Note that for a given level of wealth, some taxpayers face an average tax rate close (or equal) to the maximum, whereas others face a much lower (or even zero) average tax rate. In other words, taxpayers with similar levels of wealth were differently affected by the reintroduction of the wealth tax. This dispersion in tax rates originates from different sources: differences in taxable wealth due to main residence and business exemptions and differences in the tax liability when the limit applies. Using the average tax rate as a measure of exposure to the treatment allows us to compile all these factors into a single indicator. Figure A3.1 in Appendix 3.9.2 shows 2011 average tax rates for different types of taxpayer: a) those for whom only the main-dwelling exemption is applied, if any; b) those who also report business exemptions (including both listed and unlisted companies); c) those who qualify for the limit on tax liability and d) those who satisfy both b) and c). Most of the variation in the tax rates originated from situations b), c) and d), given that the main-dwelling exemption is bounded up to 300,000 euros.

Figure 3.2, panel (b), shows an estimation of the average tax rates that

taxpayers would have faced in 2011 if the wealth tax changes approved in 2012 had been applied in the previous year. The picture does not change greatly from panel (a). This is the case because, again, tax changes would differently affect taxpayers with similar levels of wealth due to the existence of wealth tax exemptions and the limit on wealth tax liability. Therefore, both indicators (real and estimated average tax rates) provide very similar measures of taxpayers' exposure to the wealth tax.

Part of the literature uses marginal tax rates to analyse responses to tax rate variations[49], usually in the last tax bracket. However, it is not the aim of this paper to study responses to changes in top marginal tax rates. It seeks to study responses to a tax reintroduction, which implies tax changes for all tax bases exceeding the minimum threshold. In this context, we believe marginal tax rates to be a less precise measure of treatment intensity, especially for the wealthiest. This is the case because tax brackets are wide[50] and, thus, taxpayers with different tax liabilities may face the same marginal tax rate. Therefore, for the case under study we consider it more appropriate to use average rather than marginal tax rates as our explanatory variable.[51]

Returning to Figure 3.2, it is evident that the variation in tax rates increases with wealth and that it is quite low for the bottom 50% of the observed wealth distribution. Precisely because our identification strategy relies on the variation in treatment exposure, henceforth we focus our analysis on the top 50% of the observed wealth distribution. In fact, according to the figures provided in Table 3.2, the bottom 50% only accounts for a small part of the 2011 collected wealth tax revenues, so the potential responses we fail to estimate should have little impact in terms of revenues.

Using the 2011 average tax rates as our explanatory variable has, therefore, the advantage of providing an accurate indicator of the treatment exposure, but it also has a drawback: it depends on taxpayers' 2011 wealth, income and asset portfolio. To deal with this issue, we control non-parametrically for taxpayers' 2011 wealth, income, asset portfolio, age and other characteristics that might influence our dependent variables (see the following section for further details).

[49] See, for instance, Saez, Slemrod and Giertz (2012) for a review on the elasticity of taxable income.

[50] Table A3.1 in Appendix 3.9.2 shows the statutory tax rates in Catalonia for 2011.

[51] An alternative explanatory variable could be an average tax rate expressed in terms of income rather than wealth. However, we believe the average tax rate expressed over wealth to be more accurate. Some taxpayers in our data misreport information on income and, additionally, wealth is a stock whereas income is a flow, which is more likely to fluctuate and, so, provide a distorted indicator.

3.4.2 Measuring behavioural responses to the reintroduction of the wealth tax

Unfortunately, we have no information on taxpayers' wealth for the period when the wealth tax was not in force, as it was simply not being collected. However, taking into account the largely unexpected and belated reintroduction of the tax in Catalonia (see Section 3.2.1), we argue that 2011 can serve as a control year.

This assumption is further reinforced by the fact that wealth is a stock, which is not easily adjusted instantaneously, and in any case, such adjustments are costly. The initial short-term duration of the measure (just 2 years) increased these adjustment costs. Moreover, as discussed in Section 3.2, the assessment rules do not always coincide with the market value, but depend on specific criteria, a situation that complicates the asset valuation adjustment. For instance, wealth deposited in bank accounts is valued at the highest of the 4th quarter average balance or the balance at December 31. For quoted shares and quoted bonds, the 4th term average value is also used. Banks and investment entities do not provide their customers with all this information until the first quarter of the following year when they have to file their income and wealth tax returns. Unlisted companies are assessed according to the book value obtained from their last audited balance sheet, i.e. 2010 balance sheets for the 2011 wealth tax returns. In the case of real estate, this is not assessed according to its market price either, but by the highest between its cadastral and acquisition values.

The central tax administration automatically receives information on real estate and financial assets. In this sense, it is difficult for taxpayers to hide wealth of this kind. The situation is obviously different for "unproductive" assets, such as antiques or jewellery, and indeed very few tax filers report this type of wealth. In any case, according to survey evidence, this wealth represents a very small fraction of taxpayers' total worth.[52]

While we cannot directly test the assumption that taxpayers were largely unable to react to the reintroduction of the wealth tax in 2011, we can inspect related indicators such as gifts. This is a rapid and effective manner of reducing wealth. Thus, if taxpayers had made a concerted effort to rapidly reduce their wealth at the end of 2011, we should observe a spike in the number of gifts declared during that period. However, gifts data suggest this not to be the

[52] According to the Spanish Survey of Household Finances (wave 2011), jewellery, works of art and antiques represent around 0.9% of net wealth for the last decile of the wealth distribution, i.e. the one most comparable to the taxpayers under study here.

case. Figure A3.2 in Appendix 3.9.2 shows the frequency of gifts declared in Catalonia during the last 8 weeks of every year between 2009 and 2014. Gifts declared during the last 8 weeks of year 2011 are no higher than in previous years, when the wealth tax was not in force.

In any case, we do not need a complete lack of response in 2011 for our identification strategy. What we, in fact, require is that, after controlling for 2011 reported wealth, income, asset portfolio, age and other personal characteristics (see below), taxpayers are comparable and would behave alike in the absence of the wealth tax. This requires a similar reporting (and under-reporting) behaviour among similar taxpayers based on their 2011 tax returns. In the case of significant under-reporting behaviour in 2011 due to the reintroduction of the wealth tax (which we consider implausible for the reasons outlined above)[53], the responses we estimate would be a lower bound.
The empirical specification we implement is the following:

$$Dep.var_{i,t} = \sum_{y \neq 2011} \alpha_y \cdot Y_{y=t} \cdot atr_i^{11} + \gamma_t + \delta_i + \sum_{y \neq 2011} \lambda_y \cdot Y_{y=t} \cdot X_i^{11} + \nu_{i,t} \quad (3.1)$$

where $Dep.var_{i,t}$ is one of the dependent variables that we explain below, $Y_{y=t}$ is a year dummy that takes a value of 1 when the year equals t, atr_i^{11} is 2011 average tax rates, α_y is our parameter of interest[54], γ_t captures year fixed effects, δ_i is an individual fixed effect and X_i^{11} is a set of non-parametric controls detailed below and based on the reference year, 2011. In the case of atr_i^{11}, we use both the real and the "estimated" 2011 average tax rates shown in Figure 3.2.

The dependent variables we examine are: log of taxable wealth, log of total reported wealth, log of taxable income, the probability of making (and declaring) a gift[55], the probability of facing the limit on tax liability[56], the share of long-term capital gains over taxable income, the share of exempt assets over total reported assets and different components of taxpayers' asset portfolio; specifically, the share of (i) real estate; (ii) business assets and unlisted companies; (iii) listed equity and investment funds; and (iv) bank accounts and bonds, distinguishing between exempt and taxable assets. Indeed, we are interested in the evolution of these variables with respect to the base year; hence,

[53]Here, we do not consider offshore evaded wealth, which would not have been reported either in the absence of the wealth tax due to the existence of income taxes.

[54]We later relate this coefficient to elasticities with respect to the net-of-tax rate of return.

[55]We define a dummy which takes a value of 1 if a taxpayer makes a gift in year t (and it is reported to the Catalan tax authorities), and 0 otherwise.

[56]We define a dummy which takes a value of 1 if a taxpayer faces the limit on tax liability in year t, and 0 otherwise.

the estimates are normalized with respect to 2011. Given that the type and magnitude of the responses might vary depending on the initial wealth composition, we examine heterogeneous effects according to the relative importance of unlisted companies and business assets over total reported assets in 2011.

We also show the estimation results from specification 3.1 without including the set of non-parametric controls X_i^{11} interacted with year dummies $Y_{y=t}$. To be able to talk about causal effects, the underlying assumption behind this specification would require that wealth components evolved in the same way for all taxpayers in the absence of the wealth tax, once time and individual fixed effects have been taken into consideration. However, we consider this a strong assumption to make, especially because we cannot test it, given the absence of data for the period when the wealth tax was not in force. For this reason, we include the control variables defined below.

To capture non-tax trends driven by changes in asset prices and asset-specific returns[57], we create deciles of the following asset shares: i) housing; ii) listed equity and investment funds; iii) unlisted companies and business assets; and iv) bank accounts and bonds. Since we only have information on overall taxable income, but not on capital income specifically, we control both for taxable income[58] and wealth deciles to further address differences in returns, given that there is evidence of a positive correlation between returns and the level of wealth (Fagereng et al., 2018). Additionally, controlling for income and wealth levels avoids mean reversion issues. To deal with differences in saving rates and attitudes towards inheritance and gift tax we control for age groups with the following cut-offs: 45, 65 and 75 years.[59] To further control for differences in saving rates we also include deciles of the share of debt over total assets. All these control variables are defined according to the information reported in 2011 wealth tax returns and interacted with year dummies $Y_{y=t}$. Finally, as the tax amnesty mentioned in Section 3.3 took place during the period under study, this might have affected the reporting behaviour from 2012 onwards. Thus, we also include a dummy indicating tax amnesty participation interacted with year dummies.[60] For reference purposes,

[57]Considering the specific assessment rules provided in the Wealth Tax Law, changes in asset prices might not necessarily be reflected in tax returns (for instance, those related to real estate). However, changes in asset returns might affect taxpayers' investment and saving behaviour.

[58]We define an extra category for those taxpayers who do not report information on income (representing 10% of the observations used in the main estimations). We also checked that our results do not substantially change when excluding these observations; they do not.

[59]We define an extra category for those taxpayers whose age is non-available (representing just 0.06% of the observations used in the main estimations).

[60]We do not know exactly whether a taxpayer participated in the tax amnesty or not,

we define this set of controls as "decile controls".

Constrained by the fact that we cannot test the parallel trends assumption, we also use an alternative set of non-parametric controls including the same variables detailed above, but defined more narrowly to reduce the correlation between 2011 average tax rates and 2011 taxpayers' wealth, income and asset portfolio. In particular, wealth and income are ranked every 5 and 4 percentiles, respectively. Asset shares are ranked every 2.5 percentage points, with the exception of housing shares, which are ranked every 2 percentage points. The remaining variables have the same definition as above. Again, all the control variables are defined according to the information reported in the 2011 wealth tax returns and interacted with year dummies $Y_{y=t}$. For reference purposes, we define this set of controls as "narrow controls".

Table A3.2 in Appendix 3.9.2 shows the relation between 2011 average tax rates and 2011 taxpayers' wealth, income and asset portfolio when no controls are included and when "decile" and "narrow" controls are considered.
In summary, for each dependent variable we show three different estimates:

a- Those obtained when controlling only for time and individual fixed effects.

b- Those obtained when using the "decile controls" as X_i^{11}.

c- Those obtained when using the "narrow controls" as X_i^{11}.

Next, we need to address the potential mechanical effect of taxes on wealth. If taxes are paid out of savings, then they mechanically reduce wealth, even in the absence of behavioural responses. In order to account for this potential mechanical effect, we adjust yearly reported wealth and taxable wealth with the wealth tax liabilities paid up to that date by applying a 3% net rate of return.[61,62] The mechanical effect, however, would not be present if wealth taxes were paid through consumption, substituting other expenditures for such payments. Since we have no information to test these hypotheses, our results for

but we can identify those taxpayers who submitted a 2011 wealth tax form when the tax amnesty took place (October-November 2012); time in which the voluntary period had already expired. Therefore, we consider as tax amnesty participants those taxpayers who filed a 2011 wealth tax form during, or later than, October 2012.

[61] Assuming that wealth taxes are paid out of financial assets, we compute an average gross rate of return to financial assets using the 2011 Survey of Household Finances microdata. This average is 4% for households whose net wealth is above 1.5M euros (this is the lowest net wealth value in our estimation sample). In turn, we compute the net rate of return applying capital income tax rates (25% for years 2012-2014 and 21.5% for 2015).

[62] For instance, 2012 reported wealth is adjusted with (2011 wealth tax liability)*1.03. Successively, 2013 reported wealth will be adjusted with (2011 wealth tax liability)*1.03^2 and (2012 wealth tax liability)*1.03, and so on.

taxable and total reported wealth are presented both omitting and adjusting for the mechanical effect. Results concerning wealth composition, though, only provide overall effects (behavioural + mechanical, if any), since we would need to make strong assumptions about the specific assets used to pay wealth taxes to adjust for the mechanical effect.

3.4.3 Further discussion of the identification assumptions

We would like to make clear where the variation in average tax rates comes from, after including the set of non-parametric controls. The answer is from the exemptions and the limit on tax liability. Thus, while we control for the overall housing, listed equities and unlisted companies share, the specific importance of the exemptions within these shares varies across taxpayers. For instance, imagine two identical taxpayers with just one difference: taxpayer Z owns 4% of two different unlisted companies and taxpayer S owns 6% and 2%, respectively. The overall value of these assets is the same for both taxpayers; nevertheless, taxpayer S can exempt part of these shares from the wealth tax whereas taxpayer Z cannot, as his ownership share is below 5%[63]. Consider now two other identical taxpayers with just one difference: taxpayer X owns a very expensive main dwelling, while taxpayer Y owns a small main dwelling and a second residence. The overall value of these assets is again the same for both taxpayers. However, taxpayer X will face a lower average tax rate than taxpayer Y, given that only main-dwellings are exempt from the tax, up to 300,000 euros. Because of the existence of this limit, the variation originating from the main-dwelling exemption is also limited. The last source of variation comes from the importance of long-term capital gains in taxable income. To illustrate this, imagine two identical taxpayers who sell the same shares, obtaining the same capital gain. However, one of them purchased the shares 2 months earlier than the other and so the gains qualify as long-term, whereas the others do not. The first taxpayer faces the limit on tax liability; the second does not. Table 3.4 shows the relation between 2011 average tax rates and each particular source of variation, once controlling for the "narrow" set of non-parametric variables.

The underlying assumption behind these examples and the specification employed is that, once controlling for time and individual fixed effects and the set of controls detailed above, the specific importance of the exemptions and

[63] A minimum 5% ownership share is one of the requirements to exempt business assets and holdings from the wealth tax. For further information, see Appendix 3.9.1.

long-term capital gains would not affect the evolution of reported wealth and its components in the absence of the wealth tax. Unfortunately, we cannot demonstrate this, because, again, there are no data for the period when the wealth tax was not in force, but below we provide some arguments that should help to validate this assumption.

First, the exemption status for companies, both listed and unlisted, and for business assets is simply a legal definition included in the Wealth Tax Law. The conditions required by the Law to apply this exemption do not depend on a firm's characteristics or outputs, such as number of employees, sales volume, productivity indices, profits, etc., but rather on ownership share.[64] Moreover, there is no public register or list of companies potentially exempt from the wealth tax, so there is no way for them to be readily identified. Indeed, precisely because exemption status depends on ownership share, the same company might be exempt for one taxpayer and non-exempt for another. It is the individual taxpayer that is able to accredit their exemption with regard to their own shares, not the company itself. Finally, the definition of exemption included in the Wealth Tax Law is not used in any other domain, except that of the inheritance tax. Close heirs who inherit company shares that may be exempt from the wealth tax can apply a tax deduction on the inheritance tax. Therefore, besides the wealth tax, this exemption could be important for old wealth taxpayers. Given that we control for taxpayers' age this should not be an issue. Moreover, the Catalan government practically eliminated the inheritance tax for close inheritors in June 2011[65], a fact that virtually eradicates the importance of this deduction.

In the case of the main-residence exemption, it is difficult to see why the relative importance of the value of this asset in relation to that of other residences should affect the evolution of reported wealth and its components, once housing shares, income and the set of controls described above have been taken into account. In relation to long-term capital gains, they are taxed at the same rates as financial capital income in personal income tax; thus, a priori there is no clear tax incentive, besides that of the wealth tax, to prioritize long-term capital gains realizations over other sources of capital income.

Finally, we should stress that we are focusing on the evolution of 2011 reported wealth and its components. It lies beyond the scope of this paper to evaluate the wealth already evaded in 2011. Nevertheless, as explained

[64]The Law also requires that at least one member of the family group performs remunerated management functions within the firm. See Appendix 3.9.1 for more details.

[65]The Catalan government introduced a 99% tax discount for close inheritors and, consequently, tax rates ranged between 0.07 and 0.32%. See Chapter 2 for further information.

at the beginning of this section, we do not need to assume that there is no evaded wealth for our identification strategy to hold. This strategy relies on the comparability of taxpayers according to the information reported in the 2011 wealth tax returns, meaning it assumes that their reported wealth, income and asset portfolio would evolve similarly in the absence of the wealth tax, conditional on the set of control variables and fixed effects already explained. In turn, this assumption implies that the presence of evaded wealth should not affect differently the evolution of the reported variables during the period under analysis, once all the controls and fixed effects are taken into account. Evaded wealth should be related in the main to unproductive assets, such as jewellery or antiques, and to offshore accounts. The former do not generate returns and, as we have seen, represent a very low fraction of individuals' wealth, so they should not be an issue for our identification strategy. In the case of offshore accounts, it is difficult to identify a channel via which wealth held in tax havens could affect the evolution of reported assets, besides taxpayers' attitudes towards risk and other "evader" characteristics, which would be captured by individual fixed effects, or global economic circumstances, captured by year fixed effects.

3.4.4 Extensions and general methodological comments

Finally, we check whether treatment exposure is related to the probability of disappearing from the sample. To do this, we implement the following specification:

$$Disappear_i = \gamma + \alpha \cdot atr_i^{11} + \lambda \cdot X_i^{11} + \nu_i \tag{3.2}$$

where $Disappear_i$ is a dummy which takes a value of 1 if a taxpayer who submitted a 2011 tax return subsequently disappears from the sample for reasons other than death. Alternatively, it takes a value of 0 for taxpayers who filed wealth tax returns every year between 2011 and 2015. The explanatory variable, atr_i^{11}, is the 2011 average tax rate, α is our parameter of interest and X_i^{11} is a set of non-parametric variables which include the "decile" or "narrow" controls defined above and two additional dummies which identify married tax filers and those who live in the province of Barcelona.[66] In contrast to specification 3.1, we are not able to capture unobserved individual characteristics; hence, the estimation results from specification 3.2 need to be treated with

[66] These two additional dummies are captured by individual fixed effects in specification 3.1.

caution.

Before moving to the results, some additional methodological comments need to be made. First, all monetary values are expressed in 2011 euros and, second, standard errors are clustered by the married taxpayers identified in the sample. This is the case when they submit income tax returns jointly; however, they have to submit their wealth tax returns individually so as to report their own wealth. Finally, to deal with outliers, taxpayers placed in the top 0.5% of reported wealth and taxable income distributions are not considered in the estimations.

3.5 Results

3.5.1 Main analyses

Figures 3.3-3.11 show the coefficient estimates and 95% confidence intervals resulting from specification 3.1 for the multiple outcomes previously specified. Each figure provides three different sets of estimates: a) those obtained when controlling only for time and individual fixed effects (controls -a-); b) those obtained using the "decile controls" as X_i^{11} (controls -b-); and c) those obtained using the "narrow controls" as X_i^{11} (controls -c-). Estimations have been carried out using both the real and the "estimated" 2011 average tax rates as the explanatory variable; however, as they give very similar results, we only discuss the estimates obtained with the real average tax rates. Results obtained with the "estimated" average tax rates are provided in Appendix 3.9.3.

In the case of the coefficient estimates from year 2013 onwards, we are unable to disentangle which part of the response can be attributed to the wealth tax reintroduction *per se* and which to the tax increase approved at the very end of 2012.[67] In any case, we are interested in the overall responses, even if the tax was implemented in two different steps.

Taxable and reported wealth responses

Figure 3.3 shows the coefficient estimates from specification 3.1 when considering taxable wealth. The panel to the left shows overall effects (behavioural

[67]The coefficient estimates for 2012 can be fully associated to a response to the wealth tax reintroduction. The 2012 wealth tax increase was passed on December 27, 2012 and until a few days before its approval had not been previously discussed. See: `http://www.europapress.es/catalunya/noticia-govern-reforma-impuesto-patrimonio-ingresar-70-90-millones-extra-20121227215328.html`.

+ mechanical, if any), while the panel to the right shows behavioural effects, since taxable wealth has been adjusted for the mechanical effect, assuming in this case that wealth taxes are paid out of savings. The estimates obtained are very similar when using "controls -b-" and "controls -c-", which is also the case for most of the outcomes studied. Thus, the small differences in 2011 levels when using the set of "decile" controls do not seem to matter when accounting for the trends. The estimates obtained when controlling only for individual and time fixed effects, controls -a-, are smaller (in absolute values), but follow a similar pattern.

The "control -c-" estimates, resulting from our preferred specification, reflect a negative effect of treatment exposure on taxable wealth accumulation. The response is already statistically significantly different from zero in 2012 and accumulates over time. The coefficient estimate associated with year 2012 suggests that as the 2011 average tax rate increases by 1 percentage point, taxable wealth lowers by 15.34%. This decrease accumulates to as much as 32.44% over 4 years. If we adjust taxable wealth with the (assumed) mechanical effect, the 2015 coefficient becomes -29.08%, suggesting that the behavioural (mechanical) effect accounts for 89.65% (10.35%) of the overall effect.

To interpret the coefficients, note that a 1 percentage point increase in the average tax rates represents a large experiment: applying it to the mean of 2011 average tax rates for the estimation sample, which is 0.30%, it would represent a tax increase of more than three times. For this reason, from now on we refer to the estimates in terms of a 0.1 percentage point increase.[68]

The coefficients obtained are within the range reported in the extant literature on wealth taxes. However, the comparison that follows should be treated with caution, since tax base definitions and the overall design of the tax vary across countries (for a summary of OECD cases see OECD, 2018) and they might determine the responses estimated - besides other factors such as tax morale or tax enforcement -.

Among the studies that employ similar methodologies to the one used here, the lowest estimate is reported by Zoutman (2018), who finds that a 0.1 percentage point change in the wealth tax reduces accumulated taxable wealth by 1.16% in the short-run (over 2 years) and 1.38% in the long-run (over 5 years). These estimates rise to 1.3 and 1.67%, respectively, when the author looks at households above the 75th wealth percentile, a sample that might be more comparable to ours. Yet, our 2-year estimate (-2.25%) is still higher. Jakobsen et al. (2019) report an increase of taxable wealth of about 30% over

[68] This is also the approach followed by Brülhart et al. (2017) and Zoutman (2018).

8 years for the top 1% of the wealth distribution, in response to an average tax cut of 1.56 percentage points. This estimate is almost 20% in the 4th year after the reform, which is also lower than our 4th-year coefficient. Using cross-canton data Brülhart et al. (2019) estimate that a 0.1 percentage-point rise in wealth taxes lowers reported wealth by 4.1% over 4 years. The studies employing bunching techniques - that is, Seim (2017) and Londoño-Vélez and Ávila-Mahecha (2019) - report much lower estimates: a decrease in taxable wealth of 0.027% and 0.2%, respectively, if we interpret the coefficients in terms of a 0.1 percentage point increase in the wealth tax rates.[69]

Following the reasoning of Brülhart et al. (2017), we next express our coefficient estimates in terms of the implied net-of-tax rate on the annual returns to wealth. The mean of the average income (wealth) tax rates in 2011 is 24% (0.30%) for the estimation sample. Considering a gross rate of return to net wealth of 3%, computed from the 2011 Spanish Survey of Household Finances microdata[70], the mean average wealth tax rate corresponds to a 10% tax on capital return. Hence, the net-of-tax rate, considering both income and wealth taxes, is 1-(0.24+0.10)=66%. A 0.1 percentage point increase in the wealth tax represents a 3.33 percentage point increase in the tax on capital return, which leads to a net-of-tax rate of 1-(0.24+0.1333)=62.67%. Thus, a 0.1 percentage point increase in the wealth tax, which translates to a reduction of 5.05% in the net-of-tax rate, lowers accumulated taxable wealth by 3.24% over 4 years. Therefore, the elasticity of taxable wealth with respect to the net-of-tax rate of return is 3.24%/5.05%=0.64. Comparable estimates from other studies in the wealth taxation literature take values of 1.05 in Brülhart et al. (2019), 0.5 in Jakobsen et al. (2019)[71] and 0.08 in Londoño-Vélez and Ávila-Mahecha (2019). Nevertheless, it should be noted that these estimates are sensitive to the assumed rate of return, as shown in Brülhart et al. (2017, 2019).

Figure 3.4 shows the coefficient estimates from specification 3.1 when con-

[69]The estimates in Seim (2017) and Londoño-Vélez and Ávila-Mahecha (2019) are not directly comparable because they account for the elasticity of taxable wealth with respect to the net-of-wealth tax rate. Nevertheless, taking into account that wealth tax rates are low (1.5% in Seim 2017 and 1% for the first 2010 tax bracket in Londoño-Vélez and Ávila-Mahecha 2019), we can use the property of logarithms: $log(1+x) \approx x$, for small x, to express the estimates in terms of a 0.1 percentage point change in the wealth tax rates. Considering the upper-bound estimates in both cases, the comparable coefficients are -0.027 and -0.2, respectively.

[70]We compute an average gross rate of return to net wealth using the 2011 Survey of Household Finances microdata. This average is 3% for households whose net wealth is above 1.5M euros (this is the lowest net wealth value in our estimation sample).

[71]Elasticity computed for the top 1% of the wealth distribution over an 8-year period. The change in the net-of-tax rate of return is 61% and the accumulated effect on taxable wealth is about 30%.

sidering total reported wealth. As in Figure 3.3, the panel to the left shows overall effects (behavioural + mechanical, if any), while the panel to the right shows behavioural effects, assuming the mechanical effect takes place. Interestingly, wealth taxes do not have a negative effect on wealth accumulation. Estimates from the left-hand panel suggest that wealth taxes do not have a significant impact on the evolution of total reported wealth. If we assume wealth taxes are paid out of savings (thus, mechanically reducing wealth), when we account for this effect in the right-hand panel, the estimates indicate that the taxpayers that are most exposed to the reintroduction of the tax increase their savings in the subsequent years. Specifically, as the 2011 average tax rate increases by 0.1 percentage point, reported wealth increases by 0.5% over a 4-year period. If we translate this estimate into an elasticity with respect to the net-of-tax rate of return following the same procedure as described above, it takes a value of -0.1. There could be several explanations for this: i) taxpayers derive some utility from wealth *per se*, also known as "capitalistic spirit" motive (see Kopczuk, 2010; Saez and Stantcheva, 2018) and, hence, they increase their savings to offset the mechanical effect of wealth taxes; and ii) taxpayers make use of tax avoidance strategies and defer the realization of capital income to take advantage of the limit on tax liability. The following sections seek to shed further light on this.

Avoidance responses

Figure 3.5 shows the coefficient estimates from specification 3.1 when considering potential tax avoidance strategies derived from the design of the wealth tax. As explained in Section 3.2.2, these strategies are related to the use of the limit on wealth tax liability and exempt assets. The left-hand panel shows a positive relationship between exposure to the reintroduced tax and the probability of facing the limit on wealth tax liability in subsequent years. Taxpayers respond quickly, since most of the effect has already taken place in 2012. This suggests that taxpayers take advantage of this tax feature every year and not on just one occasion. The 2012 coefficient indicates that the probability of facing the limit in 2012 increases by 3.69 percentage points as the 2011 average tax rate increases by 0.1 percentage points. This probability rises by 4.02 percentage points in 2015. This effect represents 0.28 times the share of taxpayers facing the limit in 2011.

The results in the right-hand panel of Figure 3.5 are not surprising if we take into consideration the estimates from Figures 3.3 and 3.4. Taxpayers take advantage of the wealth tax exemptions, which is why taxable wealth can fall

without reducing total reported wealth. The 2015 coefficient indicates that a 0.1 percentage point increase in the 2011 average tax rate leads to a 1.81 percentage points rise in the share of exempt assets over a 4-year period. Put differently, the differences in the share of exempt assets existing in 2011 (see Table 3.4) are reduced by one quarter after 4 years.

As discussed in Section 3.2.2, there are two procedures that can help a taxpayer benefit from the limit on wealth tax liability: reducing their realized taxable income and increasing the importance of their realized long-term capital gains in taxable income. Figure 3.6 shows that taxpayers, in fact, employ both strategies. Estimates from the left-hand panel indicate that a 0.1 percentage point increase in the 2011 average tax rate leads to a reduction in taxable income of 1.98% over 4 years. This coefficient takes a value of (1.98%/5.05%)=0.39 when expressed as an elasticity of taxable income with respect to the net-of-tax rate of return.[72] This apparently large effect is less important when we consider its potential impact on wealth accumulation. Indeed, the 4-year average decrease in taxable income of almost 8,000 euros[73] only represents 0.20% of the 2011 average reported wealth. Furthermore, this effect on taxable income does not necessarily imply a reduction in savings, since it could also be explained by an increase in unrealized capital income. If part of the foregone income is capitalized, then it should not impact wealth accumulation. It is not unreasonable to believe this to be the case, given that, as we see below, the taxpayers that are most exposed to the wealth tax increase their preference for assets that allow them to produce capital income in the form of capital gains easily. However, we have no further information on income sources to confirm this.

Apart from lowering taxable income, the importance of realized long-term capital gains increases over time. The different evolution of both effects is not surprising, given that capital gains realization is much easier to adjust than other income sources. Indeed, the 2012 response in the share of long-term capital gains accounts for half of the 4-year effect, which explains the sharp rise in the probability of facing the limit on tax liability shown in Figure 3.5. Moreover, the 2012 coefficient also tells us that in just one year taxpayers have almost reversed the differences in the share of long-term capital gains existing in 2011 (shown in Table 3.4). The estimated effect keeps rising up to a coefficient of 0.98 percentage points for 2015, which represents 0.23 times

[72]This estimate is not very different from the 0.278 capital income elasticity reported by Kleven and Schultz (2014).

[73]Considering the mean 2011 average tax rate of 0.30% and the 2011 average income of 134,277 euros.

the average share of long-term capital gains in 2011.

Figures 3.7 to 3.10 show the responses of the taxpayers' asset portfolios to the reintroduction of the wealth tax. The left-hand panel in Figure 3.7 shows that, overall, there are no significant effects of wealth taxes on the share of housing. Yet, the right-hand panel estimates suggest that higher tax rates do seem to boost the use of the main-dwelling exemption, although the effect is quite small. The 4-year estimate takes a value of 0.06 percentage points, which represents 1.2% of the average share of exempt housing in 2011. Furthermore, this coefficient tells us that the differences in the share of exempt housing existing in 2011 (see Table 3.4) are reduced by 12.78% after 4 years.

The left-hand panel in Figure 3.8 indicates that facing higher wealth taxes has a negative effect on the overall importance of unlisted companies and business assets. This negative effect derives from a decrease in the importance of taxable assets (middle panel), which are partly shifted to exempt assets (right-hand panel). The last coefficient in the right-hand panel tells us that a 0.1 percentage point increase in 2011 average tax rates leads to a rise in the share of exempt businesses of 0.96 percentage points over 4 years. This effect reduces the 2011 differences in the share of exempt businesses by 18.74% (see Table 3.4). The equivalent 4-year coefficient on taxable businesses is more than 2 times higher, with the opposite sign, which reflects a shift in preferences towards other types of asset. Estimates from Figure 3.9 confirm this is indeed the case. Facing higher wealth tax rates leads taxpayers to switch their holdings in unlisted companies and business assets to listed equity and investment funds. This response is not surprising when considering the tax liability limit. These latter assets allow taxpayers to realize capital gains much more easily than is the case with unlisted companies, and, moreover, it helps them reduce their annual capital income, especially the assets that do not produce realized income until they are sold. The results shown in Figure 3.6 are very much in line with this reasoning.

The 4th-year coefficient in the left-hand panel of Figure 3.9 indicates that a 0.1 percentage point increase in the 2011 average tax rate leads to a rise in the overall share of listed equity and investment funds of 1.15 percentage points. According to the last estimate in the right-hand panel, 70% of this effect comes from exempt assets.[74] This is a large response considering that the average share of exempt listed equity in 2011 was 1.58%. Put differently, this effect reduces the 2011 differences in the share of exempt listed companies

[74]Holdings in listed companies may also be exempt from the wealth tax if the ownership share is at least 5% and other conditions specified in the Law are satisfied. See Appendix 3.9.1 for further information.

by 46.5%.

To conclude this analysis of asset portfolio responses, Figure 3.10 shows very small effects on bank accounts and bonds (the 4th-year coefficient takes a value of -0.14 percentage points). This negative coefficient could reflect a potential mechanical effect derived from wealth tax payments. Unfortunately, we have no further information to examine this question in greater depth.

Finally, Figure 3.11 shows the effect of facing higher tax rates on the probability of making a gift (as declared to the Catalan Tax Agency) in the subsequent years. The positive effect recorded in 2012 and 2013 disappears thereafter. The 2013 coefficient indicates that a 0.1 percentage point increase in the 2011 average tax rate leads to a rise in the probability of making a gift in 2013 of 0.27 percentage points. This effect represents 0.14 times the share of taxpayers who made a gift in 2011. The fact that this response does not persist over time, contrary to the other trends described up to this juncture, suggests that taxpayers prefer tax avoidance strategies that do not imply giving up wealth. This would point to a "capitalistic motive" underlying wealth accumulation, but it may also be driven by the fact that gifts are subject to gift taxes and the other avoidance strategies are less costly, at least in taxation terms.

3.5.2 Heterogeneous effects

Below we seek to verify whether the responses described above vary according to the initial circumstances of the taxpayers in our sample. If taxpayer responses are, indeed, driven by tax avoidance strategies, we would expect those already owning a business in 2011 to make greater use of the business exemption and those who did not to take advantage of the tax liability limit. This hypothesis is based on the fact that, for non-business owners, changing their entire wealth structure to set up a company for reasons of tax exemption is costly, especially if we consider the high degree of uncertainty regarding the tax's continuity.

To determine whether this was the case, we divide the estimation sample in two groups: those whose 2011 share of unlisted companies and business assets was below the median ("Business-Low") and those whose 2011 share was above ("Business-High"). The median takes a value of 19.45%. Figure A3.3 shows the 2011 average asset portfolio for each group. Histograms from Figure A3.4 in Appendix 3.9.2 show that, not surprisingly, "Business-High" taxpayers are younger (panel b) and overall earn higher taxable income (panel a).

Figures 3.12 to 3.20 show the coefficient estimates resulting from specifi-

cation 3.1 for each of the two groups when using the set of "narrow" control variables. The outcomes analysed do not change from those already described. For purposes of comparison, the figures also include the coefficients derived from the main estimations previously shown (labelled "All"). In line with the hypothesis forwarded above, the results reflect a clear distinction in the strategies adopted by the two groups in response to the reintroduction of the tax (see, for instance, Figure 3.14). The only two outcomes for which the responses were the same are bank accounts and bonds share (Figure 3.19) and gifts (Figure 3.20).

Taxable wealth was reduced significantly more by "Business-High" taxpayers (Figure 3.12), in favour of exempt assets (right-hand panel in Figure 3.14). Figure 3.16 shows that facing higher tax rates in 2011 led "Business-High" taxpayers to rearrange their business assets and shares so that they were exempt from the tax. According to Figure 3.14, some of them also sought to benefit from the tax liability limit, presumably those who earned lower incomes, since the responses in the case of taxable income are not statistically significantly different from zero for this taxpayer group, whereas the importance of long-term capital gains increased slightly (Figure 3.15). Considering the little importance attached to listed equity and investment funds for this taxpayer group in 2011 (Figure A3.3), the switch towards this type of asset reflected in Figure 3.17 is likely to explain the effect on long-term capital gains.

If we focus on "Business-Low" taxpayers, Figure 3.14 shows that they clearly took advantage of the limit on tax liability. Facing higher tax rates in 2011 led "Business-Low" taxpayers to significantly reduce their taxable income and to increase their share of long-term capital gains in the subsequent years (Figure 3.15). Indeed, owning a higher share of listed equity and investment funds (Figure A3.3) makes it easier to realize long term capital gains. Yet, this group of taxpayers also exploited wealth exemptions. As shown in Figure 3.17, the taxpayers most exposed to wealth taxes in 2011 increased the importance of their share of exempt listed companies in the subsequent years. This response might have helped them take advantage of the tax liability limit and, at the same time, allowed them to reduce their taxable wealth. Additionally, Figure 3.18 illustrates a clear switch from taxable to exempt housing. This suggests that taxpayers changed their fiscal residence (though without necessarily changing their actual dwelling) to a property of higher value, to further exploit the main-dwelling exemption. Nevertheless, this effect is small because the exemption is limited up to 300,000 euros.

Responses related to taking advantage of the limit on wealth tax liability reflect only avoidance strategies, since taxpayers exploit the provisions fore-

seen by the Law. However, the extent to which the use of the exemptions constitutes tax avoidance or tax evasion is difficult to define, especially in the case of business exemptions. According to the Law, this exemption can only be equivalent to that part which is directly involved in a firm's economic activity. However, determining which assets are directly involved in the economic activity is clearly ambiguous as the law only provides general indications and, thus, ultimately, it is left up to the criteria of the taxpayers' themselves. The arbitrary nature of the tax regulations might in turn result in the potential abuse of this tax incentive. Indeed, Durán-Cabré et al. (2019), in estimating the tax gap in Catalonia for 2014, find that a sizable percentage of the tax gap in the wealth tax is attributable to the incorrect use of the business exemption.

To sum up, our results clearly indicate that taxpayers responded significantly to the reintroduction of the wealth tax by adopting a range of avoidance (and possibly also evasive) strategies. Just what the impact of this was in terms of tax revenues is examined in the following section.

3.5.3 Impact on tax revenues

As we have seen above, wealth tax rates have a negative effect on taxable wealth, which necessarily implies a negative effect on tax revenues. Given that wealth tax rates changed in 2012, we compute the effect on tax revenues based on an estimate of 2011 wealth tax revenues assuming that the new tax rates were already in place. By so doing, we ensure we only capture behavioural responses.

Considering the 0.3% mean for the 2011 average tax rates and the "control-c-" coefficient estimates from the left-hand panel in Figure 3, the average decrease in taxable wealth (with respect to 2011) was 4.6% in 2012, 6.76% in 2013, 8.58% in 2014 and 9.73% in 2015. If we combine this with the 2011 average taxable wealth (2,358,664 euros) and the mean of estimated 2011 average tax rates expressed over taxable wealth (0.47%), this translates into an average decrease in tax liability of 510 euros in 2012, 750 euros in 2013, 951 euros in 2014 and 1,079 euros in 2015. If we express the aggregate effect of 17,853 taxpayers in terms of 2011 estimated wealth tax revenues, we obtain the following percentages: -3.42% for 2012, -5.02% for 2013, -6.38% for 2014 and -7.23% for 2015.

However, this aggregate effect does not account for the revenue loss derived from the progressivity in the tax schedule, which implies that the remaining taxable wealth is being taxed at lower average rates. Yet, the effect on tax revenues does not stop here due to the existence of responses regarding the

limit on tax liability. Unlike the former, these responses directly affect the tax liability and, so, the impact on tax revenues might be higher. Consequently, to be able to capture the overall impact of the different set of responses, we estimate how initial exposure to the wealth tax explains the taxpayers' subsequent contributions to wealth tax revenues, relative to 2011. More specifically, we estimate specification 3.1 using as our dependent variable the tax liability of taxpayer i in year t, expressed over 2011 estimated wealth tax revenues. Here again, to exclude the mechanical effect resulting from 2012 tax changes, the 2011 tax liability is computed as if these tax changes were already in place.

In the first row of Table 3.5 we show the coefficient estimates resulting from specification 3.1 when using the set of "narrow" controls, and, in the second row, the aggregate estimates, which are obtained multiplying the former by the 0.3% mean of the 2011 average tax rates and the number of taxpayers from the estimation sample (17,853). The aggregate effect reveals a marked impact on wealth tax revenues. If we sum the annual estimates, the accumulated aggregate effect is -2.6. This number indicates that the tax avoidance strategies adopted by taxpayers between 2012 and 2015 were far from negligible, since they represent a 4-year revenue loss of 2.6 times the 2011 estimated wealth tax revenues.

On the other hand, the negative effect of wealth taxes on taxable income has a collateral negative effect on personal income tax revenues. Taking the coefficient estimates from the left-hand panel in Figure 3.6, the average decrease in taxable income is about 3,800 euros in 2013, 5,000 euros in 2014 and almost 8,000 euros in 2015.[75] Applying the 24% mean of 2011 average income tax rates, this translates into an aggregate effect of -2.45% for 2013, -3.18% for 2014 and -5.09% for 2015, expressed in terms of the 2011 income tax revenues generated by the estimation sample. When summing the annual estimates, the accumulated aggregate effect is -10.72%. Again, these estimates are a lower bound because they do not account for the revenue loss derived from the progressivity in the tax schedule.

3.5.4 Initial wealth tax exposure and subsequent tax filing

Finally, Table 3.6 shows the coefficient estimates resulting from specification 3.2. As previously stated, with this specification we are unable to capture unobserved individual characteristics that might bias the estimates; hence,

[75] Considering the mean 2011 average tax rate of 0.30% and the 2011 average income of 134,277 euro.

these results should be treated with caution. Nevertheless, we believe it is still interesting to know, especially for auditing purposes, whether there is a positive relation between exposure to the reintroduction of the wealth tax and the probability of disappearing from the sample in the subsequent years. Estimates suggest this might indeed be the case. Specifically, as 2011 average tax rates increased by 0.1 percentage points, the probability of leaving the sample between 2012 and 2015 rose by 0.2 percentage points.

Columns (3) and (4) in Table 3.6 suggest that it is the "Business-High" taxpayers that are driving this result. A potential explanation could be that taxpayers in this group are younger (see Figure A3.4) and, hence, they might be more mobile. However, we cannot determine whether they moved elsewhere or stopped filing for other reasons (other than death); thus, further information would be needed to discover the mechanism responsible for this response.

Agrawal and Foremny (2019) provide evidence of migration responses of high-income individuals to income tax differentials across Spanish regions. However, further research is needed to determine whether wealth tax differentials have a similar effect.

3.6 Conclusions

The significant growth in wealth inequality has revived the debate centred on wealth taxation, both in public policy and in academia. However, as shown above, little is known about how existing wealth taxes (or those previously imposed) affect taxpayers' behaviour. This lack of empirical evidence complicates any valid evaluation of the desirability of such taxes. Against this backdrop, this paper has examined how Catalan taxpayers reacted to the reintroduction of the wealth tax in 2011. Using the universe of wealth tax returns submitted to the Catalan Tax Agency between 2011 and 2015, we have exploited the variation in treatment exposure to analyse taxpayers' responses, not only in terms of wealth accumulation, but also of their potential avoidance strategies.

The main conclusion to be drawn from the results is that taxpayers responded significantly to the wealth tax, not in terms of savings, but through the adoption of avoidance strategies. Specifically, while facing higher wealth taxes did not have a negative effect on wealth accumulation, it did encourage taxpayers to change their asset and income composition to take advantage of wealth tax exemptions and the limit set on wealth tax liability. As such, this paper has documented two different types of response, which are more or less predominant depending on the initial importance of a taxpayer's business

assets and shares. The first type of response was precisely to reduce taxable wealth in favour of exempt assets, mainly in terms of company shares (both listed and unlisted). Estimates indicate that a 0.1 percentage point increase in the average wealth tax rate leads to a reduction in taxable wealth of 3.24% over 4 years. The second type of response - related to the application of a tax liability limit and adopted primarily by taxpayers holding few business shares - involved reducing their realized taxable income and increasing their long-term capital gains realizations, on the income side, and investing in listed companies and investment funds, on the asset portfolio side. Clearly, however, these income-asset portfolio responses were not independent of one another, as the latter helped achieve the former.

All in all, these avoidance responses are high in terms of foregone tax revenues, representing a 4-year accumulated revenue loss of 2.6 times the estimated wealth tax revenues for 2011. Hence, our results indicate that these specific tax features, initially created to incentivize small- and medium-sized businesses (in the case of the business exemption) and to prevent a confiscatory tax (in the case of the limit set on tax liability), actually have quite major perverse effects. The costs to which they give rise, in terms not only of revenues and tax auditing resources, but also of equity and efficiency, might be difficult to justify if they serve as significant channels for tax avoidance. Thus, the evidence suggests that the current Spanish wealth tax needs to be redesigned. However, this is not something that regional governments can do unaided, even though they are responsible for the administration of the tax; it requires the involvement of the Central government, which wields most of the legislative capacity with respect to the wealth tax.

A comprehensive tax base including all types of asset, with no differential treatment being applied across taxpayers with the same stock of wealth (as proposed by Saez and Zucman, 2019), would make the tax more efficient and equitable, as well as going some way to facilitating the auditing tasks for the tax administration. This in turn would allow a significant reduction in the current marginal tax rates without giving up the progressivity of the tax, as long as the minimum threshold is set high. By way of illustration, if only wealth stocks above 5 million euros were (fully) taxed - which represents roughly the top 10% of wealth taxpayers in 2011 and around 0.1% of personal income tax filers - a flat tax rate of 0.6% would be sufficient to collect revenues equivalent to the wealth tax income collected in 2011. And this flat tax rate is much lower than existing statutory tax rates for these levels of wealth.

Finally, the external validity of our results might be called into question, given that they are fully linked to the design of this particular wealth tax and

its institutional context. So, while they can be readily extrapolated to the other Spanish regions that levy the same wealth tax and share a similar institutional context, they can hardly be extrapolated to other countries where wealth taxes are (or used to be) set differently. However, the findings reported here should be useful to policy makers and administrations thinking of implementing a wealth tax insofar as they illustrate the pitfalls to be avoided.

3.7 Tables

Table 3.1: Descriptive statistics by wealth deciles, 2011

		Wealth deciles (%)				Total
		0-10	40-50	80-90	90-100	
Total reported wealth	mean	797,053	1,383,696	3,990,827	14,799,237	3,047,847
	std. dev.	*383,089*	*59,185*	*614,566*	*26,543,059*	*9,309,675*
Taxable wealth	mean	752,735	1,206,829	2,424,218	6,402,095	1,852,263
	std. dev.	*414,306*	*170,433*	*1,406,150*	*11,493,279*	*4,007,279*
Income	mean	48,937	76,164	170,631	453,006	126,333
	std. dev.	*65,922*	*126,925*	*320,785*	*1,911,277*	*648,811*
WT liability	mean	138	1,751	14,606	51,817	8,714
	std. dev.	*92*	*780*	*13,684*	*129,621*	*43,920*
Average tax rate (%)	mean	0.017	0.126	0.364	0.370	0.182
	std. dev.	*0.011*	*0.054*	*0.324*	*0.399*	*0.228*

Notes: All amounts are expressed in euros, except the average tax rate, which is computed as the Wealth Tax (WT) liability over total reported wealth and is expressed in percentage points. Wealth deciles are defined according to total wealth (taxable+exempt) reported in 2011. The number of observations is 44,236, except for income statistics which is 38,915, given that some taxpayers do not report this information.

Table 3.2: Evolution of wealth tax revenues, 2011-2015

	2011		2012	2013	2014	2015	Increase
	a.real	b.estimate					11b-15 %
[1] Total revenues *(in million €)*	385	455	397	353	351	367	-19.23
[2] Revenues from taxpayers who submit WT returns every year							
Total amount *(in million €)*	316	374	339	330	334	361	-3.64
Weight over total revenues *(%)*	82.03	82.28	85.41	93.57	95.22	98.17	
[3] Same as [2], top 50% of wealth distribution							
Total amount *(in million €)*	302	343	306	291	291	315	-8.37
Weight over total revenues *(%)*	78.33	75.50	76.98	82.65	82.91	85.65	

Notes: Monetary values are expressed in 2011 prices. Figures provided in row [1] are computed considering only those tax filers who submitted, at least, the tax return for year 2011. Therefore, they do not include revenues from taxpayers who started submitting wealth tax (WT) returns for a later year, since they do not form part of this study. Figures in rows [2] and [3] consider only those taxpayers who filed wealth tax returns every year between 2011 and 2015. To enable comparability across years, two different indicators are given with respect to 2011 revenues: a) revenues actually collected and b) an estimation of the revenues that would have been collected if the tax changes approved in 2012 had already been applied to 2011 wealth.

Table 3.3: Evolution of variables of interest, 2011-2015

	2011	2012	2013	2014	2015	Increase 11-15 %
Total reported wealth *(in million €)*	91,916	91,692	93,754	95,517	97,726	6.32
Exempt wealth						
Total reported *(in million €)*	41,314	42,072	44,062	44,608	46,321	12.12
Weight over taxable wealth *(%)*	81.65	84.79	88.67	87.63	90.11	
Taxpayers reporting exempt assets *(%)*	92.26	92.79	92.90	92.95	92.97	
Quoted shares and investment funds						
Total reported *(in million €)*	13,870	14,860	17,475	20,029	20,869	50.46
Weight over taxable wealth *(%)*	27.41	29.95	35.17	39.34	40.60	
Taxpayers reporting these assets *(%)*	79.83	82.12	83.28	84.83	86.06	
Limit on the wealth tax liability						
Revenue loss *(in million €)*	190	256	282	306	294	54.78
Weight over collected WT revenues *(%)*	62.89	83.70	96.72	105.13	93.39	
Taxpayers facing the limit *(%)*	14.26	20.88	22.43	25.31	23.73	

Notes: Monetary values are expressed in 2011 prices. Figures provided in this table consider only those taxpayers in the top 50% of the observed wealth distribution who filed wealth tax returns every year between 2011 and 2015. "Quoted shares and investment funds" include taxable assets only.

Table 3.4: Sources of variation in treatment exposure, 2011

Dep. Var.	Exempt assets	Exempt housing	Exempt listed equity	Exempt unlisted co.	Long term capital gains
All					
2011 atr	-0.7173***	-0.0412***	-0.1747***	-0.5014***	-0.0644***
	(0.0085)	(0.0013)	(0.0064)	(0.0087)	(0.0061)
Dep. var. mean	0.301	0.0495	0.0171	0.2344	0.0432
Observations	20,371	20,371	20,371	20,371	18,083
5-year filers					
2011 atr	-0.7244***	-0.0434***	-0.1731***	-0.5079***	-0.0640***
	(0.0089)	(0.0015)	(0.0070)	(0.0093)	(0.0066)
Dep. var. mean	0.2907	0.0501	0.0158	0.2248	0.0429
Observations	17,853	17,853	17,853	17,853	16,008
Controls	"narrow"	"narrow"	"narrow"	"narrow"	"narrow"
Year	2011	2011	2011	2011	2011

Notes: Robust standard errors, clustered by marriages, in parentheses. Only taxpayers in the top 50% of the observed 2011 wealth distribution are considered. Top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. *All* estimates refer to all 2011 taxpayers in the top 50%; *5-year filers* estimates refer to those who filed wealth tax returns every year between 2011 and 2015. The first four dependent variables are expressed in shares over total assets. The last dependent variable is expressed as the share of long term capital gains over taxable income. The number of observations in the last column is not as high because some taxpayers do not report information on income. "Narrow" controls include non-parametric variables which capture taxpayers' wealth, income, asset portfolio, age, indebtedness share and tax amnesty participation. For a detailed definition of these controls see Section 4.2.
***p<0.01, **p<0.05, *p<0.1.

Table 3.5: Impact of taxpayers' responses on wealth tax revenues

	2012	2013	2014	2015
a) Individual effect				
2011 atr	-0.000086***	-0.000120***	-0.000138***	-0.000139***
	(0.000005)	(0.000007)	(0.000007)	(0.000007)
b) Aggregate effect				
Deviation from 2011	-0.4585***	-0.6445***	-0.7414***	-0.7454***
estimated revenues	(0.0290)	(0.0364)	(0.0372)	(0.0390)

Notes: *Row -a-* provides coefficient estimates and standard errors, in parentheses, from specification 3.1 using the set of control variables -c- and *real* atr_i^{11} as the explanatory variable. For a detailed definition of these variables see Section 4.2. The dependent variable is the tax liability of taxpayer i in year t, expressed over the 2011 estimated wealth tax revenues. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15 (N: 17,853 taxpayers*5years). Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers.
Row -b- provides the annual aggregate impact of taxpayers' responses in terms of the estimated wealth tax revenues for 2011. These estimates are obtained by multiplying coefficients from row -a- by the mean 2011 atr (0.30%) and the number of taxpayers in the estimation sample.
***p<0.01, **p<0.05, *p<0.1.

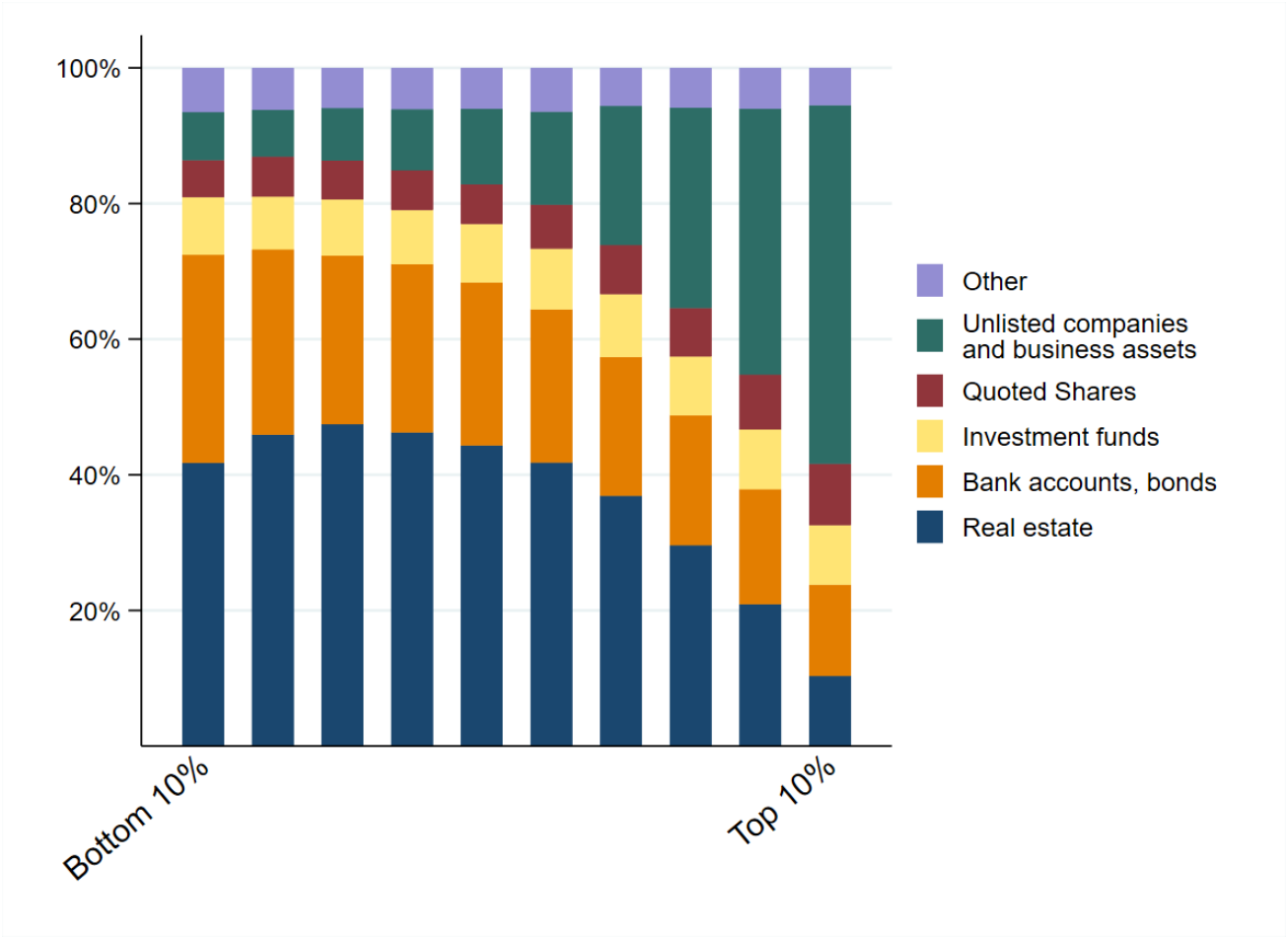
Table 3.6: Initial wealth tax exposure and subsequent tax filing

	(1)	(2)	(3)	(4)
2011 atr	0.0202**	0.0247**	-0.0050	0.0236*
	(0.0096)	(0.0099)	(0.0170)	(0.0125)
Observations	20,371	20,371	10,186	10,185
Controls	Decile	Narrow	Narrow	Narrow
Sample	All	All	Business-Low	Business-High

Notes: Robust standard errors, clustered by marriages, in parentheses. Only taxpayers in the top 50% of the observed 2011 wealth distribution are considered. Top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. "Decile" and "Narrow" controls include non-parametric variables which capture taxpayers' wealth, income, asset portfolio, age, indebtedness share and tax amnesty participation. For a detailed definition of these controls see Section 4.2. "Business-Low(-High)" taxpayers are those whose 2011 share of unlisted companies and business assets is below (above) the median. The dependent variable is a dummy which takes a value of 1 if a taxpayer stops filing wealth tax returns after 2011 for reasons other than death, and 0 otherwise.
***p<0.01, **p<0.05, *p<0.1.

3.8 Figures

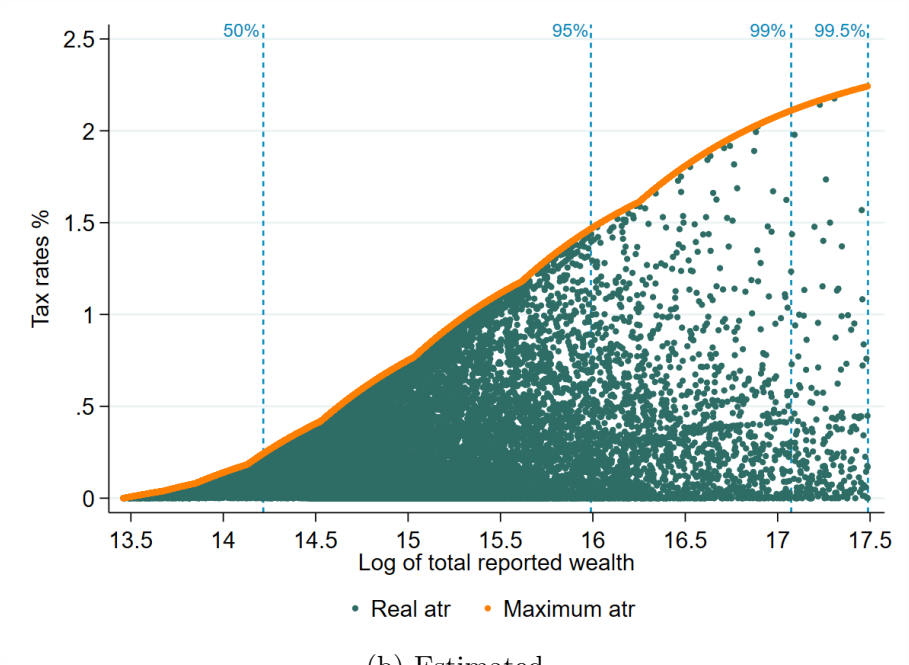
Figure 3.1: Asset portfolio by wealth deciles, 2011



Notes: Wealth deciles are defined according to total wealth (taxable+exempt) reported in 2011. The number of observations is 44,236. Real estate includes taxpayers' main dwelling, which is exempt from the wealth tax. Quoted shares, unlisted companies and business assets include both taxable and exempt assets.

Figure 3.2: Average tax rates, 2011

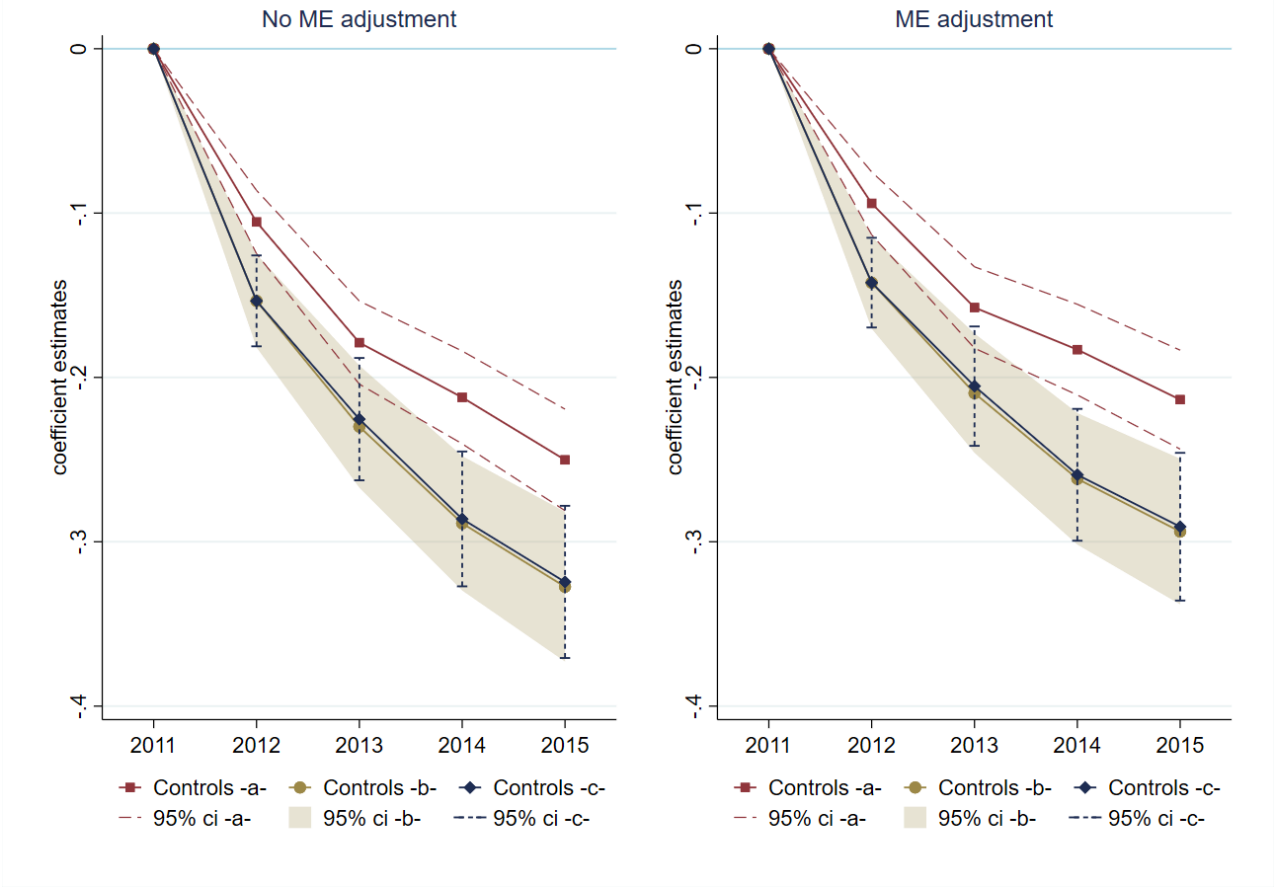
(a) Real



(b) Estimated

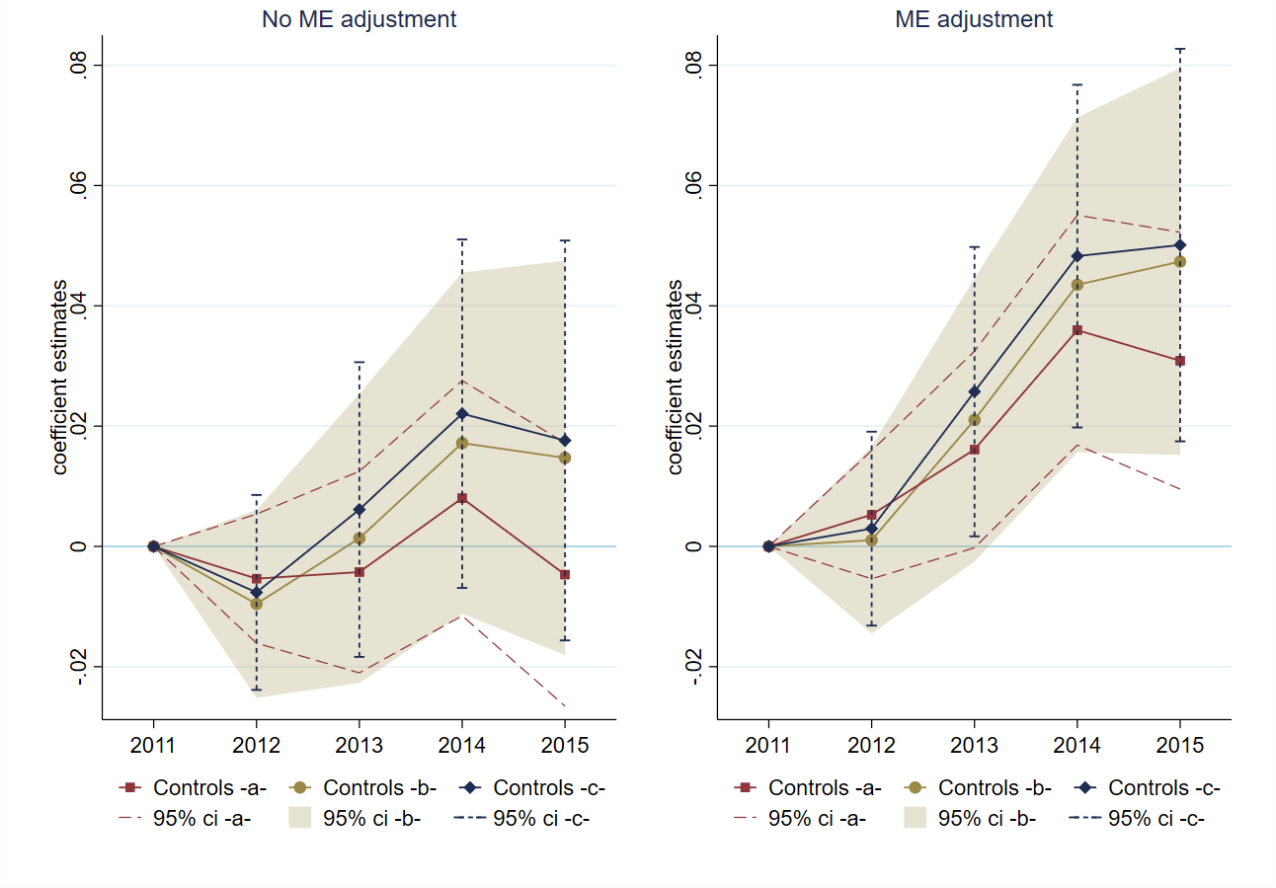
Notes: All average tax rates are expressed in percentage points and computed over the total reported wealth for 2011. The percentages next to the vertical dashed lines show the cumulative distribution of 2011 Catalan wealth taxpayers along total reported wealth.
Notes for panel (a): Maximum average tax rate is computed applying the 2011 statutory tax rates to the overall stock of reported wealth exceeding the minimum threshold (700,000€), assuming there are no wealth exemptions and the limit on tax liability does not apply.
Notes for panel (b): The estimated average tax rate is computed replicating the wealth tax liability calculations specified in the law, using 2011 taxable wealth and income and 2012 tax rates and minimum threshold. The estimated maximum average tax rate is computed by applying the tax rates and minimum threshold approved in 2012 to the overall stock of wealth reported in 2011, assuming there are no wealth exemptions and the limit on tax liability does not apply.

Figure 3.3: Effect on taxable wealth



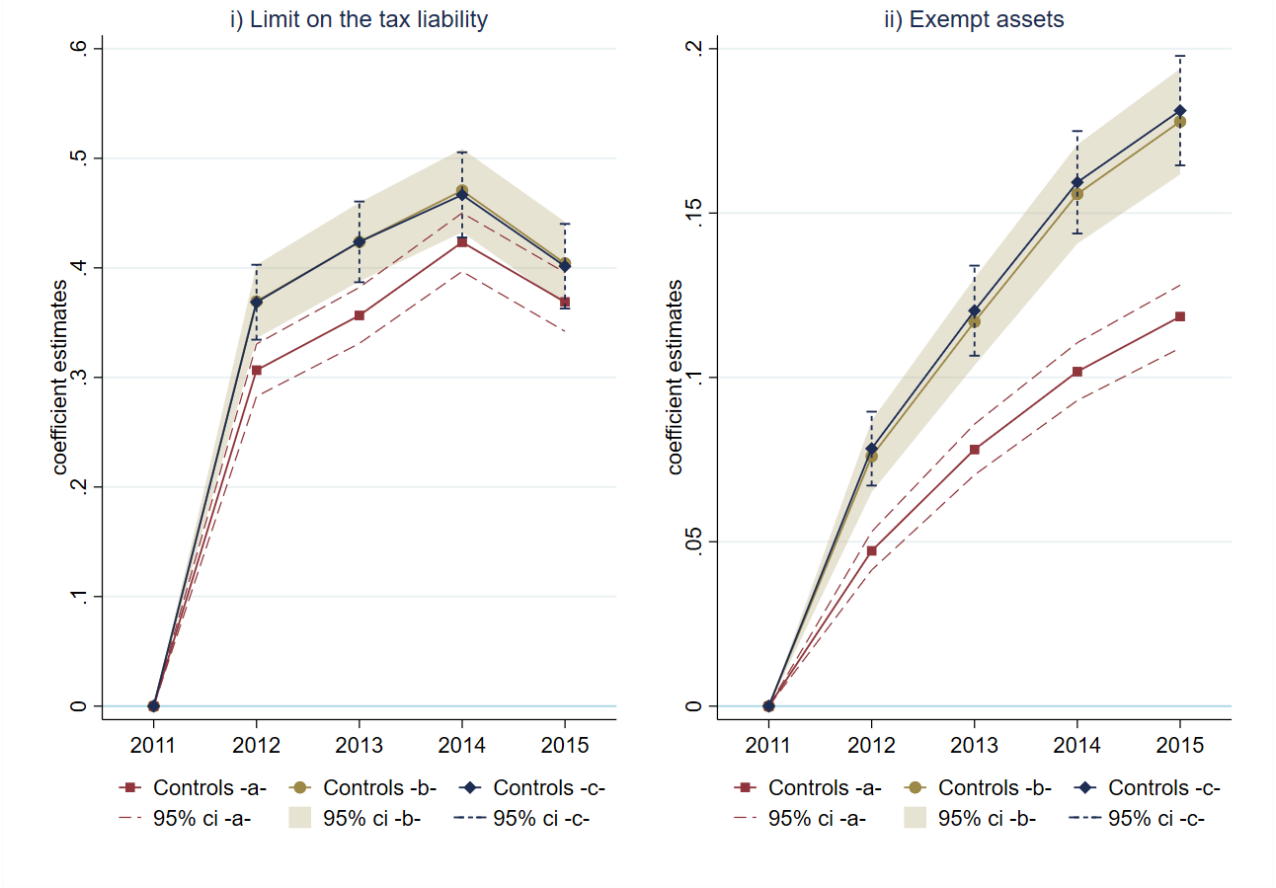
Notes: Both figures provide coefficient estimates and 95% confidence intervals from specification 3.1 with *real* atr_i^{11} as the explanatory variable. The three sets of estimates result from using alternative control variables. Controls -a- only include individual and time fixed effects. Controls -b- and -c- include, additionally, the set of "decile" and "narrow" controls, respectively, interacted with time dummies. For a detailed definition of these variables see Section 4.2. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable is the log of taxable wealth. It is (not) adjusted for the mechanical effect -ME- in the right (left) panel.
N: 88,325 obs

Figure 3.4: Effect on total reported wealth



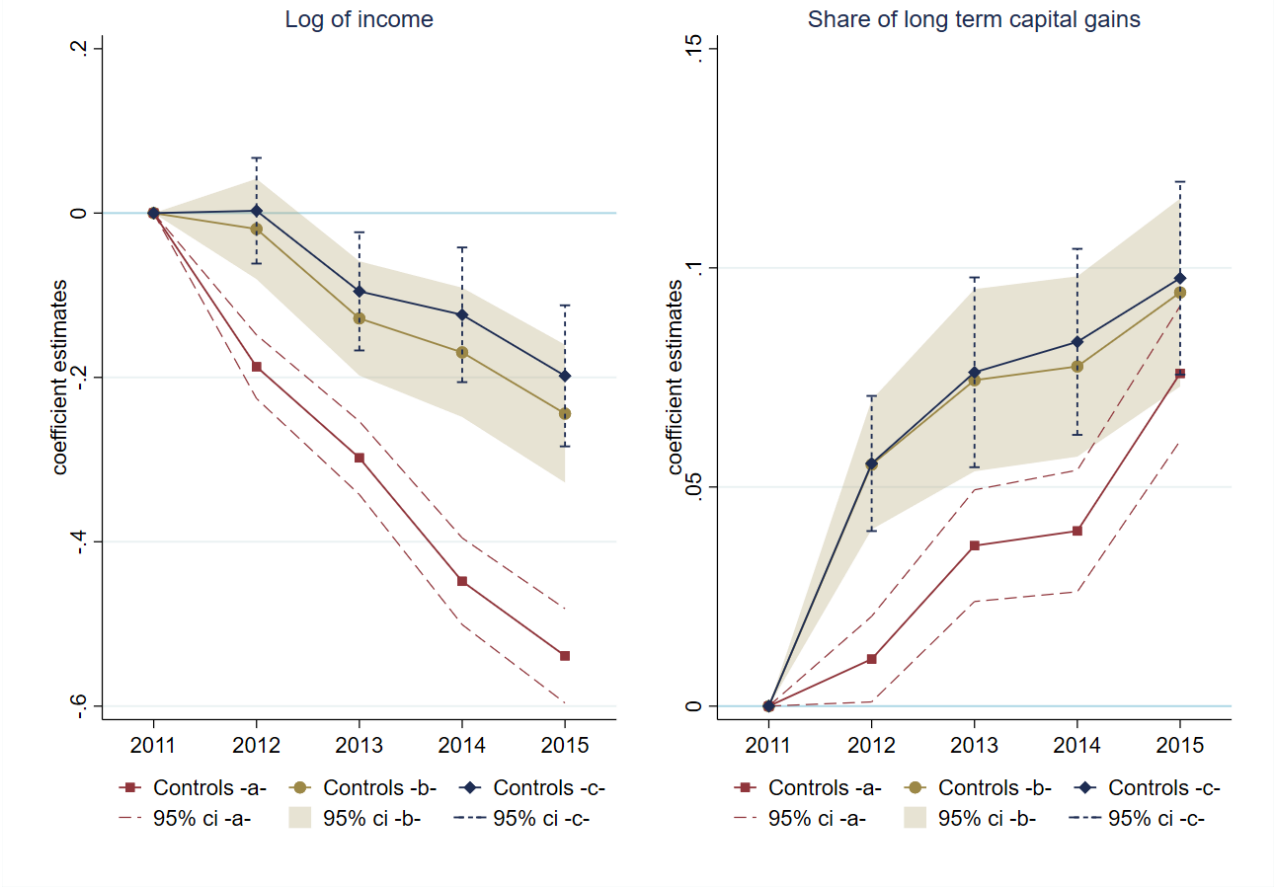
Notes: Both figures provide coefficient estimates and 95% confidence intervals from specification 3.1 with *real* atr_i^{11} as the explanatory variable. The three sets of estimates result from using alternative control variables. Controls -a- only include individual and time fixed effects. Controls -b- and -c- include, additionally, the set of "decile" and "narrow" controls, respectively, interacted with time dummies. For a detailed definition of these variables see Section 4.2. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable is the log of total reported wealth. It is (not) adjusted for the mechanical effect -ME- in the right (left) panel.
N: 89,265 obs

Figure 3.5: Effect on potential tax avoidance strategies



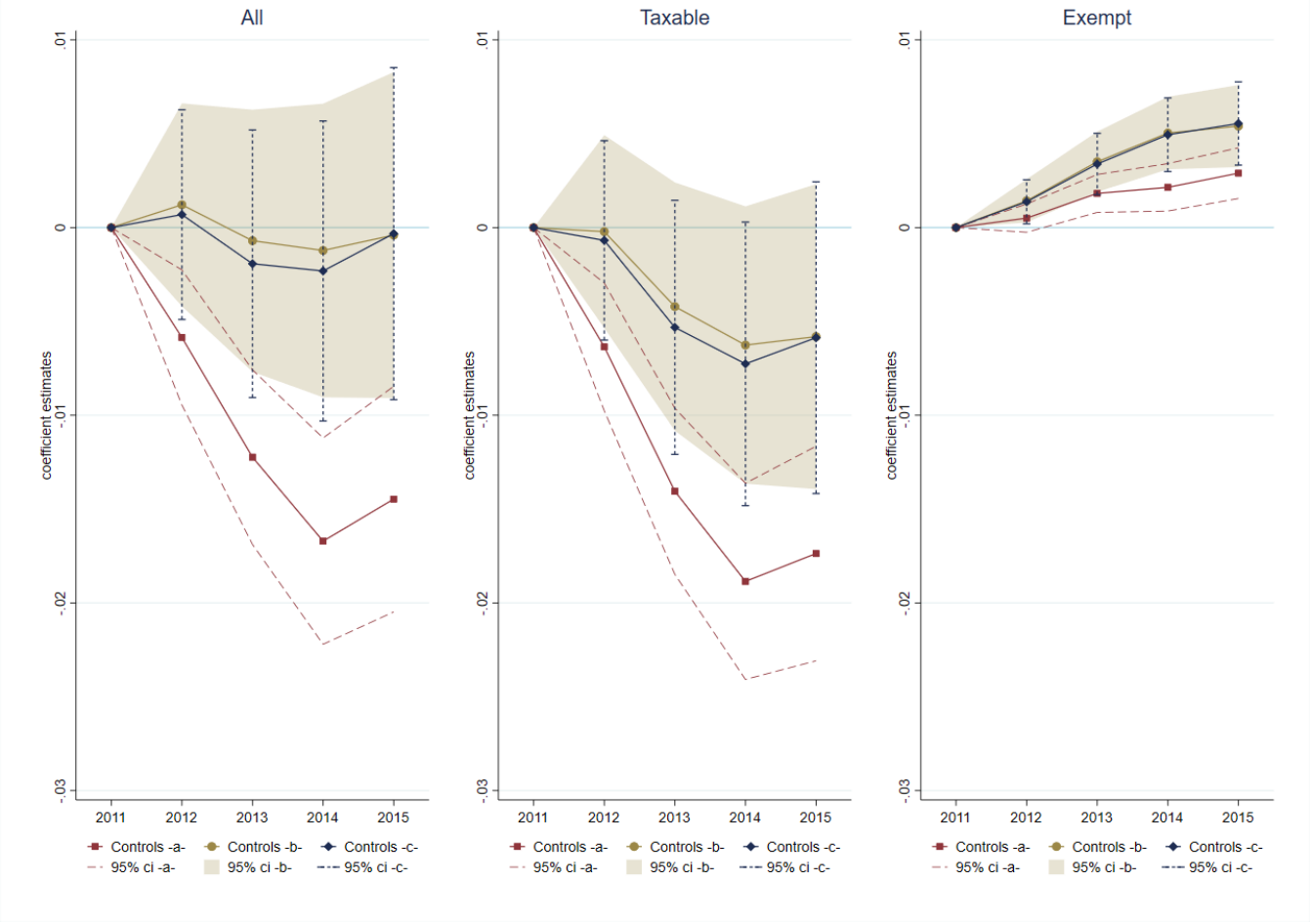
Notes: Both figures provide coefficient estimates and 95% confidence intervals from specification 3.1 with *real* atr_i^{11} as the explanatory variable. The three sets of estimates result from using alternative control variables. Controls -a- only include individual and time fixed effects. Controls -b- and -c- include, additionally, the set of "decile" and "narrow" controls, respectively, interacted with time dummies. For a detailed definition of these variables see Section 4.2. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable in the left-hand panel is a dummy which equals 1 if a taxpayer faces the limit on the tax liability in year t, and 0 otherwise. The dependent variable in the right-hand panel is the share of exempt assets over total reported assets.
N: 89,265 obs

Figure 3.6: Effect on income and long-term capital gains



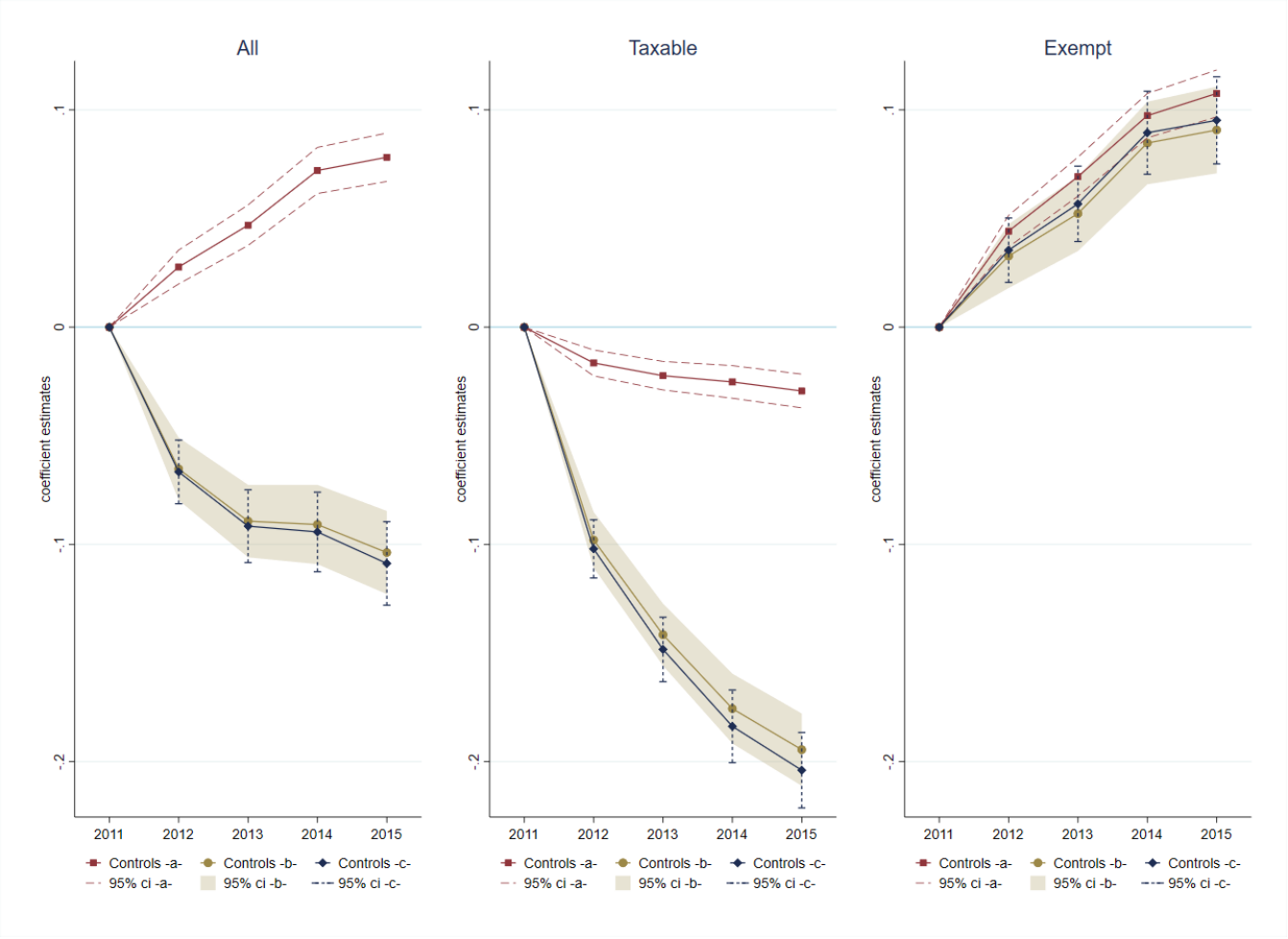
Notes: Both figures provide coefficient estimates and 95% confidence intervals from specification 3.1 with *real* atr_i^{11} as the explanatory variable. The three sets of estimates result from using alternative control variables. Controls -a- only include individual and time fixed effects. Controls -b- and -c- include, additionally, the set of "decile" and "narrow" controls, respectively, interacted with time dummies. For a detailed definition of these variables see Section 4.2. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable in the left-hand panel is the log of taxable income. The dependent variable in the right-hand panel is the share of long term capital gains over taxable income.
N: 69,405 obs

Figure 3.7: Effect on real estate



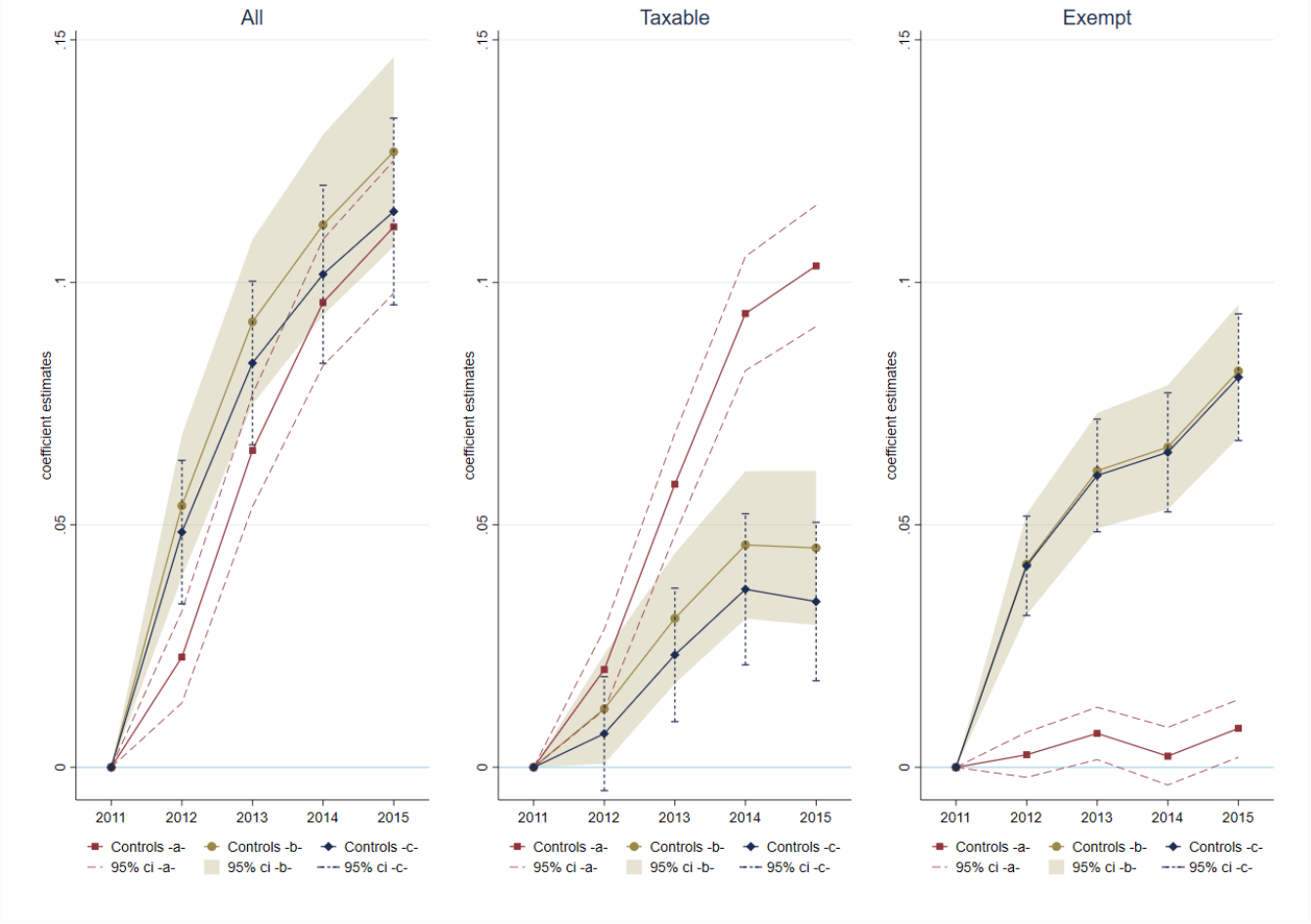
Notes: All figures provide coefficient estimates and 95% confidence intervals from specification 3.1 with *real* atr_i^{11} as the explanatory variable. The three sets of estimates result from using alternative control variables. Controls -a- only include individual and time fixed effects. Controls -b- and -c- include, additionally, the set of "decile" and "narrow" controls, respectively, interacted with time dummies. For a detailed definition of these variables see Section 4.2. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable for the panels (from left to right) is the share of (all/taxable/exempt) real estate over total reported assets.
N: 89,265 obs

Figure 3.8: Effect on unlisted companies and business assets



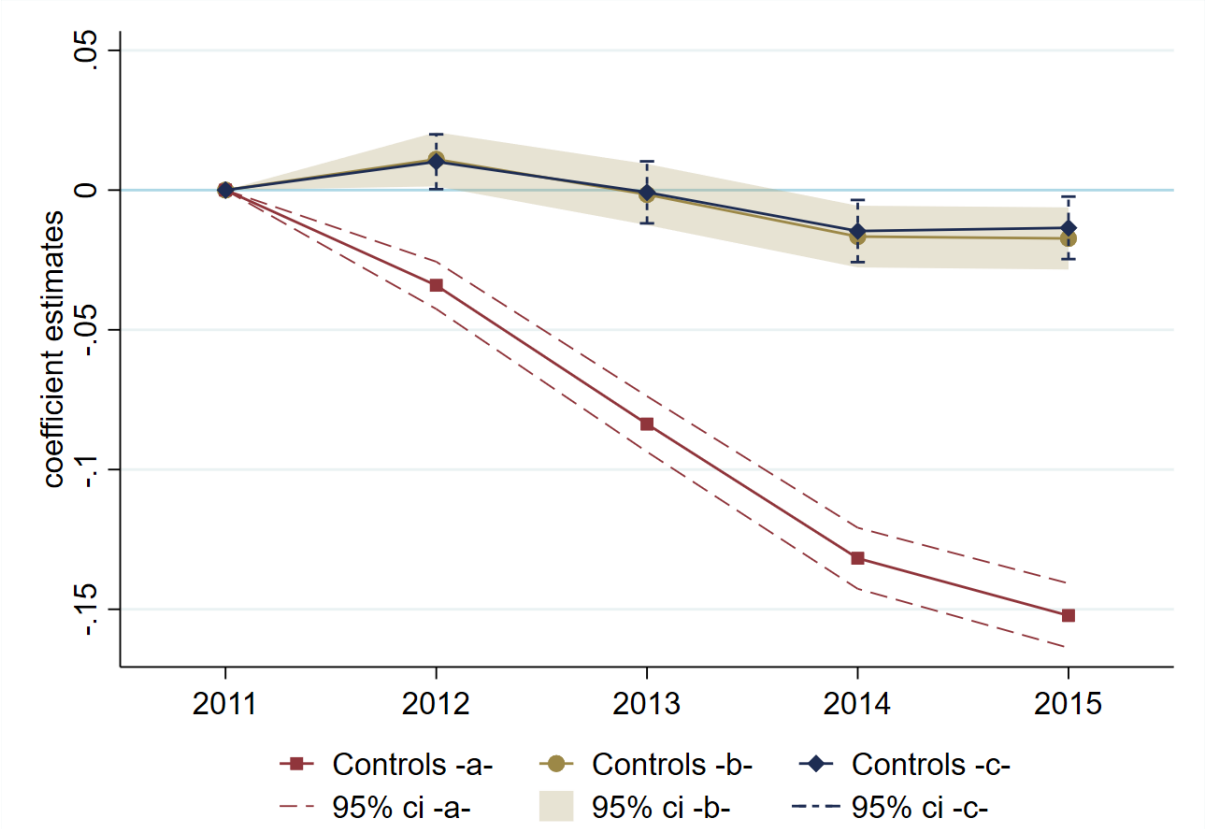
Notes: All figures provide coefficient estimates and 95% confidence intervals from specification 3.1 with *real* atr_i^{11} as the explanatory variable. The three sets of estimates result from using alternative control variables. Controls -a- only include individual and time fixed effects. Controls -b- and -c- include, additionally, the set of "decile" and "narrow" controls, respectively, interacted with time dummies. For a detailed definition of these variables see Section 4.2. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable for the panels (from left to right) is the share of (all/taxable/exempt) unlisted companies and business assets over total reported assets.
N: 89,265 obs

Figure 3.9: Effect on listed equity and investment funds



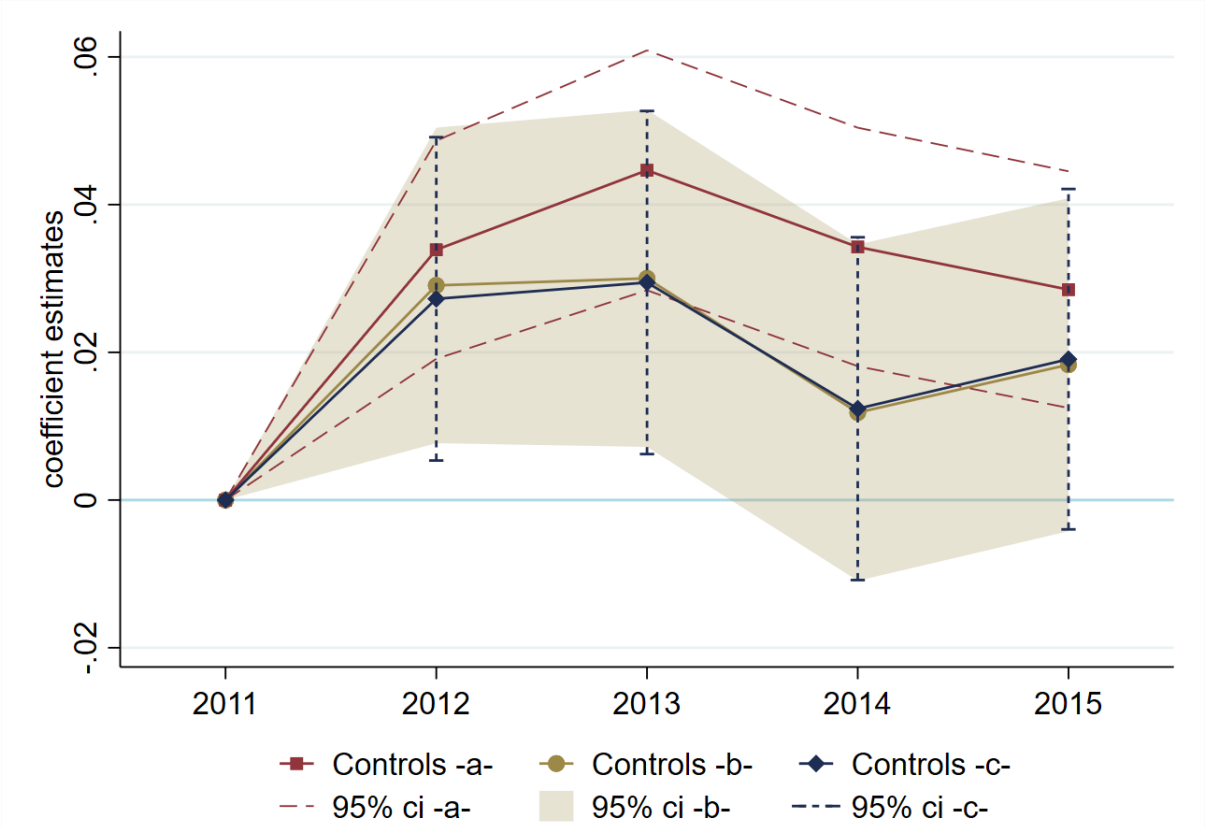
Notes: All figures provide coefficient estimates and 95% confidence intervals from specification 3.1 with *real* atr_i^{11} as the explanatory variable. The three sets of estimates result from using alternative control variables. Controls -a- only include individual and time fixed effects. Controls -b- and -c- include, additionally, the set of "decile" and "narrow" controls, respectively, interacted with time dummies. For a detailed definition of these variables see Section 4.2. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable for the panels (from left to right) is the share of (all/taxable/exempt) listed equity and investment funds over total reported assets.
N: 89,265 obs

Figure 3.10: Effect on bank accounts and bonds



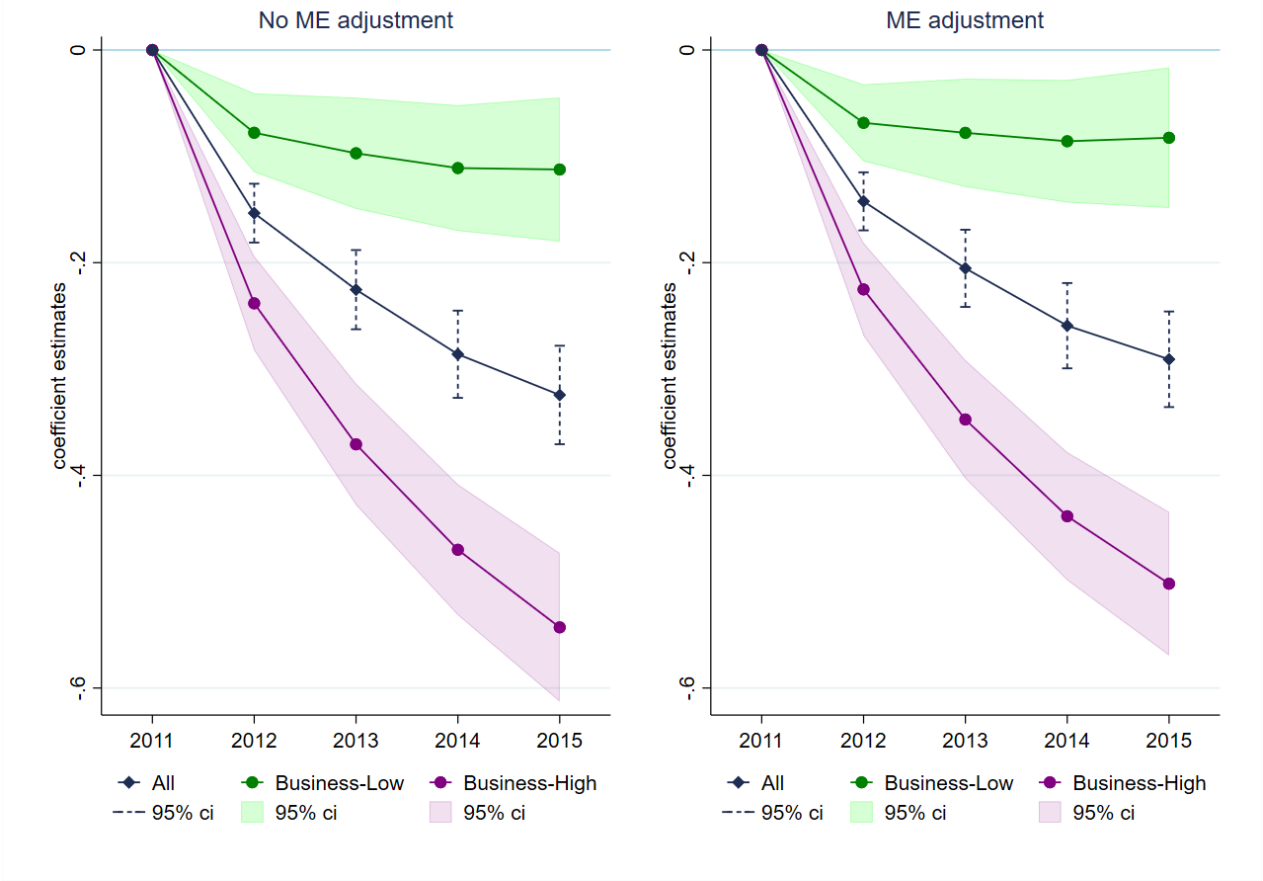
Notes: The figure provides coefficient estimates and 95% confidence intervals from specification 3.1 with *real* atr_i^{11} as the explanatory variable. The three sets of estimates result from using alternative control variables. Controls -a- only include individual and time fixed effects. Controls -b- and -c- include, additionally, the set of "decile" and "narrow" controls, respectively, interacted with time dummies. For a detailed definition of these variables see Section 4.2. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable is the share of bank accounts and bonds over total reported assets.
N: 89,265 obs

Figure 3.11: Effect on gifts



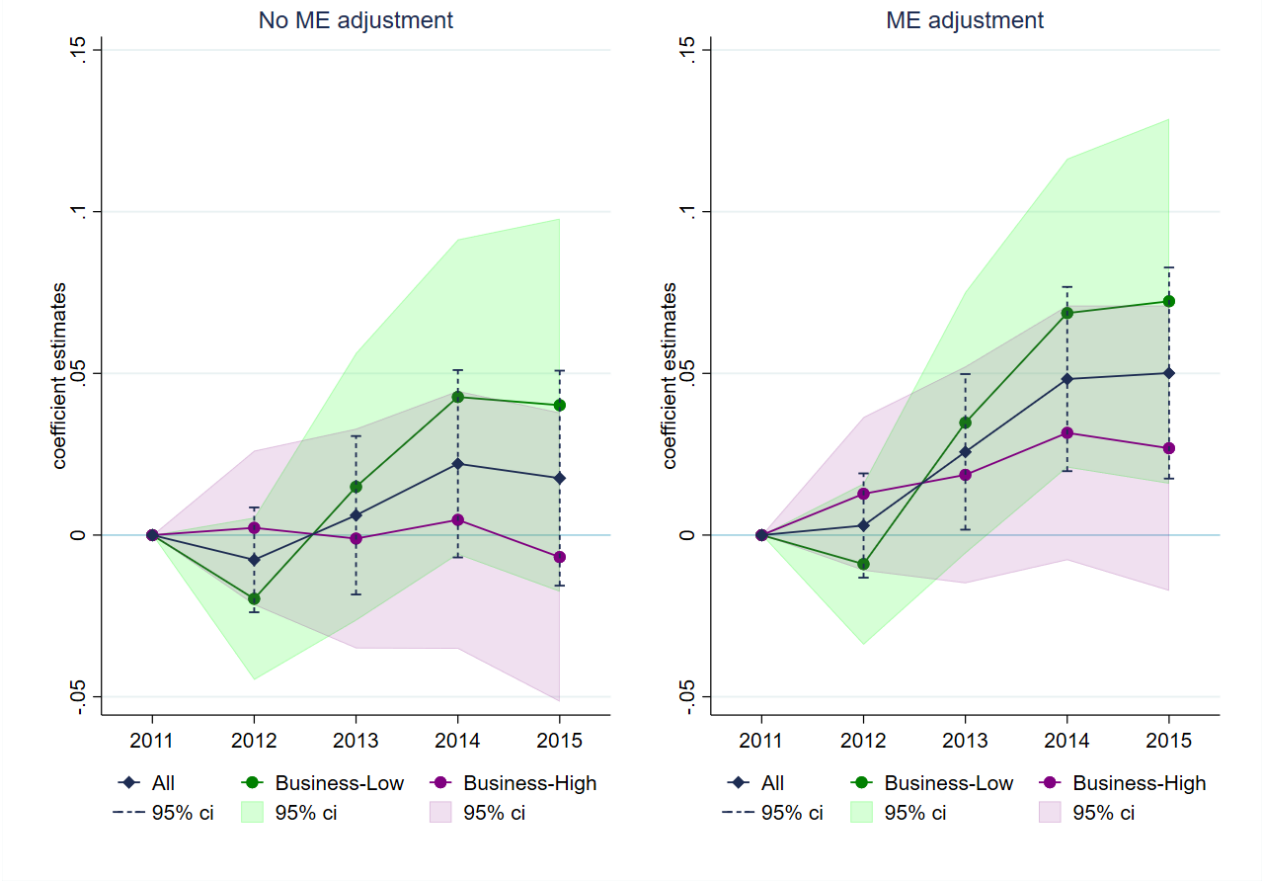
Notes: The figure provides coefficient estimates and 95% confidence intervals from specification 3.1 with *real* atr_i^{11} as the explanatory variable. The three sets of estimates result from using alternative control variables. Controls -a- only include individual and time fixed effects. Controls -b- and -c- include, additionally, the set of "decile" and "narrow" controls, respectively, interacted with time dummies. For a detailed definition of these variables see Section 4.2. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable is a dummy which equals 1 if a taxpayer makes a gift - declared to the Catalan Tax Agency - in year t, and 0 otherwise.
N: 89,265 obs

Figure 3.12: Heterogeneous effects on taxable wealth



Notes: Both figures provide coefficient estimates and 95% confidence intervals resulting from specification 3.1 using the set of control variables -c- and *real* atr_i^{11} as the explanatory variable. For a detailed definition of these variables see Section 4.2. Each figure shows three different estimates: "All", obtained when using the full estimation sample, and "Business-Low(-High)", comprising those taxpayers whose 2011 share of unlisted companies and business assets over total reported assets is below (above) the median. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable is the log of taxable wealth. It is (not) adjusted for the mechanical effect -ME- in the right-(left-) hand panel.
N: 88,325 obs (All); 45,630 obs (Business-Low); 42,695 (Business-High).

Figure 3.13: Heterogeneous effects on total reported wealth

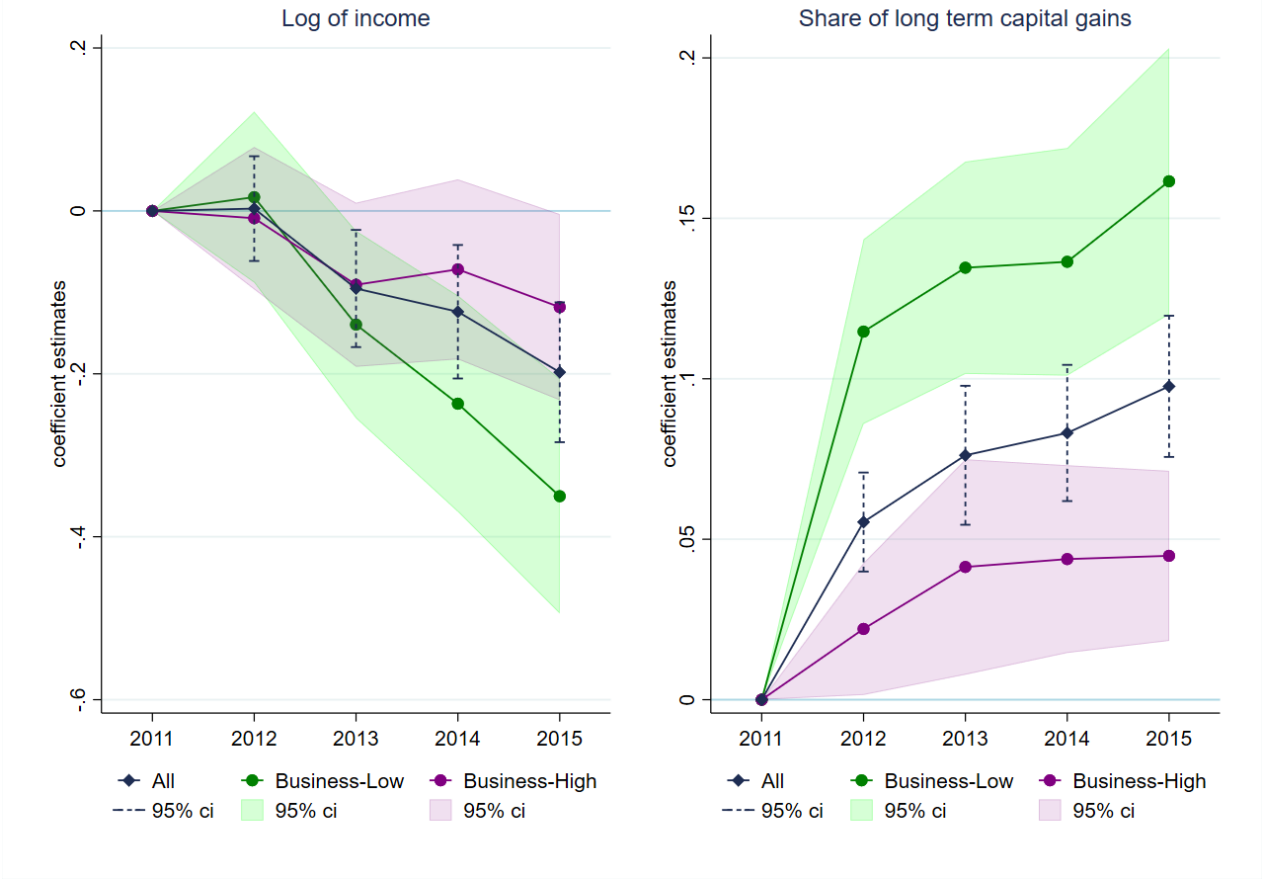


Notes: Both figures provide coefficient estimates and 95% confidence intervals resulting from specification 3.1 using the set of control variables -c- and *real* atr_i^{11} as the explanatory variable. For a detailed definition of these variables see Section 4.2. Each figure shows three different estimates: "All", obtained when using the full estimation sample, and "Business-Low(-High)", comprising those taxpayers whose 2011 share of unlisted companies and business assets over total reported assets is below (above) the median. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable is the log of total reported wealth. It is (not) adjusted for the mechanical effect -ME- in the right-(left-) hand panel. N: 89,265 obs (All); 45,700 obs (Business-Low); 43,565 (Business-High).

Figure 3.14: Heterogeneous effects on potential tax avoidance strategies

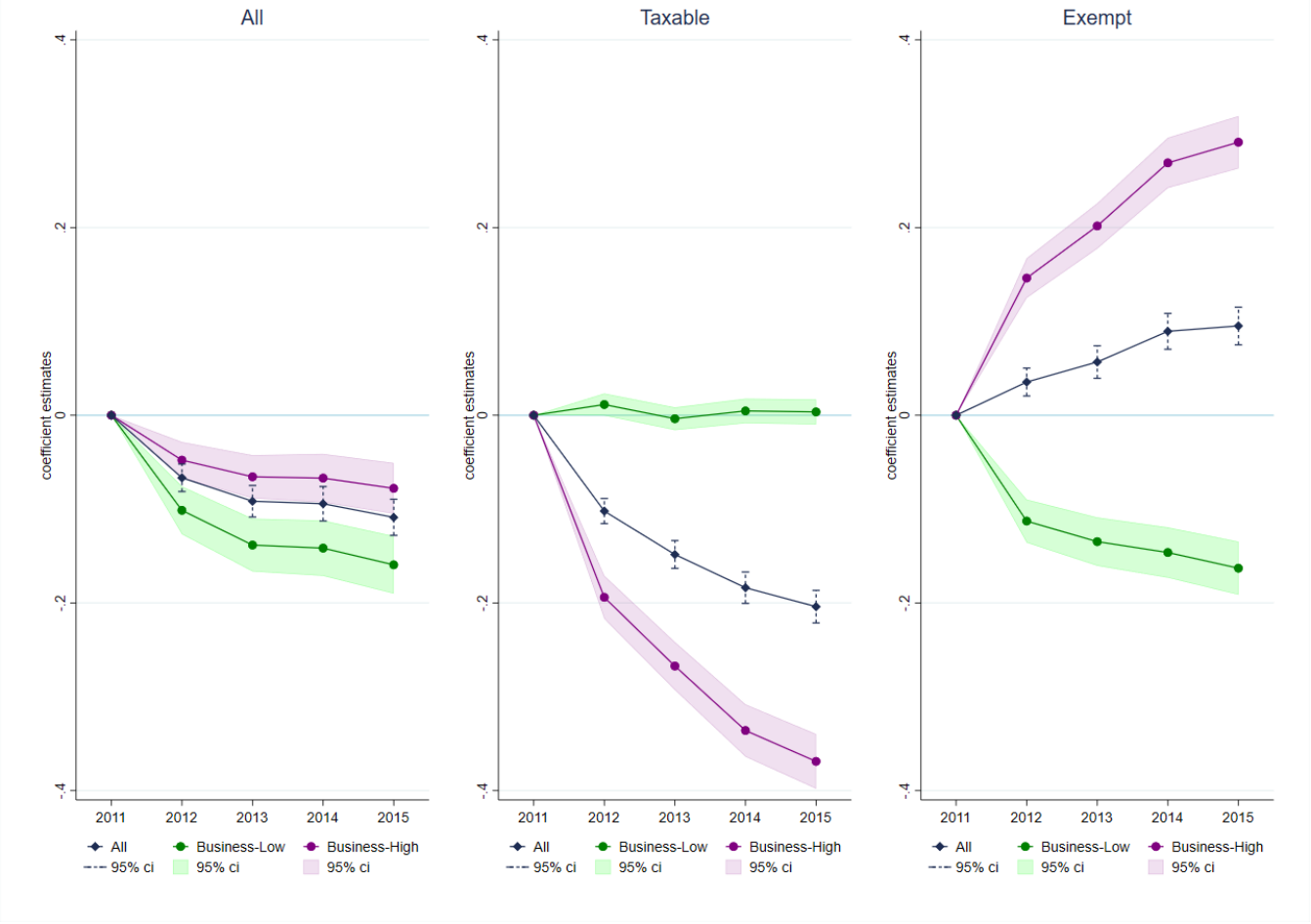
Notes: Both figures provide coefficient estimates and 95% confidence intervals resulting from specification 3.1 using the set of control variables -c- and *real* atr_i^{11} as the explanatory variable. For a detailed definition of these variables see Section 4.2. Each figure shows three different estimates: "All", obtained when using the full estimation sample, and "Business-Low(-High)", comprising those taxpayers whose 2011 share of unlisted companies and business assets over total reported assets is below (above) the median. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable in the left-hand panel is a dummy which equals 1 if a taxpayer faces the limit on the tax liability in year t, and 0 otherwise. The dependent variable in the right-hand panel is the share of exempt assets over total reported assets.
N: 89,265 obs (All); 45,700 obs (Business-Low); 43,565 (Business-High).

Figure 3.15: Heterogeneous effects on income and long-term capital gains



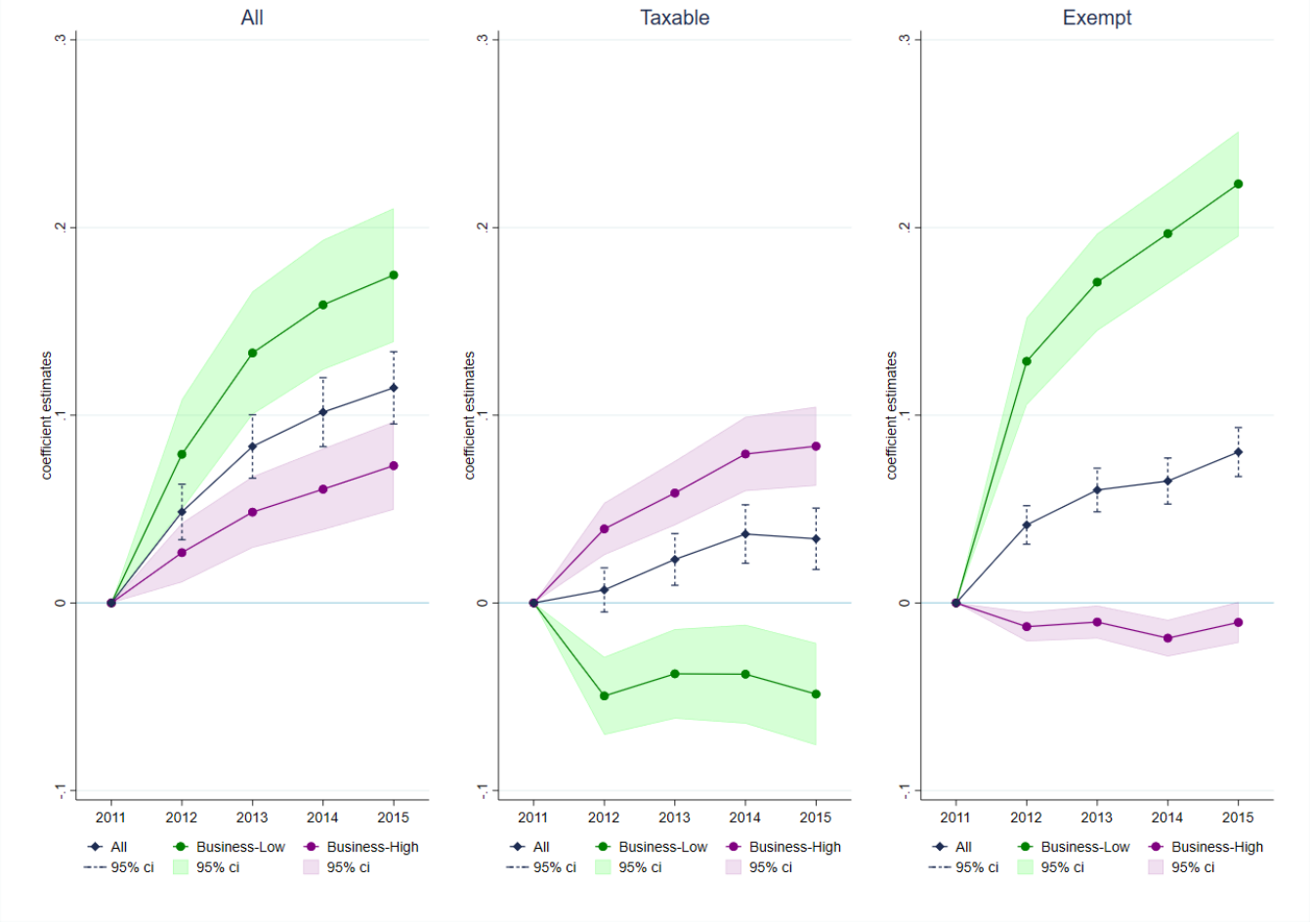
Notes: Both figures provide coefficient estimates and 95% confidence intervals resulting from specification 3.1 using the set of control variables -c- and *real* atr_i^{11} as the explanatory variable. For a detailed definition of these variables see Section 4.2. Each figure shows three different estimates: "All", obtained when using the full estimation sample, and "Business-Low(-High)", comprising those taxpayers whose 2011 share of unlisted companies and business assets over total reported assets is below (above) the median. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable in the left-hand panel is the log of taxable income. The dependent variable in the right-hand panel is the share of long term capital gains over taxable income.
N: 69,405 obs (All); 35,980 obs (Business-Low); 33,425 (Business-High).

Figure 3.16: Heterogeneous effects on unlisted companies and business assets



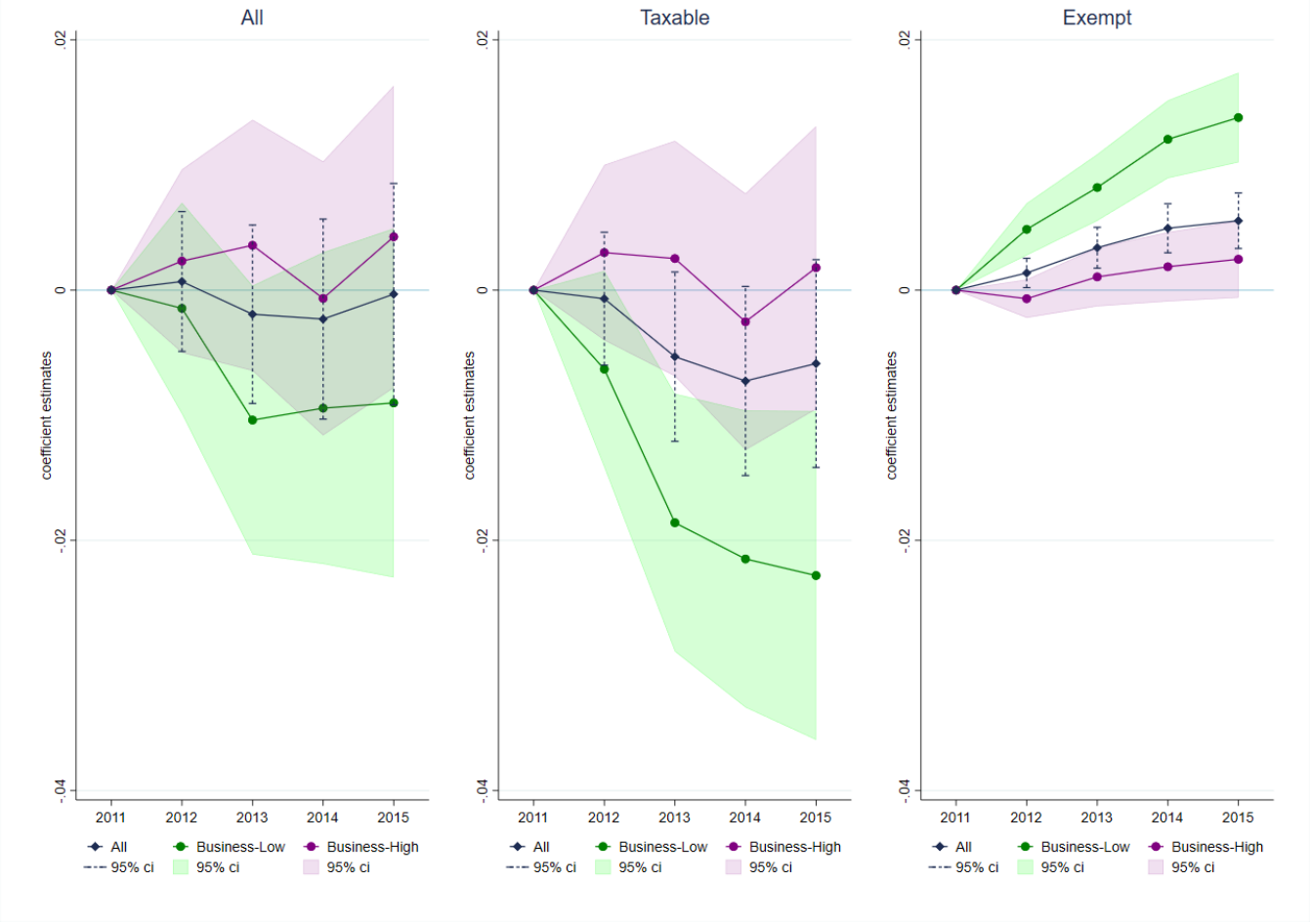
Notes: All figures provide coefficient estimates and 95% confidence intervals resulting from specification 3.1 using the set of control variables -c- and *real* atr_i^{11} as the explanatory variable. For a detailed definition of these variables see Section 4.2. Each figure shows three different estimates: "All", obtained when using the full estimation sample, and "Business-Low(-High)", comprising those taxpayers whose 2011 share of unlisted companies and business assets over total reported assets is below (above) the median. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable for the panels (from left to right) is the share of (all/taxable/exempt) unlisted companies and business assets over total reported assets.
N: 89,265 obs (All); 45,700 obs (Business-Low); 43,565 (Business-High).

Figure 3.17: Heterogeneous effects on listed equity and investment funds



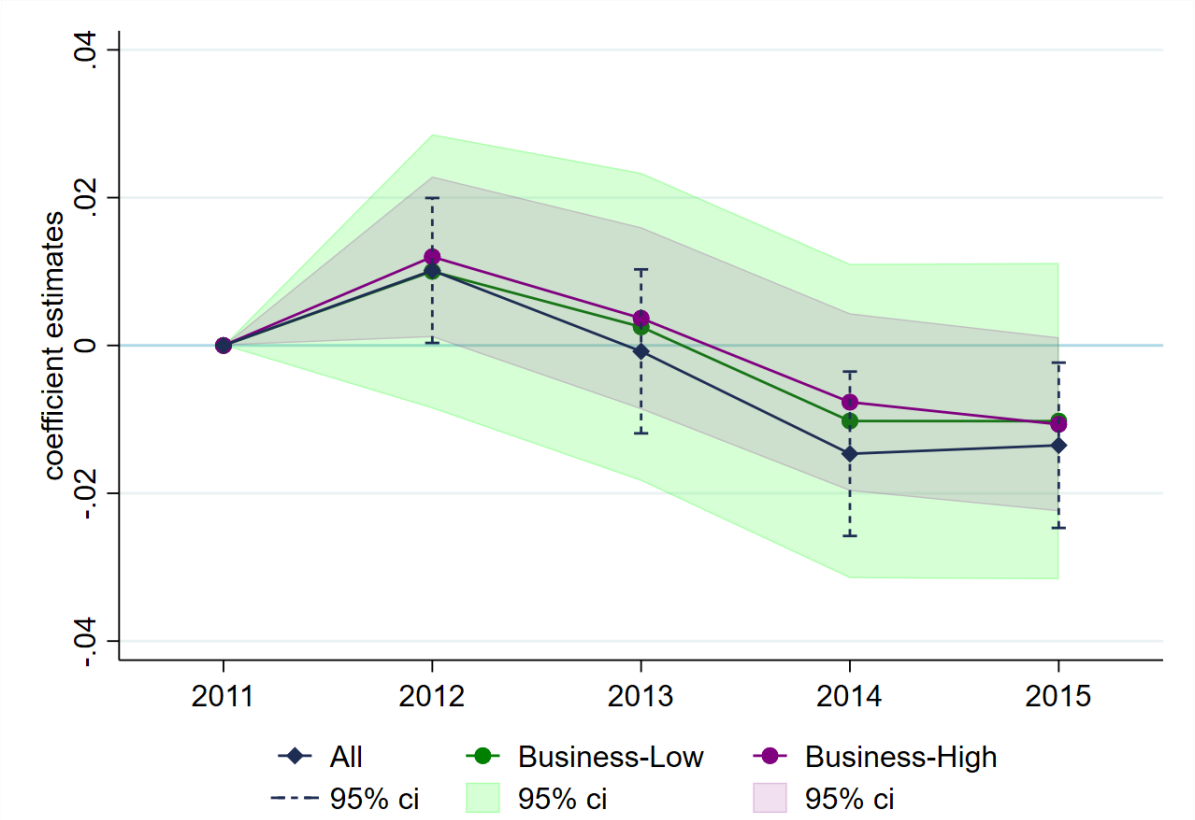
Notes: All figures provide coefficient estimates and 95% confidence intervals resulting from specification 3.1 using the set of control variables -c- and *real* atr_i^{11} as the explanatory variable. For a detailed definition of these variables see Section 4.2. Each figure shows three different estimates: "All", obtained when using the full estimation sample, and "Business-Low(-High)", comprising those taxpayers whose 2011 share of unlisted companies and business assets over total reported assets is below (above) the median. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable for the panels (from left to right) is the share of (all/taxable/exempt) listed equity and investment funds over total reported assets.
N: 89,265 obs (All); 45,700 obs (Business-Low); 43,565 (Business-High).

Figure 3.18: Heterogeneous effects on real estate



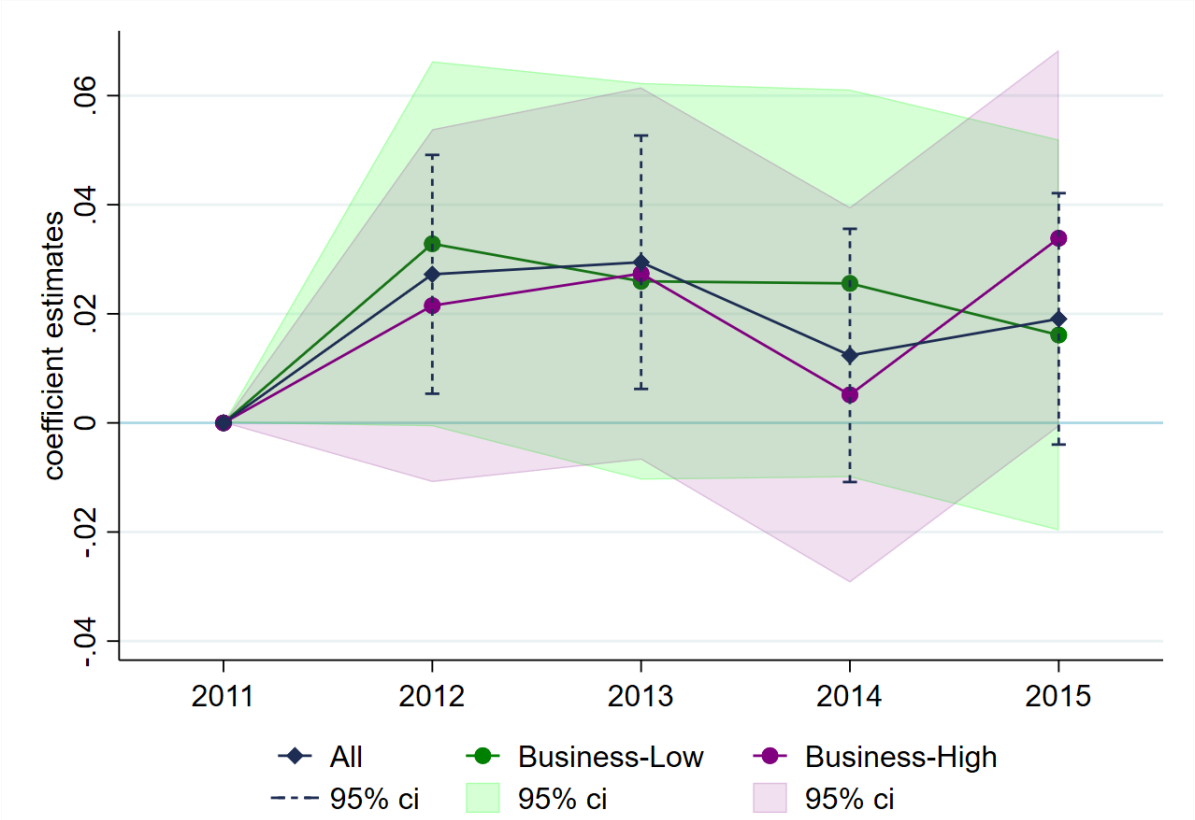
Notes: All figures provide coefficient estimates and 95% confidence intervals resulting from specification 3.1 using the set of control variables -c- and *real* atr_i^{11} as the explanatory variable. For a detailed definition of these variables see Section 4.2. Each figure shows three different estimates: "All", obtained when using the full estimation sample, and "Business-Low(-High)", comprising those taxpayers whose 2011 share of unlisted companies and business assets over total reported assets is below (above) the median. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable for the panels (from left to right) is the share of (all/taxable/exempt) real estate over total reported assets.
N: 89,265 obs (All); 45,700 obs (Business-Low); 43,565 (Business-High).

Figure 3.19: Heterogeneous effects on bank accounts and bonds



Notes: The figure provides coefficient estimates and 95% confidence intervals resulting from specification 3.1 using the set of control variables -c- and *real* atr_i^{11} as the explanatory variable. For a detailed definition of these variables see Section 4.2. Three different estimates are shown: "All", obtained when using the full estimation sample, and "Business-Low(-High)", comprising those taxpayers whose 2011 share of unlisted companies and business assets over total reported assets is below (above) the median. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable is the share of bank accounts and bonds over total reported assets.
N: 89,265 obs (All); 45,700 obs (Business-Low); 43,565 (Business-High).

Figure 3.20: Heterogeneous effects on gifts



Notes: The figure provides coefficient estimates and 95% confidence intervals resulting from specification 3.1 using the set of control variables -c- and *real* atr_i^{11} as the explanatory variable. For a detailed definition of these variables see Section 4.2. Three different estimates are shown: "All", obtained when using the full estimation sample, and "Business-Low(-High)", comprising those taxpayers whose 2011 share of unlisted companies and business assets over total reported assets is below (above) the median. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable is a dummy which equals 1 if a taxpayer makes a gift - declared to the Catalan Tax Agency - in year t, and 0 otherwise. N: 89,265 obs (All); 45,700 obs (Business-Low); 43,565 (Business-High).

3.9 Appendix

3.9.1 Business exemption

In 1994 the government introduced an exemption for business assets and closely held business shares in an effort at fostering entrepreneurial investment.[76] In 1998, this exemption was extended to listed shares.[77] However, certain conditions have to be met for these tax incentives to apply. The main requirement for the business asset exemption is that at least 50% of the taxpayers total income comes from business activities. The exemption for company shares, both listed and unlisted, applies when: (i) the company carries out an economic activity[78], (ii) the taxpayer owns at least 5%[79] of the company individually or 20% when considering the family group, and (iii) one of the family members is engaged in the management of the company and receives a retribution for these functions that represents at least 50% of their labour and business income (analogous retributions coming from other companies which also satisfy these conditions are excluded from the computation). In the case of the exemption for business shares, not only the taxpayer but the entire family group can exempt their holdings from the wealth tax if they satisfy the stipulated conditions.

According to the law, the exemption only extends as far as the share of net assets directly involved in the economic activity of the company. In this regard, although the legislation provides general instructions to determine when assets are directly involved in the economic activity[80], ultimately it is the taxpayer's responsibility to demonstrate this circumstance in the case of a tax audit being conducted.

Indeed, the way the Law was designed and its related case law initially developed greatly benefited those taxpayers able to apply the exemption. By creating the correct holding structure, a taxpayer could basically include any kind of wealth as indirect shares, since the conditions only needed to be sat-

[76] Act 22/1993, December 29th, later developed by Royal Decree 2481/1994, December 23rd.

[77] Act 66/1997, December 30th.

[78] Article 4.8. from Act 19/1991, June 6th, and Royal Decree 1704/1999, November 5th, specify the requirements to determine whether a company carries out an economic activity and all other conditions needed to apply this wealth tax exemption.

[79] 20% during 1994 and 15% until 2002. The current ownership share is well below the 25% share required in other countries such as France or Sweden (OECD, 2018).

[80] Article 6.3. from Royal Decree 1704/1999, November 5th.

isfied with respect to the direct holding.[81,82] It was not until 2007 that the legislation included the need to assess the portion of net assets directly involved in the economic activity of the indirect shares.[83]

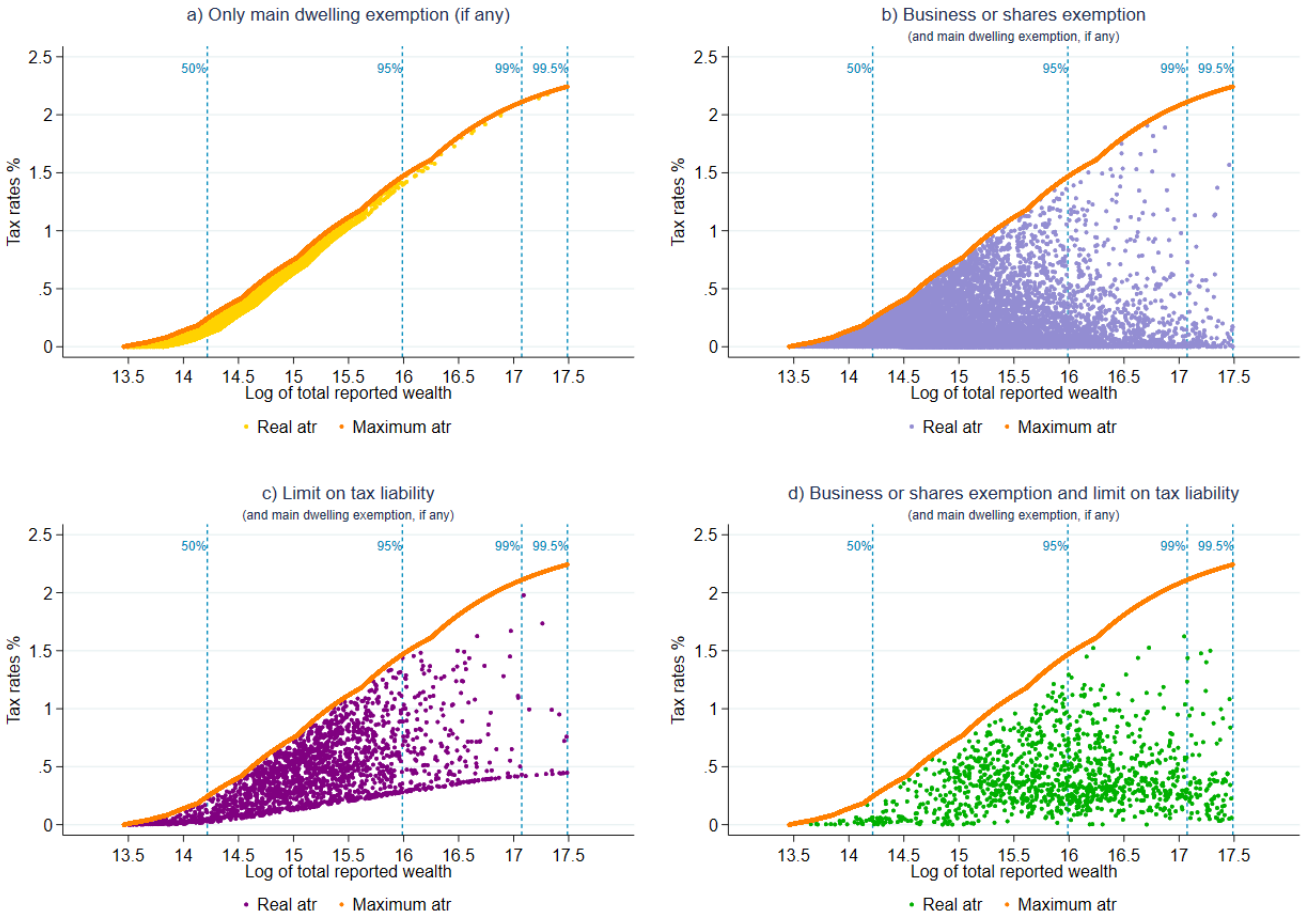
[81]The Wealth Tax Law foresees that a company which owns at least 5% of other corporations with the aim of managing their shares is carrying out an economic activity, and these shares are considered as being directly involved in the economic activity.

[82]SICAVs (Investment companies with variable capital) are the only asset type to have had their right to be exempt from the wealth tax denied by the Supreme Court, regardless of ownership via indirect shares. Indeed, this is justified by the fact that the Wealth Tax Law specifically excludes assets of this type from exemption. See Supreme Court Resolutions 21/05/2013 (Rec. 2689/2011), 03/06/13 (Rec. 2248/2011) and 16/07/2015 (Rec. 171/2014) for further information.

[83]Reform approved by Act 35/2006, November 28th.

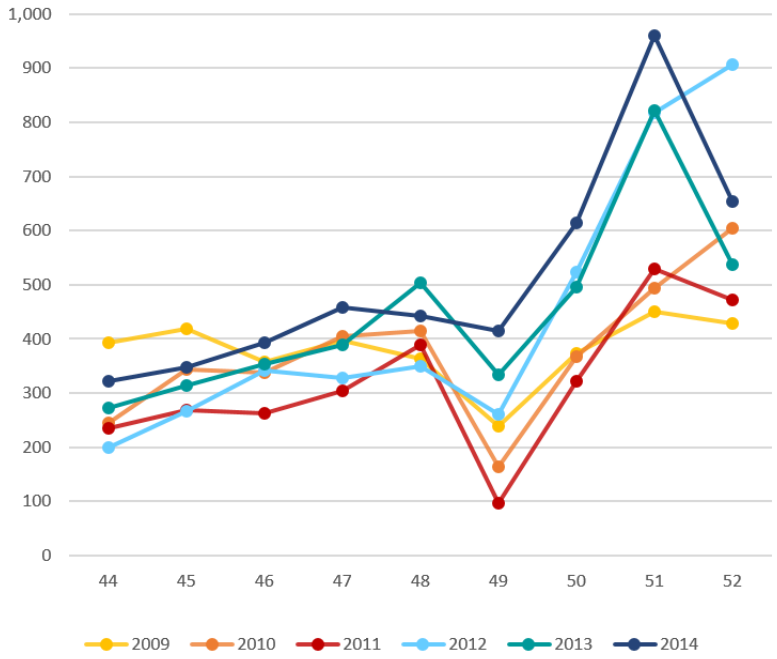
3.9.2 Figures and tables

Figure A3.1: Average tax rates, 2011



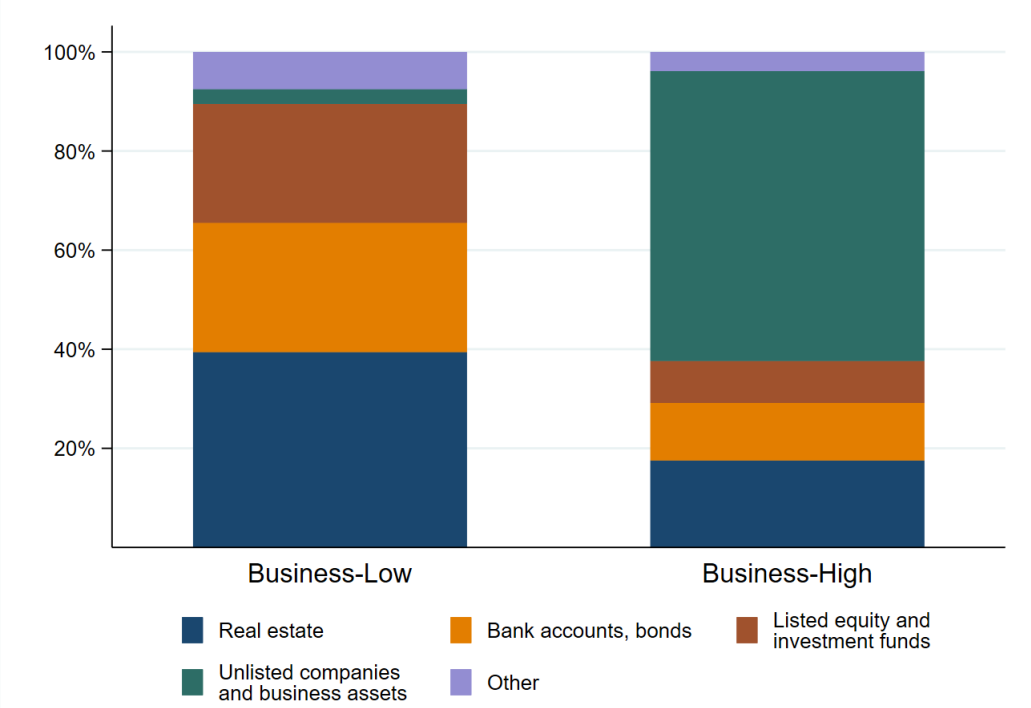
Notes: Panel a) shows the average tax rates of taxpayers who only apply main-dwelling exemption, if any. Panel b) shows the average tax rates of taxpayers who also report business exemptions (including both listed and unlisted companies). Panel c) shows the average tax rates of taxpayers who face the limit on tax liability. Panel d) shows the average tax rates of taxpayers who satisfy both cases b) and c). The real average tax rate is computed as the wealth tax liability over total reported wealth for 2011, in percentage points. Maximum average tax rate is computed applying the 2011 statutory tax rates to the overall stock of reported wealth exceeding the minimum threshold (700,000€), assuming there are no wealth exemptions and the limit on tax liability does not apply. The percentages next to the vertical dashed lines show the cumulative distribution of 2011 Catalan wealth taxpayers along total reported wealth.

Figure A3.2: Frequency of gifts made during the last 8 weeks of the year between 2009 and 2014



Notes: This figure only includes gifts reported to the Catalan Tax Agency.

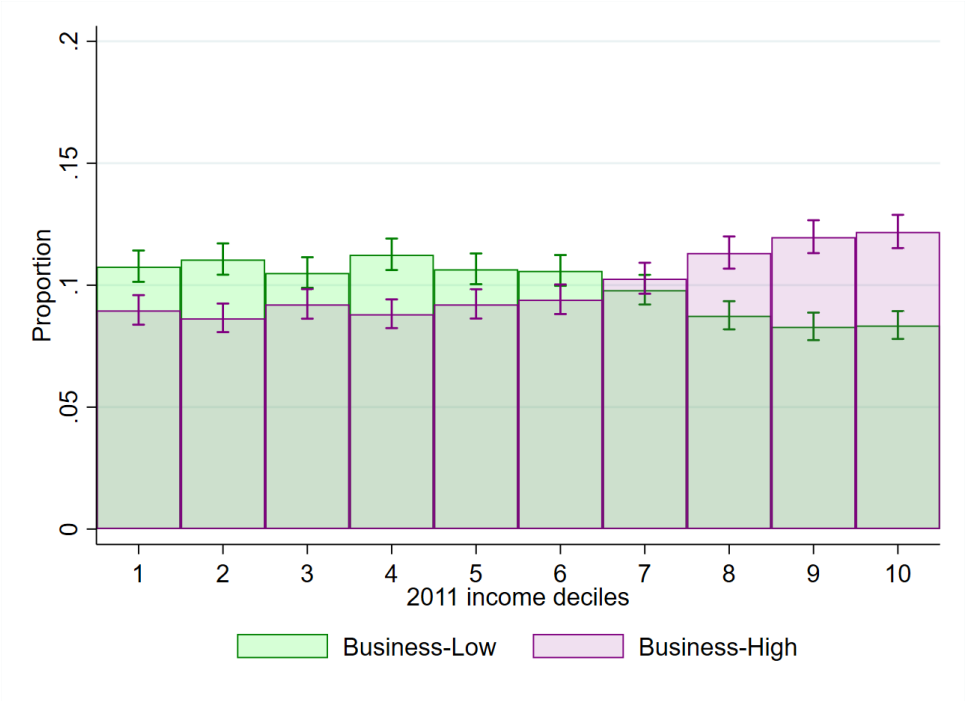
Figure A3.3: 2011 average asset portfolio by taxpayer groups: Business-Low vs. Business-High



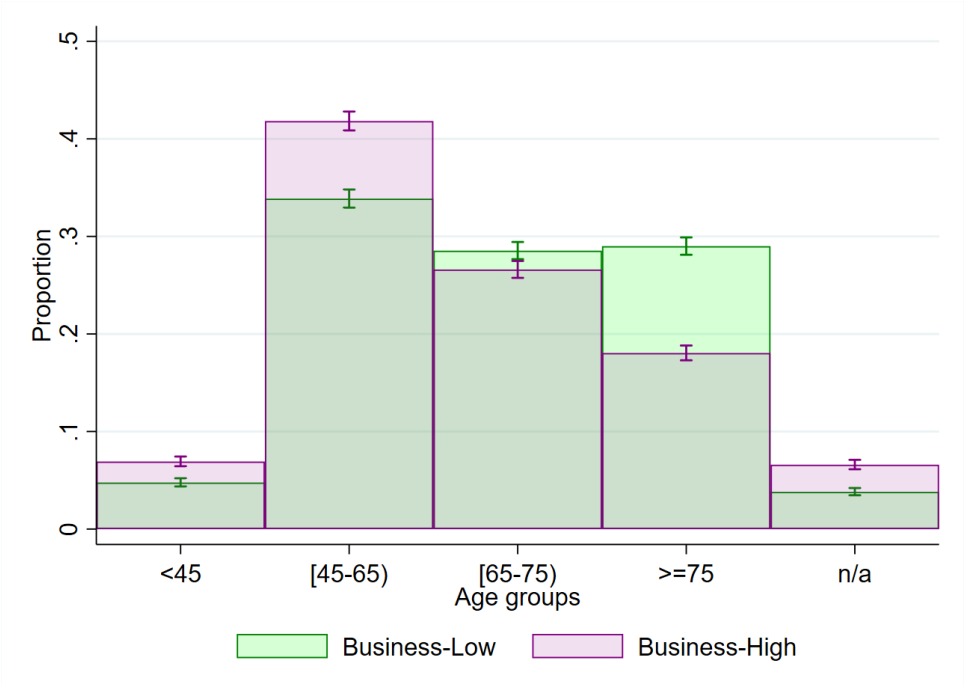
Notes: "Business-Low(-High)" taxpayers are those whose 2011 share of unlisted companies and business assets is below (above) the median. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15.

Figure A3.4: Differences between Business-Low and Business-High taxpayers

(a) 2011 income distribution



(b) 2011 age distribution



Notes: Both figures provide proportion estimates and 95% confidence intervals from the distribution of each taxpayer group across 2011 income deciles (panel a) and age groups (panel b). "Business-Low(-High)" taxpayers are those whose 2011 share of unlisted companies and business assets is below (above) the median. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15.

Table A3.1: Statutory tax rates, 2011

Tax bracket (in euros)	Marginal tax rate (%)
0.00	0.2
167,129.45	0.3
334,252.88	0.5
668,499.75	0.9
1,336,999.51	1.3
2,673,999.01	1.7
5,347,998.03	2.1
10,695,996.06	2.5

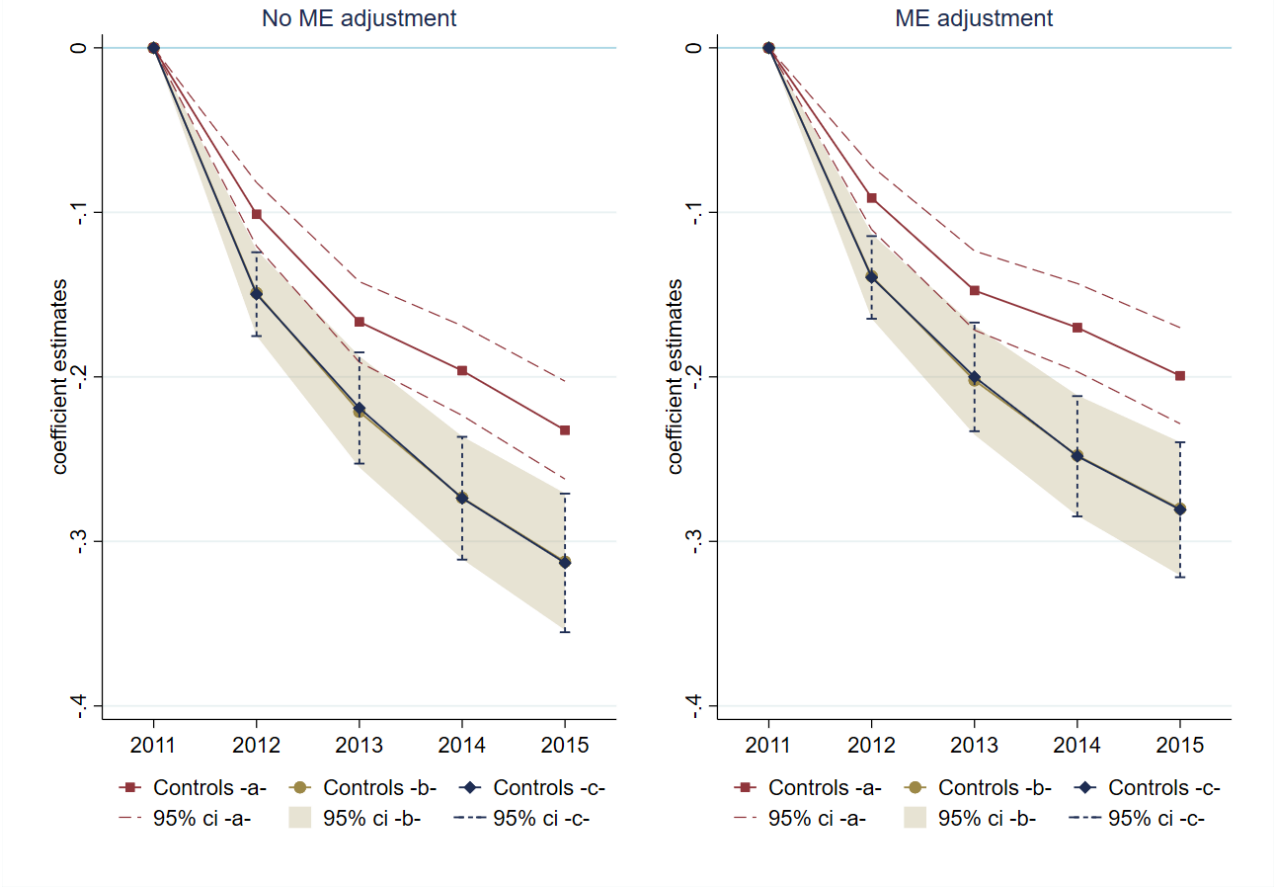
Table A3.2: Relation between average tax rates and taxpayers' wealth, income and asset portfolio in 2011

Dep. var	Log of wealth		Log of taxable income		Housing		Listed equity		Unlisted companies		Bank accounts and bonds	
	all	5y filers	all	5y filers	all	5y filers	all	5y filers	all	5y filers	all	5y filers
No controls												
2011 atr	0.4695***	0.4505***	1.1775***	1.1321***	0.0552***	0.0564***	0.1949***	0.1979***	-0.6016***	-0.5984***	0.2713***	0.2678***
	(0.0174)	(0.0189)	(0.0255)	(0.0269)	(0.0067)	(0.0074)	(0.0066)	(0.0071)	(0.0088)	(0.0094)	(0.0062)	(0.0067)
"Decile" controls												
2011 atr	0.0224**	0.0262**	0.0917***	0.0754***	-0.0003	0.0005	-0.0163***	-0.0164***	-0.0201***	-0.0219***	0.0075***	0.0068***
	(0.0107)	(0.0113)	(0.0146)	(0.0150)	(0.0011)	(0.0012)	(0.0023)	(0.0025)	(0.0014)	(0.0015)	(0.0018)	(0.0019)
"Narrow" controls												
2011 atr	-0.0025	0.0060	0.0100	-0.0032	-0.0003	-0.0003	-0.0003	-0.0003	-0.0000	0.0001	0.0000	-0.0001
	(0.0067)	(0.0068)	(0.0102)	(0.0109)	(0.0002)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Dep. var. mean	14.9554	14.9412	11.3635	11.3458	0.2815	0.2877	0.1628	0.1643	0.3127	0.3009	0.1855	0.1901
Observations	20,371	17,853	18,083	16,008	20,371	17,853	20,371	17,853	20,371	17,853	20,371	17,853

Notes: Robust standard errors, clustered by marriages, in parentheses. Only taxpayers in the top 50% of the observed 2011 wealth distribution are considered. Top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. *All* estimates refer to all 2011 taxpayers in the top 50%; *5y filers* estimates refer to those who filed wealth tax returns every year between 2011 and 2015. The last four dependent variables are expressed in shares over total assets. The number of observations related to *Log of taxable income* estimates is not as high because some taxpayers do not report information on income. "Decile" and "Narrow" controls include non-parametric variables which capture taxpayers' wealth, income, asset portfolio, age, indebtedness share and tax amnesty participation. For a detailed definition of these controls see Section 4.2. ***p<0.01, **p<0.05, *p<0.1.

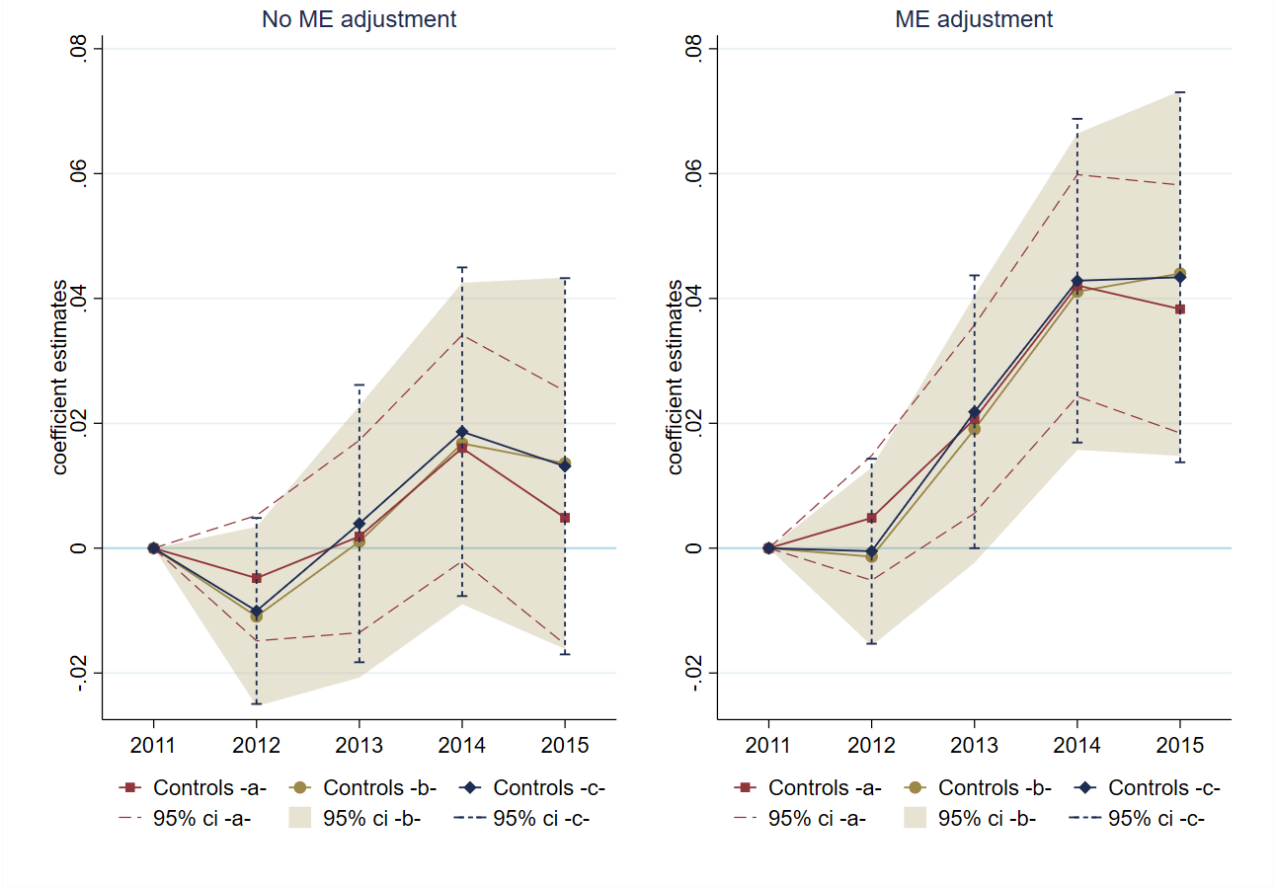
3.9.3 Main estimation results using *"estimated atr"* as the explanatory variable

Figure A3.5: Effect on taxable wealth



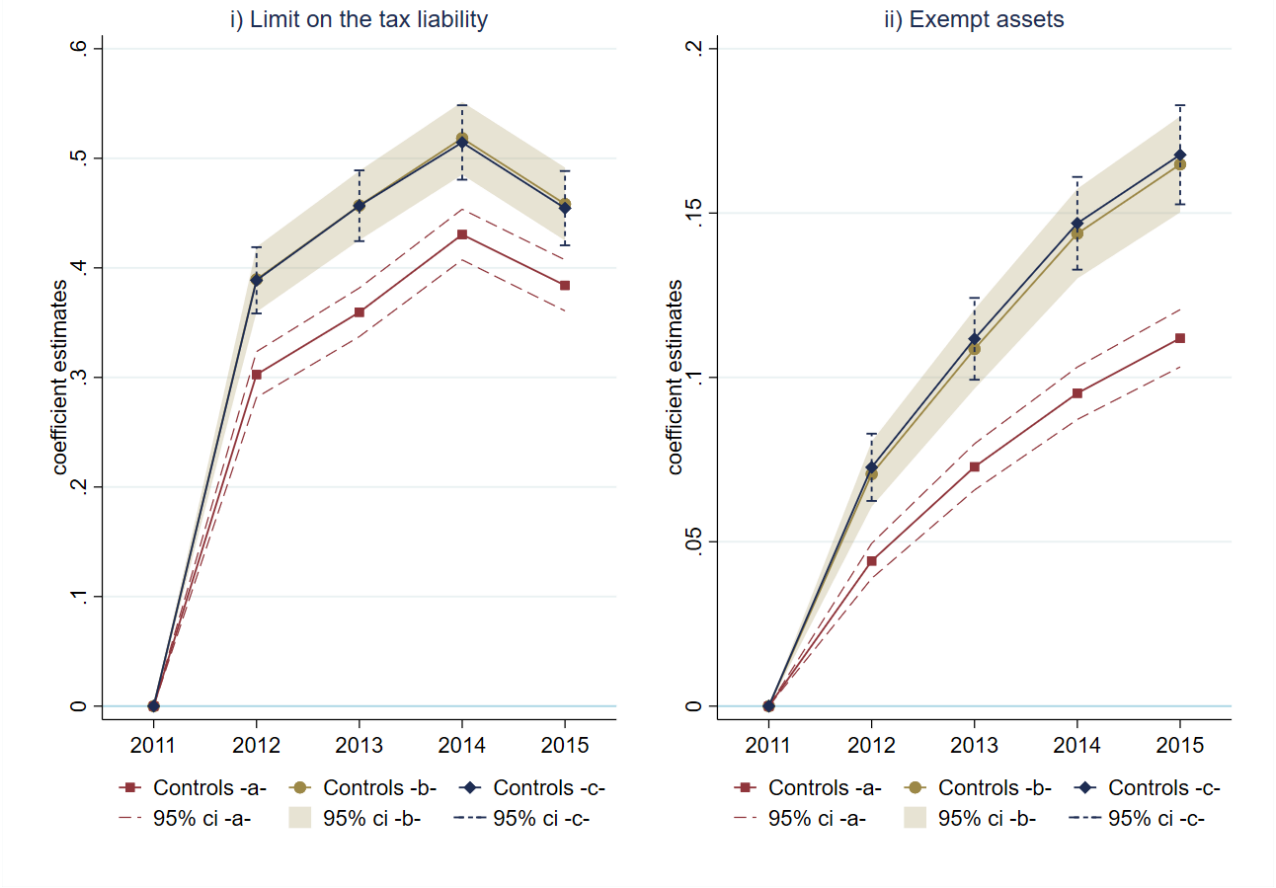
Notes: Both figures provide coefficient estimates and 95% confidence intervals from specification 3.1 with *estimated* atr_i^{11} as the explanatory variable. The three sets of estimates result from using alternative control variables. Controls -a- only include individual and time fixed effects. Controls -b- and -c- include, additionally, the set of "decile" and "narrow" controls, respectively, interacted with time dummies. For a detailed definition of these variables see Section 4.2. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable is the log of taxable wealth. It is (not) adjusted for the mechanical effect -ME- in the right (left) panel.
N: 88,325 obs

Figure A3.6: Effect on total reported wealth



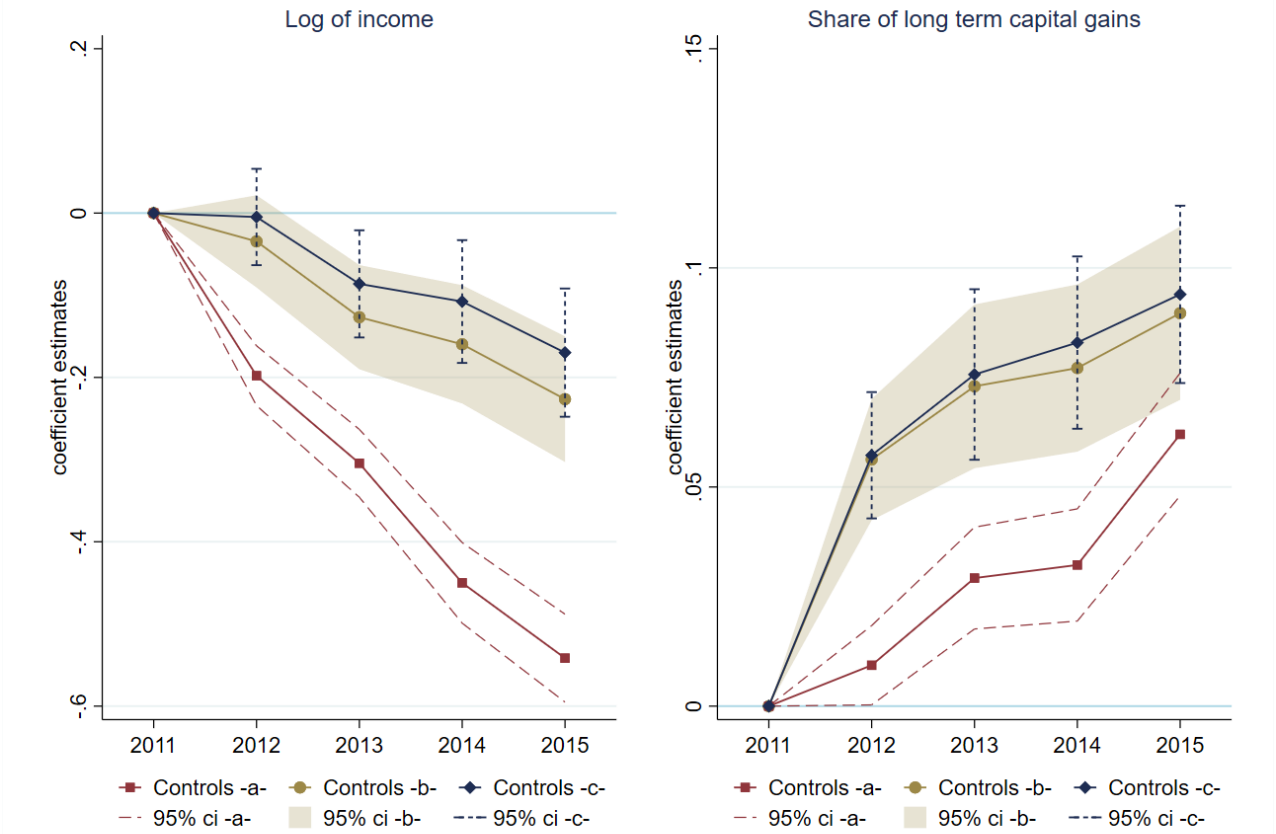
Notes: Both figures provide coefficient estimates and 95% confidence intervals from specification 3.1 with *estimated* atr_i^{11} as the explanatory variable. The three sets of estimates result from using alternative control variables. Controls -a- only include individual and time fixed effects. Controls -b- and -c- include, additionally, the set of "decile" and "narrow" controls, respectively, interacted with time dummies. For a detailed definition of these variables see Section 4.2. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable is the log of total reported wealth. It is (not) adjusted for the mechanical effect -ME- in the right (left) panel.
N: 89,265 obs

Figure A3.7: Effect on potential tax avoidance strategies



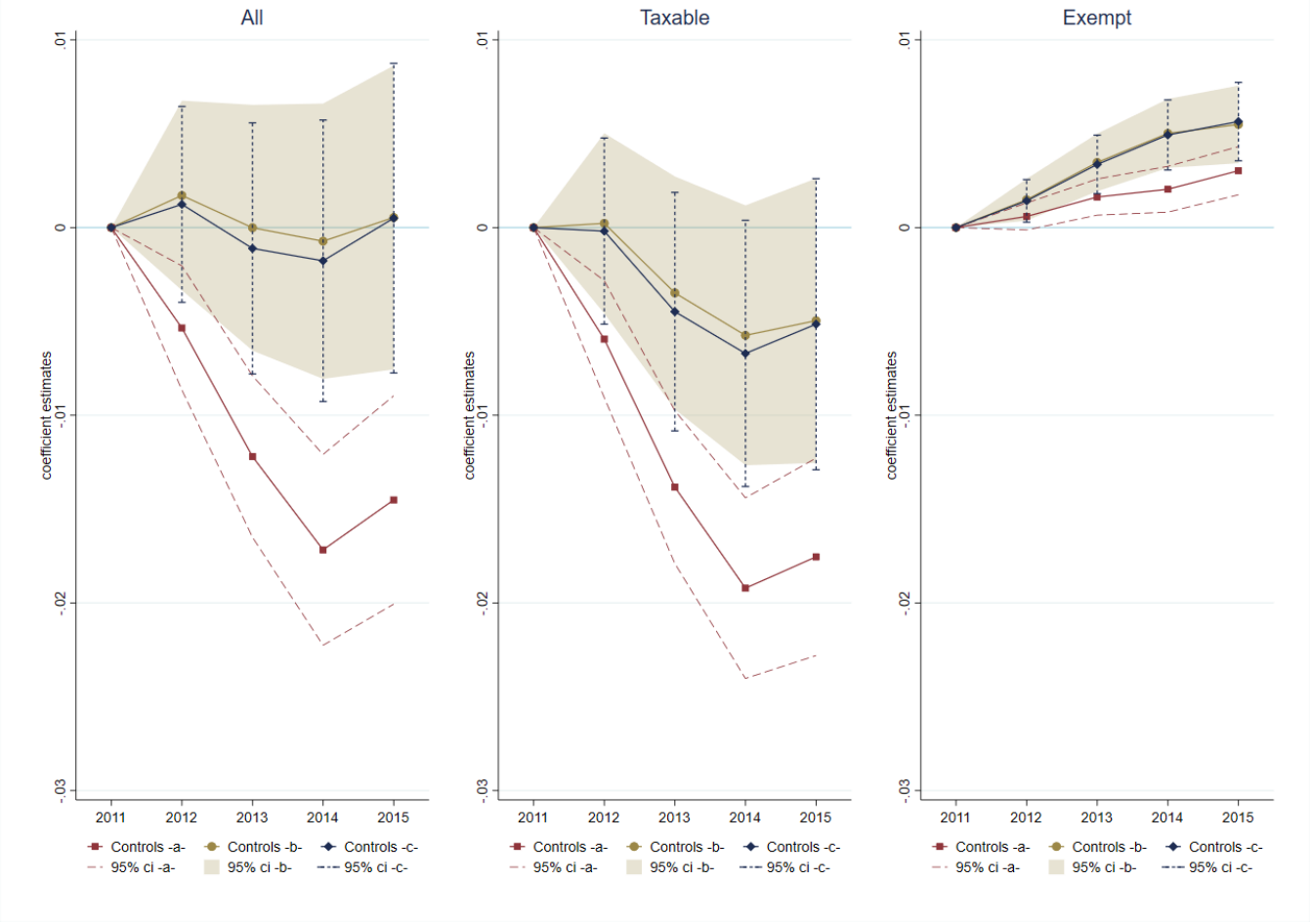
Notes: Both figures provide coefficient estimates and 95% confidence intervals from specification 3.1 with *estimated* atr_i^{11} as the explanatory variable. The three sets of estimates result from using alternative control variables. Controls -a- only include individual and time fixed effects. Controls -b- and -c- include, additionally, the set of "decile" and "narrow" controls, respectively, interacted with time dummies. For a detailed definition of these variables see Section 4.2. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable in the left-hand panel is a dummy which equals 1 if a taxpayer faces the limit on the tax liability in year t, and 0 otherwise. The dependent variable in the right-hand panel is the share of exempt assets over total reported assets.
N: 89,265 obs

Figure A3.8: Effect on income and long-term capital gains



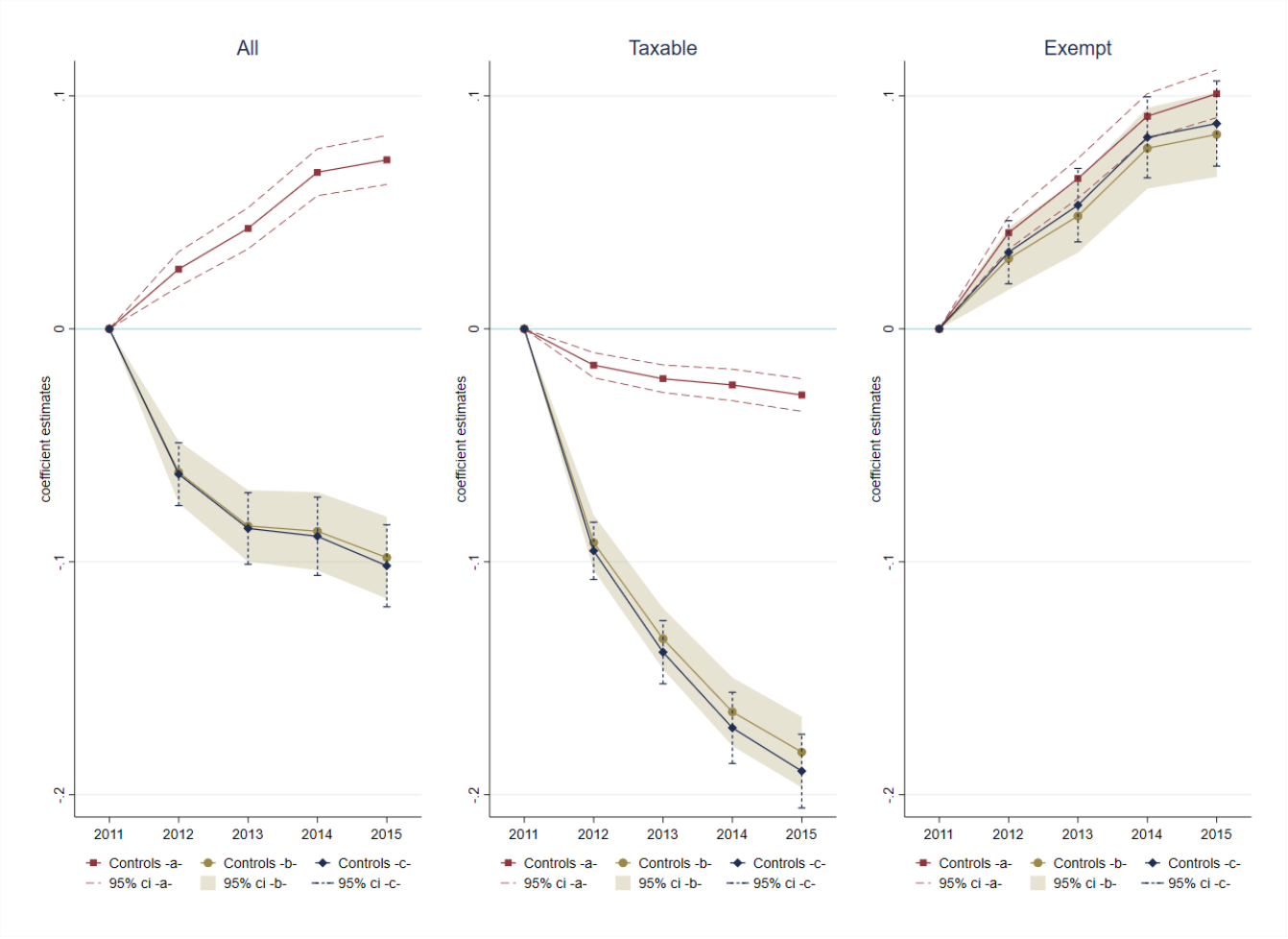
Notes: Both figures provide coefficient estimates and 95% confidence intervals from specification 3.1 with *estimated* atr_i^{11} as the explanatory variable. The three sets of estimates result from using alternative control variables. Controls -a- only include individual and time fixed effects. Controls -b- and -c- include, additionally, the set of "decile" and "narrow" controls, respectively, interacted with time dummies. For a detailed definition of these variables see Section 4.2. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable in the left-hand panel is the log of taxable income. The dependent variable in the right-hand panel is the share of long term capital gains over taxable income.
N: 69,405 obs

Figure A3.9: Effect on real estate



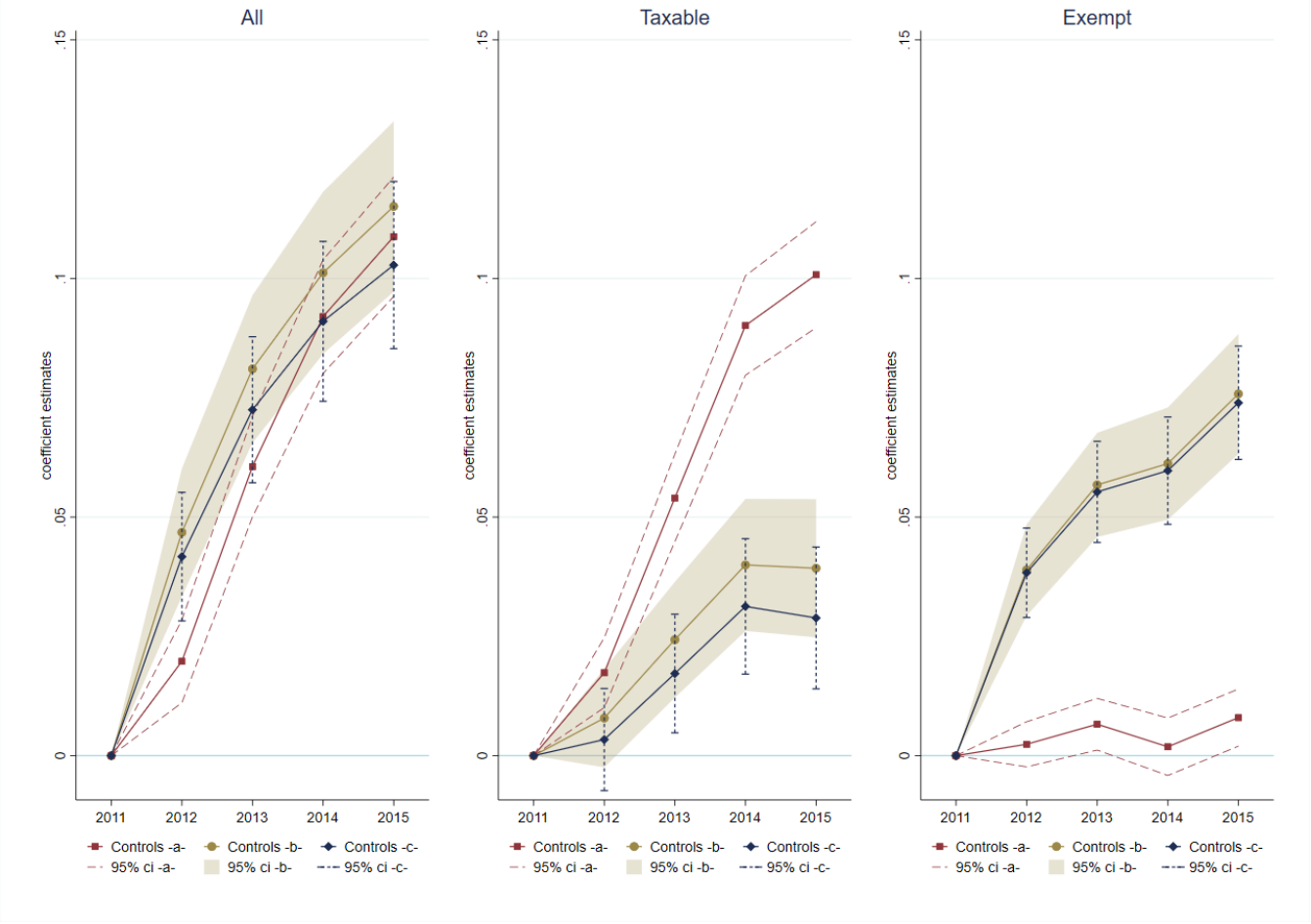
Notes: All figures provide coefficient estimates and 95% confidence intervals from specification 3.1 with *estimated* atr_i^{11} as the explanatory variable. The three sets of estimates result from using alternative control variables. Controls -a- only include individual and time fixed effects. Controls -b- and -c- include, additionally, the set of "decile" and "narrow" controls, respectively, interacted with time dummies. For a detailed definition of these variables see Section 4.2. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable for the panels (from left to right) is the share of (all/taxable/exempt) real estate over total reported assets.
N: 89,265 obs

Figure A3.10: Effect on unlisted companies and business assets



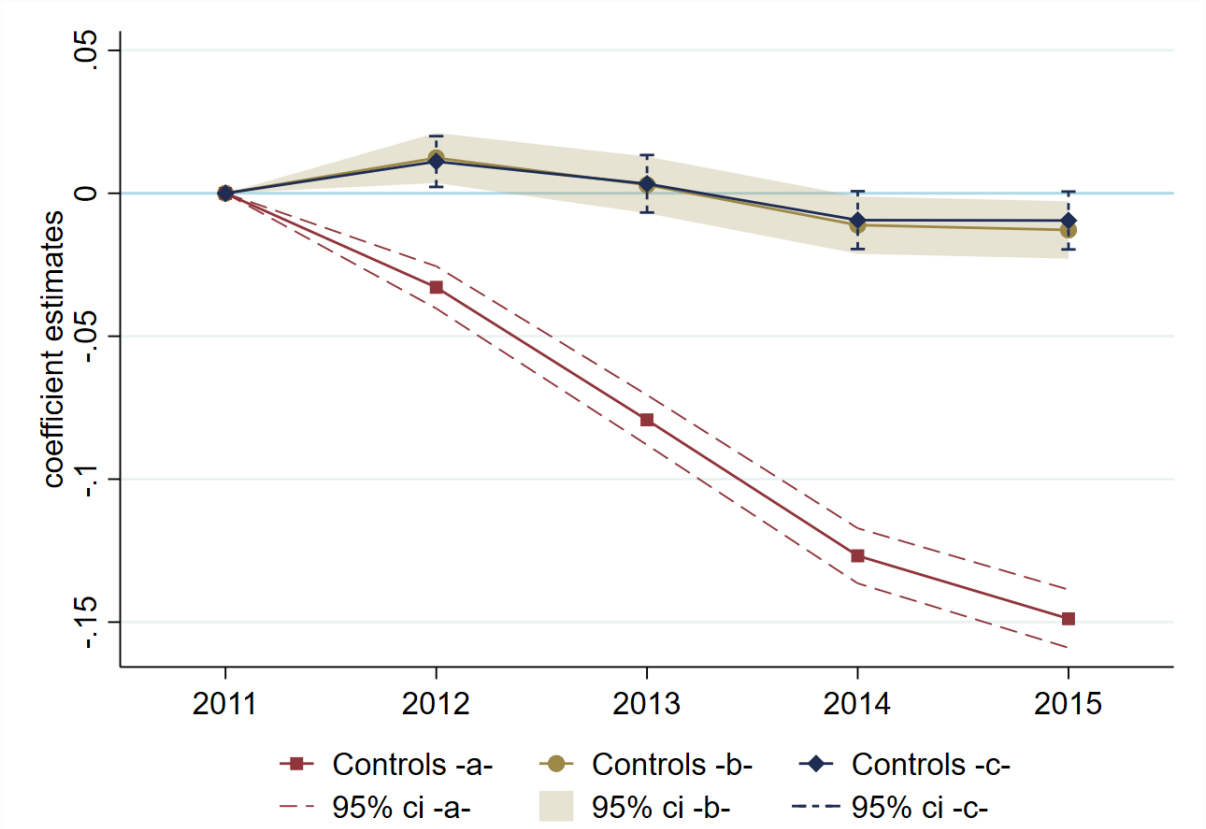
Notes: All figures provide coefficient estimates and 95% confidence intervals from specification 3.1 with *estimated* atr_i^{11} as the explanatory variable. The three sets of estimates result from using alternative control variables. Controls -a- only include individual and time fixed effects. Controls -b- and -c- include, additionally, the set of "decile" and "narrow" controls, respectively, interacted with time dummies. For a detailed definition of these variables see Section 4.2. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable for the panels (from left to right) is the share of (all/taxable/exempt) unlisted companies and business assets over total reported assets.
N: 89,265 obs

Figure A3.11: Effect on listed equity and investment funds



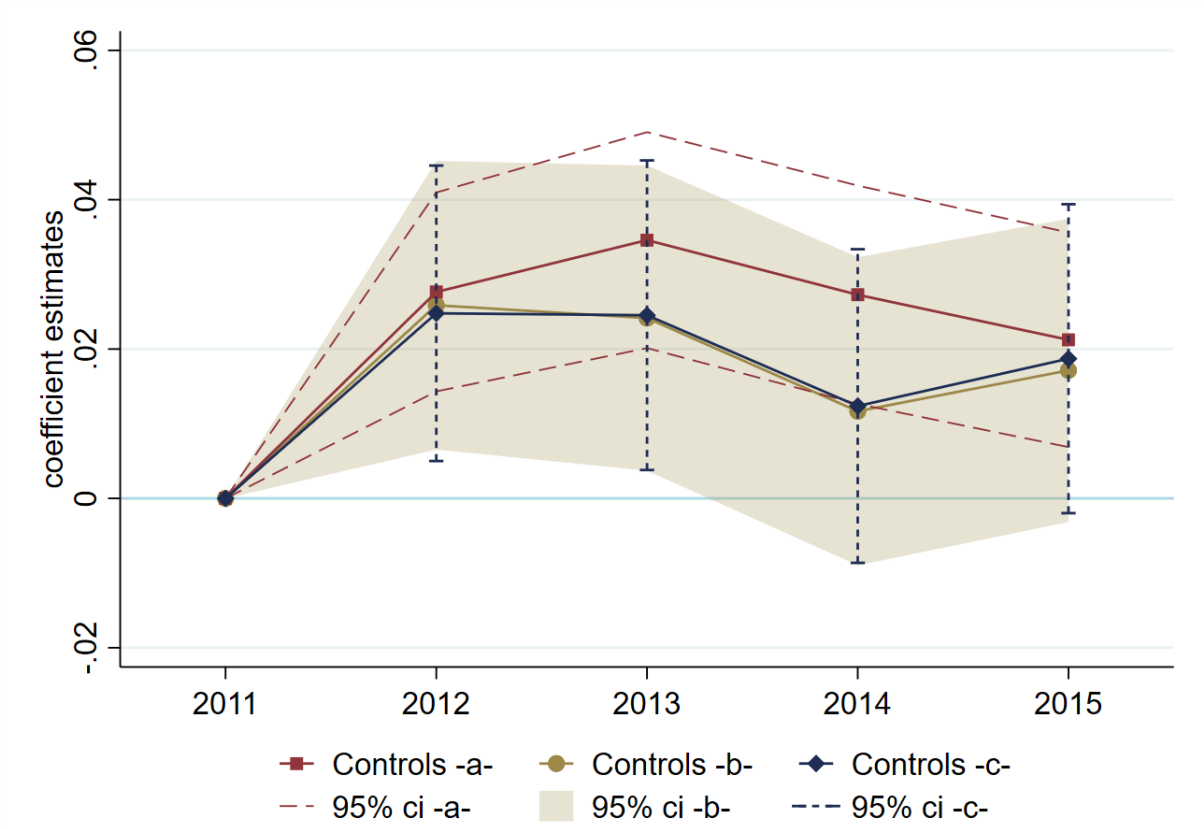
Notes: All figures provide coefficient estimates and 95% confidence intervals from specification 3.1 with *estimated* atr_i^{11} as the explanatory variable. The three sets of estimates result from using alternative control variables. Controls -a- only include individual and time fixed effects. Controls -b- and -c- include, additionally, the set of "decile" and "narrow" controls, respectively, interacted with time dummies. For a detailed definition of these variables see Section 4.2. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable for the panels (from left to right) is the share of (all/taxable/exempt) listed equity and investment funds over total reported assets.
N: 89,265 obs

Figure A3.12: Effect on bank accounts and bonds



Notes: The figure provides coefficient estimates and 95% confidence intervals from specification 3.1 with *estimated* atr_i^{11} as the explanatory variable. The three sets of estimates result from using alternative control variables. Controls -a- only include individual and time fixed effects. Controls -b- and -c- include, additionally, the set of "decile" and "narrow" controls, respectively, interacted with time dummies. For a detailed definition of these variables see Section 4.2. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable is the share of bank accounts and bonds over total reported assets.
N: 89,265 obs

Figure A3.13: Effect on gifts



Notes: The figure provides coefficient estimates and 95% confidence intervals from specification 3.1 with *estimated* atr_i^{11} as the explanatory variable. The three sets of estimates result from using alternative control variables. Controls -a- only include individual and time fixed effects. Controls -b- and -c- include, additionally, the set of "decile" and "narrow" controls, respectively, interacted with time dummies. For a detailed definition of these variables see Section 4.2. The estimation sample is a balanced panel of the 50% richest taxpayers, according to the stock of wealth reported in 2011, who filed wealth tax returns every year between 2011-15. Standard errors are clustered by marriages and top 0.5% of income and wealth distributions are excluded from the estimations to avoid outliers. The dependent variable is a dummy which equals 1 if a taxpayer makes a gift - declared to the Catalan Tax Agency - in year t, and 0 otherwise.
N: 89,265 obs

Chapter 4

Detecting Tax Evasion Through Wealth Tax Returns

4.1 Introduction

Tax evasion has important and harmful consequences for society; it distorts the equity and fairness of the tax systems and reduces government budgets, which in turn translates into less public investment and less social expenditure. The main challenge tax agencies face in fighting this problem is its undetectability. The existence of jurisdictions with banking secrecy and low or no taxation - commonly known as tax havens - extremely complicates the traceability of evasion practices.

Indeed, wealth held offshore does not seem negligible: Zucman (2013) estimates that the equivalent of 10% of world GDP is held in tax havens, although there is heterogeneity across countries (Alstadsæter, Johannesen and Zucman, 2018). Alstadsæter, Johannesen and Zucman (2019) show that, in the case of Scandinavian countries, offshore tax evasion is very concentrated at the top of the wealth distribution. In particular, authors find that the 0.01% richest households evade about 25% of their taxes.[1] Overall, little is still known about tax evasion of richest individuals because it can hardly be detected through random tax audits (Alstadsæter, Johannesen and Zucman, 2019).

In this context, this paper[2] exploits a tax amnesty implemented by the Spanish government in 2012 to study tax evasion among the wealthiest taxpayers. Using administrative data we are able to identify wealth tax evaders

[1] This share is far above the 2.8% or the 2.2% income tax gap estimated for Denmark in Kleven et al. (2011) and Alstadsæter, Johannesen and Zucman (2019), respectively, from using different waves of random audits conducted by the Danish Tax Authority.

[2] This paper is joint work with Daniel Mas Montserrat.

and observe the information they were reporting while evading. In particular, through belated wealth tax returns submitted after the voluntary period - by the end of the tax amnesty program -, we are able to identify taxpayers voluntarily disclosing previously hidden wealth and quantify the levels of evasion.

In this regard, the objective of the paper is twofold. First, we want to describe the evasion voluntarily disclosed. Not only in aggregate terms, but also across taxpayers' wealth distribution. As previously anticipated, little is still known about the levels of evasion among the wealthier and its distribution. Moreover, little information from the Spanish tax amnesty is publicly available, thus the findings reported here might be useful to learn more about who, and to what extent, participated in this voluntary disclosure program. Second, we want to learn whether tax evaders can be detected with the information they initially report - i.e. when evasion is still not disclosed -, and if so, how can they be detected. The answer to this question might have relevant policy implications since it can be of great use for governments and tax agencies fighting against tax fraud.

Wealth taxpayers in Catalonia disclosed previously hidden wealth of, at least, 10,829 million euros, which accounts for 5.4% of the Catalan GDP. The data indicates that most of the disclosed wealth relates to financial assets, which necessarily must reflect wealth held abroad (except for cash), since the Spanish Tax Agency automatically receives information on financial assets held in Spanish entities.

Taxpayers initially reporting lower levels of wealth are less likely to voluntarily disclose evaded wealth, but, in the case they do, the portion disclosed and the share of taxes evaded is higher, on average. When ranking taxpayers according to their total wealth (including the portion disclosed), the probability of voluntarily disclosing hidden assets increases with wealth, up to almost 45% for the top 1% of wealth taxpayers (which represent around 0.01% of the population of income tax filers). Wealth disclosers evaded, on average, 30% of their wealth, regardless of their position in the upper half of the wealth distribution. Evaders who filed in the voluntary period were initially evading, on average, 60% of their wealth tax liabilities and between 5 and 30% of the income taxes owed. The former average stays constant across most of the distribution, but the latter increases with wealth.

This first part of the paper contributes to the broad literature on tax evasion[3], but in particular, to the literature studying offshore evasion (e.g. Roine

[3]See Slemrod (2018) for a review of recent studies.

and Waldenström, 2009; Zucman, 2015; Alstadsæter, Johannesen and Zucman, 2018) and, more specifically, to the scarce empirical literature analysing, at individual level, the participation in tax amnesties and voluntary disclosure programs (Johannesen et al., 2018; Alstadsæter, Johannesen and Zucman, 2019; Londoño-Vélez and Ávila-Mahecha, 2019).[4]

Next, we frame tax evasion detection as a binary classification problem. Given the values reported in wealth tax returns filed during the voluntary period by each taxpayer, we estimate the probability of this being evader with a binary classifier. We train and evaluate multiple classifiers commonly used in supervised machine learning methods. Accuracy rates are very similar between linear and non-linear methods and approximate the upper bound of the estimated maximum achievable accuracy, which is 68.8%. Therefore, with the relatively little information available from wealth tax returns, which mostly relates to wealth composition and income levels, it is already possible to distinguish evaders from (presumably) non-evaders with an accuracy around 65%.

This second part of the paper contributes to the literature on machine learning and tax fraud detection. While machine learning, and recently Deep Learning, are commonly used in solving many problems of computer vision and natural language processing[5], such methods are still less predominant in economics and other social sciences.[6] Nonetheless, they have also been used in detecting fraudulent activities: unauthorized use of credit card or mobile transactions (e.g. Adewumi and Akinyelu, 2017; Choi and Lee, 2018), fraudulent insurance claims (e.g. Palacio, 2018), corruption (e.g. López-Iturriaga and Sanz, 2018) and tax evasion (e.g. Serrano et al., 2012; Castellón González and Velásquez, 2013; Junqué de Fortuny et al., 2014; Tian et al., 2016; Shukla et al., 2018; Pérez López, Delgado Rodríguez and de Lucas Santos, 2019). The existing literature mainly studies tax evasion detectability in common taxes such as personal or corporate income taxation or VAT. Hence, this is - to the best of our knowledge - the first paper trying to predict wealth tax evasion among the wealthier. We are aware of the limitations of this exercise, which relate to a potential self-selection of evaders participating in voluntary disclosure programs. Nonetheless, given that little is still known about wealth evasion

[4]Other papers analyse tax amnesties and voluntary disclosure programs from a theoretical perspective or from an aggregate level (Bayer, Oberhofer and Winner, 2015; Langenmayr, 2017; Andersson, Schroyen and Torsvik, 2019).

[5]LeCun, Bengio and Hinton (2015) provide an explanation of different methods and several examples.

[6]For those readers not familiarized with machine learning techniques, Mullainathan and Spiess (2017) provide an insightful illustration of how supervised machine learning methods work and discuss which kind of economic problems can and cannot be solved by applying these methods.

and wealthy evaders, we believe it might still be useful to detect this type of evaders, not only for research purposes, but also to governments and tax authorities. Moreover, the same exercise could be applied to evaders named in leaked data such as Swiss leaks or Panama papers (as long as tax authorities collect enough observable characteristics).

The remaining of the paper proceeds as follows: In section 4.2 we present the institutional setting regarding the tax amnesty studied. In section 4.3 we introduce the data employed and discuss evasion categorization. In section 4.4 we quantify the levels of evasion voluntarily disclosed and in section 4.5 we describe its distribution across taxpayers' wealth percentiles. In section 4.6 we present the tax evasion detection exercise and section 4.7 concludes.

4.2 Tax amnesty

At the end of March 2012, the Spanish government passed a law which enabled to regulate and implement a tax amnesty until November of that year. The legislation which regulated the particularities of the tax amnesty was passed on May 31[7], although two additional reports were issued by the Ministry of Finance on June 27 and October 11 to clarify several aspects of this measure. In this regard, the tax amnesty was initially perceived as a 10% tax on evaded assets and rights held until the end of 2010. Nevertheless, the first report issued by the Ministry of Finance changed the interpretation of the norm and stated that the 10% tax should be only applied to the evaded wealth generated during the non-prescribed years.[8] Thus the tax amnesty offered the possibility to regularize evaded income by paying a 10% tax on the gross revenues generated

[7] *Orden HAP/1182/2012, de 31 de mayo, por la que se desarrolla la disposición adicional primera del Real Decreto-ley 12/2012, de 30 de marzo, por el que se introducen diversas medidas tributarias y administrativas dirigidas a la reducción del déficit público, se aprueban cuantas medidas resultan necesarias para su cumplimiento, así como el modelo 750, declaración tributaria especial, y se regulan las condiciones generales y procedimiento para su presentación.*

[8] Tax prescription period in Spain is four years starting when the voluntary tax filing period ends. In the case of tax crimes (i.e. when the owed tax liability exceeds 120,000 euros), the prescription period at that time was of five years instead. The voluntary period to file personal income taxes of calendar year t ends at the very end of June or at the beginning of July of year $t+1$. Therefore, in the case of natural persons, the non-prescribed years affected by the tax amnesty were 2007 to 2010 (or 2006 to 2010 for potential tax criminals willing to avoid criminal charges) if the voluntary disclosure form was submitted before July 2012. On the contrary, if the voluntary disclosure form was submitted from July 2012 on, the non-prescribed years were 2008 to 2010 (or 2007 to 2010 for potential tax criminals). In the case of corporations it depended on the specific fiscal year of the firm.

from evaded wealth between 2008 and 2010.[9] Moreover, taxpayers participating in this program would be exempt from fines, interests and fees and also prevented from tax crime charges. Additionally, the amnesty regulation ensured further protection to participants with regards to their anonymity - participants' identity could not be disclosed - and tax audits procedures, which could not be initiated with this tax declaration.

Evaders could also legalise their situation through the standard procedure, which consisted of paying back taxes from the non-prescribed years with an additional charge up to 20% and a 5% interest rate.[10] The personal income tax rates enforced at that time ranged between 18% (2007-2009) to almost 21% (2010) for financial capital income. The top marginal tax rate for the remaining types of income was of 43% during the 2007-2010 period, and it was applicable on taxable bases exceeding around 50,000 euros.

The tax amnesty allowed to regularize evaded income earned until 2010, thus it was very likely that participants in the program had to amend 2011 income tax returns as well. Moreover, the amnesty only reached income taxes (either personal, corporate or non-resident income taxes), which in turn implied that its participants needed to legalise their situation with respect to other taxes such as VAT or the wealth tax. The Spanish government had reintroduced the net wealth tax in 2011[11] and hence taxpayers participating in the amnesty needed to submit an amended 2011 wealth tax return to avoid being sanctioned (and eventually prosecuted for tax crimes).

The last month of the tax amnesty was accompanied by a tightening of the tax law and sanctions. On October 29, 2012, the government passed a law which requires tax residents to report assets held abroad and highly sanctions those failing to do so.[12] In particular, each omitted value carries a 5,000 euros fine. Moreover, if the Tax Agency discovers these undeclared assets, they will be considered as unjustified capital gains from the oldest non-prescribed year and taxed accordingly.[13] Besides charges and interests, an additional fine of

[9]The way to compute the evaded income was not straightforward because of many specificities of its regulation; however, it goes beyond the scope of the paper to go deeper into this matter.

[10]The interest rate was only enforceable when the emended tax returns were submitted more than 12 months later than the voluntary period.

[11]Chapter 3 provides detailed information on the reintroduction of the wealth tax and its regulation.

[12]Additionally, during the amnesty period it was being processed a change in the criminal law to harden imprisonment charges for tax crimes and to increase the prescription period from 5 to 10 years. This legislative change was finally passed on December 27, 2012.

[13]Unjustified capital gains are classified as "general" income instead of financial, and hence they could be taxed up to 43% during the 2008-2010 period.

150% of the tax owed will be also imposed.

Overall, very little information has been revealed about the tax amnesty. On January 2013 the Minister of Finance reported some general facts[14]: 29,683 taxpayers participated in the amnesty program, being 98% of them natural persons; 93% of the forms were submitted during the last month of the program; the amnesty collected 1,192 million euros (without considering the indirect revenues emerging from it) and it legalized around 40,000 million euros of previously hidden wealth, but 70% of it was related to prescribed years.

Putting these 40,000 million euros in perspective: i) they account for 3.85% of the Spanish GDP in 2012;[15,16] ii) they represent one third of the wealth held in tax havens by Spaniards in 2007 according to Alstadsæter, Johannesen and Zucman (2018)[17], although comparable shares reduce to about one fifth when using Spaniards' undeclared wealth estimates from later years;[18] iii) according to the information reported by taxpayers to the tax agency as a result of the new law passed on October 2012, the total wealth held abroad by Spanish residents in 2012 amounted to 91,004 million euros, including the assets voluntarily disclosed in the tax amnesty.[19]

4.3 Data

This paper uses the universe of anonymized wealth tax returns filed by Catalan taxpayers for the year 2011. These microdata, provided by the Catalan Tax Agency, contains information on wealth composition and taxable income

[14]See the press release from the Ministry of Finance on January 23, 2013.

[15]GDP Source: The National Statistics Institute (INE).

[16]As a comparison, the wealth disclosed in the voluntary disclosure program carried out in Colombia and studied in Londoño-Vélez and Ávila-Mahecha (2019) accounted for 1.73% of GDP.

[17]This share is higher than the one resulting from offshore wealth disclosed by U.S. households estimated in Johannesen et al. (2018). Authors' estimations suggest that offshore wealth disclosed in 2009 represented around 10% of the total offshore wealth owned by U.S. households computed in Alstadsæter, Johannesen and Zucman (2018).

[18]Zucman (2014) estimates an amount of 144,000 million euros of unreported offshore wealth held by Spanish households in 2013. Following a similar methodology than Zucman (2013, 2014), complemented with information on assets held abroad reported to the Spanish tax authorities, Artola Blanco et al. (2019) estimate that unreported offshore wealth amounted to 158,915 million euros in 2012. Alternatively, Durán-Cabré et al. (2019) estimate an amount of 75,062 million euros for 2014 following the methodology proposed by Roine and Waldenström (2009). If we express the 40,000 million euros disclosed in 2012 relative to the different estimates of undeclared offshore wealth, including the disclosed wealth in the denominator, we obtain shares of 22%, 20% and 35% respectively.

[19]Source: Press release from the Ministry of Finance, July 29, 2016 *Evolución del patrimonio neto a partir del 'modelo 720'.*

of each taxpayer. In particular, it provides the total stock of reported wealth classified into real estate and main residence exemption, bank accounts, bonds, investment funds, business assets, quoted shares and unlisted companies - both exempt and non-exempt -, life insurance, vehicles, jewellery, artwork, property rights, debts and "other", including all taxable wealth not previously categorized. Chapter 3 provides a more detailed description of this database and the institutional context regarding the wealth tax.

The submission date is also available and this is crucial for our analysis because it allows us to identify tax returns submitted later than the voluntary filing period. Figure 4.1 shows the histogram of 2011 wealth tax returns by submission date. Each bar comprises one week. We categorize as (former) evaders those taxpayers filing 2011 wealth tax returns from October 2012 onwards, time when the voluntary period had already expired. We cannot certainly know whether these taxpayers participated in the tax amnesty, however, the timing and magnitude of the submissions strongly suggest a relation with the voluntary disclosure program. As explained in the previous section, the amnesty only reached income taxes. Consequently, once the voluntary disclosure form was filed, taxpayers needed to amend returns from other taxes, such as the wealth tax, to avoid being sanctioned or prosecuted for tax crimes.[20] Therefore, amnesty participants were very likely to submit 2011 wealth tax returns during the last two months of 2012.

To further assure that belated 2011 returns are related to the voluntary disclosure program and not to something recurrent, Figure A4.1 shows the histogram of wealth tax returns from 2012 to 2015 by submission date. This Figure allows to verify that filing wealth tax returns months after the end of the voluntary period was not a usual fact, besides 2011 returns. Contrary to what happened at the end of 2012, wealth tax returns submitted by the end of the following years are indeed negligible.[21]

We cannot distinguish taxpayers directly involved in the tax amnesty from those who did not participate in the program but, given the hardened laws and sanctions, decided to disclosure hidden wealth through the standard procedures described in the previous section. Nonetheless, both types of taxpayers share the same label - they are evaders - and both situations share the same result: the voluntary disclosure of evaded wealth, which was the ultimate goal of the

[20] Official reports from the Ministry of Finance and the Spanish Tax Agency confirm this was indeed the case. See the Annual Tax Collection Report from 2012 or the press release from September 20, 2016 titled *"Efecto del '720' y el '750' en el Impuesto sobre el Patrimonio"*.

[21] Wealth tax returns from 2012 to 2015 submitted in October of the following year, or later on, represent between 0.10% and 0.17% of all wealth tax returns filed for a given period.

enforcement initiatives carried out by the government during that period.

It could be the case that amnesty participants filed the wealth tax return already incorporating previously hidden wealth during the voluntary period and, hence, they did not submit amended returns later on. In this situation, we would be missing to identify some true evaders. However, this is very unlikely to be the case for several reasons. First, the interpretation of the law regulating the tax amnesty was very ambiguous until the Ministry of Finance issued the first clarifying report on June 27, 2012. Given the particularities of the law and the report, it was difficult to prepare the voluntary disclosure form and the wealth tax return within 5 days. Second, as explained in footnote 8, the non-prescribed years affected by the tax amnesty reduced from 2007-2010 to 2008-2010 if the voluntary disclosure form was submitted from July 2012 on, once the voluntary period to file personal income and wealth taxes was ended. And third, as mentioned in the previous section, 93% of the voluntary disclosure forms were submitted during November 2012, the last month of the program.

4.4 Evasion voluntarily disclosed in belated wealth tax returns

Focusing on those categorised as (former) tax evaders, we observe the following facts: 6,728 taxpayers filed a 2011 wealth tax return since October 2012. They represent 15.2% of all wealth taxpayers in Catalonia for the year 2011. This number of taxpayers also accounts for 22.7% of the overall tax amnesty participants in Spain, excluding corporations. Out of the 6,728 taxpayers, 4,474 of them had previously filed a wealth tax return during the voluntary period.

In terms of wealth holdings, these 4,474 evaders account for almost 20% of the overall stock of wealth reported during the voluntary period (see section [b.1] of Table 4.1). This share raises up to 26.56% when including the previously hidden wealth in the numerator (see section [b.2]). Therefore, the evaded wealth by this group represents 6.73% of the overall wealth holdings reported during the voluntary period by all taxpayers. More specifically, as shown in Table 4.1, the total difference in reported wealth holdings between the last and the former returns of the 4,474 evaders amounts to 8,066 million euros, which accounts for almost 34% of the wealth initially reported by this group. Put differently, these taxpayers were hiding 25% of their wealth holdings or more than half of the assets that should be taxed. Indeed, the last section of panel B of Table 4.1 also shows that this evaded wealth corresponds to taxable wealth

almost entirely.

In this regard, Figure 4.2 provides the asset composition of the 8,066 million euros previously evaded. In particular, it shows the difference in reported amounts between the last and former returns for each type of asset, relative to the total evaded wealth. According to what is reflected in Table 4.1, most of the evaded wealth is taxable; exempt assets barely change and, if anything, the reported values decrease. The categories which explain a higher portion are mainly related to financial assets, taxable unlisted companies and "other". Evaded financial assets must reflect wealth held abroad (except for cash), since the Spanish tax administration automatically receives information on financial assets held in Spanish financial entities. Evaded unlisted companies could reflect wealth evaded through shell companies, whereas the "other" category usually reflects credit rights, among others.[22]

Panel (a) of Figure A4.2 shows, in the left-axis, the wealth composition of the evaders filing during the voluntary period, once the former evaded wealth is declared, and, in the right-axis, it shows the portion previously evaded of each wealth category. The evaded share of all categories related to taxable assets ranges around 40% or above - up to almost 80% -, except for unlisted companies (30%) and real estate (5%). The categories most evaded are bonds (or similar assets), listed equity and "other" (i.e. the remaining assets not categorized).

Coming back to panel B of Table 4.1, it also provides information on evaded income. The taxable income reported by the 4,474 evaders during the voluntary period accounts for about 16% of the overall taxable income reported during that period.[23] The total difference in reported taxable income between the last and the former returns amounts to 254 million euros, which accounts for 35.57% of the income initially reported by this group. Nevertheless, this difference should be considered as an upper bound, since around 10% of the tax evaders did not fill the information on taxable income during the voluntary period. If we only consider those tax evaders initially reporting information on income, the total difference reduces to 198 million euros (which should be considered as a lower bound).

Finally, the panel C of Table 4.1 provides information on the remaining 2,254 evaders who did not submit a 2011 wealth tax return during the voluntary

[22]Credit rights would emerge, for instance, when accounts that used to be held individually are now co-owned, and the co-owners establish lending agreements between them to avoid being levied by the gift tax.

[23]This share is imprecise because some taxpayers fail to report information on income (13% of them report zero income), although they might report it correctly in the personal income tax returns.

period; they filed it for the first time on October 2012 or later on. The total stock of wealth and income reported by this group amounts to 5,446 and 225 million euros, respectively.[24] However, it might not be correct to associate the totality of these amounts to previously hidden wealth. It could be the case that their taxable wealth held in Spain was lower than the 700,000 euros taxable threshold and, hence, they opted not to file wealth tax returns during the voluntary period. Additionally, as seen above, it is very unlikely that previously hidden wealth comes from exempt assets. Therefore, a (very high) upper bound of evaded wealth would result from assuming that all reported wealth was previously hidden, but exempt assets. It amounts to 4,333 million euros. A lower bound of evaded wealth results from assuming that all reported wealth below the taxable threshold was already legalized and only the wealth fully taxed - i.e. exceeding the threshold - was previously hidden. This lower bound corresponds to 2,763 million euros.

Taking the most conservative value of 2,763 million euros of evaded wealth by the "initially non-filers", together with the 8,066 million euros evaded by the "initial filers", it translates into a total evaded wealth of 10,829 million euros. Putting this figure into perspective, it equals to 27% of the 40,000 million euros legalized by the entire population participating in the tax amnesty all over Spain. This share is close to the portion of tax amnesty revenues collected from tax residents in Catalonia relative to Spain's total[25] - i.e. 25.4% -, which in turn indicates the portion of wealth related to non-prescribed years that was disclosed by individuals residing in Catalonia.[26] Alternatively, the 10,829 million euros disclosed in 2011 wealth tax returns represented 5.4% of the Catalan GDP in 2011.[27]

Table 4.2 shows the impact of the disclosure of this previously hidden wealth in terms of 2011 tax revenues. The extra wealth tax revenues accrued from October 2012 on amount to 107 million euros (85 from evaders that were already filing wealth tax returns during the voluntary period and 22 from initially not filing evaders). Hence, the first type of evaders was evading almost 62% of the wealth taxes owed and the second type was evading the 100%. All in all, the disclosure of hidden wealth increased 2011 wealth tax revenues by 39%. In the case of income tax revenues, the magnitudes should be taken with caution given that some taxpayers failed to report information on income and

[24] Panel (b) of Figure A4.2 shows the wealth composition of this group of evaders.

[25] See `https://www.nuevatribuna.es/articulo/economia/madrid-y-cataluna-mas-beneficiados-amnistia-fiscal/20130909174629096246.html`.

[26] This is the case because the amnesty levied a 10% rate, and hence the revenues collected were proportional to the wealth related to non-prescribed years.

[27] GDP Source: The National Statistics Institute (INE).

that (part of) the income reported by the "initially not filing" evaders could not be evaded. An upper bound of the increase in 2011 income tax revenues would be 128 million euros (68 from evaders filing in the voluntary period and 60 from those who did not). The lower bound can be obtained when considering only those tax evaders initially reporting information on income[28] and assuming that the income reported by the "initially not filing" evaders was fully declared. This lower bound amounts to 52 million euros and accounts for 4% of the total income tax liabilities reported during the voluntary period.

Table 4.3 provides a summary of the evasion ranges discussed in this section. The only type of evasion that we are able to pinpoint precisely is the wealth tax evasion. On the contrary, the data employed does not allow us to determine the exact level of undeclared wealth and income, nor the evaded personal income taxes.

4.5 The distribution of evasion

Since individuals are required to file wealth tax returns only when they face a positive tax liability or when their overall gross wealth exceeds 2 million euros, with the data employed we cannot draw the wealth distribution of the entire population, but only for wealth tax filers. Considering the taxable threshold of 700,000 euros and the main residence exemption of 300,000 euros, together with the fact that real estate is assessed below market prices, wealth tax filers should be placed at the top of the wealth distribution. Indeed, as explained in Chapter 3, wealth tax filers in Catalonia accounted for about 1.27% of income tax filers in 2011. Hence, they represented the - known - richest 1% of income taxpayers.[29]

First, we will focus on the 4,474 evaders filing in the voluntary period, since we can compare their situation in the voluntary period to that resulting from the latest tax return, after voluntarily disclosing hidden wealth. Later we will compare these taxpayers filing in the voluntary period to those who were initially non-filers and submitted wealth tax returns for the first time from October 2012 onwards.

[28] Around 90% of the evaders filing during the voluntary period reported information on income.

[29] One issue of working with administrative data is that we cannot account for non-filers, thus the *true* richest 1% of income taxpayers could differ from the *known* richest 1%. Again, research is needed to learn further about tax evasion among the wealthier.

4.5.1 Taxpayers filing in the voluntary period

The distribution of evasion changes depending on how evaders are ranked along the wealth distribution. Taxpayers' wealth distribution has been computed according to the total wealth reported during the voluntary period by all tax filers, both evaders and (presumably) non-evaders. Table A4.1 provides descriptive statistics of the percentile groups of the *initial* wealth distribution used in this section. Once this wealth distribution is defined, evaders can be ranked according to their initial position, this is, the percentile position they would take considering the net wealth reported during the voluntary period, or, alternatively, according to their final position, this is, the percentile position they would take considering the net wealth reported in the latest tax return, which includes the formerly evaded wealth. Figures 4.3 to 4.5 presented below will differentiate between the initial and the final position.

Left panels of Figure 4.3 provide the percentile shares of initially reported and evaded wealth over the total. Right panels provide the same information for initially accrued and evaded tax liabilities.[30] If evaders are ranked according to the wealth initially reported, both evaded wealth and tax liabilities are less concentrated at the top of the distribution than the initial counterparts. The situation changes when evaders are ranked according to their final reported wealth. In this case, the distributions get closer and evaded wealth is almost exactly distributed across wealth percentiles as initially reported wealth, except for the 95-99 and 99-100 percentiles, in which the former is less concentrated. On the contrary, evaded wealth tax liabilities are more concentrated at the top of the wealth distribution than those initially accrued.

Figure 4.4 shows the portion of self-disclosed evaders filing in the voluntary period by wealth percentiles. The probability of voluntarily disclosing assets increases with wealth, and the slope becomes steeper when evaders are ranked according to their final reported wealth. Taxpayers placed at the top 5% of the *initial* wealth distribution were 40% likely to voluntarily disclose hidden wealth.

Lastly, Figure 4.5 provides the average share of evaded wealth - panel (a) - and the average share of evaded wealth tax liabilities - panel (b) - by wealth percentiles. Evaders initially reporting lower levels of wealth disclosed about 30% of their total wealth. This portion gets lower as initially reported wealth increases, up to 10% for the last wealth percentile. The percentile averages

[30]Figure A4.3 provides the same information with respect to income and income tax liabilities. However, the distributions might not be fully accurate given that some taxpayers misreported information on income.

of the evaded share of wealth tax liabilities follow also a descending pattern, ranging between 80% for the bottom of the distribution to 50% for the highest percentiles. These trends change when considering evaders' final position: the average share of evaded wealth increases with final reported wealth up to 25-27%. The average share of evaded wealth tax liabilities ranges around 60% for most of the wealth distribution.

Figure A4.4 provides the same information than Figure 4.5 but with respect to income and income tax liabilities. However, Figure A4.4 only considers evaders filing in the voluntary period who report accurate information on income. In this case, the shares of evaded income and evaded income tax liabilities follow a very similar trend since average income tax rates barely changed after including the formerly evaded income. Although we do not observe taxpayers' income composition, the relatively low average tax rates, compared to tax base levels, especially in the upper part of the wealth distribution, suggest that an important component is financial capital income (financial capital income was taxed at a 21% flat rate above 6,000 euros, whereas *general* income was taxed at progressive tax rates ranging between 24 and 49%). In particular, the mean of evaders' *final* average income tax rates (i.e. including evaded income) increases progressively from 21% at the bottom of the wealth distribution to 28% at the top, whereas the mean of *final* taxable income ranges from 80,000 euros to almost 1 million euros, respectively. For these levels of taxable income, average tax rates would range between 32% and 47% if tax bases were fully taxed as *general* income. Thus, real average tax rates are far below these thresholds. Similar to Figure 4.5, when evaders are ranked according to their final position, the average share of evaded income and evaded tax liabilities increase with wealth, from around 4% at the bottom of the distribution to about 33% at the top 1%.

4.5.2 All evaders voluntarily disclosing wealth

This section will compare the evasion disclosed by taxpayers who filed in the voluntary period with that disclosed by taxpayers filing for the first time in October 2012 onwards. Since we cannot observe the initial position of evaders not filing in the voluntary period, we will rank all evaders according to their final position (i.e. considering the wealth reported in the latest tax return). Likewise, to get a wealth distribution that considers all taxpayers, even those not filing in the voluntary period, it needs to be computed according to the wealth reported in the latest return submitted by each taxpayer, and hence it will account for previously hidden wealth. Table A4.2 provides descriptive

statistics of the percentile groups of this *final* wealth distribution. The Figures presented in this section are constructed using this *final* distribution, although Figures A4.5 to A4.7 show that things do not substantially change if taxpayer's *initial* wealth distribution (computed in the previous section) is used instead.

As detailed in section 4.4, we cannot determine the exact amount of previously hidden wealth for evaders not filing in the voluntary period. Hence, we will consider its lower bound, which corresponds to the portion of wealth exceeding the taxable threshold.

Figure 4.6 provides the percentile shares of evaded wealth and evaded wealth tax liabilities over the total and shows that evasion is more concentrated among evaders filing in the voluntary period.

Figure 4.7 shows the portion of the two groups of evaders by wealth percentiles. One could expect "initially not filing" evaders to be placed at the bottom of the distribution, but the Figure shows they are quite uniformly distributed. Around 5% of wealth taxpayers were not filing wealth tax returns when they had to, regardless of their position in the wealth distribution, except for the highest percentile, where the portion lowers to 2%. If considering all 2011 wealth tax filers, regardless of their submission date, those placed in the richest percentile (which account for approximately 0.01% of income tax filers) are 45% likely to voluntarily disclose hidden wealth and, hence, to evade taxes. This share is close to the 40% rate reported in Londoño-Vélez and Ávila-Mahecha (2019) and much higher than the 14% rate provided in Alstadsæter, Johannesen and Zucman (2019).

Figure 4.8 provides the average share of evaded wealth by wealth percentiles.[31] As already seen in the previous section, the share of evaded wealth increases with wealth. Compared to evaders filing in the voluntary period, those who initially did not file wealth tax returns evaded, on average, a considerably higher portion of wealth.[32] When considering all evaders voluntarily disclosing wealth, the average share of evaded wealth ranges around 30% for the top 60% of the distribution. Strikingly, the share of evaded wealth is the same for disclosers in Scandinavian countries (see Alstadsæter, Johannesen and Zucman, 2019) or in Colombia (see Londoño-Vélez and Ávila-Mahecha, 2019).

[31]Figure A4.8 provides the same information with respect to the share of evaded wealth tax liabilities, although it does not add new relevant information to what has already been discussed in Section 4.5.1, since the evaded share of evaders not filing in the voluntary period is 1.

[32]Note that in the case of evaders not filing in the voluntary period, the average share of evaded wealth is computed using the lower bound of previously hidden wealth. Hence, the average would be even higher if the upper bound was considered instead.

4.6 Tax evasion detection

4.6.1 Methodology

As previously stated, we are interested in studying whether tax evaders can be detected with the information they initially report (thus evasion is still not disclosed at that time). Hence, for the exercise of tax evasion detection developed in this section, we will use the information initially reported in the wealth tax returns filed during the voluntary period, both for those 4,474 taxpayers categorized as tax evaders and those who - presumably - are not. The information reported in wealth tax returns provides 34 predictors per taxpayer, which are mostly related to wealth composition, taxable income and wealth and income tax liabilities.

Figures 4.9 to 4.11 show the initial wealth composition of different taxpayer types. In particular, the Figures show the average share of financial assets and unlisted companies (Figure 4.9), the share of real estate, "unproductive" and "other" assets (Figure 4.10) and the share of debts (Figure 4.11), by evaders status (evaders vs. non-evaders) and wealth percentiles groups (0-50, 50-95 and 95-100). According to these Figures, wealth reported by evaders during the voluntary period had a different composition than wealth reported by (presumably) non-evaders. Evaders reported a lower share of bank accounts, life insurances and debts, regardless of the percentile group. On the contrary, evaders reported a higher portion of unlisted companies (both taxable and exempt) and vehicles, jewellery and artwork, although the weight of these last assets is very small (they account for less than 0.3% of reported wealth). Evaders from percentiles 0-95 also reported a higher share of investment funds and listed equity and a lower share of real estate. In addition to the common differences, evaders from the highest 5 percentiles reported a lower share of bonds and similar assets, investment funds and "other" assets.

In the remaining of the section, we will evaluate how useful these differences are to detect tax evasion. Since we only observe evaders who voluntarily disclosed previously hidden wealth, we might not be able to detect all types of wealth evaders, but only those willing to participate in this type of programs. The methods implemented in this study would allow to detect wealth evaders not willing to participate in voluntary disclosure programs if they shared relevant and observable characteristics with those evaders participating in these programs. Alstadsæter, Johannesen and Zucman (2019) show that, in the case of Scandinavian countries, self-selection into amnesty programs is negatively correlated with wealth compared to offshore leaked data, although it is quan-

titatively small. However, a further comparison of individuals named in offshore leaks with amnesty participants would be needed to determine whether the later type of evaders is self-selected in terms of asset portfolio or other characteristics observable in wealth tax returns. Nonetheless, even in the case that the values reported in wealth tax returns only help to detect evaders who would potentially participate in a tax amnesty, this is still helpful to tax authorities and governments, since it would dissipate the need to implement this type of programs, which are unfair to tax compliers and politically costly.

Tax evasion detection as a binary classification problem

Tax evasion detection can be framed as a binary classification problem. In order to estimate the probability of a given individual, x, being evader, we use a binary classifier $f(x)$. The classifier assigns a probability of being evader p to each individual x. According to this estimated probability p, an individual is predicted to be an evader if $p \geqslant 50\%$. Alternatively, an individual is predicted as a non-evader if $p < 50\%$.

We try several binary classifiers commonly used in supervised machine learning methods that range over different interpretability and flexibility: Logistic Regression, Support Vector Machine (SVM) with linear and Radial Basis Function (RBF) kernels, k-Nearest Neighbour (k-NN), Random Forest (RF), and a Multi-Layer Perceptron (MLP). Appendix 4.10.2 provides a brief description of each. While classifiers such as logistic regression or linear SVM can be interpreted by examining their weights, they might lack enough flexibility to capture non-linear behaviours. On the other hand, methods such as non-linear SVMs and neural networks can capture complex non-linear behaviours but can be difficult to interpret.

If trained properly, the accuracy difference between linear models (Logistic regression and linear SVM) and non-linear models (MLP and RBF SVM) can provide some insight into the nature of the data. For example, if linear models perform much better than non-linear methods, we might be overfitting the non-linear methods. On the contrary, if non-linear methods are performing much better than the linear ones, we might be facing data that is complex and non-linear. When both approaches provide similar accuracies, we might have data that has a linear behaviour and, therefore, complex non-linear methods are not needed.

We implement the tax evasion detection exercise as follows: first, we express each predictor relative to total wealth and we normalize it to have zero mean and unit variance. Then, we randomly discard some non-evader individ-

uals to have the same number of observations for each category. This results in a dataset of 8,948 observations. We then randomly divide this dataset in training, validation and testing sets including 5,726, 1,432 and 1,790 individuals, respectively. Finally, we train the binary classifiers.

The training set is used to fit the parameters of each method.[33] The validation set is used to find the best configuration of the classifier. More specifically, each classifier has different possible configurations (hyperparameters) that define the size and complexity of the method.[34] So first, a wide range of classifiers with different hyperparameters are learned using the training set. Then, each of these classifiers is evaluated with the validation set, and the classifiers with the hyperparameters that obtain higher accuracy are selected (e.g. if a k-NN classifier with $K = 3$ has higher accuracy than a k-NN with $K = 10$, the former is used). After the best method configuration is chosen, the classifier is evaluated with the testing set in order to obtain an accuracy value that reflects the performance when new observations are presented.

In this regard, the training, validation and testing set splits are used in order to obtain models that will perform properly with new observations. If only a unique set is used for fitting and evaluating the method, it is very likely that the classifier will perform successfully with the already seen observations, but will fail when previously unseen observations are presented.

As shown in Figure 4.4, the portion of self-disclosed evaders increases with wealth, especially in the highest percentiles. To ensure that wealth is not driving the entire classification problem, we express the predictors relative to wealth, as we explained above, and we also implement the tax evasion detection exercise just described for the bottom 50% of the taxpayers' wealth distribution.

Estimation of the expected maximum accuracy

Given that the data employed in this paper has not been used for evasion detection purposes before, we need to learn how useful is the information reported in the tax returns to classify an individual as evader or non-evader. In particular, an estimate of the maximum accuracy that could be achieved with the given predictors would help us to evaluate the performance of the classifiers employed. This indicator can be obtained by estimating the Bayes

[33] In the case of Logistic Regression, SVM and MLP, these parameters include weights and bias. In the case of a Random Forest, these parameters include the values of the leaves of the trees.

[34] The hyperparameters include regularization constants for SVMs, number and size of hidden layers in MLP, number and size of trees in RF and K in k-NN.

Error Rate (BER).

The BER gives a lower bound on the error achievable for a classification problem acting on a given feature or predictor space. The BER is non-zero when the classification labels are not deterministic (a given set of predictors has a non-zero probability of belonging to more than one class). In other words, if the BER is non-zero, that means that two individuals could be described with identical predictors and each of them belong to different categories. For example, a BER of 0.5 in a binary classification indicates that no classifier will surpass random chance accuracy, while a BER of 0 indicates that a powerful enough classifier could obtain a 100% classification accuracy. Hence, the BER can be used to estimate the maximum obtainable classification accuracy.

In order to compute the BER, the probability distribution of an individual belonging to each category given its predictors is needed. Such probability distribution is rarely known, therefore the BER needs to be approximated. In perceptual tasks such as image classification, human error can be used as a proxy for the BER (typically assumed to be negligible). However, in non-perceptual tasks like tax evasion detection, statistical estimators of the BER need to be used. Appendix 4.10.3 describes how the bounds of the BER can be estimated.

The bounds of the BER, $P_e(f_1, f_2)$, can be used to estimate the bounds of the expected maximum accuracy Acc as: $Acc = 1 - P_e(f_1, f_2)$.

In the following section we present the estimated bounds on the Acc for our tax evasion detection problem.

4.6.2 Results

Table 4.4 (top) presents the accuracy rate for each classifier in validation and testing sets.[35] Table 4.4 (bottom) shows the bounds of the estimated maximum achievable accuracy. Accuracy bounds higher than 50% indicate that the data contains some information that can help to detect tax evaders. The predictors with slightly better performance are MLP and RF, with an accuracy rate of almost 69% and about 65.5% in the validation and testing sets, respectively. Nevertheless, linear and non-linear classifiers have similar accuracy rates, which lie within the bounds of the estimated maximum accuracy. Therefore, the performance of the detection methods employed is close to the estimated maximum achievable with the information available. In order to increase the accuracy of the classifiers, additional taxpayers' information should

[35]Because using the totality of the data instead of using a balanced subset does not provide a significant change of accuracy, we will only report results with the balanced subset.

be needed.

As a robustness check, Table 4.5 presents the accuracy rate obtained with each classifier in validation and testing sets when implementing the tax evasion detection exercise for the bottom 50% of taxpayers' wealth distribution. Accuracy rates are very similar to those presented in Table 4.4.

As an illustration, Figure 4.12 shows two histograms of the estimated probability of being evader p for each group of taxpayers.[36] The blue distribution relates to those taxpayers categorized as non-evaders and the orange distribution relates to those categorized as evaders. Panel (a) shows the histograms of the two groups for the testing set of 1,790 individuals. Panel (b) considers all taxpayers who filed wealth tax returns during the voluntary period. The top (bottom) of the estimated probability distribution reflects those evaders (non-evaders) better predicted by the classifier. Interestingly, the non-evaders distribution (blue) also presents a peak at high levels of p. Hence, it reflects those taxpayers initially classified as non-evaders who have an estimated probability of being evader around 70%.

In this regard, Table 4.6 summarizes the number of taxpayers categorized as non-evaders whose p exceeds 50%, 60%, 70% and 80%, according to each classifier employed in this paper. The number of taxpayers with an estimated probability of being evader higher than 70% ranges between 1,758 and 4,004, depending on the method employed. These numbers represent between 4.7% and 10.7% of all taxpayers categorized as non-evaders (i.e. 37,402). These intervals lower to 141 (0.4%) and 1,145 (3%) when considering those taxpayers with an estimated probability above 80%. Nonetheless, the involvement of the tax administration would be required to assess the validity of these predictions.

4.7 Conclusions

In the context of a tax amnesty carried out by the Spanish government in 2012, this paper quantifies the wealth voluntarily disclosed and shows how this type of evasion was distributed across wealth levels. In line with findings from other countries, the data indicates that the probability of voluntarily disclosing hidden assets increases significantly with wealth and that, on average, wealth disclosers were evading around 30% of their net worth.

The existence of these levels of evasion harms the fairness of the tax systems and undermines the redistributive role of income and wealth taxation.

[36] In this case, p is estimated with the classifier Support Vector Machine (SVM) with Radial Basis Function (RBF), but these distributions can be obtained for each other classifier.

As a way of fighting this problem, this paper also shows that machine learning methods can be useful tools for governments and tax administrations to detect tax evasion. In particular, we study whether wealth evaders can be detected with the information they initially report in wealth tax returns. We frame tax evasion detection as a binary classification problem and train and evaluate multiple classifiers commonly used in supervised machine learning methods. The main conclusion from this exercise is that the relatively little information available from tax returns, which mostly relates to wealth composition and income levels, it already allows distinguishing evaders from (presumably) non-evaders. Nonetheless, we hypothesize that acquiring more information from taxpayers, and hence providing a richer description of their personal, professional and financial profiles might lead to better detectability.

Indeed, a large amount of taxpayers' information is already available to public institutions, so an intensive use of it, together with its release for research purposes, might improve fraud detection methods. This has been, in fact, the path adopted by some tax administrations such as the IRS in the US, which has been implementing big data analytics programmes since years ago.[37]

[37] https://www.irs.gov/about-irs/strategic-goals/advance-data-analytics

4.8 Tables

Table 4.1: 2011 wealth and income reported by different groups of taxpayers

	All wealth	Taxable wealth		Exempt wealth	Taxable income
		Fully taxed	Below the threshold		
A: All taxpayers filing in the voluntary period					
[a] Total reported during the voluntary period (in €M)	119,817	40,508	28,527	50,782	4,550
% All wealth		*33.81*	*23.81*	*42.38*	
B: Evaders filing in the voluntary period					
[b.1] Total reported during the voluntary period (in €M)	23,763	7,097	3,045	13,621	713
% All wealth		*29.87*	*12.81*	*57.32*	
% wrt [a]	*19.83*	*17.52*	*10.67*	*26.82*	*15.68*
[b.2] Total reported since October 2012 (in €M)	31,829	15,117	3,127	13,585	967
% All wealth		*47.49*	*9.82*	*42.68*	
% wrt [a]	*26.56*	*37.32*	*10.96*	*26.75*	*21.25*
[b.2]-[b.1] Difference (in €M)	8,066	8,020	82	-36	254
% All wealth		*99.43*	*1.02*	*-0.44*	
% wrt [b.1]	*33.95*	*113.01*	*2.69*	*-0.26*	*35.57*
% wrt [b.2]	*25.34*	*53.05*	*2.62*	*-0.26*	*26.24*
C: Evaders not filing in the voluntary period					
[c] Total reported since October 2012 (in €M)	5,446	2,763	1,570	1,113	225
% All wealth		*50.73*	*28.84*	*20.43*	
% wrt [a]	*4.55*	*6.82*	*5.51*	*2.19*	*4.95*

Notes: The table provides information on 2011 total wealth and taxable income reported by different groups of taxpayers. In the case of wealth, it distinguishes between *all* wealth and wealth considered as *taxable/exempt* by the Wealth Tax Law. Among the wealth considered as taxable, only the amount exceeding the taxable threshold of 700,000 euros is *fully taxed*; the amount *below the threshold* is not levied by the wealth tax. 41,876 taxpayers filed a wealth tax return during the voluntary period. 4,474 (2,254) taxpayers belong to the group of evaders (not) filing a wealth tax return in the voluntary period.

Table 4.2: Accrued 2011 revenues by different groups of taxpayers

Accrued tax liabilities:	(1) In voluntary period	(2) since October 2012	(3) (2)-(1) Difference
ALL TAXPAYERS FILING IN THE VOLUNTARY PERIOD			
Wealth tax (in €M)	274	-	-
Income tax (in €M)	1,272	-	-
EVADERS FILING IN THE VOLUNTARY PERIOD			
Wealth tax (in €M)	53	138	85
% All wealth tax revenues accrued in the voluntary period	*19.28*	*50.39*	*31.12*
Income tax (in €M)	211	279	68
% All income tax liabilities reported in the voluntary period	*16.55*	*21.93*	*5.38*
EVADERS NOT FILING IN THE VOLUNTARY PERIOD			
Wealth tax (in €M)	-	22	-
% All wealth tax revenues accrued in the voluntary period		*8.08*	
Income tax (in €M)	-	60	-
% All income tax liabilities reported in the voluntary period		*4.68*	

Notes: 41,876 taxpayers filed a wealth tax return during the voluntary period. 4,474 (2,254) taxpayers belong to the group of evaders (not) filing a wealth tax return in the voluntary period.

Table 4.3: Summary of evasion ranges

	Lower bound	Upper bound
Evaded wealth (in €M)	10,829	12,400
% All wealth	*8.12*	*9.30*
Evaded wealth tax (in €M)	107	107
% All wealth tax revenues	*28.16*	*28.16*
Evaded income (in €M)	198	479
% All income	*3.93*	*9.52*
Evaded personal income tax (in €M)	52	128
% All income tax liabilities	*3.74*	*9.14*

Notes: *All wealth (income)* refers to the sum of total wealth (income) lastly reported by each taxpayer in 2011 wealth tax returns, including evaded wealth (income). *All wealth tax revenues* refers to the total wealth tax revenues accrued in 2011. *All income tax liabilities* considers the latest income tax liabilities reported by each taxpayer in the 2011 wealth tax returns.

Table 4.4: Accuracy of binary classifiers and accuracy bound estimations

Method	Validation Accuracy	Testing Accuracy
Logistic Regression	66.0%	64.6%
Linear SVM	65.3%	63.8%
RBF SVM	66.9%	64.7%
k-NN	64.3%	62.4%
MLP	68.7%	65.4%
RF	67.4%	65.5%
$1 - P_e(f_1, f_2)$ Lower Bound	57.1%	
$1 - P_e(f_1, f_2)$ Upper Bound	68.8%	

Table 4.5: Accuracy of binary classifiers with 50% lower wealth

Method	Validation Accuracy	Testing Accuracy
Logistic Regression	61.4%	64.5%
Linear SVM	60.5%	61.2%
RBF SVM	63.7%	66.3%
k-NN	61.8%	64.0%
MLP	64.5%	65.8%
RF	64.1%	63.6%

Table 4.6: Summary of taxpayers categorized as non-evaders whose estimated probability of being evader exceeds 50%

Method	$p > 50\%$	$p > 60\%$	$p > 70\%$	$p > 80\%$
Logistic Regression	12,095	6,452	2,081	384
SVM (Linear)	11,429	6,792	2,513	284
SVM (RBF)	12,142	8,608	4,004	141
k-NN	11,998	5,163	1,758	300
MLP	13,662	8,000	3,555	1,145
RF	12,100	6,525	2,651	447

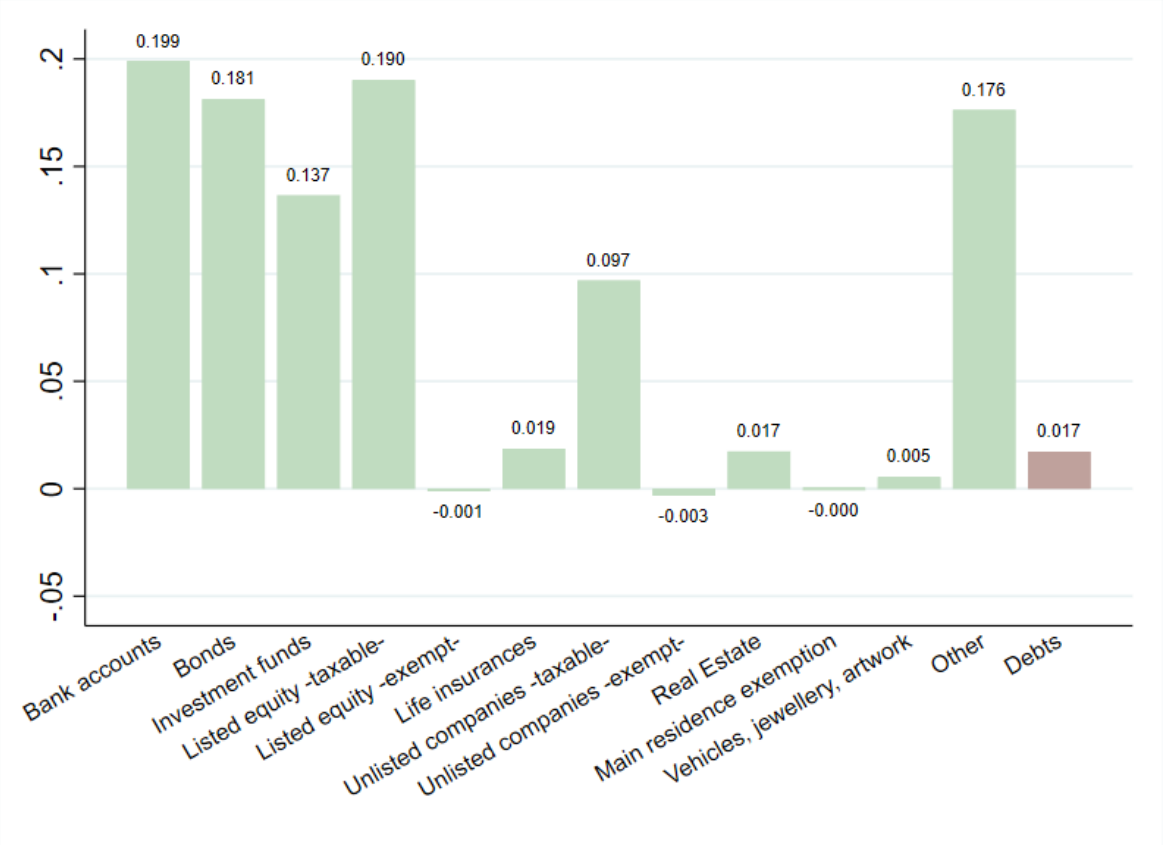
Notes: This table summarizes the number of taxpayers categorized as non-evaders whose estimated probability of being evader p exceeds 50%, 60%, 70% and 80%, according to each classifier employed. The total number of taxpayers categorized as non-evaders is 37,402.

4.9 Figures

Figure 4.1: Histogram of 2011 wealth tax returns by submission week

Notes: Each bar comprises one week. The red vertical line is placed at the end of the voluntary filing period (July 2), whereas the green vertical line is placed at the end of the tax amnesty program (November 30).

Figure 4.2: Asset composition of evaded wealth



Notes: This figure compares, for each category, the total amounts reported since October 2012 with those reported in the voluntary period by the 4,474 tax evaders who were filing wealth tax returns in both periods. Each category difference is expressed in terms of the total wealth difference (€M 8,066). The two categories of *Unlisted companies* also include business assets. The positive sign of *Debts* indicates an increase in the reported amounts, and hence it has a negative impact on total wealth.

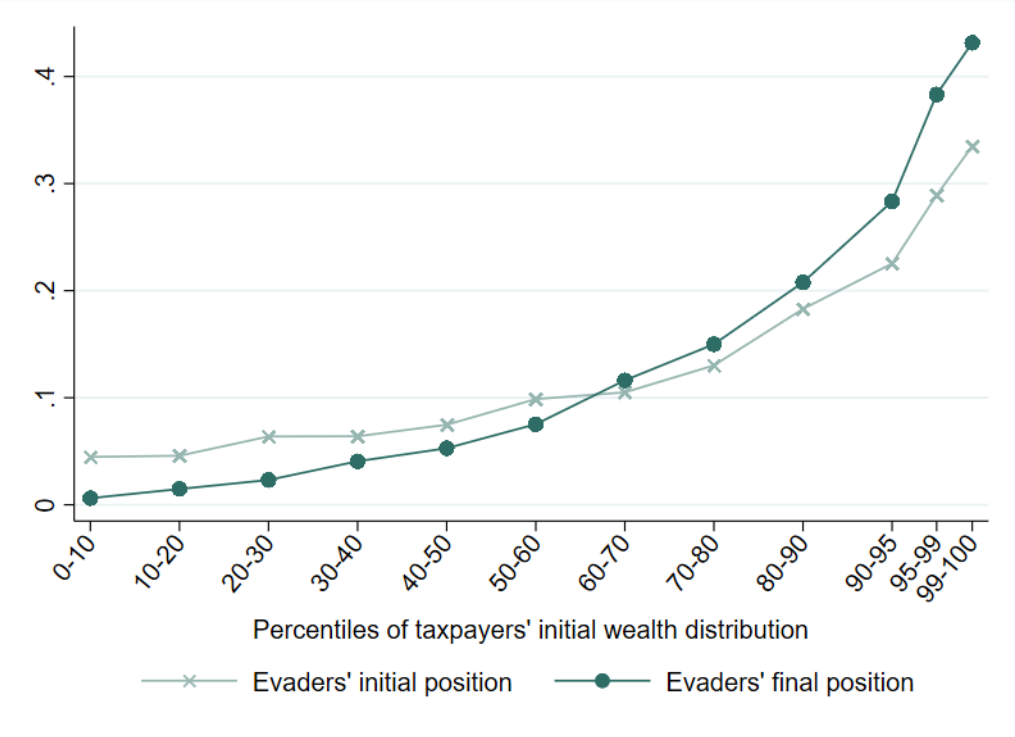
Figure 4.3: Distribution of reported and evaded wealth and tax liabilities

(a) Evaders' initial position

(b) Evaders' final position

Notes: Each distribution of each graph shows the percentile shares over the total. Wealth percentiles are defined according to taxpayers' initial wealth distribution, this is, according to the total wealth reported during the voluntary period. The distributions plotted in each graph are computed considering only the 4,474 evaders who filed during the voluntary period. *Evaders' initial position* reflects the percentile position they would take according to the wealth reported during the voluntary period. *Evaders' final position* reflects the percentile position they would take according to the wealth reported in the latest tax return, once the formerly evaded wealth is included.

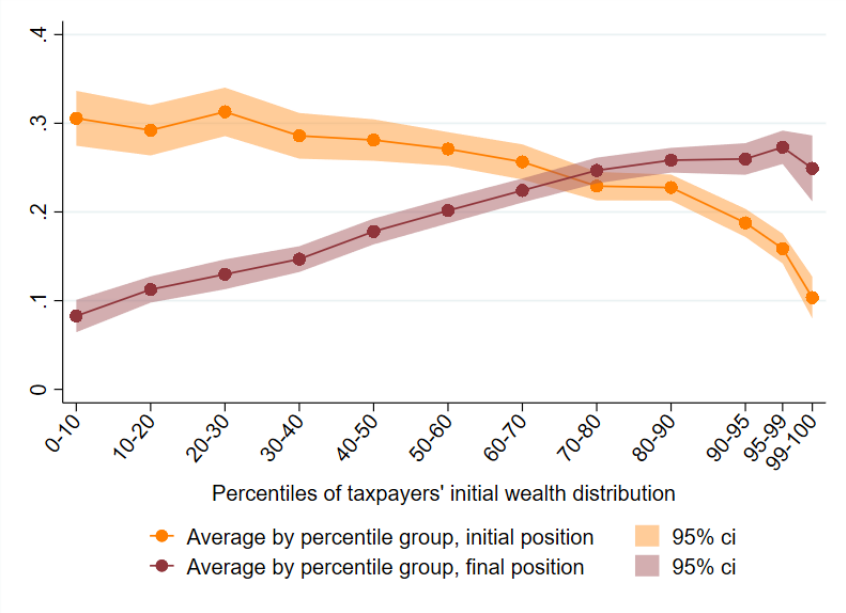
Figure 4.4: Portion of self-disclosed evaders filing in the voluntary period by wealth percentiles



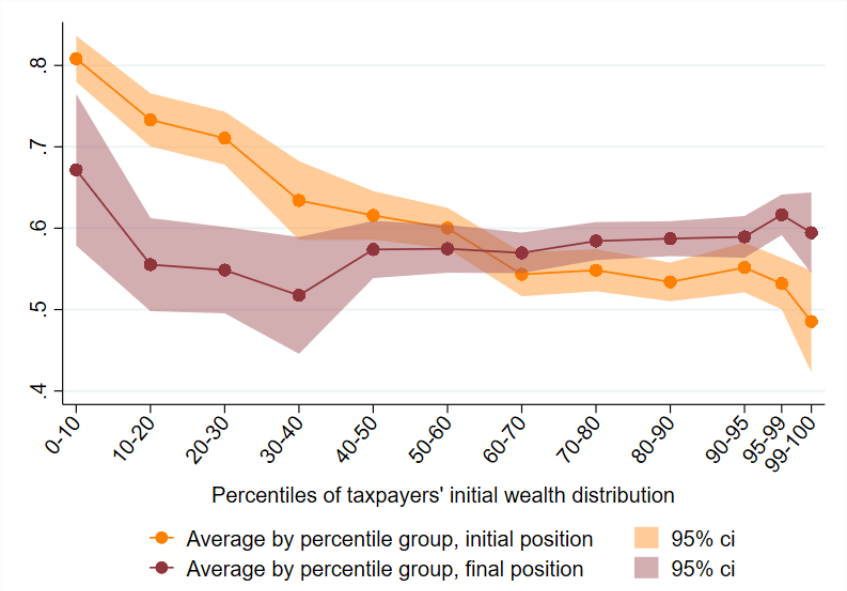
Notes: The figure shows the portion of self-disclosed evaders among all taxpayers filing during the voluntary period by wealth percentiles. Wealth percentiles are defined according to taxpayers' initial wealth distribution, this is, according to the total wealth reported during the voluntary period. *Evaders' initial position* reflects the percentile position they would take according to the wealth reported during the voluntary period. *Evaders' final position* reflects the percentile position they would take according to the wealth reported in the latest tax return, once the formerly evaded wealth is included.

Figure 4.5: Percentile averages of evaded wealth and tax liabilities voluntarily disclosed by evaders filing in the voluntary period

(a) Share of evaded wealth

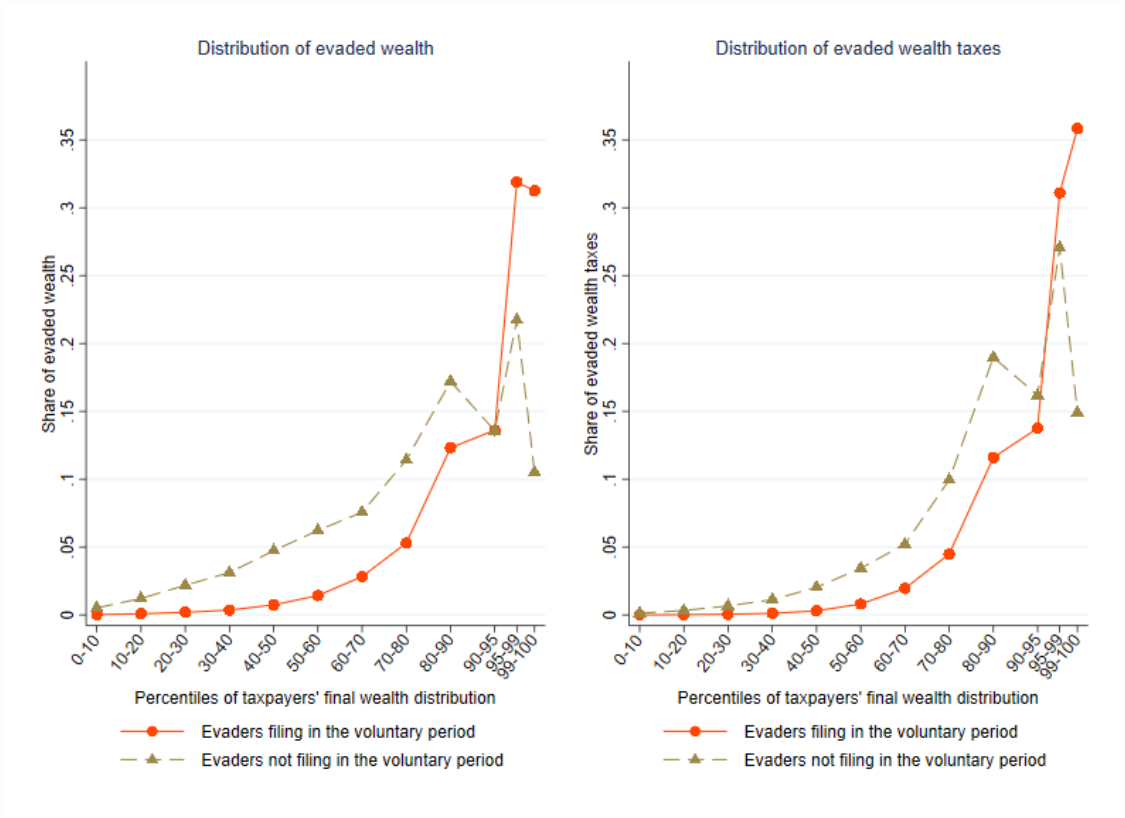


(b) Share of evaded wealth tax liabilities



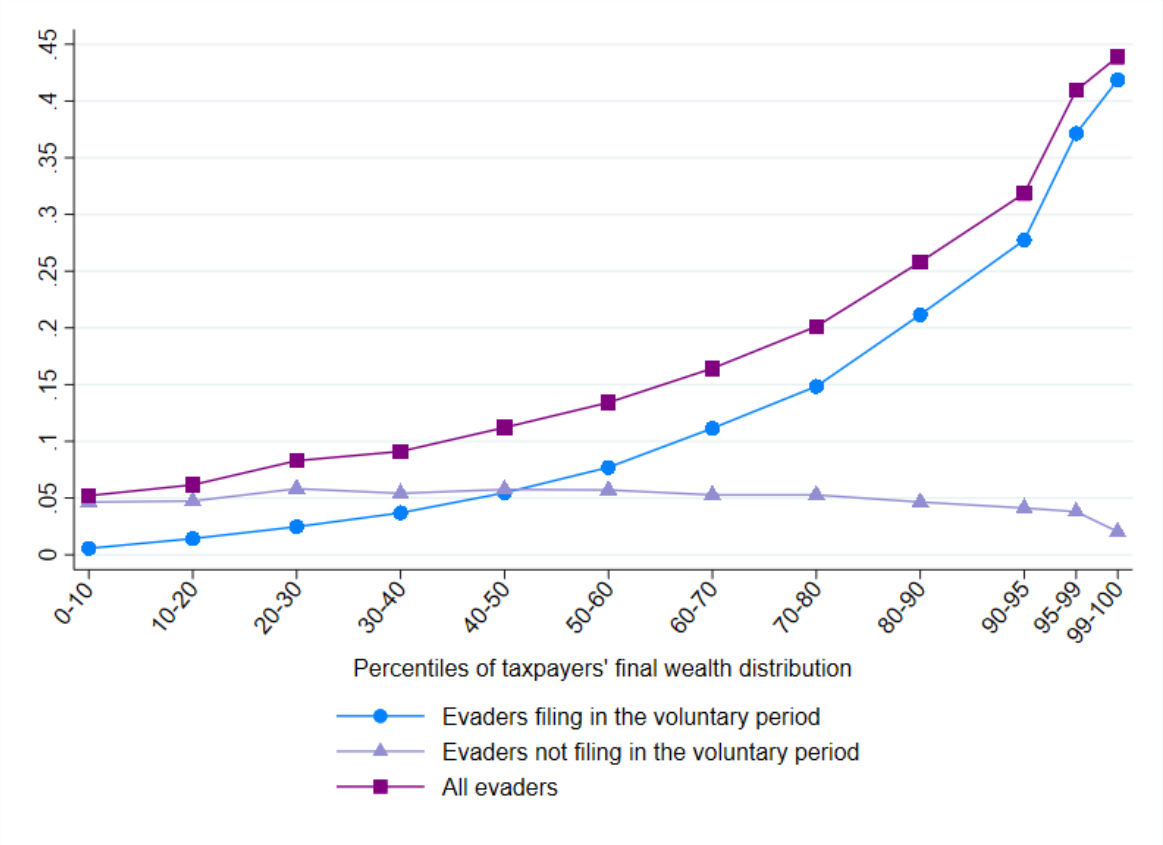
Notes: The figure provides, by wealth percentiles, the average share of evaded wealth - *Panel (a)* - and the average share of evaded wealth tax liabilities - *Panel (b)* - with their 95% confidence intervals. The plotted averages only consider the 4,474 evaders who filed wealth tax returns during the voluntary period. The individual share of evaded wealth and evaded wealth tax liability is computed over taxpayer's total, including the evaded part in the denominator. Wealth percentiles are defined according to taxpayers' initial wealth distribution, this is, according to the total wealth reported during the voluntary period. *Evaders' initial position* reflects the percentile position they would take according to the wealth reported during the voluntary period. *Evaders' final position* reflects the percentile position they would take according to the wealth reported in the latest tax return, once the formerly evaded wealth is included.

Figure 4.6: Distribution of evaded wealth and tax liabilities;
Filers vs. non-filers in the voluntary period



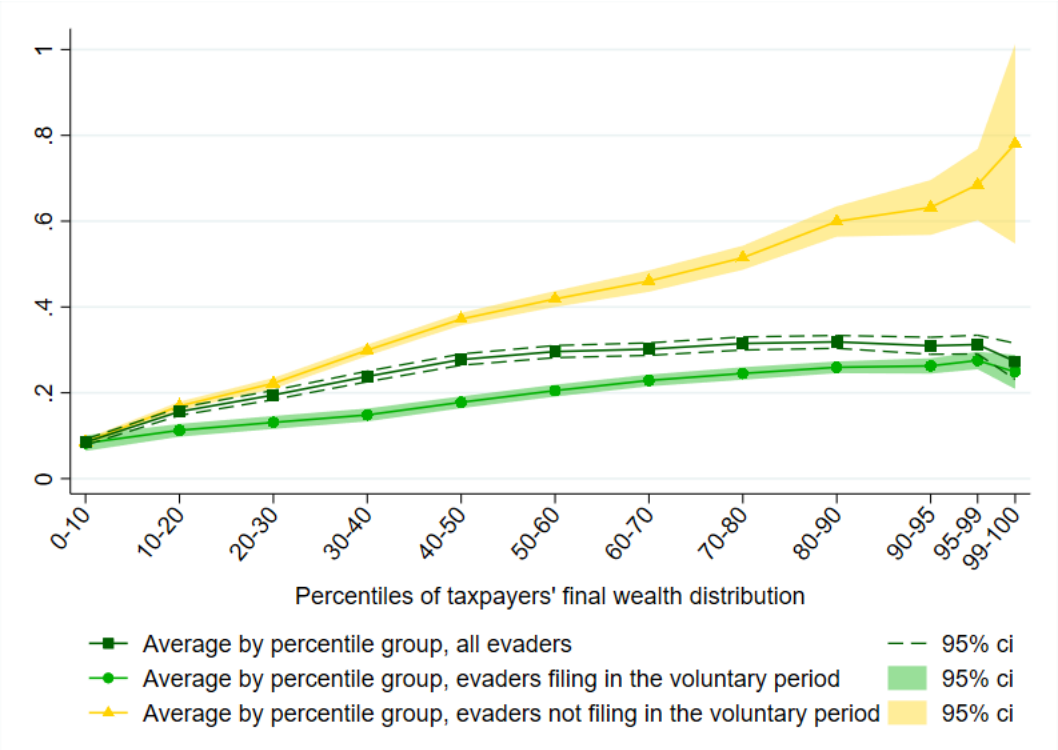
Notes: Each distribution of each graph shows the percentile shares over the group's total. 4,474 (2,254) taxpayers belong to the group of evaders (not) filing a wealth tax return in the voluntary period. In the case of evaders not filing in the voluntary period, the evaded wealth is computed as the portion exceeding the taxable threshold of 700,000 euros, which might be a lower bound. Wealth percentiles are defined according to taxpayers' final wealth distribution, this is, considering the voluntarily disclosed wealth reported in the latest tax returns, together with that wealth already reported in the voluntary period.

Figure 4.7: Portion of self-disclosed evaders by wealth percentiles



Notes: The figure shows the portion of (initially filing/initially not filing/all) evaders among all wealth taxpayers by wealth percentiles. Wealth percentiles are defined according to taxpayers' final wealth distribution, this is, considering the voluntarily disclosed wealth reported in the latest tax returns, together with that wealth already reported in the voluntary period.

Figure 4.8: Percentile averages of the share of evaded wealth;
Evaders filing vs. not filing in the voluntary period



Notes: The figure provides, by wealth percentiles, the average share of evaded wealth with its 95% confidence intervals. The individual share of evaded wealth is computed over taxpayer's total, including the evaded part in the denominator. In the case of evaders not filing in the voluntary period, the evaded wealth is computed as the portion exceeding the taxable threshold of 700,000 euros, which might be a lower bound. Wealth percentiles are defined according to taxpayers' final wealth distribution, this is, considering the voluntarily disclosed wealth reported in the latest tax returns, together with that wealth already reported in the voluntary period.

Figure 4.9: Initial wealth composition. Financial assets and unlisted companies

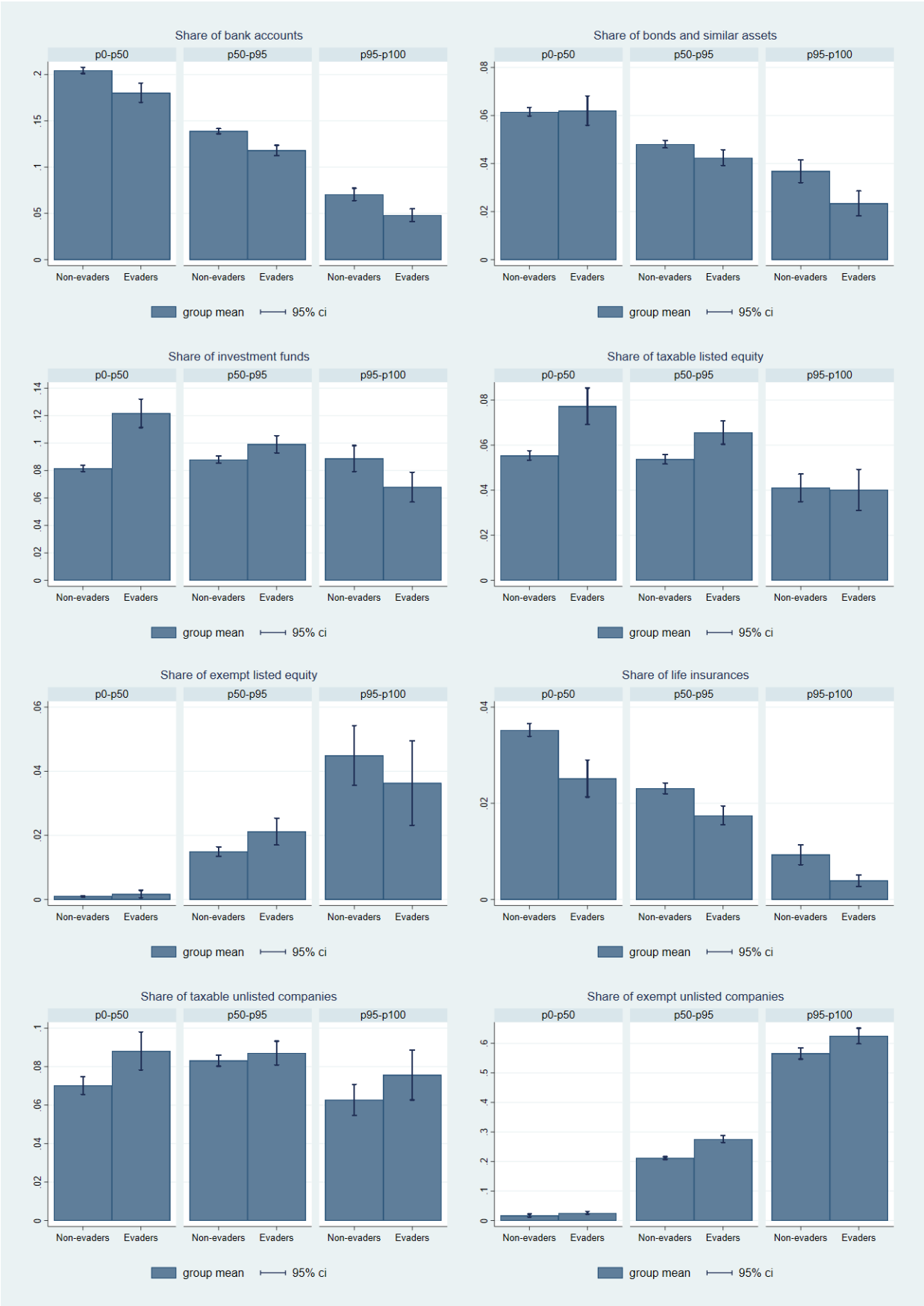


Figure 4.10: Initial wealth composition. Real estate, 'unproductive' assets and other

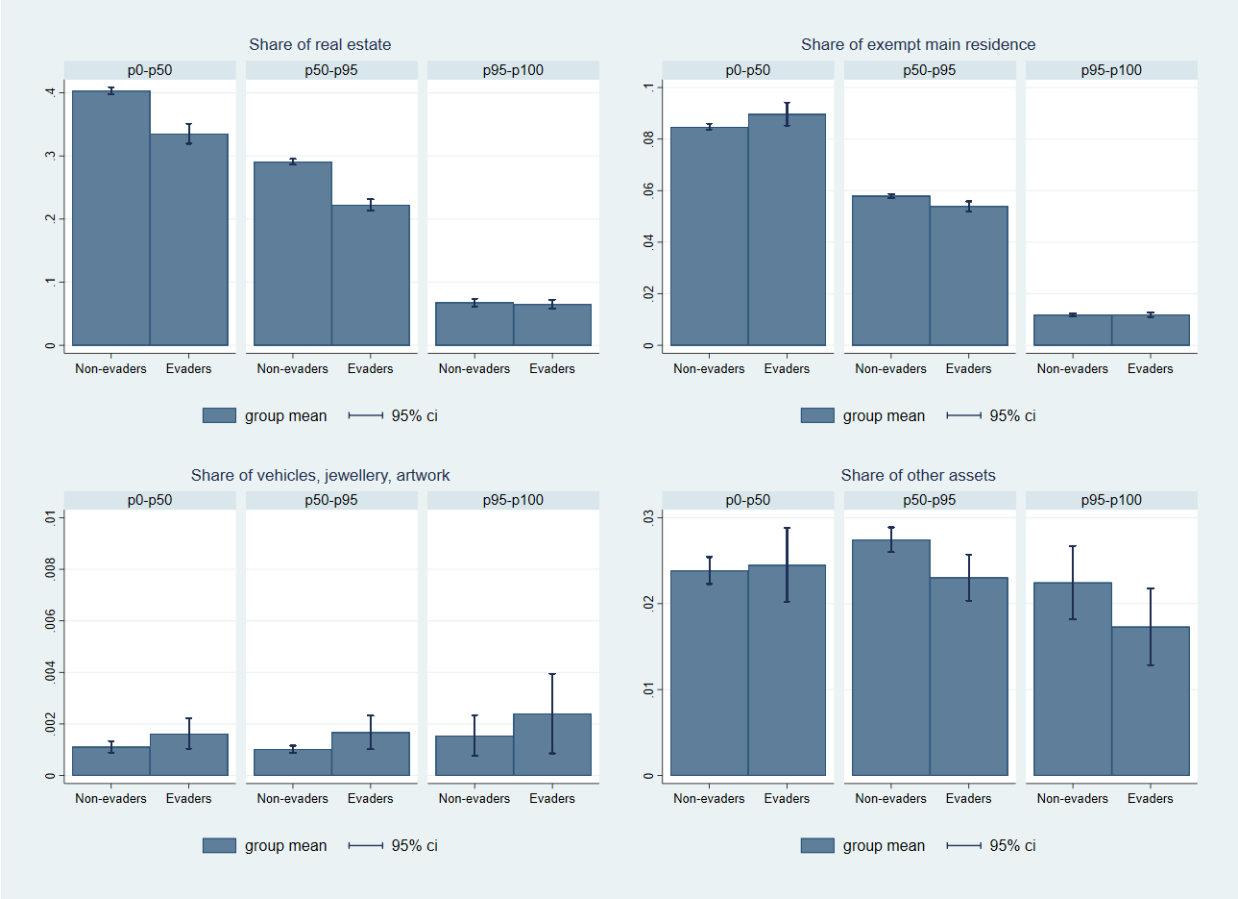
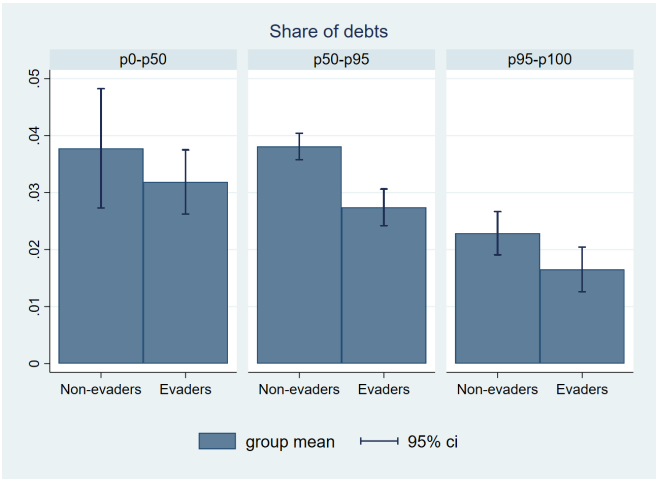


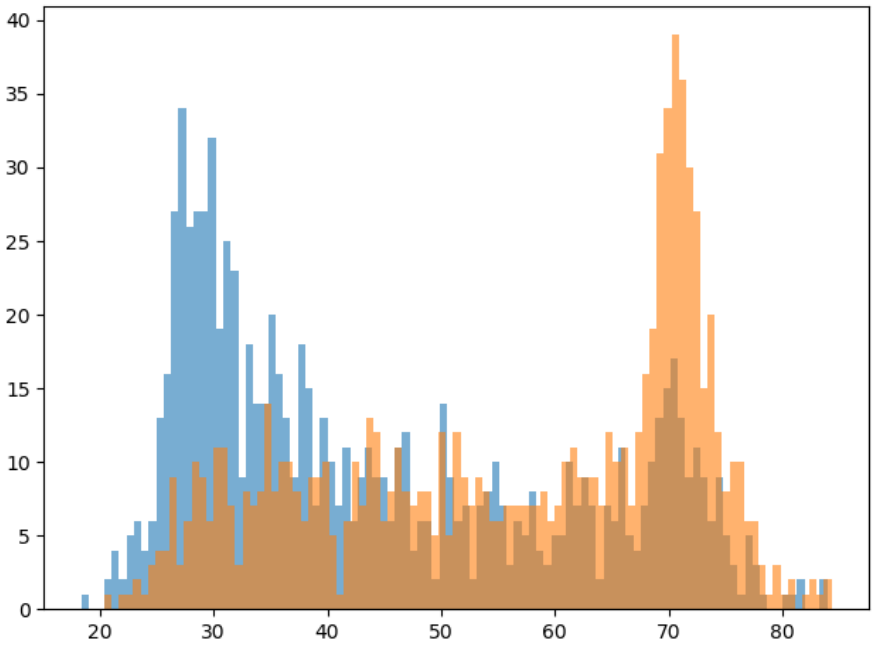
Figure 4.11: Initial wealth composition. Debts



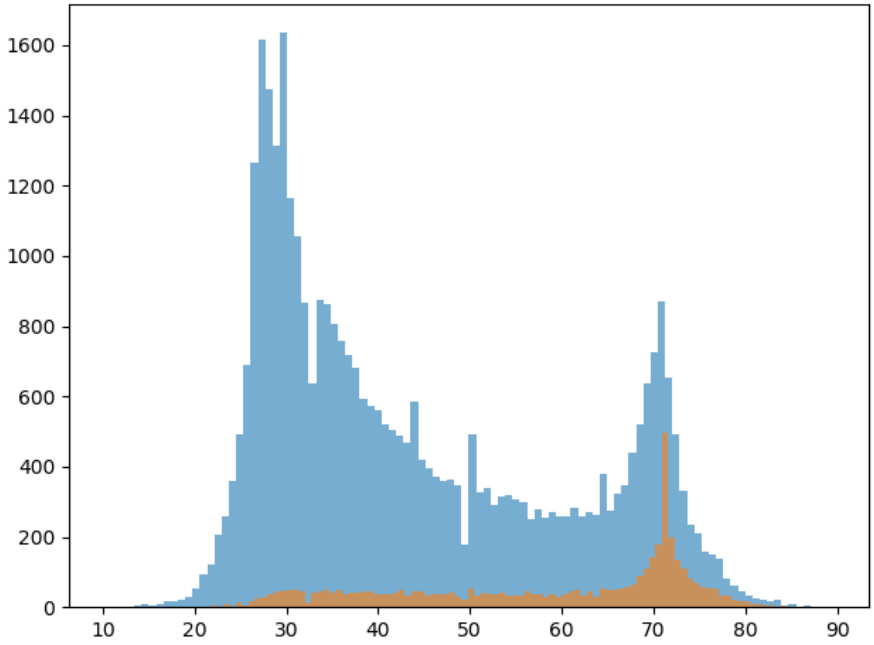
Notes for Figures 4.9, 4.10 and 4.11: The Figures provide the average initial wealth composition by different taxpayer groups and 95% confidence intervals. This information is provided by percentiles groups (0-50, 50-95 and 95-100) and distinguishing between (presumably) non-evaders and (self-disclosed) evaders. Each asset (debt) share is computed over total wealth, considering the amounts reported during the voluntary filing period.

Figure 4.12: Histograms of the estimated probability of being evader

(a) Testing set



(b) All

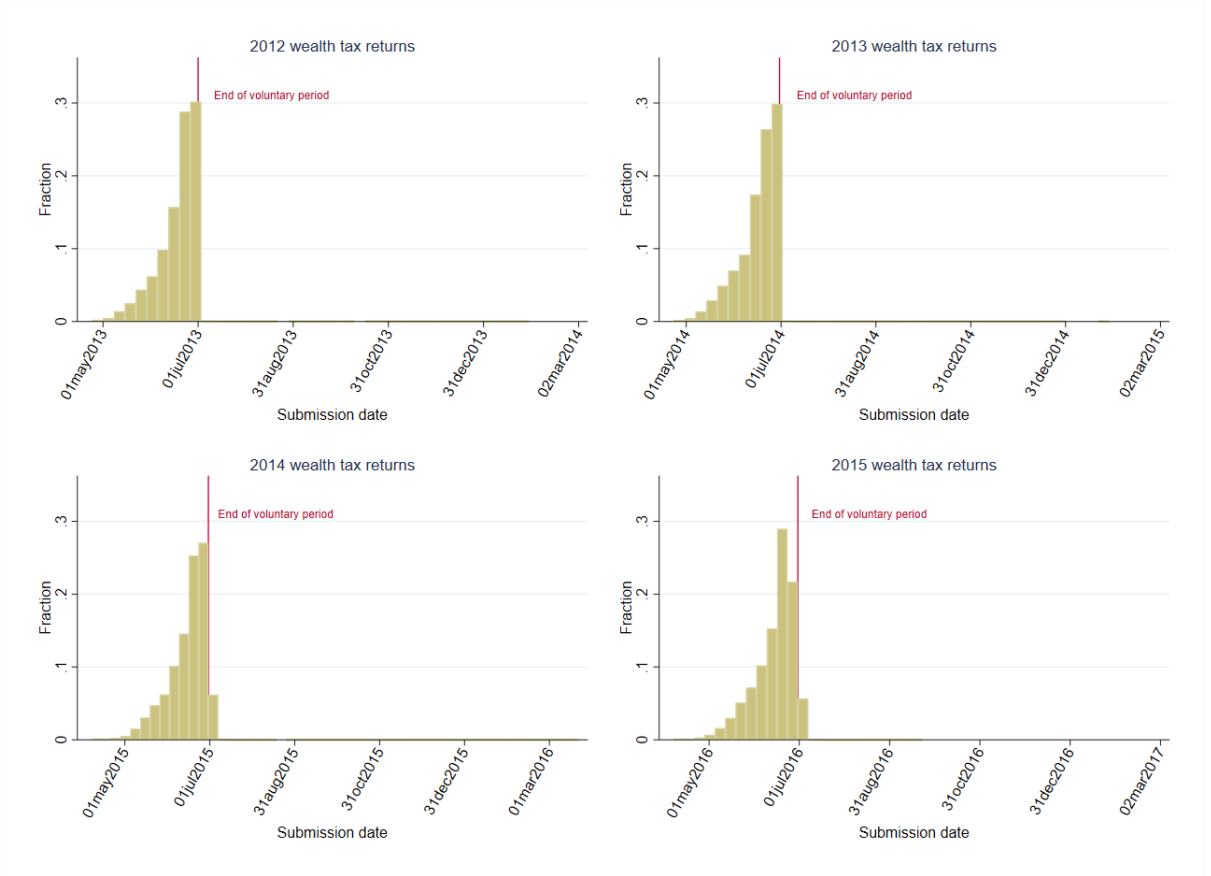


Notes: The Figures from panel (a) and panel (b) show the histogram of the estimated probability of being evader (in the x axis) for those categorized as non-evaders (in blue) and for those categorized as evaders (in orange). Panel (a) considers the testing set of 1,790 observations. Panel (b) considers all the 41,876 wealth taxpayers who filed in the voluntary period. The binary classifier employed to estimate the probabilities presented here is the Support Vector Machine (SVM) with Radial Basis Function (RBF).

4.10 Appendix

4.10.1 Figures and tables

Figure A4.1: Histogram of 2012-2015 wealth tax returns by submission week

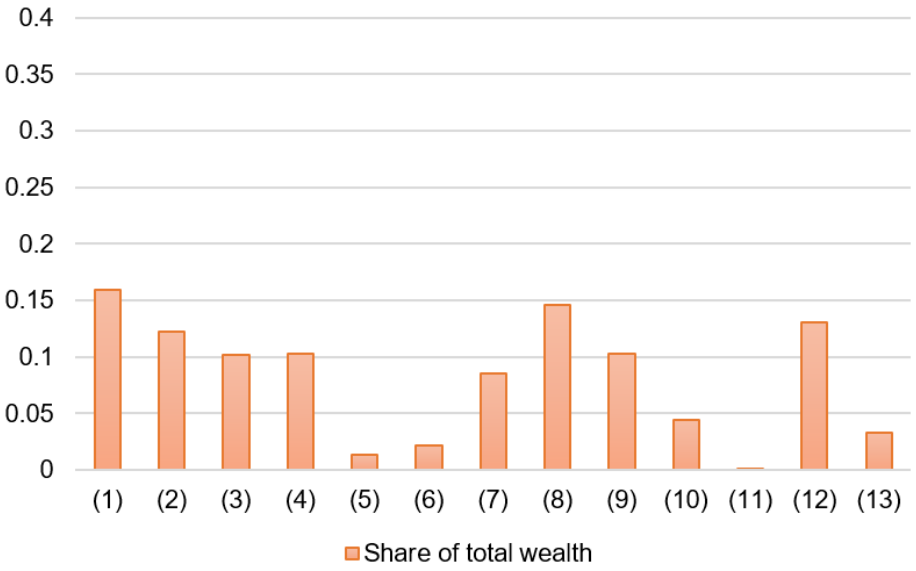


Notes: Each bar comprises one week. The red vertical lines are placed at the end of the corresponding voluntary filing period.

Figure A4.2: Evaders' wealth composition

(a) Evaders filing in the voluntary period

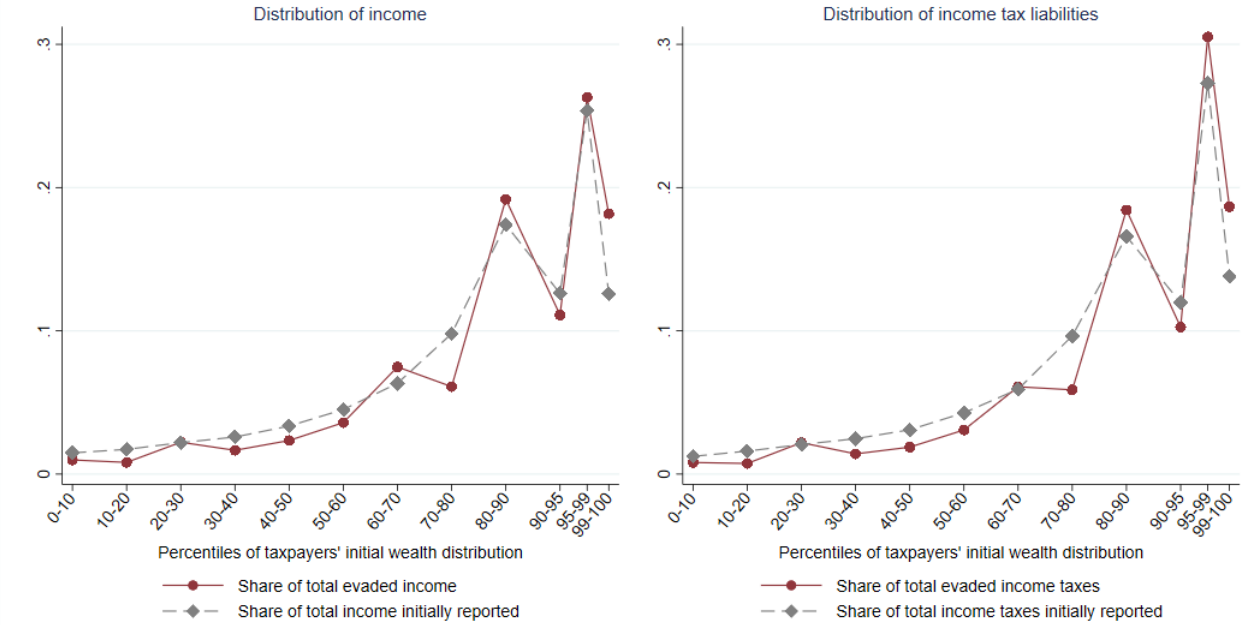
(b) Evaders not filing in the voluntary period



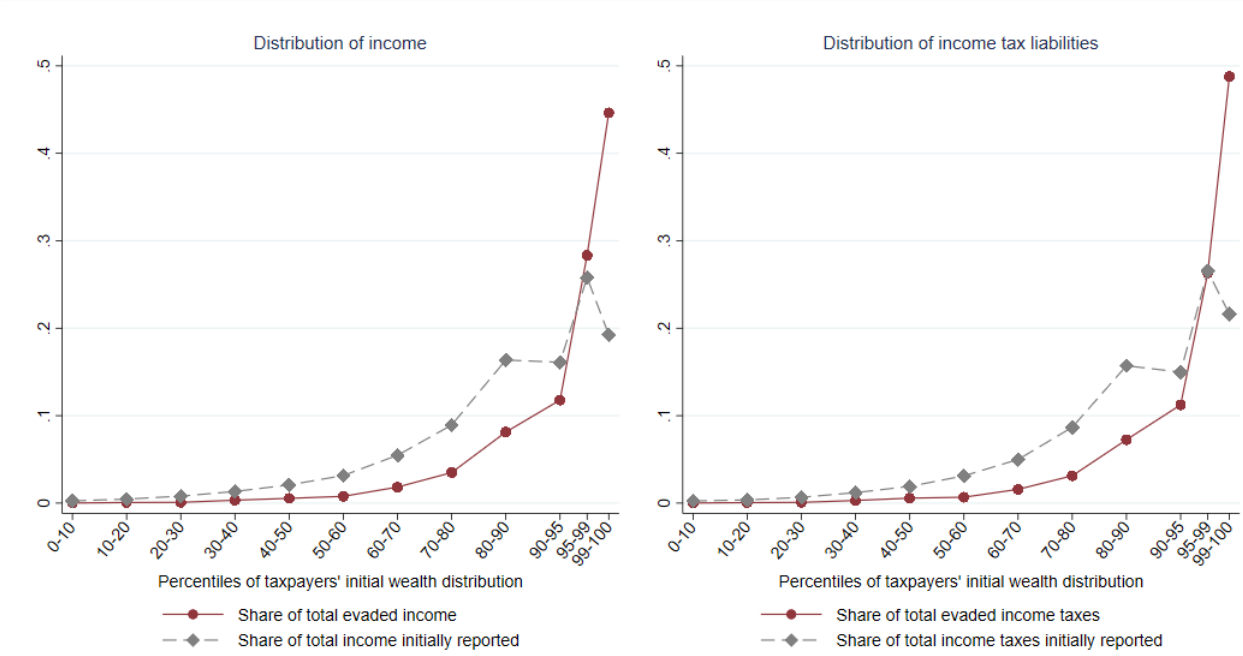
Notes: **(1)** Bank accounts, **(2)** Bonds, **(3)** Investment funds, **(4)** Listed equity -taxable-, **(5)** Listed equity -exempt-, **(6)** Life insurances, **(7)** Unlisted companies and business assets -taxable-, **(8)** Unlisted companies and business assets -exempt-, **(9)** Real Estate, **(10)** Main residence exemption, **(11)** Vehicles, jewellery, artwork, etc., **(12)** Other, **(13)** Debts. Each bar shows, in the left-axis, the weight of that category over total wealth, according to the amounts reported in the latest 2011 wealth tax returns (which already include formerly hidden wealth). The share of *(13) Debts* is expressed in absolute values and has a negative impact on total wealth. Dots of *Panel (a)* indicate, in the right-axis, the (formerly) evaded portion of each category.

Figure A4.3: Distribution of reported and evaded income and tax liabilities

(a) Evaders' initial position



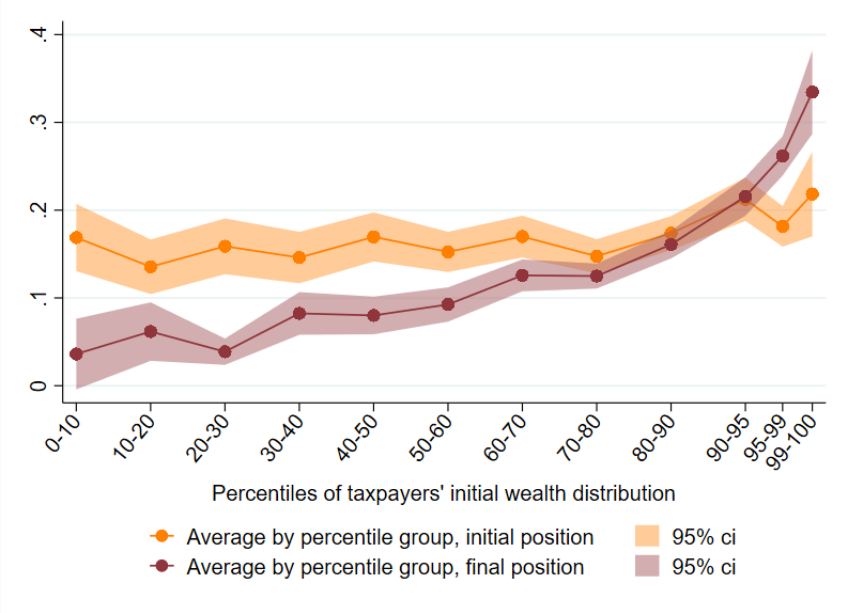
(b) Evaders' final position



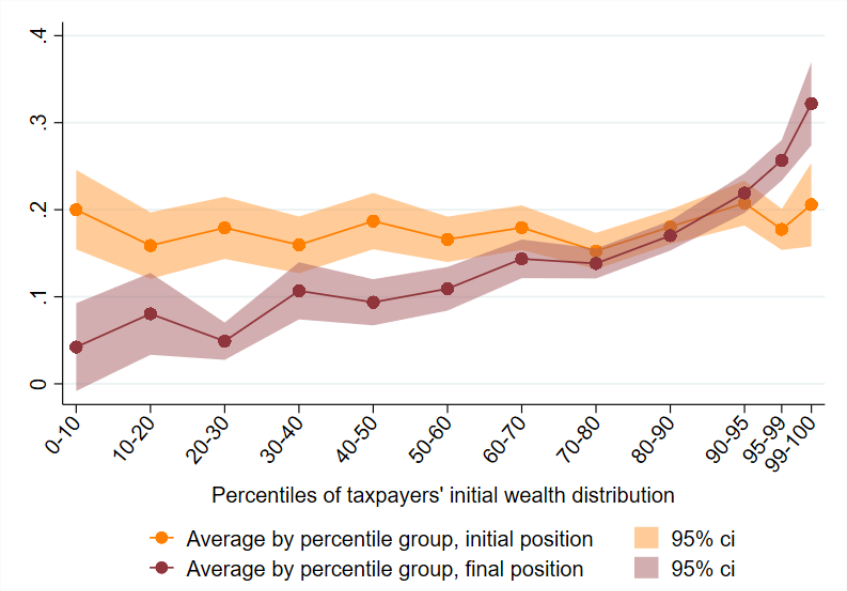
Notes: Each distribution of each graph shows the percentile shares over the total. Wealth percentiles are defined according to taxpayers' initial wealth distribution, this is, according to the total wealth reported during the voluntary period. The distributions plotted in each graph are computed considering only 3,800 evaders who filed during the voluntary period and seem to report information on income accurately. *Evaders' initial position* reflects the percentile position they would take according to the wealth reported during the voluntary period. *Evaders' final position* reflects the percentile position they would take according to the wealth reported in the latest tax return, once the formerly evaded wealth is included.

Figure A4.4: Percentile averages of evaded income and tax liabilities voluntarily disclosed by evaders filing in the voluntary period

(a) Share of evaded income

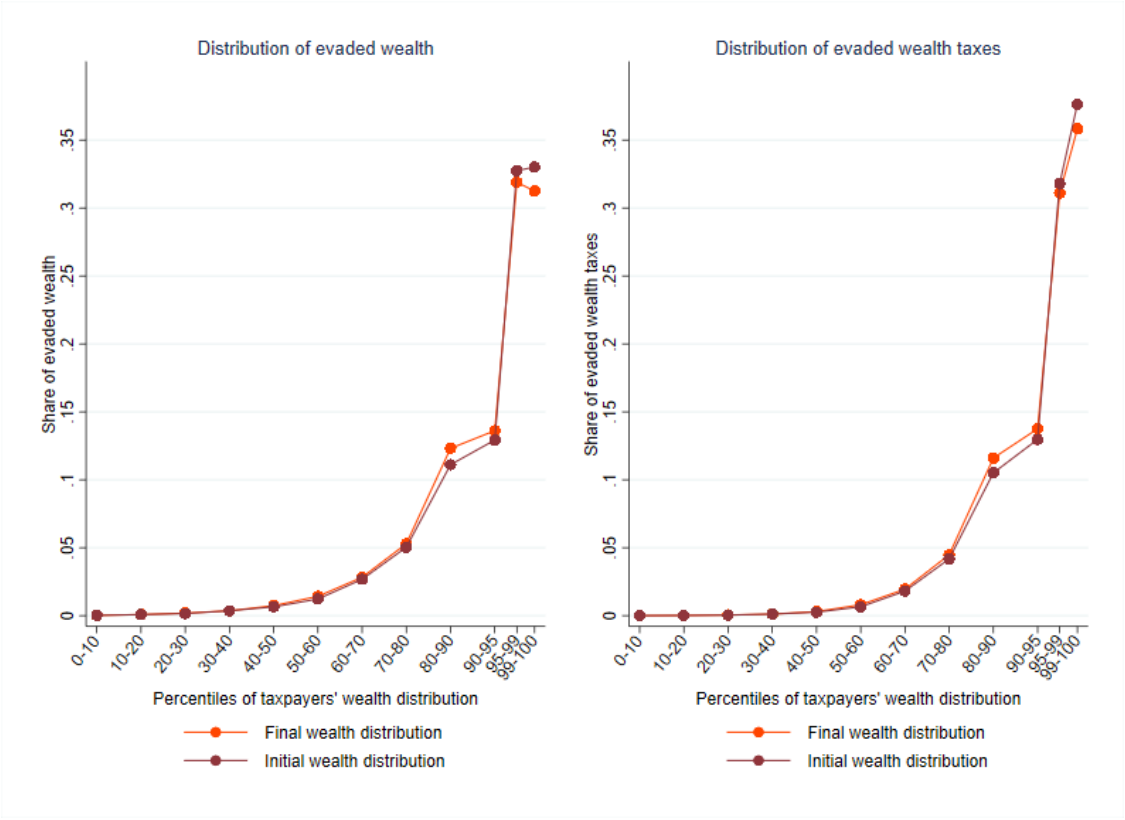


(b) Share of evaded income tax liabilities



Notes: The figure provides, by wealth percentiles, the average share of evaded income - *Panel (a)* - and the average share of evaded income tax liabilities - *Panel (b)* - with their 95% confidence intervals. The plotted averages only consider 3,800 evaders who filed during the voluntary period and seem to report information on income accurately. The individual share of evaded income and evaded income tax liability is computed over taxpayer's total, including the evaded part in the denominator. Wealth percentiles are defined according to taxpayers' initial wealth distribution, this is, according to the total wealth reported during the voluntary period. *Evaders' initial position* reflects the percentile position they would take according to the wealth reported during the voluntary period. *Evaders' final position* reflects the percentile position they would take according to the wealth reported in the latest tax return, once the formerly evaded wealth is included.

Figure A4.5: Distribution of evaded wealth and tax liabilities; Initial vs. final wealth distribution



Notes: Each distribution of each graph shows the percentile shares over the total. The two distributions plotted in each graph are computed considering only the 4,474 evaders who filed during the voluntary period. The difference between the two comes from whether evaders are placed according to the initial or the final wealth distribution (x-axis). In both cases, the evaders' percentile assignment is made according to the wealth reported in their latest tax returns (i.e. *final position*). The *Initial wealth distribution* is defined according to the total wealth reported during the voluntary period. The *Final wealth distribution* is defined considering the voluntarily disclosed wealth reported in the latest tax returns, together with that wealth already reported in the voluntary period.

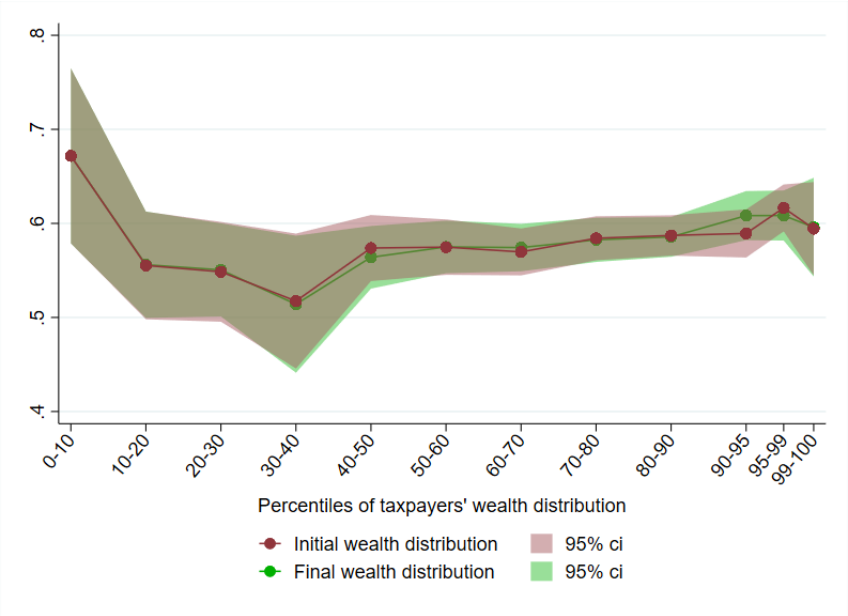
Figure A4.6: Portion of self-disclosed evaders filing in the voluntary period; Initial vs. final wealth distribution

Notes: The figure shows the portion of self-disclosed evaders among all taxpayers filing during the voluntary period by wealth percentiles. The difference between the two plotted lines comes from whether evaders are placed according to the initial or the final wealth distribution (x-axis). In both cases, the evaders' percentile assignment is made according to the wealth reported in their latest tax returns (i.e. *final position*). The *Initial wealth distribution* is defined according to the total wealth reported during the voluntary period. The *Final wealth distribution* is defined considering the voluntarily disclosed wealth reported in the latest tax returns, together with that wealth already reported in the voluntary period.

Figure A4.7: Percentile averages of evaded wealth and tax liabilities voluntarily disclosed by evaders filing in the voluntary period; Initial vs. final wealth distribution

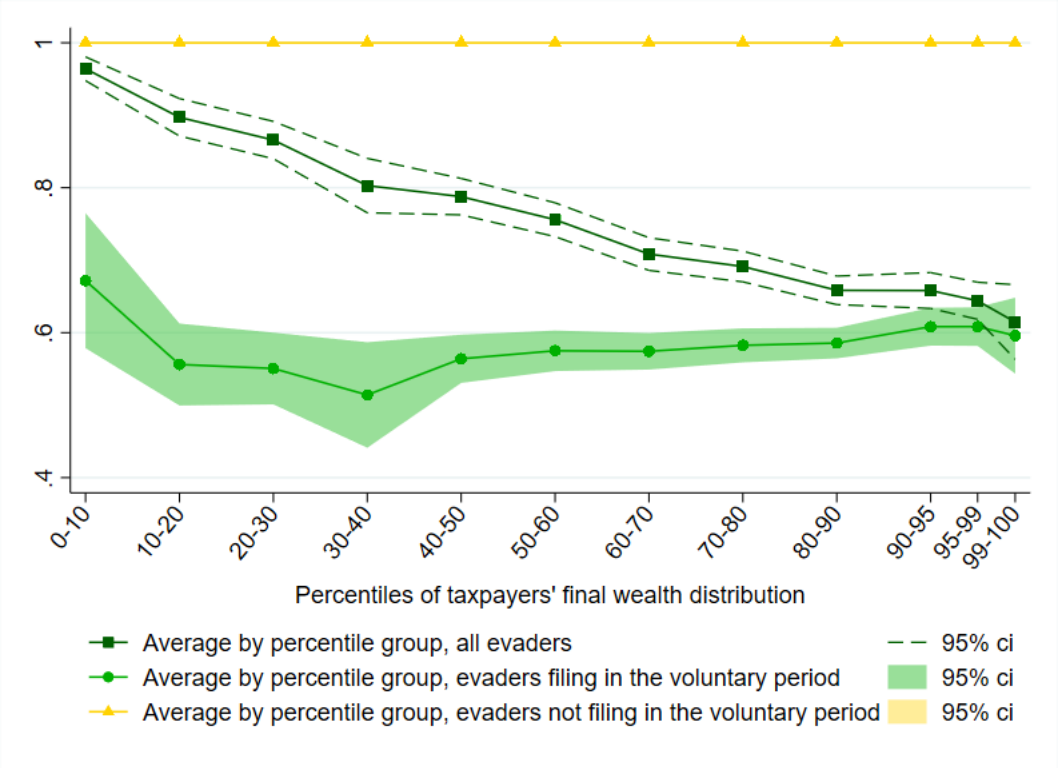
(a) Share of evaded wealth

(b) Share of evaded wealth tax liabilities



Notes: The figure provides, by wealth percentiles, the average share of evaded wealth - *Panel (a)* - and the average share of evaded wealth tax liabilities - *Panel (b)* - with their 95% confidence intervals. The two averages plotted in each graph are computed considering only the 4,474 evaders who filed during the voluntary period. The difference between the two comes from whether evaders are placed according to the initial or the final wealth distribution (x-axis). In both cases, the evaders' percentile assignment is made according to the wealth reported in their latest tax returns (i.e. *final position*). The *Initial wealth distribution* is defined according to the total wealth reported during the voluntary period. The *Final wealth distribution* is defined considering the voluntarily disclosed wealth reported in the latest tax returns, together with that wealth already reported in the voluntary period.

Figure A4.8: Percentile averages of the share of evaded tax liabilities; Evaders filing vs. not filing in the voluntary period



Notes: The figure provides, by wealth percentiles, the average share of evaded wealth tax liabilities with its 95% confidence intervals. The individual share of evaded wealth tax liability is computed over taxpayer's total, including the evaded part in the denominator. Wealth percentiles are defined according to taxpayers' final wealth distribution, this is, considering the voluntarily disclosed wealth reported in the latest tax returns, together with that wealth already reported in the voluntary period.

Table A4.1: Taxpayers' initial wealth distribution

Percentiles	Obs	Mean	Std. Dev.	Min	Max
0-10	4,188	793,634	393,298	-21,000,000	876,550
10-20	4,188	935,164	33,232	876,579	993,419
20-30	4,186	1,053,554	34,847	993,471	1,113,622
30-40	4,188	1,185,599	43,458	1,113,632	1,263,646
40-50	4,188	1,354,224	55,633	1,263,847	1,455,341
50-60	4,188	1,583,424	78,704	1,455,369	1,731,765
60-70	4,187	1,943,477	130,890	1,731,853	2,184,479
70-80	4,187	2,527,261	223,388	2,184,525	2,957,772
80-90	4,188	3,745,262	549,875	2,957,899	4,908,941
90-95	2,094	6,209,951	865,561	4,909,163	7,993,319
95-99	1,676	12,612,187	3,967,261	8,003,489	23,552,314
99-100	418	53,475,493	51,836,413	23,577,301	436,577,889

Table A4.2: Taxpayers' final wealth distribution

Percentiles	Obs	Mean	Std. Dev.	Min	Max
0-10	4,413	797,065	383,559	-21,000,000	882,141
10-20	4,413	942,486	34,543	882,154	1,003,050
20-30	4,413	1,065,564	36,189	1,003,056	1,129,059
30-40	4,413	1,204,295	45,726	1,129,063	1,286,116
40-50	4,413	1,383,357	59,270	1,286,136	1,492,912
50-60	4,413	1,631,045	86,423	1,492,953	1,794,655
60-70	4,413	2,017,887	136,701	1,794,740	2,273,037
70-80	4,413	2,643,875	238,473	2,273,109	3,107,274
80-90	4,413	3,986,656	612,843	3,107,347	5,313,979
90-95	2,207	6,728,028	972,538	5,315,929	8,760,935
95-99	1,764	13,773,217	4,364,665	8,761,278	25,878,253
99-100	442	56,613,970	54,454,528	25,879,222	436,577,889

Notes for Tables A4.1 and A4.2: According to the Wealth Tax Law, individuals must submit wealth tax returns when their overall gross wealth exceeds 2 million euros, although their taxable wealth is below the minimum threshold and hence their tax liability is zero. This is the reason why the first percentile group includes negative wealth. In fact, 13 tax filers report negative wealth and 35 tax filers (in Table A4.1) and 32 (in Table A4.2) report taxable wealth below the taxable threshold of 700,000 euros. *Taxpayers' initial wealth distribution* is defined according to the total wealth reported during the voluntary period. *Taxpayers' final wealth distribution* is defined considering the voluntarily disclosed wealth reported in the latest tax returns, together with that wealth already reported in the voluntary period.

4.10.2 Binary classifiers

Table A4.3: Summary of machine learning binary classifiers

Binary classifier[38]	Description	Related references
Logistic regression	Logistic regression performs classification by using a linear multiplication of the input predictors and applying a Sigmoid function to obtain a probabilistic representation.	McCullagh and Nelder (1989); Friedman, Hastie and Tibshirani (2001)
Linear Support Vector Machine (SVM)	Linear SVM also applies a linear combination of the input predictors, but instead of using a Sigmoid function, a score value representing each category is estimated.	Hearst et al. (1998); Friedman, Hastie and Tibshirani (2001)
SVM based on Radial Basis Function (RBF)	A SVM based on RBF classifies each observation by computing a smooth distance (through a RBF) with training samples.	Hearst et al. (1998); Friedman, Hastie and Tibshirani (2001)
k-Nearest Neighbour (k-NN)	k-NN performs classification by computing a distance (typically euclidian distance) between an observation and the training samples. The most common category of the K closest training samples is assigned to the observation.	Cover and Hart (1967); Friedman, Hastie and Tibshirani (2001)
Random Forest (RF)	The RF is a model made up of many decision trees. Each tree learns from a random sample of the training set and a random subset of the predictors. At test time, classification is made by averaging the predictions of each decision tree.	Breiman (2001); Friedman, Hastie and Tibshirani (2001)
Multi-Layer Perceptron (MLP)	The MLP is a type of Neural Network that performs classification by combining linear and non-linear (e.g. Sigmoid) operations.	Haykin (1994); Friedman, Hastie and Tibshirani (2001)

[38] See `https://towardsdatascience.com` to find different examples and applications of these methods, intuitive explanations and codes.

4.10.3 Bayes Error Rate estimation

A tight bound on the Bayes Error Rate (BER) for binary classification problems was recently proposed by Berisha et al. (2016). This bound can be directly estimated from the data and is based on the Henze-Penrose (HP) divergence measure, $D_{HP}(f_1, f_2)$, introduced by Berisha and Hero (2015); Henze and Penrose (1999). The estimation of the Henze-Penrose divergence is based on the multivariate runs test proposed by Friedman and Rafsky (1979) that consist of computing the Euclidean minimal spanning tree (MST) of the data. The Friedman-Rafsky test statistic, $R_{1,2}$, equals the number of edges in the MST of the data that connect a sample from class 1 to a sample from class 2.

It is shown in Berisha et al. (2016); Henze and Penrose (1999) that if $n_1 \to \infty$, $n_2 \to \infty$, and $n_1/(n_1 + n_2) \to \delta \in (0, 1)$ then,

$$1 - \frac{n_1 + n_2}{2n_1 n_2} R_{1,2} \to D_{HP}(f_1, f_2) \tag{4.1}$$

Where n_1 and n_2 are the number of samples for class 1 and 2, f_1 and f_2 are the distributions of class 1 and 2 respectively. Therefore, the number of cross-connections between the classes in the Euclidean MST is inversely proportional to the HP-divergence.

Finally, if both categories have equal prior probability, $p_1 = p_2$, the HP-divergence $D_{HP}(f_1, f_2)$ can be used to bound the Bayes error rate, $P_e(f_1, f_2)$, as:

$$\frac{1}{2} - \frac{1}{2}\sqrt{D_{HP}(f_1, f_2)} \leq P_e(f_1, f_2) \leq \frac{1}{2} - \frac{1}{2} D_{HP}(f_1, f_2) \tag{4.2}$$

Chapter 5

Conclusions

This PhD thesis provides abundant empirical evidence on avoidance and evasive practices adopted by taxpayers, and more precisely, by rich taxpayers. Therefore, the most direct and obvious conclusion that can be extracted from it is that wealthy taxpayers do avoid and evade taxes. And, at least for the taxes studied, they do it substantially.

I refer to the rich because, on the one hand, I focus on estates placed at the top 5% of the estates' distribution and, on the other hand, I study wealth taxpayers, who represent around 1% of the population of income tax filers and should be placed in the top of the wealth distribution. Therefore, the taxpayers' responses studied in this Thesis relate to taxes levied on wealth, this is, the inheritance tax and the annual net wealth tax. In this regard, the Thesis contributes to two main strands of the taxation literature: that related to wealth taxation and that studying avoidance and evasion.

More specifically, in the second chapter of this Thesis I contribute to the literature on inheritance taxation by showing that inheritance taxes influence both the apportionment of estates and the reporting and assessment of inherited assets. In relation to the first finding, this chapter shows that the distribution of the estate between spouses and descendants is partly determined by the will to reduce the tax burden. Put differently, spouses are more likely to inherit the entire estate when there is no need to minimize tax payments. In relation to the second finding, this chapter shows that the quasi-repeal of the inheritance tax induced taxpayers to report assets that otherwise would have been evaded, such as cash, art pieces, antiques, etc., and, more importantly, it also incentivized them to increase the assessment of assets which have implications for other taxes. This is mainly the case of real estate properties, given that the value reported when inherited is then used to determine the capital gains realized when they are sold. Therefore, while this practice does not imply

inheritance tax evasion, it might imply the evasion of future personal income taxes.

The third chapter of this Thesis contributes to the literature on annual net wealth taxation by showing that taxpayers reorganize their income and asset portfolio to avoid the net wealth tax. Specifically, while the reintroduction of the Spanish wealth tax did not have a negative effect on wealth accumulation, it did encourage taxpayers to change their asset and income composition to take advantage of exemptions and a limit set on tax liability. In this regard, one type of response was precisely to reduce taxable wealth in favour of exempt assets, mainly in terms of company shares (both listed and unlisted). Alternatively, taxpayers intended to benefit from the limit on tax liability by reducing their realized taxable income and increasing their long-term capital gains realizations, on the income side, and by investing in listed companies and investment funds, on the asset portfolio side. All in all, these avoidance responses are non-negligible in terms of foregone tax revenues.

The fourth chapter of the Thesis contributes to the literature on offshore tax evasion and, in particular, to that studying voluntary disclosure programs, by providing new estimates of evaded wealth and evaded taxes and by analysing the detectability of wealth evaders. In particular, in the context of a tax amnesty carried out by the Spanish government in 2012, this chapter quantifies the wealth voluntarily disclosed and shows how this type of evasion was distributed across wealth levels. In this regard, the data indicates that the probability of voluntarily disclosing hidden assets increases significantly with wealth and that, overall, wealth disclosers were evading an important share of their stock of wealth and their wealth taxes.

All the avoidance and evasive practices identified above have a common implication: they harm the equity and fairness of the tax system and, moreover, they might undermine the redistributive role of wealth and income taxes, which is, indeed, the main justification for their existence. Hence, it is important to, first, identify the factors that facilitate the adoption of these practices and, second, to assess how tax administrations can deal with these issues.

In this regard, some of the taxpayers' responses identified in this Thesis can arise due to the particularities and special treatments present in the design of the tax. This is especially the case of the net wealth tax. As discussed in Chapter 3, a comprehensive tax base with no differential treatment being applied across taxpayers with the same stock of wealth would make the tax more efficient and equitable. Moreover, it would facilitate the auditing tasks for the tax administration. This broadening of the tax base in turn would allow to reduce the current marginal tax rates and, at the same time, to increase the

taxable threshold. In this regard, taxing only the very wealthy at lower tax rates should alleviate the concerns about liquidity constraints.

Other types of taxpayers' practices can arise due to the information which is (not) available to the tax administration. This is the case of evaded wealth, either held abroad or that related to unproductive assets such as cash, jewellery, etc., but it also relates to the assessment of assets.

Considering the "big data" era we are living in, tax agencies can take advantage of it and use the massive information that is constantly generated beyond tax records. Indeed, some administrations such as the IRS in the US have been implementing big data analytics programmes since years ago.

As discussed in Chapter 2, the provision of accurate market price estimations from the tax administration would avoid the over and under assessment of assets from taxpayers. With the employment of big data techniques, this should be a feasible solution, especially in the case of real estate properties given the large size of this market. Apart from easing the filing and control tasks to taxpayers and the tax administration, respectively, the employment of market price estimations would improve the horizontal equity of taxes which levy real estate properties and currently rely on cadastral values.

With regard to wealth held in tax heavens, it is a problem that cannot be solved by a single country individually; the cooperation between jurisdictions is needed. This does not mean that tax agencies should give up on fighting this problem when cooperation is not achieved. In line with the previous discussion, tax administrations can still exploit the data available to approach tax evasion detectability.

In this regard, the tax evasion detection exercise implemented in Chapter 4 shows that the information initially reported in wealth tax returns is already useful to detect wealth evaders. Nonetheless, the provision of a richer description of taxpayers' profiles might help to achieve a better detectability. Moreover, the tax evasion prediction exercise implemented in this chapter could be also applied with evaders named in leaked data such as Swiss leaks or Panama papers if sufficient information is available. Indeed, further research is needed to learn more about offshore evaders.

As a final consideration, it is important to point up that part of the responses reported in this Thesis could be a lower bound of the overall responses adopted by taxpayers. By this I mean that the data employed does not allow to capture some types of responses such as the mobility of taxpayers to other territories. Hence, further research is also needed to assess how important is this phenomenon in the presence of both inheritance and wealth taxes which differ considerably across regions.

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