Death and Taxes: Does the Lock-in Effect Fade when Capital Gains Must be Taxed at Death?

Sobia H. Jafry
University of Toronto

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Abstract

This paper examines how changes in capital gains tax rates affect individual and household realization behaviour, using Canada as a natural setting. Canada taxes unrealized gains at death, partly eliminating the deferral incentive that exists in systems with forgiveness of tax at death. Using theoretical and empirical evidence, this paper shows that the lock-in effect arising from realization based taxes is low in Canada. I implement a difference-in-differences design, using deceased individuals, who realize their entire stock of accrued gains, as a comparison group for living individuals, who choose how much to realize. If the living respond to lower tax rates by increasing the fraction realized out of their stock of accrued gains, differences between the two groups' realization changes capture that effect. This novel identification strategy addresses the challenge that tax reforms are often preceded by changes in capital markets that affect the stock of accrued gains – an omitted variable, proxied in this paper by realizations of the dead, who are matched to living realizers on observable characteristics. I study the year 2000 reduction in Canada's capital gains tax using a 20% random sample of administrative tax records. The results show a dynamic realization response: a significant short-term increase in realizations, but no lasting effect in the medium to long run. Overall, the findings suggest that, in the absence of preferential treatment of gains at death, changes in capital gains tax rates have only limited long-term effects on realization behaviour.

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1 Introduction

How much tax revenue can a given increase in capital gains tax rate generate? With growing fiscal pressure on governments, this question is increasingly relevant. Most countries tax capital gains income at lower rates than other ordinary income[1], creating an opportunity to raise revenue by increasing those rates. However, the potential impact on revenue is uncertain due to behavioural responses. If behavioural responses to capital gains tax are strong then raising tax rates may not result in higher revenue. To accurately predict the revenue impacts, it is important to measure the strength of behavioural responses to capital gains tax rates and determine the factors that affect these responses.

Strength of behavioural responses to tax also impacts the efficiency of household investment choices. As capital gains income is taxed only when the underlying assets are sold and the gain is realized[2], it inherently creates an advantage in deferring realizations on appreciated assets as deferral leads to lower effective tax cost. This advantage incentivizes investors to forgo a higher pre-tax return on new investments i.e. they get "locked-in" to their existing holdings. This "lock-in" effect can lead to capital misallocation and inefficient portfolio selection (Auerbach, 1991) – a problem that is intensified by higher tax rates. A strong lock-in effect will be observed in the form of strong behavioural responses to changes in capital gains tax. Thus, concern for efficiency losses in capital markets when individual investors fail to make efficient portfolio choices, also makes it important to measure behavioural responses to capital gains tax rates.

This paper provides theoretical and empirical evidence of the strength of behavioural responses to changes in capital gains tax rates and factors that affect it. A key policy parameter used to measure changes in realization behaviour is an elasticity of capital gain realizations to changes in tax rates. This paper measures this policy parameter using Canada as a natural setting. Prior work using panel and time series data in the United States (US) has yielded contradictory results. Estimates of elasticity of capital gain realizations to tax

[1] Canada taxes capital gains income at half the rates as other ordinary income, in addition to other exemptions.

[2] Exceptions to this exist, most notably some realizations may be deemed realizations and not involve an actual sale of assets.

rates range from very high (-1.3 from Dowd and McClelland, 2019) to relatively mild (-0.5 from Agersnap and Zidar, 2021). Unobserved contemporaneous shocks in time series data which affect the stock of accrued gains, and may also be correlated with the timing and size of tax reforms, pose a key challenge in existing empirical approaches (Sarin et al., 2022). As stock of accrued gains is an unobserved variable in most datasets, inability to account for changes in this omitted variable remains an unresolved issue.

I propose a novel comparison group to overcome this omitted variable problem, namely decedent realizers in Canada. Unlike the US, Canada imposes mandatory tax on unrealized gains at death. Dead individuals have no choice; they must realize their entire stock of accrued gains at the time of death. In contrast, living individuals choose what fraction of their accrued gains to realize. If realizations respond to tax changes, differences between the two groups' realization changes capture that effect. This forms the basis of my identification strategy that addresses the longstanding problem of the lack of a clean comparison group, while also separating measured behavioural responses from the effects of unobserved shocks in time series data that may be correlated with tax rate changes.

I develop a conceptual framework to model dynamic realization behaviour under uncertainty in the presence of mandatory tax on accrued gains at death. This model is an extension of the static model proposed by Auerbach (1991). The benefit of the dynamic model over the static one is that the former characterizes an option value of deferring realizations created by realization based taxes. The lock-in effect will always exist in a system that taxes capital gains income on a realization basis. Adding the feature of taxation of accrued gains at death, results in a theoretical prediction that the lock-in effect becomes weaker in a system with mandatory tax at death as opposed to one with forgiveness of tax at death. I then provide empirical evidence of this theoretical result through a causal estimation of the strength of behavioural responses to capital gains tax in Canada.

The identification strategy is based on one of the model's theoretical predictions that living realizers choose to realize a fraction of their stock of accrued gains – a fraction that is decreasing in tax. As deceased individuals in Canada, must realize their entire stock of accrued gains, it provides an opportunity to measure the stock of accrued gains in their

death year. Realizations of the deceased can serve as a proxy for the stock of accrued gains of similar living individuals. I identify the causal effect of a tax change on the amount of capital gain realizations by comparing changes in realization of living individuals to those of dead individuals, using a difference-in-differences specification. I also investigate the extensive margin response using an indicator of whether an individual realizes any gains, which I call the propensity to realize. As tax rates are endogenous to income, I use quasi-experimental variation in marginal tax rates caused by a tax reform in Canada. In the year 2000, Canada reduced the inclusion rate[3] of capital gains income from 75% to 50%. This translated into a single large cut in effective tax rates on capital gains realization for all income tax brackets.

I construct a panel of 2.9 million living realizers and 0.4 million deceased realizers in Canada, using the Longitudinal Administrative Databank (LAD), which is a panel of 20% sample of tax filers in Canada. Individuals who are alive in the observation year form the treated group, while the deceased, in the year of their death, form the comparison group. I use a matching strategy to reweight the dead group so as to reflect the true couterfactual for the living group. I match 45 to 100 year-old tax filers who are alive and observed in any given year from 1995 to 2007 to a comparison group of individuals who die in the observation year, and have identical demographic characteristics in that year, and nearly identical income characteristics in the four years prior to the observation year. I use matching with replacement as the number of dead is much smaller than the number of living[4]. This results in a repeated cross-sectional matched sample of 21.1 million observations over 13 years.

The reform occurred in the year 2000, which is the treatment event, and I use 1998 as the base year. An identifying assumption is that mean realizations of the living and mean realizations of the dead must be on parallel trends leading up to the reform. I confirm

[3]Canada uses the same progressive tax rates for capital gains income as well as other personal income. However, the amount capital gains income is adjusted lower by applying the inclusion rate. For example, suppose an individual's marginal tax rate was 30% on the first dollar of capital gains income, then $75\% \times 30\% = 22.5\%$ would be the effective tax rate prior to the reform while it would be $50\% \times 30\% = 15\%$ post reform.

[4]Effectively, this results in younger individuals from the dead group to be reweighted higher while older individuals from the dead group to be reweighted lower to match the characteristics of the living group.

that this assumption holds in the pre-reform years 1995 to 1999. This is consistent with my hypothesis that living realizers realize a fraction of their stock of unrealized gains, and that fraction does not change as long as the tax rate is unchanged. Post reform, any change in realized gains that cannot be explained by a corresponding change in stock of accrued gains is the Average Treatment Effect on the Treated (ATT). I measure ATT as the percentage change in realizations of the living that is in excess of the percentage change in stock of accrued gains (i.e. the percentage change in realizations of the matched dead). I calculate elasticity of realizations to (net of) tax as a Wald estimator defined by the ratio of the ATT and percentage change in (net of) effective tax rates of the living, due to the reform.

Results show that living realizers react to the tax cut by realizing a very large fraction of their stock of accrued gains in the reform year, and the ATT for year 2000 is 103%. This immediate response is consistent with the literature of realization responses to capital gains tax changes (Lavecchia and Tazhitdinova, 2024; Agersnap and Zidar, 2021; Dowd and McClelland, 2019; Bakija and Gentry, 2014; Burman and Randolph, 1994). However, the chosen fraction returns to pre-reform levels in the medium term, and ATT for remaining post reform years is not statistically significant. This is clear evidence that tax cuts do not result in any sizable permanent change in realization behaviour. Even though the tax reform leads to a permanent decline in effective tax rates of over 40%, reduced form results show no permanent change in realization behaviour. The increase in net of tax rates is over 10%. The short term elasticity of realizations to (net of) tax is -2.41 (9.98), as measured in year 2000 only. Elasticity of realizations to (net of) tax is not statistically different from zero in all years except the reform year. These results show that capital gain realizations are not responsive to tax rates in the medium to long term. Moreover, these results confirm the theoretical prediction that the lock-in effect is weak in a system that has no forgiveness of tax at death.

Heterogeneity analysis reveals that the short-run response is strongest among individuals with large accrued gains in base year and those under the age of 65 years, a result that is consistent with theoretical predictions of this paper's model. Individuals with large accrued gains in base year show effects that persist into the medium to long run. However,

on average there is no lasting effect in the medium to long run.

Finally, to quantify the welfare impacts of this Canadian tax policy change, I calculate the marginal value of public funds (MVPF) for this tax reform (Hendren and Sprung-Keyser, 2020). MVPF estimates using different specifications range from $1.05 to $1.30. These estimates suggest that as a result of the tax cut of year 2000, every dollar in revenue lost by the government was a dollar in benefits gained by realizers, with some small additional welfare benefits created. This result when viewed alongside existing evidence that over 70% of capital gains in Canada are earned by families in the top 10% of the income distribution (Smart and Jafry, 2021), suggests that the primary beneficiaries of this policy change were those at the top of the income distribution.

1.1 Connection to existing literature

This paper contributes to the literature studying the strength of behavioural responses to the capital gains tax, through an estimate of an elasticity of capital gains realization to changes in the capital gains tax rate (see Table A1 for a detailed comparison). It estimates a short term elasticity to tax of -2.41, that is higher than US estimates from Dowd and McClelland (2019). Medium to long term elasticity, at -0.13, is not statistically different from zero and lower than the most recent US estimate from Agersnap and Zidar (2021). Other than the US, very few empirical estimates exist of a behavioural realizations elasticity to tax on capital gains income. Msall and Næss (2025) for Norway, Jacob (2018) for Sweden, and Jacob (2013) for Germany, provide evidence of capital gains realizations behaviour in response to changes in capital gains tax structure without explicitly measuring a behavioural elasticity to tax rate. The only Canadian measurement in this literature is by Lavecchia and Tazhitdinova (2024). Lavecchia and Tazhitdinova's measurement exploits an expiring favorable provision in tax, and the realization response observed in that case may be different from a response to a change in effective tax rates[5]. A policy relevant

[5]In 1994, Canada eliminated the Lifetime Capital Gains Exemption from tax of upto $100,000 in realized capital gains that had existed before, leading to a surge in capital gains realizations. Lavecchia and Tazhitdinova (2024) measure realizations elasticity to tax rates of -0.75 to -1.61 in the short run and 0.02 to 0.59 in the long run by exploiting this reform (calculated as reported elasticity times the average marginal tax rate).

parameter that denotes permanent responses must measure behaviour in response to a tax change that is not pre-announced (Gravelle, 2021).

Existing empirical approaches to estimating a causal response of realizations to tax rate changes have faced several challenges. One longstanding issue is the possibility that measured responses may be ascribing to tax changes, effects of contemporaneous changes that could be affecting realization behaviour. Governments often change capital gains tax rates in response to changes in capital markets. These changes can affect realization behaviour through a very important channel, the stock of accrued gains, which is generally not observed by researchers.

Most recent empirical estimates utilize data sources in which the stock of accrued gains is unobserved (Lavecchia and Tazhitdinova, 2024; Agersnap and Zidar, 2021; Dowd et al., 2015; Bakija and Gentry, 2014; Burman and Randolph, 1994). This paper addresses this omitted variable problem by using the realizations of decedents as a proxy for the stock of accrued gains of similar living realizers, benefiting from an insight into the Canadian tax feature of mandatory tax at death. In doing so, it measures permanent responses that are not influenced by confounding factors in time series data, or varying stock of accrued gains across individuals and across time. A related empirical problem is that tax reforms generally affect all taxpayers and it is hard to find a control group that is not treated by the reform. Deceased realizers in Canada do not have an opportunity to respond to tax changes, as the law requires them to realize their entire stock of accrued gains in the death year, which allows this paper to address the lack of control group problem.

A notable exception in recent literature is Dowd and McClelland (2019), who *do* observe stock of accrued gains for individual taxpayers for all asset sale transactions during a single tax year. However, this dataset excludes stock of accrued gains on assets that are not sold in that year, and this lack of realization is also a response that should be included in measured estimates of permanent responses. Moreover, Dowd and McClelland (2019) measure a short term response to tax as they utilize a bunching approach around the timing of a pre-announced reform that changed tax rates based on an asset's holding period. A short term elasticity to tax does not measure permanent behavioural responses to tax, which

is the goal of this paper. If tax hikes cause taxpayers to make less frequent but larger sized realizations, the medium term revenue response may be null, but when responses are measured using a narrow window before and after a reform, they may not be able to measure both these margins of response for a medium to long term. This paper measures dynamic responses over 8 years post reform and investigates annual as well as cumulative responses, on the intensive and extensive margins, in response to the tax change.

Some studies use state-level aggregate realizations over time to study responses to changes in tax rates (Agersnap and Zidar, 2021; Bakija and Gentry, 2014; Bogart and Gentry, 1995). Using state level aggregates overcomes an important problem in individual panel data which is that there are many observations with zero gains, and regressions using log transformation of the gains variable can lead to biased estimates. On the other hand, state level aggregates can suffer from aggregation bias and the variation created by small state level tax changes may not be salient enough to prompt individuals to respond (Saez et al., 2012). This paper uses an individual panel and overcomes the problem of log of zeroes by implementing a Poisson regression as well as a levels regression, following the recommendation in Chen and Roth (2024). Moreover, this paper utilizes tax variation arising from a single large tax cut that applies to all taxpayers.

Other problems in using individual data include strategic loss harvesting and movement of individuals in and out of tax brackets due to transitory income changes. While this paper's findings remain susceptible to the former problem, it is worth noting that the latter problem is less severe for this paper's approach as the variation in tax rates does not arise from a tax reform that differentially affects taxpayers in different tax brackets. Furthermore, this paper uses an explanatory variable defined as the first dollar effective tax rate on capital gains based on an individual's current year's taxable income exclusive of capital gains[6].

This paper also contributes to the literature on taxation of interegenerational transfers. This tax can take many forms such as gift, estate and inheritance tax. Canada does not impose any of these taxes. Intergenerational transfers in Canada are taxed primarily through

[6]This approach is needed as Canada applies the same progressive tax rates on capital gains income as applicable on other ordinary income.

the capital gains tax, whether the transfer is made inter vivos or at death; although death remains a significant event for transfers. In this paper, the dead group's realization can be considered as comprising entirely of interegenerational transfers happening at death. These transfers at death show very little change in response to the tax cut. Evidence from US time series data suggests that timing of intergenerational transfers is sensitive to tax (Joulfaian, 2004). The lack of response by dead group and transitory nature of response from living group in this paper, suggests that when intervivos and death transfers attract the same tax treatment, their sensitivity to tax changes is also dampened. This finding also supports Joulfaian (2000) and Auten and Joulfaian (2001)'s conclusion that the estate tax mitigates the lock-in effect of capital gains tax, as the mandatory tax of gains at death in Canada shares many features of an estate tax.

Some authors (Sarin et al., 2022; Dowd and Richards, 2021) argue that the possibility of indefinite deferrals may be responsible for measured realization responses to tax changes in the US that are higher than the true responsiveness. A narrow tax base may result in measured estimates of elasticity that are much higher than the true responsiveness to tax (Slemrod and Kopczuk, 2002). Indeed, the tax base for capital gains income is broad in Canada as unrealized gains at death cannot escape taxation. This paper is the first to show, using both theoretical and empirical evidence, that behavioural responses to capital gains tax in a system where the tax base encompasses gains at death is lower than the alternative systems.

Elasticity of any taxable income to changes in tax rates is not a structural parameter (Slemrod and Kopczuk, 2002), and the elasticity of realizations is no exception. It crucially depends upon other features of tax structure. This paper highlights the importance of one feature in particular i.e. the taxation of unrealized capital gains at death. In doing so, it adds to the broad literature that deals with issues in measuring elasticity of taxable income (ETI). See Saez et al. (2012) for a comprehensive overview of these issues. Many ETI studies utilize tax reforms that affect individuals in certain tax brackets and not others. This paper is unique in its ability to measure an ATT for all taxpayers, as it utilizes a reform that affects all tax brackets. I also confirm that a symmetric response occurs in a different reform in 1988 and 1990 that increased tax rates in Canada.

This paper contributes to the modeling of the dynamic realization decision by extending Auerbach's, (1991) static model to arrive at an option value in deferral of realizations. The theoretical predictions of this model are in line with simulation based results found in Dammon et al. (2001) and are mostly in line with the theoretical results found in the static model of Holt and Shelton (1962). Finally, this paper is the first one to quantitatively assess the welfare impact of a major tax policy reform in Canada from the year 2000. This is done by applying the MVPF technique proposed by Hendren and Sprung-Keyser (2020).

The plan of the paper is as follows. Section 2 describes the Canadian institutional setting and data. Section 3 develops a dynamic model of gains realization. Section 4 describes the estimation strategy. Section 5 presents the empirical results followed by estimates of elasticity and welfare effects. Finally, Section 6 concludes.

2 Institutional Setting and Data

Canada has a population of roughly 41 million. Tax-filing rates are quite high, with most non-filers[7] exhibiting characteristics consistent with those unlikely to earn capital gains income. Capital gains income comprises 3.5% of aggregate net income of individuals [8] and 7.6% of aggregate net taxable income of businesses [9]. Much of capital gains income is concentrated at the top of the income distribution (Smart and Jafry, 2021). In fact, the majority of Canadian families report no capital gains income.

Canada first started taxing capital gains income in 1972 as a result of a major tax reform[10]. Unlike some other countries which employ a schedular system, Canada reduces taxes on capital gains by including only a fraction of realized gains in taxable income. That fraction is called the inclusion rate. The inclusion rate for realized gains was initially set at 50%.

[7] 10-12% of the working age population in 2016 according to Robson and Schwarz

[8] Aggregate taxable capital gains in individual tax returns were $59 billion out of net income of $1,661 billion in year 2022 Individual income tax returns statistics 2022

[9] Aggregate taxable capital gains for business enterprise tax returns were $45 billion out of net taxable income of $596 billion in 2022 Statistics Canada Table 33-10-0498-01

[10] Canada Department of Finance, 2016, "Summary of 1971 Tax Reform Legislation," Available at summary of 1971 reform (accessed on: 2022-08-13)

Since that first imposition, the inclusion rate in Canada has undergone several changes as described in Table 1. In contrast, mandatory realizations at death feature has remained unchanged since its first introduction in 1972. Canada also eliminated all estate and gift taxes when capital gains tax was introduced. It is also important to note that the unit of taxation in Canada is individual and not family.

At least two other commonly used treatment of unrealized gains at death have been employed by countries across the world, other than mandatory taxation. One is carry-over basis[11] in which the asset with unrealized gains is transferred to the deceased's heir at the same cost and the same unrealized gains with no tax incidence at death. The unrealized gains do not escape tax altogether but will be taxed when the heir finally sells the asset. The second one is the step-up in basis[12], which allows forgiveness of tax at death and the asset is transferred to heirs with a cost-basis that is stepped-up to the market value of the asset. In this case, the unrealized gains at death escape taxation altogether. In choosing mandatory taxation of unrealized gains at death, Canada has selected a broad income base for imposing capital gains taxes, as opposed to countries that choose step-up or carry-over in basis treatment of unrealized capital gains at death.

The Canadian tax reform of year 2000 happened in two steps. Federal budget and fall statements of 1999 hinted at the possibility of lowering capital gains taxes in the future[13]. The first announcement was made on 28-February-2000 in which inclusion rate declined from three-fourth to two-third, and the change was effective immediately. With an upcoming federal election expected in November 2000, the incumbent party made a further cut in inclusion rate prior to the election. This was announced on 17-October-2000 [14] and was effective immediately. The second reduction resulted in an inclusion rate of one-half, and it has remained unchanged to date.

[11] applied in many European countries

[12] applied in the US and the UK

[13] These documents seem to consider and then reject a change in inclusion rate, while maintaining that such a change can be considered in the future. The documents also suggest that some groups were advocating in favor of a cut in inclusion rate.

[14] As an aside, the incumbent government succeeded in winning a majority government in November elections.

Capital gains arising from sale of an individual's primary residence are exempt from taxation. Over time, there have been changes in other exemptions by type of property. A lifetime capital gains exemption (LCGE) on all capital property was introduced in 1985 and later eliminated in 1994. Just prior to elimination, LCGE was subject to a limit of $100,000 in gains for individuals. Elimination of LCGE on all capital property was announced in February 1994 but individuals were given a chance to take advantage of the expiring LCGE and claim exemptions on gains realized in 1994. Moreover, these gains could in fact be "crystallized gains" such that actual sale was not necessary and a deemed realization could suffice. Unsurprisingly, there was a sharp increase in gains realizations in 1994 as people tried to realize tax-free gains before the exemption limit was set to expire (Lavecchia and Tazhitdinova, 2024).

Even though the broader LCGE on all capital property is no longer available, taxpayers are still entitled to a cumulative LCGE on net gains realized only on the disposition of qualified property[15]. Gains and other investment income in registered savings accounts are exempt from tax until withdrawals are made[16].

The cost of exemptions and other favorable tax treatments are termed "tax expenditures" that are measures to achieve social or policy objectives but administered through the tax system in Canada. About 3.6 million individuals and 311,100 corporations reported capital gains in 2021 in Canada[17]. Estimates suggest that federal revenue lost due to partial inclusion of capital gains amounts to a total of $30 billion in 2021 (almost 1% of nominal GDP). Additionally, the principal residence exemption cost about $13 billion and LCGE about $2.5 billion in 2021[18]. These estimates, of course, do not include any behavioral response to ensue if these exemptions were removed or altered.

Estimates also suggest that non-taxation of investment income in registered retirement savings accounts (RRSPs) cost almost $19.5 billion in 2021. Capital gains realized in RRSPs must therefore be a portion of this $19.5 billion. Since the realization of these gains does

[15] Qualified property includes qualified small business corporation shares and qualified farm or fishing property, for gains upto $1,250,000 in 2024, and brought forward reserves for either of these.
[16] For ordinary withdrawals, the amounts withdrawn are taxed at normal personal income tax rates.
[17] Report on Federal Tax Expenditures - Concepts, Estimates and Evaluations 2024
[18] ibid

not immediately trigger taxation, this paper argues that timing decisions of such capital gains will not be sensitive to changes in capital gains tax rate. Moreover, the level of separation that arises when investments in registered accounts are third-party managed such as by mutual funds and investment companies, timing of realizations becomes even less discretionary for individuals. Assets held directly (outside registered accounts) are more actively under control of individual taxpayers. Realization decisions and associated timing for such assets is discretionary. The purpose of this paper is to measure realization responses to tax changes. The Longitudinal Administrative Databank (LAD) reports total capital gains income that is taxable. These are gains that will be subject to partial inclusion for tax purposes. Gains realized inside registered accounts as well gains on principal residences are not included here. As argued above, timing decisions for these gains will not be sensitive to capital gains tax rate and are an accurate representation of tax sensitivity. LAD reported capital gains income includes gains in qualified property for which an exemption can be claimed. To measure the true behavioral response to tax, the outcome of interest must be purged of these exempt gains and section 2.2 discusses how to do that.

2.1 Data

The tax administrative records exist as the T1 Family File (T1FF), which includes 100% of Canadian tax filers. Individuals are linked to their spouses and children through census families. Income and demographic information is available at the individual level as well as aggregated to the census family level. Statistics Canada collects a 20% random sample of the T1FF and makes it available to researchers as the Longitudinal Administrative Databank (LAD) . Individuals once sampled into the LAD remain in the sample as long as they file a tax return. Identifying information is removed and all data processing for this paper was performed on a secure server onsite at the Toronto Research Data Center.

LAD reports income tax filing information along with some demographic characteristics. Although the sampling is on an individual basis, family level income information is also available. Family level variables are tied to an individual and do not require all family members to be sampled into the LAD. As an example, it is possible to observe capital gains

income of an individual sampled into the LAD along with the sum of capital gains earned by that person's entire family in any given year. Once sampled, individuals can be linked across different years giving the dataset a panel nature. Individuals exit the LAD through death or exit from Canada. The sample grows each year with population growth.

2.2 Deriving the Outcome Variable of Interest

Income variables in the LAD broadly follow reporting lines on the income tax return. This paper is concerned with response of capital gains realizations to changes in tax rates. The primary outcome of interest is the full dollar amount of realized capital gain that is responsive to tax changes. Certain types of capital gains are exempt from tax, as explained at the start of this section, and should not be considered part of the outcome variable. Under Canadian tax law, the dollar amount of capital gains realized will first be multiplied by an inclusion rate, before being counted in taxable income. Thus, if an individual earns $100 capital gains income that is not exempt, and the inclusion rate is 50%, only 50% x 100 = $50 will appear as a line item on the tax return. For the purpose of this paper, it is the unadjusted gross amount of $100 that should be the outcome of interest. Suppose, an individual realizes capital gain of G in a given year. This is the sum of gains that are exempt G_{exempt} and those that are taxable $G_{taxable}$ [19].

$$G = G_{exempt} + G_{taxable}$$

If an inclusion rate for capital gains ω applies throughout the year, LAD reported capital gains variable is equivalent to $\omega \times G$. This is problematic in 2 ways: first, it is adjusted for the inclusion rate; second, it includes exempt gains. The appropriate outcome variable of interest should be the gross dollar gain that is not tax-exempt and not adjusted for inclusion rate, namely $G_{taxable}$. Luckily, another LAD variable reports the amount $\omega \times$

[19] Exempt gains are those that occur from sale of shares in qualified small businesses (QSBC) or shares in qualified farm and fishing businesses(QFFP) within the Lifetime Capital Gains Exemption (LCGE) limit

G_{exempt}. And the outcome of interest can be derived as,

$$G_{taxable} = \frac{\omega \times G \; - \; \omega \times G_{exempt}}{\omega}$$

This paper will use the above variable as the primary outcome of interest[20]. An additional outcome will be an indicator variable for non-zero $G_{taxable}$ to estimate extensive margin response.

2.3 Deriving the Marginal Tax Rates

The change in marginal tax rate on capital gains income serves as the instrument in my identification strategy. To measure this change, I need the first dollar marginal tax rates on capital gains income for each individual in each year in the sample. Using each individual's total taxable income less $G_{taxable}$, I find the marginal tax rate applicable in their province of residence, for the observation year, through the Canadian Tax and Credit Simulator (CTaCs) (Milligan, 2016) for their income level. This rate is the marginal tax rate that will be applicable on the first dollar of capital gains earned by that individual.

2.4 New Descriptive Facts

Over the period 1982 to 2021, the average annual capital gain realization of a dead individual is roughly 15.5 times the average capital gain realization of a living individual. Not only are the mean levels higher at death, the average dead individual is 2.5 times more likely to post a gain in the death year than an average living individual is likely to post in a year. These facts underscore the importance of death as a significant event for gains realization.

[20]This approach to deriving the outcome of interest works well in all years in which a single inclusion rate applies throughout the year; this is not the case for the reform year 2000 when inclusion rates of 75%, 67% and 50% applied at different periods during the year. To address this problem, I use additional information about gains realized in the 3 different periods of year 2000 from T1FF Schedule 3 for year 2000 dataset especially developed by Statistics Canada for this purpose. Details are described in the Appendix.

Using yearly cross-sections and matched living and dead realizers on observable characteristics, I divide the sample into matched strata based on age, sex, marital status and prior 4-year average income. In each stratum, I use the mean gain of dead group as the implicit stock of accrued gains of the living group. I rank the strata based on the percentile of stock of accrued gains, and document following stylized facts:

Stylized Fact 1: Individuals realize a fraction of their stock of accrued gains, and this fraction is lower for higher stocks of accrued gains. Figure (4a) shows that living individuals realize a fraction of their entire stock of unrealized gains, and this fraction becomes lower at higher stock levels. This observation is supported by the theoretical model in section (3), which predicts that high stock of accrued gains intensifies the lock-in effect. Individuals holding an asset with high stock of accrued gains are likely to hold onto it even when it offers a relatively poor return as compared to alternatives. This is because the prospective tax cost of realization based taxes makes it financially more feasible to not realize. This observation highlights the importance of the unobserved stock of accrued gains, as it is a factor that is correlated with the realization choice.

Stylized Fact 2: Capital gains realization are concentrated at the top; individuals with larger stock of gains also have higher propensity to realize. When ranking individuals by the size of their stock of accrued gains, I find that individuals with larger stocks also have higher propensity to realize in any given year. This fact highlights the concentrated nature of the earners and realizers of capital gains income, and can be viewed in Figure (4b). This observation further reinforces the need to empirically measure extensive margin response in addition to the intensive margin response of realization to changes in tax rates.

Stylized Fact 3: Capital gains realization are concentrated at the top and are highly persistent. I count the number of times in the past 8 years an individual had realized capital gains. Figure (4c) plots the mean of this number against ranking of individuals by their stock of accrued gains. Clearly, individuals with larger gains also exhibit a high frequency of realizations over multiple years. This observation highlights how persistent capital gains realization is for the group of people who earn it. It also emphasizes the importance of measuring dynamic realization responses as opposed to static ones.

Unconditional Results I use this approach to also derive some unconditional results. Figure (6) plots the fraction of stock of gains realized by living individuals as a bin-scatter over the percentile of implied stock of gains separately by years. Years 1995 to 1999 are characterized by stable and high tax rates on capital gains realization in Canada, while the tax reform of year 2000, reduced tax rates on capital gains realizations for everyone. The fraction realized responds to changes in tax rates; cuts in tax rates lead to higher fraction realized. Figure (6a) shows that fraction realized in 1996 is almost the same as the fraction in base year 1998. In the tax reform year of 2000 (Figure 6b), fraction realized jumps much higher than the base year fraction. This result reinforces this paper's identification strategy, which relies on the living group changing its choice of fraction realized in response to tax changes. This spike in fraction realized as a response to lower tax rates is short lived, however, and returns to pre-reform levels soon. By year 2005, Figure (6c) shows that the fraction realized is almost identical to base year levels. These unconditional results provide strong justification for the use of a dynamic difference-in-differences empirical framework.

3 Theoretical Model

Consider an agent whose current portfolio is worth W, of which a fraction $0 \leq \alpha < 1$ is unrealized capital gains. The agent chooses between $x = 1$ (hold existing asset) or $x = 0$ (hold alternative safe asset) every period. The existing asset earns return $1 + r$ before taxes. The alternative asset earns return $1 + i$ before taxes. Return on existing asset accumulates tax free until the gains are realized, and only then they are taxed at rate τ. Alternative asset returns are taxed every period at rate τ. Note that i, r and τ can take on values between 0 and 1.This setup is inspired from Alan Auerbach's (1991) static model for realization decision in the presence of realization based taxes. I call it the dynamic realization problem.

The transition rule for wealth in the dynamic realization problem is,

$$W' = \left[x\,(1+r) \;+\; (1-x)\,(1-\tau\alpha)\,\left(1+(1-\tau)i\right) \right] W \tag{1}$$

where W' is wealth next period.

If the agent chooses to hold the alternative asset, the unrealized share resets to $\alpha' = 0$, but if she holds the existing asset, it evolves depending upon r. In total,

$$\alpha' = \chi \cdot \frac{\alpha + r}{1 + r} \tag{2}$$

The agent maximizes expected wealth at death, where the per period probability of death is $\mu > 0$. If the agent dies, all unrealized gains (i.e. $\alpha > 0$) are realized and taxed. This represents the tax treatment of unrealized gains at death in Canada. The timeline of events is summarized in Figure (1).

The agent knows the existing asset return that is about to accrue in the current period with certainty but future period returns are uncertain. Future period returns on existing asset are assumed to be iid of current period return. The need to assume this element of uncertainty is twofold; first, this allows the choice to be dynamic, as in the case of complete certainty, the agent will simply choose an asset in current period and never switch to the other; second, since existing asset returns affect future unrealized gain fraction α' non-linearly, future period wealth will be stochastically determined by future r's. Continuation value will be expressed in expectation of return on existing asset in next period.

The agent's mortality risk is assumed to be constant at $\mu > 0$. In the timeline of events, death occurs after the agent has made the realization choice. The value function can simply be expressed as a mortality weighted average of values in case of death or survival in the current period to account for this risk.

Finally, the value function can be normalized with beginning net of tax wealth. This normalized value function can be expressed as the sum of a default value in case of realizing the gain on existing asset (or choosing $\chi = 0$) plus, in case of holding the existing asset (or choosing $\chi = 1$), the advantage to holding as opposed to realizing (see Appendix A.2 for details). Both the default value of realizing as well as the advantage to holding can be expressed as mortality weighted average values in the respective case.

Let $V(.)$ be the agent's value function. Existing unrealized gain fraction α and current

period return on existing asset r are the state variables. Mortality risk μ, tax rate τ and alternative asset return i are part of the agent's information set. The problem can be represented by the following functional equation,

$$V(\alpha, r) = \max_{x \in \{0,1\}} C_0 + x \cdot \left[\mu \, \Delta_d(\alpha, r) + (1-\mu) \, \Delta_a(\alpha, r) \right] \tag{3}$$

where, C_0 is the mortality weighted value of realizing in current period or the default value, i.e.

$$C_0 = \big(1 + (1-\tau)i\big) \left[\mu + (1-\mu) \, \mathbb{E}V\big(0, r'\big) \right] \tag{4}$$

The expectation in continuation value term is on expected return on existing asset in next period. If the agent chooses to realize today, and dies immediately after, she will earn the net of tax return i on existing wealth and the problem will end. In case she survives till next period, α' resets to 0, and she will face another choice in next period. Notice that C_0 will always be the same for an agent of mortality μ regardless of her current state.

In (3), Δ_d is the advantage of holding in case of death in current period,

$$\Delta_d(\alpha, r) = (1-\tau) \left(\frac{r}{(1-\tau\alpha)} - i \right) \tag{5}$$

and, Δ_a is the advantage of holding in case of survival in current period,

$$\Delta_a(\alpha, r) = \left(1 + \frac{(1-\tau)}{(1-\tau\alpha)} r \right) \mathbb{E}V\big(\alpha', r'\big) - \big(1 + (1-\tau)i\big) \, \mathbb{E}V\big(0, r'\big) \tag{6}$$

In the above, α' denotes $\alpha'|(x = 1)$, and note that $\alpha'|(x = 0) = 0$.

Optimal decision rule is given by,

$$\begin{aligned} x^* = 1 \quad & \textit{iff} \quad \mu \, \Delta_d(\alpha, r) + (1-\mu) \, \Delta_a(\alpha, r) \geq 0 \\ 0 \quad & \textit{otherwise} \end{aligned} \tag{7}$$

The lock-in effect of capital gains tax would predict that the agent would be willing to remain invested in the existing asset even for some values of expected return that are less than the alternative asset return i.e. for some $r < i$. I show in the Appendix, that when $\tau = 0$, there is no lock-in effect and the agent chooses whichever asset offers the higher return. For $\tau > 0$, the optimal decision rule can be stated in terms of a hurdle rate for the existing asset return, as shown by Proposition 1.

Proposition 1 *It is optimal to hold the existing asset as long as the expected return on it is not lower than the hurdle rate,* r^*. *It is optimal to hold iff:*

$$r \quad \geq \quad (1-\tau\alpha)i - \textit{option value of deferral} \quad \equiv \quad r^*$$

where,

$$\textit{option value of deferral} \;= (1-\mu)\,\frac{1-\tau\alpha}{1-\tau}\,\left(\Delta_a(\alpha, r) - \Delta_d(\alpha, r)\right)$$

The hurdle rate is the lowest return on the existing asset given which the agent continues to hold the existing asset and does not realize the accrued gain α. This result provides evidence that the lock-in effect exists in the dynamic realization problem. Since, the hurdle rate $r^* < i$, when the agent is faced with the prospect of a non-zero realization based tax, she will choose to remain in the existing asset even for some values of r that are less than i. Furthermore, higher tax rates push the hurdle rate even lower. Intuitively, this means that the agent will be willing to forgo a higher pre-tax return on new investments when holding an existing asset with accrued gains, when the tax cost of realization is high. Formally, Proposition 2 states the comparative statics result for the hurdle rate r^* with respect to tax rate τ.

Proposition 2 *The hurdle rate for holding is decreasing in the tax rate on capital income.*

$$\frac{\partial r^*}{\partial \tau} \quad < \quad 0$$

The lock-in effect can be defined as the willingness to forgo a higher pre-tax return on new investments to compensate for the deferral advantage of realization based taxes. In this

problem,

$$\textit{lock-in effect} \;=\; i \;-\; r^*$$

and Proposition 2 implies that the lock-in effect is increasing in the tax rate.

Agents in the dynamic realization problem differ only with respect to their mortality rate μ. Agents with the same μ will always make the same realization decision when they are in the same state (α, r). The distribution of α for all agents with mortality rate μ is denoted by $F_{\alpha|\mu}$. Proposition 3 characterizes the average stock of unrealized gains in this economy for an agent of type μ.

Proposition 3 *Average stock of unrealized gains for an agent of type μ is the expected value of α for that type. The average stock of unrealized gain for an agent of type μ is given by,*

$$s_\mu \;=\; \mathbb{E}[\alpha \mid \mu] \;=\; \int \alpha \, dF_{\alpha|\mu}(\alpha|\mu)$$

Realizations in the economy are composed of all the α's of agents who make the choice to realize given their state and current period return. In other words, all agents of type μ whose current period return r falls short of the hurdle rate r^* make the choice to realize i.e. choose $x^* = 0$. Their realized gain equals their entire α. The distribution of current period returns is denoted by F_r. Figure 2 represents a hypothetical distribution of returns for type μ agents in state α. All agents whose return r is less than the hurdle rate are realizers and the remaining are holders.

The hurdle rate r^* is dependent upon state α. In fact, Proposition 9 (found in the Appendix) states that the hurdle rate is decreasing in α. Current α is a function of the agent's past realization choices and therefore it is a function of past returns. However, since future period returns on existing asset are i.i.d., the distribution of current period returns F_r is independent of the distribution $F_{\alpha|\mu}$. Proposition 4 characterizes the average realized gains in this economy for an agent of type μ.

Proposition 4 *Average realized gains for an agent of type μ is the expected value of α of only*

the realizers of that type. The average realized gain is given by,

$$g_\mu \;=\; \mathbb{E}[(1-x^*)\alpha \mid \mu] \;=\; \int_\alpha \int_{r=0}^{r^*(\alpha)} \alpha \; dF_r(r) \; dF_{\alpha|\mu}(\alpha|\mu)$$

The objective of this paper is to study behavioral responses to changes in capital gains tax. Average stock of gains of an agent of type μ is a function of the state variable and thus unaffected by any unanticipated changes in τ that happen in current period. Average realized gains, however, are dependent on the hurdle rate and from Proposition 2, the hurdle rate decreases when tax rates go up. Figure 3 shows that a lower hurdle rate implies lower realizations on average. Thus, when tax rates go up realizations should decline, under the assumption that asset returns are unaffected by changes in tax rates.

Total realized gains in the economy must be less than or equal to the total stock of gains. As lower tax rates lead to higher realizations, it must be that a higher fraction of the beginning stock of gains is chosen to be realized. Proposition 5 formalizes this result.

Proposition 5 *The ratio of average realized gains to average stock of gains for agents of type μ is a function of the hurdle rate. Unanticipated declines in the tax rate on capital income result in an increase in this ratio.*

$$\frac{\partial \frac{g_\mu}{s_\mu}}{\partial \tau} \;<\; 0$$

Finally, using Proposition 5, I can define a function $h(\tau)$, such that

$$g_\mu \;=\; h(\tau)\; s_\mu \tag{8}$$

where, $h(\tau)$ is a fraction that decreases in tax rates, i.e. $\frac{\partial h(\tau)}{\partial \tau} \;<\; 0$.

Equation (8) will form the basis of the estimation strategy discussed in section 4.

To see how the hurdle rate in this problem compares to one in a system which allows carry-over basis for unrealized gains at death, one can simply set the parameter $\mu = 0$. The value of switching to alternative asset as well the advantage of holding are both higher when $\mu = 0$. This is because the continuation values receives full weight of 1 and there is

no weight on the lower instantaneous value in case of death this period. By setting $\mu = 0$, the problem allows for no tax at death and the next recipient of the asset is assumed to behave just like the original agent and retains the cost basis. The option value of deferral in such a case will be much higher and the hurdle rate lower. Proposition 6 formalizes this result. See Appendix for details.

Proposition 6 *The hurdle rate in a system which allows for carry-over basis for unrealized gains at death,* $r^*_{carry_over}$*, will be lower than the hurdle rate in a system with mandatory taxation of unrealized gains at death,* $r^*_{mandatory_tax}$*, because the option value of deferral in the former case is higher.*

$$r^*_{carry_over} < r^*_{madatory_tax}$$

On the other hand, a system that allows step-up in basis feature will also result in a higher advantage to holding as the death event results in a reset of future α to 0 without incurring any tax on existing α. Modeling a system with step-up in basis would retain $0 < \mu < 1$ parameter values but it will change equation (20) such that in case of death and choice of $x = 1$, there is no tax applied and future α is reset to 0. Proposition 7 formally states this result. See Appendix for details.

Proposition 7 *The hurdle rate in a system which allows for step-up in basis for unrealized gains at death,* $r^*_{step_up}$*, will be lower than the hurdle rate in a system with mandatory taxation of unrealized gains at death,* $r^*_{mandatory_tax}$*, because the option value of deferral in the former case is higher.*

$$r^*_{step_up} < r^*_{madatory_tax}$$

The above results predict that the lock-in effect is weaker in a system with mandatory taxation of unrealized gains at death, a result that is confirmed by this paper's empirical findings. Msall and Næss (2025) show that in a static setting, the lock-in effect is stronger in a system with step-up as opposed to one with carryover basis, an argument also made by Holt and Shelton (1962). This paper shows the dampening effect of mandatory tax at death as opposed to step-up in basis holds in a dynamic setting, which is a new theoretical

result. It goes on further to show that under the assumption that the heir is no more likely to die than the benefactor, the lock-in effect is also weaker in a system with mandatory tax at death, as opposed to one with carryover basis, which is another new result, although intuitively unsurprising. Mandatory tax at death and step-up in basis can be thought of two extreme versions of tax treatment of unrealized gains at death, while carryover basis is an interim system. It makes intuitive sense that the lock-in effect intensifies in moving from one extreme to the other.

In this partial equilibrium model, I assume that the distributions F_r and $F_{\alpha|\mu}$ are stationary in equilibrium. An unanticipated tax cut at time $t = 0$ will act as shock to this equilibrium and result in an increase in average realizations in that period. In period $t = 1$, the distribution $F_{\alpha|\mu}$ will change and become much more right-skewed than in equilibrium. This is because a lot more α's have been reset to zero due to the tax shock, and $F_{\alpha|\mu}$ will have a larger mass at $\alpha = 0$. Many values of $\alpha = 0$ at time $t = 1$ will mean lower realizations in $t = 1$. Due to the lower tax rates, agents will continue to realize a higher fraction of s_μ. As the economy transitions back to equilibrium, the distribution of $F_{\alpha|\mu}$ will again reach a stationary state. Agents will now be choosing to realize a higher fraction of s_μ. Thus, the predictions about dynamic changes following a tax cut are:

- Time $t = 0$: τ goes down, s_μ is unaffected and $\frac{g_\mu}{s_\mu}$ goes up
- Time $t = 1$: many values of $\alpha = 0$, $\frac{g_\mu}{s_\mu}$ goes down
- Time $t = 2$ till time $t = T - 1$: transition period
- Time $t = T$: $\frac{g_\mu}{s_\mu}$ is stationary and at higher level than before time $t = 0$

4 Estimation

4.1 Definition of target parameter

The empirical objective of this paper is to measure the lock-in effect or the strength of behavioural responses to changes in capital gains tax rate. These behavioural responses are observed as changes in capital gains realization. A policy relevant parameter is the elasticity of realizations to changes in tax or net of tax rate. To measure the elasticity, the first objective is to measure the causal effect on realizations due to exogenous variation in tax rates. I define treatment as the timing of a tax reform in year 2000 that reduced tax rates for all tax-payers. According to equation (8) from section (3), in the absence of a tax change, individual realizations should grow at the same rate as the growth in their accrued stock. An unexpected tax cut causes individuals to realize a larger fraction of their accrued stock, and this change allows us to measure the causal effect of tax changes. The target parameter is an average treatment effect on the treated (ATT), defined as the percentage change in individual realizations in excess of the change in their stock of accrued gains. Once this ATT is measured, the elasticity can be calculated as the ATT divided by percentage change in tax rates.

4.2 Differences in mean gains of living and dead realizers

The model equation (8) from section (3) can be used to express an individual's realization choice in a way that is similar to the very basic model of earned income from Saez et al., (2012). In year t, individual i realizes capital gains g_{it} and faces a marginal tax rate of τ_{it}. Realized capital gains g_{it} are chosen as a fraction $h(\tau_{it})$ of the stock of accrued gains s_{it}. The fraction realized $h(\tau_{it})$ in equation (8) can take on the functional form[21] $(1-\tau_{it})^{\epsilon}$, where ϵ is the elasticity with which the agent responds to net of tax rate on capital gains

[21]The choice between tax rate or net of tax rate is stylistic – both convey the idea of income sensitivity to tax or net of tax rates. I am using net of tax rate in keeping with convention in the elasticity of taxable income literature.

realization.

$$g_{it} \;=\; h(\tau_{it}) \cdot s_{it} \;=\; (1-\tau_{it})^{\epsilon} \cdot s_{it}$$

Conceptually, s_{it} is the capital gains income earned when marginal tax rate is zero, similar to the earned income concept that Saez et al. call *potential income*. Unlike other forms of income that are taxed on an accrual basis, capital gains income is taxed on a realization basis, and only the portion of accrued gains that is realized gets taxed. When marginal tax rates are zero, the individual is indifferent between realized and unrealized gains, and for this reason potential gains equal the entire stock of accrued gains.

$$\textit{potential gains} \;=\; s_{it} \;=\; \textit{stock of accrued gains}$$

A naive OLS regression of $\log\ g_{it}$ on $\log(1-\tau_{it})$ would not identify ϵ because the marginal tax rate τ_{it} is endogenous to realizations g_{it}. This paper will rely on changes in the tax rate due to a tax reform as an instrument for $\log(1-\tau_{it})$. A long line of empirical literature uses the difference-in-differences approach to measure changes in taxable income of a group that experiences a change in tax rates, by comparing it to the changes in taxable income of another group which experiences smaller or no change in tax rates.

In this problem, there is no group which experiences smaller or no change in tax rates. Instead, I will use living realizers as the treated group while the deceased are the comparison group. I denote the living group experiencing the tax change as L and the dead group (those who die in year t) as D. In this setting, group D does indeed experience the same proportionate change in tax rates as L, however, because this group dies in year t, individuals in group D cannot change their realization behaviour in response to the tax change. Mandatory taxation at death implies that in each year t, group D realizes the entire potential gains whereas group L realizes only a fraction of it, i.e.

$$g_{it} = \begin{cases} s_{it} & \forall\ i \in D \\ (1-\tau_{it})^{e} \cdot s_{it} & \forall\ i \in L \end{cases}$$

where, e is the elasticity to net of tax rate for living individuals. Individual i cannot be observed as both dead and living in year t. Dead individual j matched to living i on

observables X provides the potential outcome for i, in case i had died in year t, under the assumption that their stock of unrealized gains evolve similarly. For j matched to i on observables X,

$$g_{jt} \;=\; s_{jt} \;\sim\; s_{it}$$

Now, this setup can easily be used to estimate the ATT using a log approximation.

$$\text{ATT} = \mathbb{E}[\, \log g_{it} - \log g_{jt} \mid X \,] = e \cdot \mathbb{E}[\, \log(1 - \tau_{it}) \mid X \,] \tag{9}$$

The main identification assumption is that differences in mean gains between living and matched dead should remain constant if tax rates are constant.

4.3 Estimating elasticity of realizations to tax changes

In the absence of a tax reform, the mean realized gain of individual i is the same fraction of the mean stock of gains. If stock of accrued gains for living realizers could be observed, then the pattern of realized capital gains and stock of accrued gains would be parallel in trends while tax rates do not change. Matching allows us to consider the outcome of individual j matched to i on observables X as the counterfactual stock of accrued gains of i, had i not experienced the tax reform. Equation (9) can also be written as,

$$\mathbb{E}\,[\, \log g_{it} \mid L \,] - \mathbb{E}\,[\, \log g_{it} \mid D \,] = e \cdot \mathbb{E}\,[\, \log(1 - \tau_{it}) \mid L \,]$$

Estimation of elasticity e involves the use of a tax reform event that causes exogenous variation in tax rates. Let us denote the pre-reform year by t_0 and the post-reform year by t_1. The traditional approach to two-stage-least-squares regression of

$$\log g_{it} = \epsilon \cdot \log(1 - \tau_{it}) + a \cdot \mathbb{I}(t = t_1) + b \cdot \mathbb{I}(i \in L) + \varepsilon_{it} \tag{10}$$

on a repeated cross-section sample in which we observe L and D's realized gains in both years, while using the post reform and treatment group interaction $\mathbb{I}(t = t_1) \times \mathbb{I}(i \in L)$ as an instrument for $\log(1 - \tau_{it})$ would result in the classical difference-in-differences estimate that can be scaled by the ratio of tax changes experienced by the two groups to arrive at

the elasticity for the living group e.

An alternative approach is to measure elasticity by running separate regressions for the reduced form and the first stage equations, and calculating elasticity as a Wald estimator which is a ratio of the coefficients from each regression. The reduced form equation is:

$$\log g_{it} = \alpha + \delta\, \mathbb{I}(i \in L) + \lambda\, \mathbb{I}(t = t_1) + \beta\, \mathbb{I}(i \in L) \times \mathbb{I}(t = t_1) + u_{it}$$

where, $\mathbb{I}(i \in L)$ is the treatment indicator that equals 1 if i is living and 0 if i is dead, and $\mathbb{I}(t = t_1)$ is an indicator for post reform year. Since, the outcome variable is in logs, the ATT is measured by coefficient of interaction term β. And, the first stage equation is:

$$\log(1 - \tau_{it}) = \alpha' + \delta' \mathbb{I}(i \in L) + \theta\, \mathbb{I}(t = t_1) + \gamma\, \mathbb{I}(i \in L) \times \mathbb{I}(t = t_1) + v_{it}$$

which gives percentage change in marginal tax rate of living group as $\theta + \gamma$. Elasticity of realizations to the net of tax rate is given by the Wald estimator which equals the ratio of percentage change in realizations of living due to the reform and percentage change in marginal tax rate of living group, i.e.

$$e \;=\; \frac{\beta}{\theta + \gamma}$$

This paper will use the latter approach to measure elasticity through a Wald estimator. Since, this involves a nonlinear combination of coefficients from two different regressions, I will calculate bootstrapped standard errors for the Wald estimate.

4.4 Sample Construction

This paper studies how living taxpayers respond to changes in capital gains tax using Canadian administrative tax data. Individual date of death is recorded on the final tax return filed for a deceased person. Tax administrative records for both dead and living persons record annual taxable capital gains realizations which are adjusted for inclusion rate. I convert these measures into the outcomes of interest, which is the full dollar amount of

taxable capital gains realizations (see section 4 for details). I analyze how these outcomes change following a tax decrease in the year 2000, by matching living individuals aged 45 to 100 to a comparison group of dead individuals, in yearly cross-sections, who were similar on a rich set of observable characteristics four years prior. I then compare these matched individuals using a non-parametric difference-in-difference specification on repeated cross sections. I analyze prior outcomes to see whether the two groups were following similar trends leading up to the event, and identify how their outcomes diverged after the tax decrease.

I study gains realization behavior in the years 1995 to 2007, which I call the sample period. For each of these years, I partition the sample into two groups: a treated group comprising of those who were living in that year, and a control group comprising of those who died in that year. This section describes how these groups were constructed.

4.4.1 Analysis Sample

The analysis sample consists of 45 to 100 year olds with some income in the four years prior to the observation year. I exclude individuals living in the territories, and those who report net capital losses. These restrictions lead to a sample of roughly 3.3 million unique individuals and 28.9 million observations over the 13 years in the sample period. Out of these individuals, roughly 12.5% die during the sample period. The analysis sample covers 99.5% of the 45-100 year old tax-filers in the provinces studied. In each year of the sample period, an individual is considered living if their year of death is missing or is later than that year. Dead individuals are classified as dead in their year of death and later. This leads to individuals who may be part of the living group in one year and the dead group in a later year. Once dead, however, the individual is not part of the analysis sample in any years following the death year.

4.4.2 Matched Sample

The econometric challenge in this paper is to estimate the counterfactual realizations of living individuals that would have occurred absent the tax reform. Motivated by the result of the dynamic realization model of section 3, this challenge is reduced to estimating the stock of accrued gains. Mandatory realizations at death in Canada allow us to observe the stock of accrued gains for individuals who die. These realizations can be used as a proxy for the implied stock of accrued gains of living individuals who are similar to the dead. The counterfactual realizations of living individuals can then be estimated as the pre-reform realized gains growing at the same rate as the implied stock of accrued gains.

In the analysis sample of living and dead groups, there is an imbalance on observable characteristics. The dead group is predominantly older. Since, the theoretical model of section 3 predicts that age also affects realization behaviour, this makes it necessary to employ a matching design. I match each dead individual to an individual from the living group, and match with replacement. I prioritize matching as many dead individuals as possible because dead individuals are scarce in the analysis sample.

I apply the matching procedure in two steps: first, I create exact matches on decile of 4-year average income including capital gains, sex, marital status, and whether or not the individual has minor children. In this step, for those in the top decile income group only, I exact match on percentile of 4-year average income excluding capital gains, percentile of 4-year average family income (including and excluding capital gains income), an indicator of investment expertise[22], and an indicator for ownership in a Canadian controlled private corporation (CCPC)[23]. I carry out this finer matching in the top income bins as this is where most of the capital gains realizations arise from, and there is substantial heterogeneity in realization behaviour in these income bins. In the second step of matching, I make coarse

[22]To measure investment expertise I create an indicator for whether an individual's family realized any capital gains in the year 1994; the year 1994 was characterized by a crystallization reform in which individuals were allowed to book gains to take advantage of an expiring lifetime capital gains exemption (LCGE) limit without actually having to make any asset sales. The argument here is that if an individual's family took advantage of that reform, that individual possesses some investment expertise.

[23]owners in CCPC's receive favorable tax treatment of capital gains income earned on qualified shares under the LCGE provisions described in section 2

matches on year of birth within the exactly matched strata from the first step. I exclude strata that do no contain at least 1 living and at least 1 dead individual. In this manner, I am able to match 87% of the living sample and 97% of the dead sample. The matched sample size is 2.9 million unique individuals and 21.1 million observations.

I calculate match weights to determine average treatment effect on the treated (ATT) for each yearly cross section. I reweight the dead group to make its distribution of observable characteristics similar to that of the living. For example, the dead group is on average 14 years older than the living group. Matching increases the weight on younger individuals and lowers the weight on older individuals in the dead group. These weights are calculated as follows:

Individual-year observations of the living group receive a weight of $w_{\text{living}} = 1$, while individual-year observations of the dead group in strata s receive a weight of

$$w_{\text{dead}} = \frac{n_{\text{living,s}}}{n_{\text{dead,s}}} \times \frac{N_{\text{dead}}}{N_{\text{living}}}$$

where, $n_{\text{living,s}}$ and $n_{\text{dead,s}}$ respectively are the number of living and dead individuals in strata s. Meanwhile, N_{living} and N_{dead} respectively are the number of living and dead individuals in the entire yearly cross-section. The resulting matched sample is well balanced on observable characteristics, as shown in Figure (10). A natural concern is the possibility that individuals who are about to die may behave differently from the living, in anticipation of death. I rule out this concern through tracing out realization behaviour leading upto death event for the matched sample, and I discuss this in section 5.

4.5 Empirical Specification

I identify the economic impact of lowering taxes on capital gains income by comparing the evolution of capital gain realization among living individuals who experience the reform in the year 2000 with the evolution of the implied stock of accrued gains measured through capital gain realizations among matched dead individuals. I use this to measure the elasticity of realizations to changes in tax. The lock-in effect predicts that agents have

a willingness to forgo higher pre-tax returns on new investments when holding assets with accrued gains, in order to compensate for the deferral advantage of realization based taxes. This willingness declines when tax rates are cut, leading to a rise in realizations as individuals becomes less "locked-in". The elasticity of realizations to changes in tax rates measures the lock-in effect, which is the same as the strength of behavioural responses to tax.

Regression Specification

The reduced form equation is:

$$Y_{it} = \alpha + \delta \text{ Living}_i + \lambda \text{ Post}_t + \beta \text{ Living}_i \times \text{Post}_t + u_{it} \tag{11}$$

I run the above difference-in-difference regression separately for years $t = 1995$ to 2007, using ATT weights and normalize the estimates using 1998 as base year. Outcome Y can be log of capital gains realized, dollar amount of capital gains realized, or an indicator for non-zero capital gains realized. Subscript i denotes individuals and subscript t denotes the observation years. Living_i is an indicator for the living group. α measures the mean Y of the dead group in base year, while δ measures the base year difference between the mean Y of the living and the dead groups. λ's estimate the evolution of mean Y over time among the matched dead group. β's are the coefficients of interest; they estimate the difference in the evolution of mean Y over time between the living individuals and the matched dead group. When Y is measured in logs, β's have a percentage change interpretation. Each β estimates the percentage change in mean living realizations over the base year that is not attributable to the percentage change in stock of gains over the base year. I estimate robust standard errors.

The first stage equation is:

$$X_{it} = \alpha' + \delta' \text{Living}_i + \theta \text{ Post}_t + \gamma \text{ Living}_i \times \text{Post}_t + v_{it} \tag{12}$$

where X_{it} can be $\log(1 - \tau_{it})$or $\log \tau_{it}$. Tax rate is defined as the effective tax rate on the first dollar of capital gains income, which equals the inclusion rate times the marginal tax

rate applicable to the first dollar of capital gains income (see section 2.1 for details). α' and δ' are analogous to α and δ in the reduced form equation. The reduced form equation is used to estimate the ATT and elasticity of realizations to the net of tax rate (or tax rate) is given by the Wald estimator:

$$e = \frac{ATT}{\theta + \gamma} \tag{13}$$

4.6 Measuring the ATT

ATT when Y is in Logs

When using the reduced form equation (11) with logged dependent variable, the coefficient of interaction term β has a percentage change interpretation and the resulting ATT is calculated as,

$$ATT_{logs} = \beta$$

As I discuss below, there is a potential bias in estimating ATT_{logs} in this setting, and I use two other methods to overcome it. I describe this first because conceptually, the elasticity is most easily explained using ATT_{logs}. Additionally, some of the earlier work in this literature uses the logged outcome variable.

Problem of Zeroes

Estimation of ATT using logged capital gains realization variable is problematic due to the bias resulting from presence of zeros in the outcome variable (Chen and Roth, 2024). To avoid this bias, I use two approaches to obtain the ATT. The first is to estimate the reduced form equation (11) when Y is in levels. The second approach is estimate the ATT using Poisson Pseudo Maximum Likelihood (PPML) regression (Correia et al., 2020).

ATT when Y is in Levels

An approach recommended by Chen and Roth to avoid the problem of zeroes is to measure the ATT using reduced form regression (11) when the dependent variable is in dollar amounts instead of logged amounts. This regression in levels is the main reduced form

specification of this paper. The ATT in this case can be constructed as,

$$ATT_{levels} = \frac{\alpha + \delta + \lambda + \beta}{\alpha + \delta} - \frac{\alpha + \lambda}{\alpha} \tag{14}$$

ATT using Poisson regression

This approach requires estimating the following conditional mean function,

$$\mathbb{E}[g_{it}|Living] = \exp\left(\alpha + \delta\ Living_i + \lambda\ Post_t + \beta\ Living_i \times Post_t\right) u_{it} \tag{15}$$

where, g is the capital gains realized in levels (dollar amount). The exponentiated coefficient $\exp(\lambda + \beta) - 1$ can be interpreted as the percentage change in realizations of the living group over time, whereas the exponentiated coefficient $\exp(\lambda) - 1$ can be interpreted as the percentage change in realizations of the dead group. Using a combination of these regression coefficients, I construct the ATT as follows:

$$ATT_{poisson} = \exp(\lambda + \beta) - \exp(\lambda) \tag{16}$$

In all three cases i.e. logs, poisson and levels, the elasticity of realizations to the net of tax rate (or tax rate) is given by the Wald estimator:

$$e = \frac{ATT}{\theta + \gamma}$$

where, ATT can be ATT_{logs}, ATT_{levels} or $ATT_{poisson}$, while θ and γ are estimates from the first stage equation (12).

I run the levels and poisson specifications and get exactly the same ATT estimates i.e. $ATT_{poisson} = ATT_{levels}$. Note that this identical result is specific to my context where the ATT is defined as the excess change in realizations of the living over the change in realizations of the dead, resulting in the evolution of comparison group mean which subsumes the entire year-fixed effect. As the elasticity is calculated using coefficients from 2 different regressions, I bootstrap standard errors for elasticity estimates.

Identification Assumption of Parallel Trends

The estimated ATT's identify the average causal effect of treatment on the treated (the living) if the gains realized by living individuals would have evolved in parallel to the matched dead group's realizations absent the tax reform. This identifying assumption can be evaluated by looking for parallel trends in the pre-period or making sure that ATT is not different from 0 for every pre-reform year.

4.7 Measuring Other Responses

Extensive Margin Response

I also investigate extensive margin response by estimating the reduced form equation (11) with the dependent variable as an indicator for non-zero capital gains realized. This response shows how the tax reform changed the propensity to realize among the living. If tax hikes cause taxpayers to make less frequent but larger sized realizations, the overall response may be null, but when responses are measured using only realizations in levels and in a small window around the timing of a tax cut, the measured responses may be overstated. It is important to measure dynamic extensive margin responses to be able to accurately capture overall behavioural responses.

Response Conditional on Non-zero Gains

When the capital gains realization outcome is investigated conditional on non-zero realization, it indicates how the size of realizations changed for non-zero realizations. This response gives a sense of whether the overall response is coming through the extensive or intensive margin, although it cannot be considered a causal effect as realization size and propensity to realize are correlated.

Cumulative Years Response

It is possible that taxpayers' response to a tax cut is spread across several years. Instead of realizing one large gain immediately in response to a tax cut, individuals may decide

to distribute that realization over a few years. A dynamic difference-in-differences specification using annual outcomes will not be able to measure this effect. A static difference-in-differences specification using annual outcomes will come closer to capturing this effect however, if there were substantial offsetting behaviour among different individuals across the years, the static effect will smooth over it. The only way to capture this effect is to follow individuals over time, and ideally measure cumulative outcomes dynamically. The panel nature of Canadian tax administrative data, allows me to follow individuals over time to measure their cumulative response to the tax cut.

To measure the cumulative individual responses, I accumulate individual realizations over multiple years. This cumulative n-year effect is estimated using (11) and replacing the dependent variable with $Y_{it,n}$ which is cumulative outcome over n years ending in t. Meanwhile, the dependent variable in first stage equation (12) is replaced with $X_{it,n}$, which is the log of average tax rate or average net of tax rate on the first dollar of capital gains income over the n years ending in t. The base period is the n year period ending in 1998.

The matching strategy is now changed to reflect the cumulative nature of the outcome being studied. Matching must now be conducted over the history of individual covariates. As matching on the entire history of covariates is very demanding of the data, to preserve sample size, I match only on the first and last year covariates over the n years. For this reason, estimates for large n such as $n > 5$ should be interpreted with caution.

I measure the cumulative n-year responses dynamically for $n = 2$. However, due to sample size constraints, for $n = 3, 4$, and 5, I can only measure cumulative responses using a static 2x2 difference-in-differences specification. I investigate both intensive as well as extensive margin response using cumulative outcomes. Finally, I estimate the cumulative specification using log, poisson as well as the levels regression.

Heterogeneity in Treatment Effects

The theoretical model of section (3) makes predictions for at least two individual characteristics. Firstly, Proposition 9 predicts that if an individual has high stock of accrued gains, their hurdle rate for realization will be lower which indicates greater lock-in effect. Empir-

ically, this can be tested to see if individuals with high stock of accrued gains in base year show greater responsiveness to the reform. To test this, I use the mean dead realizations in each matched strata in base year 1998, and consider them the implied stock of accrued gains for the matched living. I restrict this analysis to individuals whose implied stock of gains in base year was at least $2,000. Next, I divide these individuals into 2 groups based on whether their stock is above or below the median stock of accrued gains in base year. I run the reduced form regression for the 2 groups separately.

The second prediction of the model, according to Proposition 8, is that the lock-in effect in a system with mandatory tax of accrued gains at death, is decreasing in mortality risk, which means that at higher ages individuals should exhibit lower lock-in effect. To test this empirically, I divide the sample into two groups based on whether age is over 65 years or not. I run the reduced form regression for the two age groups separately.

Canadian administrative data provides a rich set of observables that allow me to investigate how responses differ across other individual characteristics as well. I conduct heterogeneity analysis for groups defined by sex, marital status, and presence of children, as well as the interaction of marital status and sex.

5 Results

Mean annual realized gains of the living and dead group, normalized to 1998 base year means, were on parallel trends leading up to the reform year as see in Figure (7b). This is in line with the model prediction that living individuals realize a fraction of their entire stock of gains and that fraction does not change as long as tax rates do not change. The tax reform happened in the year 2000, and mean realizations of the living increased by 112% over their base year mean. Realizations of the dead, however, only rose by about 9% in the year 2000 over their base year mean. Using reduced form equation (11), these changes translate into an ATT_{levels} equal to 103% in year 2000. This change in realizations is short-lived, however, and from year 2001 onwards Figure (7) shows that the change in realizations of living is not different from that of the dead over the base year.

First stage results in Figure (5) show the change in tax rates and net of tax rates of the living group over time. Mean annual effective tax rate of the living were steady in the years leading to the reform and declined by 43% in the year 2000 as compared to base year, as seen in Figure (5a). Over the following 7 years, effective tax rates remained 48% lower on average. Similarly, Figure (5b) shows that mean net of tax rates of the living group increased by over 10% in the year 2000, and remained that high until 2007. Overall, both first stage results show that the tax change caused large and permanent cut in effective tax rates for the living group.

Table (2) reports the details of reduced form coefficients and converted ATT_{levels} for a single year - the reform year 2000. Column (1) reports reduced form results from regression (11) when the outcome is in levels. Mean realized gains of the living group were on average $\$3,325$ lower than the mean realized gains of the dead group in the base year 1998. In the year 2000, the size of dead group's average realizations increased by \$355, which was a 9% increase over base year mean for this group. Living realizations, on the other hand, surpassed this increase even in dollar amounts, and rose by \$766 over their base year mean. In percentage terms, this represented an increase of 112%. The ATT_{levels} for year 2000, as represented by the wald numerator in the table, is the change in realizations of the living that was in excess of the change in their stock of gains. This excess change in realizations was $112\% - 9\% = 103\%$. Column (2) reports coefficients of the poisson regression (15). As mentioned in section 4, the $ATT_{poisson}$ is exactly the same as ATT_{levels}. First stage results using regression equation (12) when outcome is log of effective tax rates are listed in column (3), and when outcome is log of net of effective tax rates are listed in column (4). Adding coefficients for the post-reform indicator and the interaction terms results in the change in tax rates for the living group. Effective tax rates for the living group declined by 43% over the base year, while net of effective tax rates increased by 10%. Elasticity to effective tax rates and net of effective tax rates using the Wald estimator from equation (13) is listed in the bottom row. The short term elasticity to effective tax rates is -2.4 in the reform year and it is statistically significant. Similarly, elasticity to net of tax rates is 9.98 in the reform year, and statistically significant. Column (6) lists the coefficients for the reduced form regression run with dependent variable as an indicator of any non-zero realized gain in annual data. The reform year shows that the annual

propensity to realize increased significantly for the dead while the propensity to realize for the living increases by slightly more. Column (6) should be viewed with caution as the parallel trends assumption for the indicator for any non-zero gains variable does not hold in annual outcomes as seen in Figure (14e) in the Appendix.

Relative mean dollar values of annual gains realization for all years in the sample period can be can be seen in Figure (7b) . These levels have been normalized to the base year 1998. These indicate that leading upto the reform year living and dead realizations followed a parallel trend. In the reform year living realization rise faster than the rise in dead realizations. The percentage increase in living realizations that exceeds the percentage increase in dead realizations is the ATT_{levels}. The ATT_{levels} measures can be viewed in Figure (7a).

Table(3), Panel A reports results when using annual outcomes only for all post-reform years. Column (1) presents ATT_{levels} using reduced form regression (11) when outcome is measured in levels. First stage results list the coefficients $\theta + \gamma$ from regression (12), representing the percentage change in outcome for the living group only, when outcome is log of effective tax rates in column (2), and log of net of effective tax rates in column (4). These first stage results are also plotted in Figure (5). Elasticity to effective tax rates and net of effective tax rates using the Wald estimator from equation (13) is listed in columns (4) and (5) respectively. As also seen in Table (2), the short term elasticity to effective tax rates is -2.4 in the reform year and it is statistically significant. For every other year in the post-reform period, though, the elasticity to effective tax rates is not statistically different from zero. Similarly, elasticity to net of tax rates is 9.98 in the reform year, but not statistically significant in any other post-reform year. Column (6) lists the difference-in-difference estimate or coefficient β when the reduced form regression (11) is run with dependent variable as an indicator of any non-zero realized gain in annual data. The reform year does not show any change, whereas the years 2001 to 2004 show persistent decline in annual propensity to realize of the living relative to the dead. Taken together, this suggests that after a large increase in realization sizes in the reform year, the following years saw fewer realizations, but the realizations were overall of similar sizes relative to stock of gains as the pre-reform ones. Moreover, after this temporary dip for a few years,

even the realization propensity of the living went back to pre-reform levels relative to the propensity of the dead.

Using cumulative outcomes of a single individual over n-year post reform can help clearly demonstrate if the response to the reform was purely a re-timing response. Panel B of Table (3) presents these results when outcome is measured as cumulative realized gain n-years following the reform for values of $n = 2, 3, 4$, and 5. The normalization period is n-years ending in 1998, so as to maintain a consistent base period. As discussed in section 4, use of cumulative outcomes requires matching on history of covariates which causes sample attrition. To preserve sample size, I match only on the first and last years' covariates in the n-year period. This makes results less reliable as n increases. For this reason, I report results for $n <= 5$ only. For $n = 5$, the sample is already reduced to almost half the size of the sample using annual outcomes. In the 2-years ending in 2001, realizations of the livings increased by 111% more than their stock of gains over the base period. The average effective tax rate declined by 40% over the same period resulting in an elasticity to tax rate of -2.8. Likewise, the elasticity to net of effective tax rates was 11.4. Both these elasticities are statistically significant. As the accumulation period increases, however, the effect dissipates. For 3-years ending in 2002, realization of the living exceed the increase in their stock of gains by only 24% over the base period, and this change is not statistically significant. For 4-years ending in 2003, as well as 5-years ending in 2004, I do not find statistically significant changes in realized gains. Both average effective tax rates as well as average net of effective tax rates show permanent change. Moreover, the extensive margin result also becomes negligible over the cumulative periods[24]. Overall, the cumulative outcome results confirm what the annual outcome results were suggesting; the reform was successful in triggering a response that was mostly a re-timing response.

Using a static difference-in-difference set up with annual outcomes all grouped as post reform or not, produces results shown in Panel C of Table (3). Elasticity to effective tax rate is -0.3 over the 8 years period post reform. This elasticity is not statistically different from zero. This point estimate is on the lowest end of elasticity estimates produced by

[24]These are static 2x2 difference-in-difference results. For 2-year cumulative outcomes, parallel trends assumption holds as shown in Figure (8).

studies in the US. The net of tax elasticity for the same period is 1.3, which is also on the lowest end of existing estimates. The extensive margin result in the static case is negative and statistically significant. Looking at the annual, cumulative and static results for extensive margin suggests that the reform caused many individuals to take a gap in making any realizations in the aftermath of the initial surge in realization sizes. However, over the long run they return to pre reform frequency and this impact is not significant.

The extensive margin response using annual outcomes violates parallel trends assumption. It may be the case that outcome of propensity to realize responds to the tax reform over a period that is longer than 1 year. I use a 2-year cumulative outcome in the reduced form regression (11). For this 2-year cumulative outcome for extensive margin, I find that parallel trends assumption does hold. These results are plotted in Figure (8). Regression results for both levels outcome and indicator for any non-zero gains over 2-cumulative years are listed in Table (4) along with elasticity measures. In the years 2002 and 2003, 2-year cumulative propensity to realize for the living falls more than the propensity for the dead. From 2005 onwards, the difference in propensity to realize for the two groups returns to pre-reform levels.

Realization behaviour in anticipation of death

A possible concern is that individuals may change their realization behavior in anticipation of death, if death is somehow foreseen. To check if this poses a problem, I track individual outcomes for the two groups in a yearly cross-section for a decade leading upto the death year. I stack these observations at the death year for all yearly cross-sections. I calculate relative means of realized gains in levels as well as an indicator for non-zero gains normalized to the base year, which is one year before death. Results are plotted in Figure (12). In terms of propensity to realize, living individuals and matched dead have identical behavior leading up to the death year. Individuals who are approaching death do not become more or less likely to realize gains. In terms of size of realized gain, the means closest to the death year are very noisy, and show marginally larger sized realizations earned by individuals who are approaching death. While the difference in means between living and matched dead is statistically not significant, it is useful to think about what potential bias

such behaviour may introduce in my estimates. If the dead group was more likely to make larger realizations in the years leading up to death, the gains realized at the time of death will be understated, and resulting ATT overstated.

Conditional gains and log gains responses

Figure (14) shows results using annual outcomes of realized gains conditional on realizing, log of realized gains and an indicator for any non-zero realization.

The outcome realized gains conditional on realizing is endogenous. Figure (14b) shows that conditional on realizing, individual responses persisted for more than just the reform year. Thus, those who realized kept realizing a larger fraction for longer. However, this response too drops to pre-refom levels at about 4 years post-reform.

The outcome log of realized gains suffers from the problem of log of zeroes. To see the extent of bias created by this problem, one can note the ATT_{logs} in Figure (14d). In the reform year, ATT_{logs} is roughly half the size of ATT_{levels}. Additionally,the parallel trends assumption does not hold for the reduced form regression with logged outcome.

The extensive margin outcome is an indicator of any non-zero realizations. This outcome when measured on annual basis, violates the parallel trends assumption[25] as seen in Figure (14f). There is a sharp dip in this annual outcome for the living group in the years following the reform year. Taken together with the conditional gains response this shows that after the reform year, the extensive and intensive margin responses worked in opposite directions. Fewer people made realizations, but those who did were made larger sized realizations. Overall, individuals may have switched to making larger sized realizations but less frequently. However, this change in behaviour is not permanent and both responses return to pre-reform levels in the medium to long term.

Evidence of symmetric response to tax cuts and increases using the inclusion rate increase in 1988 and 1990

Canada implemented changes in its inclusion rate in 1988 and 1990. Those two reforms

[25]For this reason, I also investigate a 2-year cumuative extensive margin outcome as discussed above.

involved an increase in the inclusion rate from 50% to $66\frac{2}{3}$% effective in 1988, followed by an increase from $66\frac{2}{3}$% to 75% effective in 1990. Both changes were announced simultaneously on June 18, 1987[26]. There was ample warning and time to adjust behaviour in anticipation of the reform. Both changes lead to a substantial increase in effective tax rates on capital gains income. The model predicts that an unanticipated reform of this nature should cause living individuals to realize a smaller fraction of their stock of gains, leading to lower realizations. Figure (13) plots results for the living and matched dead realization behaviour around these reforms. Panel (a) shows relative means of realized gains normalized to 1987 levels. Living individuals did not respond to the 1988 reform right away, which may be because they were already aware of the reform coming up in 1990. Dead individuals' realized gains rose sharply in 1989 indicating higher stock of gains due to appreciation of market prices. However, living individuals refrained from making larger sized realizations. This pushes the ATT_{levels} in 1989 sharply lower. In 1990, dead realizations were still larger in size as compared to 1987 levels, and the living continued to realize small amounts. ATT_{levels} in the year 1990 remains negative. Similar to the baseline results for the year 2000 reform, this negative response was also short-lived. Living individuals realization levels recovered to pre-reform levels by the year 1991. On the extensive margin side, living individuals showed immediate response to the 1988 reform, by higher increase in propensity to realize as compared to the living. This response dissipated by the year 1990. Overall, these results are not exactly the mirror opposite of the 2000 reform but in the same direction. The extensive margin reaction is immediate in this case whereas, it was more delayed in the case of the year 2000 reform. This may be explained by the pre-announced nature of the reform as well as the fact that there were two changes that occurred in quick succession.

Did market conditions affect the realization response?

The dynamic realization model predicts that an individual may choose to defer realizations due to the lock-in effect of realization based taxes. However, if the expected future returns on the existing asset are high enough, a higher option value may also drive the individual to defer realizations. Thus, expected returns in the market may also cause lower realizations.

[26]Canada, Department of Finance, The White Paper: Tax Reform 1987

As Canadian tax administrative data does not include asset level information, it is not possible to isolate the impact of this factor. One way to determine how market expected returns affect realization behaviour is to look at similar market conditions that did not coincide with a tax cut event.

Figure (9) part (a) shows year end levels of the TSX index. The year 2000 coincided with a stock market peak. In the following two years, the index level declined. Lower prices in these years could indicate higher expected returns in the future. As a result of higher expected returns, individuals may choose to hold their existing assets thereby lowering realizations. I identify four other roughly similar movements in the TSX index in years 2007, 2010, and 2014. These three years represent a market peak that was followed by a year-on-year index decline of over 5% . Moreover, there was no simultaneous cut in the capital gains inclusion rate in these years. I run the reduced form equation (11) assuming the market peak year to be the event year and setting the base year as two years prior to the event year. The resulting ATT_{levels} are plotted in panels (b) to (d), along with the results for the baseline year 2000 reform. None of the market crash events lead to results similar to the 2000 results for ATT_{levels}. This result dispels the concern that expectations of higher returns may be responsible for the dynamic response to the year 2000 reform.

Heterogeneity analysis

Figure (11) shows heterogeneity in response to tax changes exhibited by various subgroups including by initial stock of accrued gains, age, marital status, and lastly by marital status times sex. It plots estimated ATT_{levels} using reduced form regression (11) run separately on every subgroup.

The mean dead realizations in each matched strata in base year 1998, can be considered the implied stock of accrued gains for the matched living. I exclude individuals whose implied stock of gains in base year was less than $2,000. The remaining sample is divided into 2 groups based on whether the implied stock is above or below the median stock of accrued gains in base year. As predicted by the model of section (3) that individuals with high stock of accrued gains should exhibit greater lock-in effect, I find that the observed response of those with high stock gains exceeds the response of those with low stock of

gains. This result can be seen in Figure (11a).

Next, I divide the matched sample into two groups based on whether the individual's age in the observed year is less than 65 years or not. ATT_{levels} for these two groups are shown in Figure (11b). The theoretical model predicts that at higher ages, individuals should exhibit lower lock-in effect. Results confirm this prediction, as the group aged less than 65 years of age shows greater sensitivity to the tax change.

Dividing the sample by marital status does not produce any meaningfully different results. I conclude that married and single individuals on average behave similarly, as seen in Figure (11c). Similarly, dividing the sample by sex of the individual also shows that men and women behave similarly in response to the tax change in the reform year, as seen in Figure (11d). Dynamic response among men and women differs somewhat although the estimates are noisy.

The behaviour of men and women when interacted with marital status leads to a curious result. Single women show the highest sensitivity to the tax change followed by married men and women, and finally by single men. Married men and women behave similar to each other. In Figure (11e), I plot ATT_{levels} of single men and single women only to emphasize their difference in behaviour. In order to understand why single women show high sensitivity, I first turn to age. Single women in my sample have an average age of 70 years while single men have an average age of 62 years. Age acts to lower sensitivity to tax, but I find the exact opposite in this case. Advanced age also means that an individual has had more time to accumulate stock of accrued gains. Indeed, the stock of gains of single women is on average higher than single men. In the case of single women, age and stock of gains are opposite forces affecting sensitivity to tax. Advanced age should lower sensitivity, while higher stock of gains should increase sensitivity. Overall, the stock of gains turns out to be the more dominant force, and ultimately results in single women exhibiting higher sensitivity to tax.

Welfare impacts

In order to assess the overall welfare impact of this policy change, I first calculate the

Marginal Value of Public Funds (MVPF) as follows:

$$MVPF = \frac{\text{WTP}}{\text{Cost}} \tag{17}$$

where *WTP* is the the per-capita willingness to pay for the tax cut, and Cost is the observed causal effect of the policy on the government budget. Following the approach outlined in Hendren and Sprung-Keyser, (2020), let individual i has pre-tax realized capital gains income of g_i. They face a marginal tax rate schedule of $T(\cdot)$ such that their after-tax capital gains income is $g_i - T(g_i)$. Let $T^0(\cdot)$ denote the pre-reform tax schedule for capital gains income. And let $T^1(\cdot)$ denote the post-reform tax schedule. An individual who would realize capital gains income of g_i^0 under the pre-reform tax schedule would be willing to pay $T^0(g_i^0) - T^1(g_i^0)$ to be in the post-reform tax schedule. In this way, $T^0(g_i^0) - T^1(g_i^0)$ captures the mechanical cost of the reform holding realized capital gains income constant. Aggregating across individuals the per-capita willingness to pay is,

$$WTP = \mathbb{E}\big[\, T^0(g_i^0) - T^1(g_i^0) \,\big]$$

The observed causal effect of the policy on the government budget is the difference between expected tax revenue under the pre-reform tax schedule using counterfactual incomes and expected post-reform tax revenue. This can be calculated as follows,

$$\text{Cost} = \mathbb{E}\big[\, T^0(g_i^0)\big] - \mathbb{E}\big[T^1(g_i^1) \,\big]$$

This cost includes both mechanical effect of the reform as well as the impact of any behavioural responses in the form of higher realizations.

Using reduced form regression (11), Table 5 shows how MVPF is estimated for the year 2000. The mean realized gains for the dead group increased by 9% from the base year to the year 2000. This should have been the growth rate for mean realized gains of the living group in the absence of a tax reform. In the counterfactual, living realized gains should have been \$740 on average in the year 2000. The difference between the tax raised on this amount at the pre-reform tax rate and post-reform tax rate provides the *WTP*. For the year 2000, *WTP* is estimated at \$58 on average. Behavioural response to lower tax rates caused

living realizers to increase their realizations in excess of the growth implied by the change in their stock of gains. The realized gain of the living group is estimated to be $\$1,442$ on average, and the tax raised at post-reform tax schedule amounts to $\$209$. The tax raised on the counterfactual realized gains of the living at pre-reform tax schedule amounts to $\$165$. The behavioural response to the reform exceed the mechanical effect of the reform. The $Cost$ in this year is negative, leading to an infinite $MVPF$.

I repeat this exercise in Table 6 , using regression (11) on annual outcomes over the 8 post-reform years (2000 to 2007), to find an MVPF of $\$1.30$ over this period. This can be interpreted as follows: the marginal benefit of the tax reform was 1.3 times the net marginal cost to the government; Crucially, this net marginal cost includes the impact of any behavioral responses of capital gains realization on the government budget. In aggregate, $\$4.7$ billion in tax revenue was lost on counterfactual realized gains resulting in a benefit to living realizers over the 8 years following the tax reform. The cost to the government budget was lower than this benefit at $\$3.6$ billion over the 8 years following the tax reform.

Finally, I repeat this exercise using 5-year cumulative outcomes in regression (11) with the post reform period as the 5-years ending in 2004, and base period as the 5-years ending in 1998. The MVPF in this case is much lower and amounts to $\$1.05$ over the 5-years ending in 2004, as seen in the last row of n Table 6. The reform was barely successful in making a dollar for dollar transfer from the government coffers to living realizers. From a revenue perspective, the reform was far from the self-financing reform that similar tax cuts in the US at the time were purported to be.

Overall, these MVPF estimates suggest that as a result of the tax cut of year 2000, every dollar in revenue lost by the government was a dollar in benefits gained by realizers, with very small additional welfare benefits created. This result, when viewed alongside the fact that over 70% of capital gains in Canada are earned by families in the top 10% of the income distribution (Smart and Jafry, 2021), suggests that the primary beneficiaries of this policy change were those at the top of the income distribution.

6 Conclusion

This paper shows that a large cut in tax rates on capital gains income leads to limited change in long term realization behaviour. Individuals respond by increasing capital gain realizations sharply in the immediate term but then resume pre-reform behaviour in the medium to long run. Propensity to realize responds with a lag, and declines sharply in the years following the reform year but then recovers to pre-reform levels. A large and permanent decrease in tax rates does not lead to a permanent rise in realizations.

This dampened response can be explained by mandatory taxation of unrealized gains at death in Canada which reduces the incentive to defer realizations. This empirical result is also supported by a dynamic theoretical model for realization behaviour developed by this paper, which predicts that the lock-in effect is weaker in such a system as compared to one which allows forgiveness or delay of tax on gains at death. Other theoretical predictions of the model include that in a system with mandatory tax on accrued gains at death, the lock-in effect of realization based taxes increases in the tax rate, increases in the fractional share of accrued gains in asset values, and decreases in mortality risk.

Overall, the empirical and theoretical findings draw attention to taxation of unrealized gains at death as an important feature in tax design that affects a key policy parameter, namely the estimate of elasticity to tax. It remains an open question for future research whether preferential taxation of capital gains income encourages enterpreneurship and business creation. This paper finds that weak behavioural responses to changes in capital gains tax rate suggest that there is limited concern for adverse tax revenue impacts and capital misallocation from eliminating preferential tax rates on capital gains income, in a system that imposes mandatory tax on accrued gains at death.

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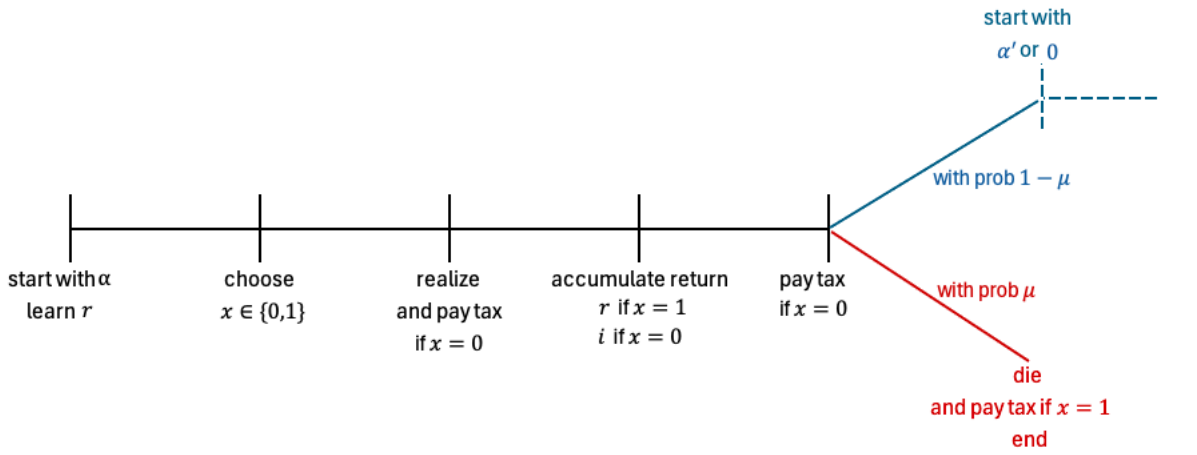
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7 Figures

Figure 1: Dynamic realization problem model timeline



Notes: This figure depicts the timeline of events in the dynamic realization model. At time 0, the agent starts the problem in state α, which represents the fraction of wealth that is unrealized gains. The agent knows own mortality risk μ and learns the return that the existing asset will earn over the current period, r. Alternative asset return i is also known. The agent choose between realize the gain on existing asset or hold the existing asset. In case of realize choice, the agent pays tax on the accrued gain, and then earns after tax return of i on remaining wealth. If the agent chooses to hold, accrued gain grows at rate r. After accumulation of return the agent may die with probability μ, in which case, all accrued gains are realized and taxed. If the agent does not die, the problem continues in the next period with new unrealized gain fraction.

Figure 2: Hypothetical distribution of current period returns on existing asset F_r for agents in state α and type μ

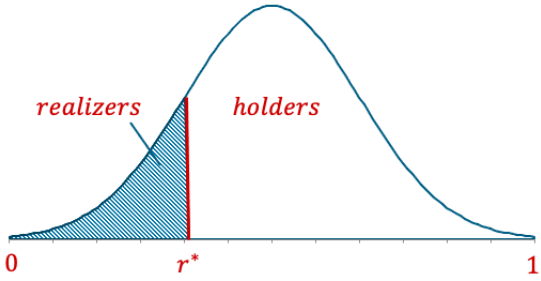
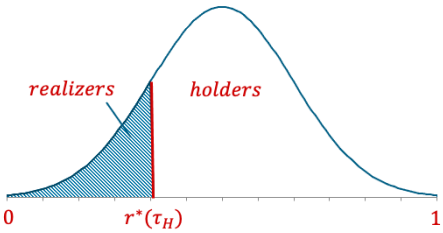
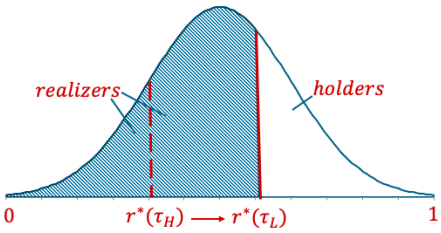


Figure 3: Realizations increase as tax rates decrease in a hypothetical distribution of current period returns on existing asset

(a) High tax rate τ_H



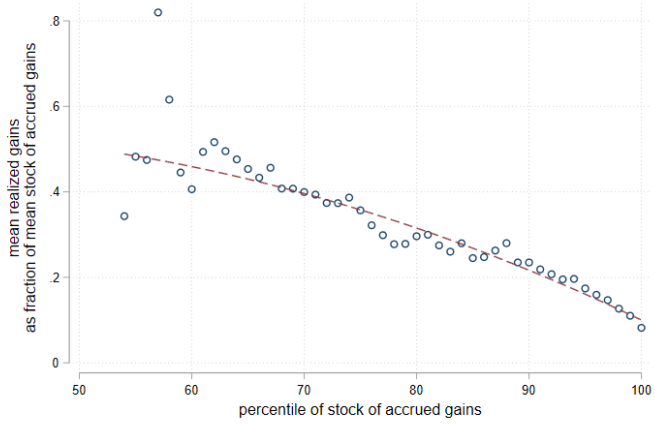
(b) Low tax rate τ_L



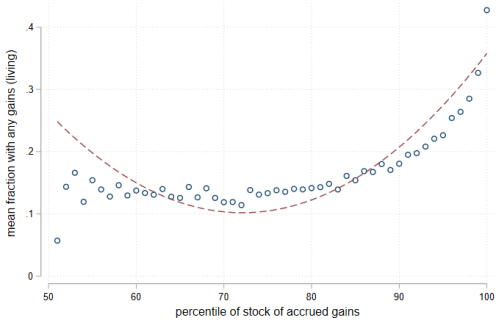
Notes: Figure 2 shows a hypothetical distribution F_r of returns in current period on the existing asset, for agents of mortality risk μ in a state such that initial unit wealth comprises of fraction α of unrealized gains. All agents whose existing asset return falls below the hurdle rate, will choose to realize. Figure 3 plots the same figure in two hypothetical cases: one when the tax rate on capital income is high and the other when it is low. As the hurdle rate is decreasing in tax rate, a low tax rate pushes the hurdle rate upwards thereby triggering more realizations in the economy.

Figure 4: Stylized facts

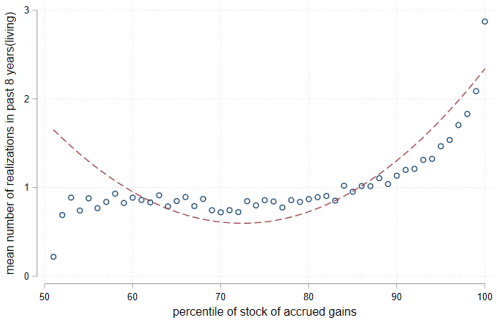
(a) Individuals realize a fraction of their stock of accrued gains, and this fraction is lower for higher stock of accrued gains



(b) Individuals with larger stock of accrued gains have higher propensity to realize



(c) Individuals with larger stock of accrued gains have higher frequency of realizations

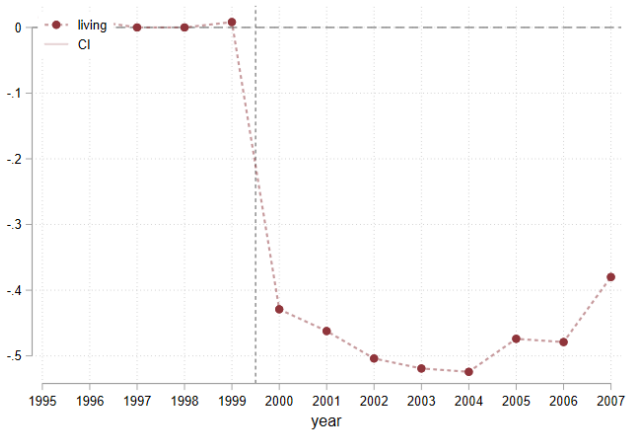


Notes: Using yearly cross-sections and matched living and dead realizers on observable characteristics, the analysis sample is divided into matched strata based on age, sex, marital status and prior 4-year average income (see matching details in section 4.4.2). In each stratum, the mean gain of dead group is used as the implicit stock of accrued gains of the living group. Using this approach, the stylized facts in Panels (a) to (c) are documented. X-axis is a percentile ranking of the implied stock of accrued gains for the living . Panel (a) plots a bin scatter of the fraction of gains realized by the living versus the stock of unrealized gains. As the stock of accrued gains increases, living individuals' chosen fraction realized declines. A fitted quadratic line is shown as the dashed red line. In Panel (b), y-axis is the mean fraction of living individuals with any gain. As the stock of accrued gains increases, individuals become more likely to realize. In Panel (c), y-axis is the mean number of realizations in the past 8 years. As the stock of accrued gains increases, individuals become more frequent realizers.

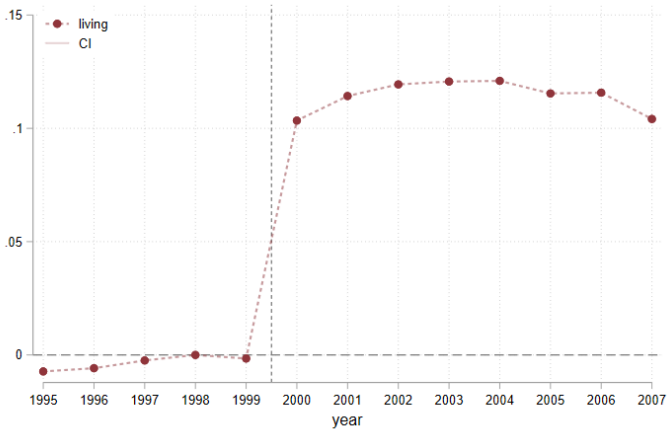
Figure 5: First stage results show permanent decline in effective tax rates on capital gain realizations of living due to the reform

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(a) Percentage change in effective tax rate of living



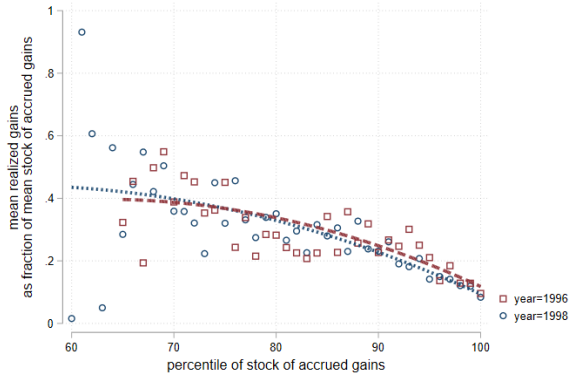
(b) Percentage change in net of effective tax rate of living



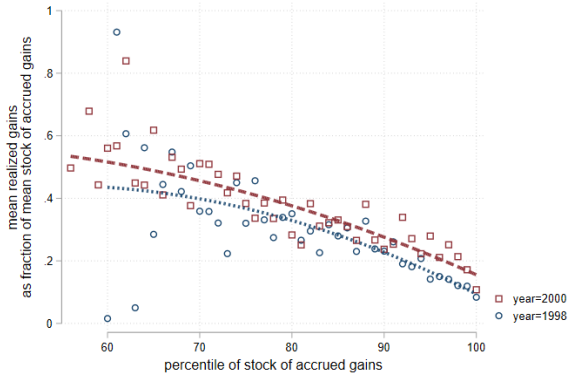
Notes: These figures plot estimates of $\theta + \gamma$ using the first stage regression (12) when dependent variable is log of effective tax rate $\log \tau_{it}$ in Panel (a) and log of net of effective tax rate $\log(1 - \tau_{it})$ in Panel (b). Y-axis indicates percentage change in rates for that year over the rates in year 1998. The year 2000 reform caused first dollar effective tax rates to switch from 75% to 50% of marginal tax rates. The change in both outcomes persists in all post-reform years. Robust standard errors are calculated and 95% confidence intervals are plotted in both panels, which are too narrow to be visible.

Figure 6: Unconditional results show that the fraction realized responds to changes in tax rates; cuts in tax rates lead to higher fraction realized ... but not persistently

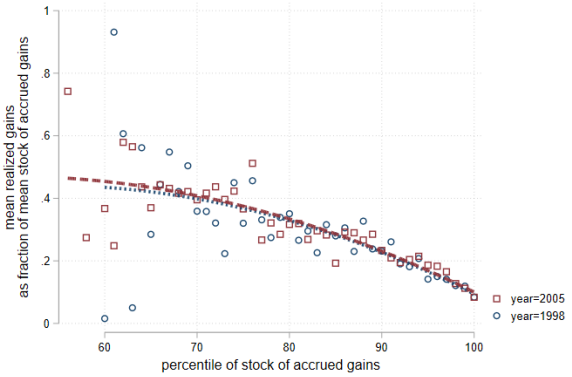
(a) Pre-reform year has similar fraction realized as base year



(b) Reform year has higher fraction realized than base year



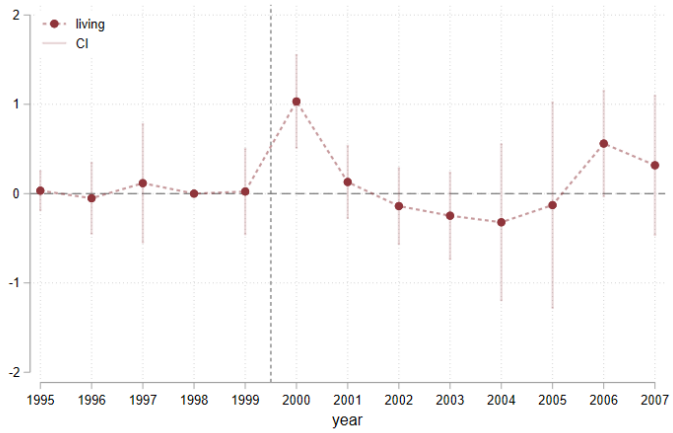
(c) Post reform fraction realized returns to base year levels



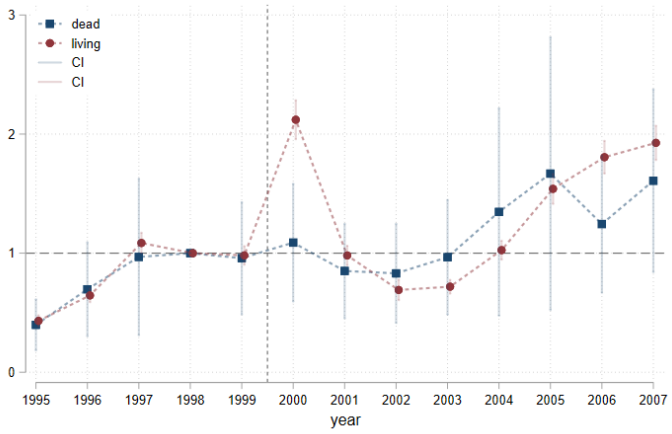
Notes: This figure makes a similar bin scatter plot to Figure (4a) but separately by years. X-axis is a percentile ranking of the implied stock of accrued gains for the living and y-axis is the fraction of gains realized by the living. A fitted quadratic line for each year is shown as a dotted (for base year 1998) or dashed (for years 1996, 2000 or 2005) line. Panel (a) makes separate bin scatters for years 1996 and 1998, which are both pre-reform years characterized by high tax rates on capital gain realizations. Panel (b) makes separate bin scatters for years 2000 and 1998. Panel (c) makes separate bin scatters for years 2005 and 1998. A tax reform caused tax rates on capital gain realizations to decrease substantially in the year 2000. Living individuals across the board increased the fraction of gains realized in the reform year, but the effect dissipates by the year 2005.

Figure 7: Main reduced form result shows that tax reform causes living to increase realizations, but not persistently

(a) ATT_{levels} using annual outcome of capital gain realizations



(b) Relative mean dollar capital gain realizations of living and dead

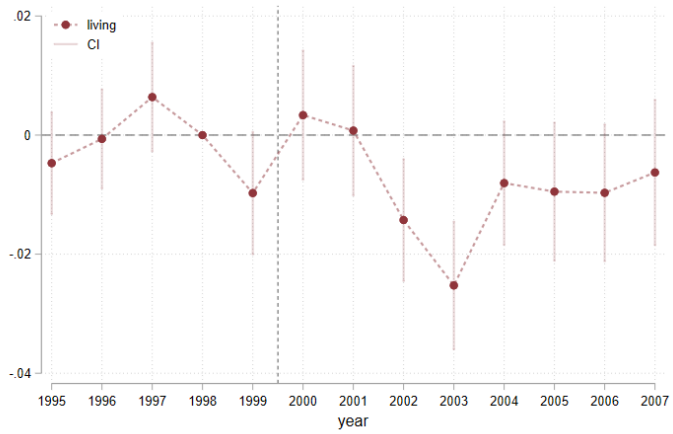


Notes: Panel (a) plots ATT_{levels} defined in equation (14) for annual capital gain realizations calculated using coefficients from the reduced form regression (11) . The coefficients have percentage change interpretation, and measure the change in realizations of the living that is in excess of the change in their stock of accrued gains. Panel (b) coefficients represent mean dollar capital gains realization of living and dead group each year, normalized to the base year (1998) means. Y-axis shows changes in times the base year mean. In the reform year, capital gains realization of living group rose by over 2x the base year mean, and those of the dead group stayed almost the same. The percentage change in living realizations that was not explained by the percentage change in stock of gains (i.e. dead realizations) is represented by the Panel (a) coefficients, and it was 103%, in the year 2000. This response was not permanent. Robust standard errors are calculated and 95% confidence intervals are plotted in both panels.

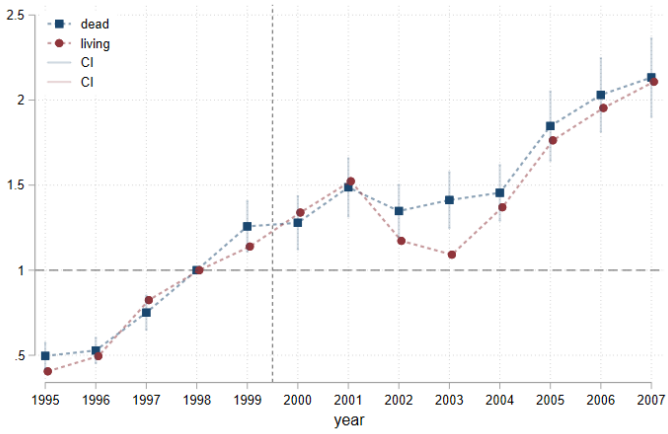
Figure 8: Extensive margin result shows that fewer individuals post realizations after the initial reaction to the reform, but this change is also not persistent

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(a) β when outcome is indicator for non-zero gains in 2 cumulative years



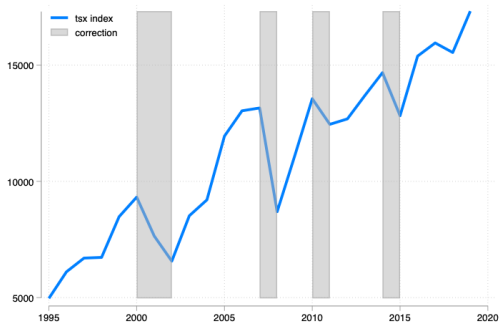
(b) Relative mean indicator for non-zero gains in 2 cumulative years by living and dead



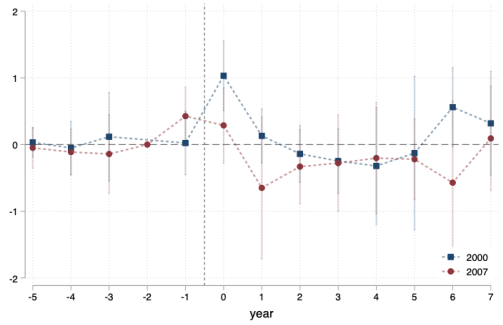
Notes: This figure plots estimates of β from specification (11) when the outcome is an indicator for non-zero gains in 2 cumulative years. Following the reform, initially there is no change in the relative propensity to realize for the living and dead, but starting from 2001, much fewer living individuals choose to realize as compared to the dead. This change is also not permanent, and propensity to realize recovers to pre-reform levels by 2004. Robust standard errors are calculated and 95% confidence intervals are plotted in both panels.

Figure 9: Other stock market crash events do not lead to similar changes in realization behaviour

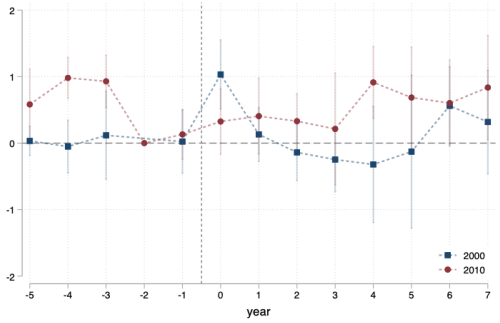
(a) TSX year end index



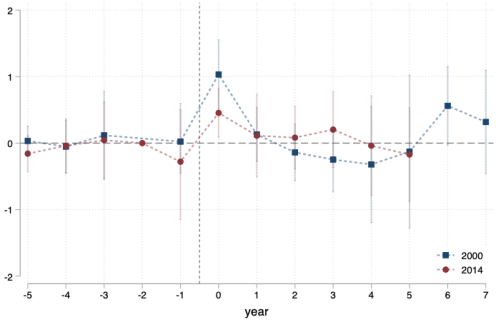
(b) 2000 vs. 2007



(c) 2000 vs. 2010

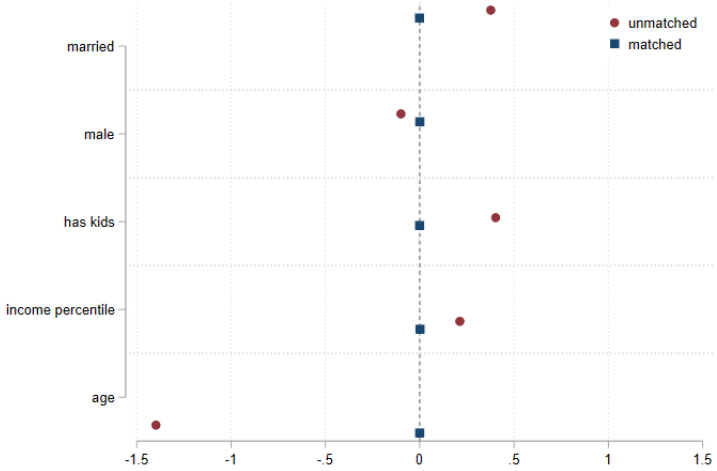


(d) 2000 vs. 2014



Notes: Panel (a) plots the year end Toronto Stock Exchange (TSX) index level and highlights index crash events that lead to more than 5% year-on-year decline. Clearly, year 2000 was a market peak followed by a crash. Panels (b) to (d) plot ATT_{levels} defined in equation (14) for annual capital gain realizations calculated using coefficients from the reduced form regression (11) over several time periods using a market peak as the event. The base year in each case is 2 years prior to the market peak and the market peak year is event 0. The coefficients have percentage change interpretation. Panels (b) to (d) use the market crash following the respective peak in years 2007, 2010, and 2014 and compare them to the market crash following the year 2000 peak. Robust standard errors are calculated and 95% confidence intervals are plotted in Panels (b) to (d). Market crashes do not seem to cause similar changes in realization behavior as the tax reform of year 2000.

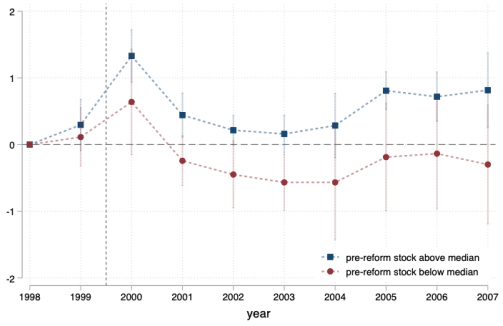
Figure 10: Balance table for matching covariates for all years



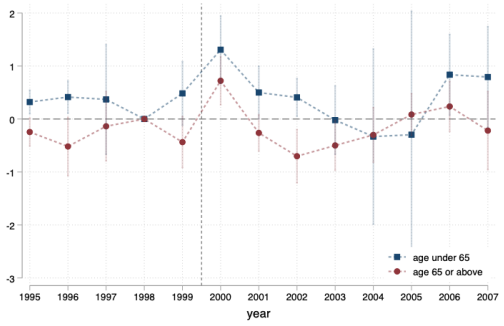
Notes: This figure shows covariate balance for the matched sample over the entire sample period (21.1 million observations and 2.9 million unique individuals). Covariates have been standardized to center at 0. Standard errors are also plotted but they are too small to be noticeable. The x-axis shows distance from the mean in standard deviations. In terms of balance, the dead group was less likely to be married, more likely to be male, less likely to have minor children, likely to have lower past incomes, and was about 14.4 years older on average than the living group.

Figure 11: Heterogeneity in response to tax

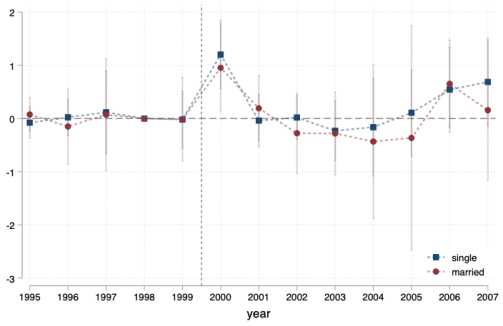
(a) Pre-reform stock of accrued gains



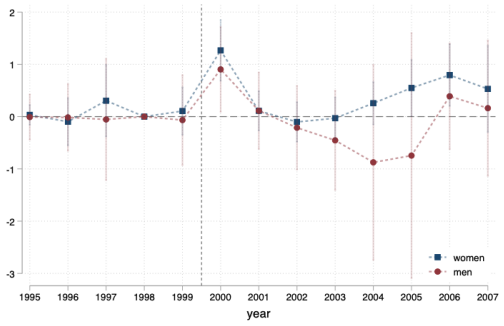
(b) Age



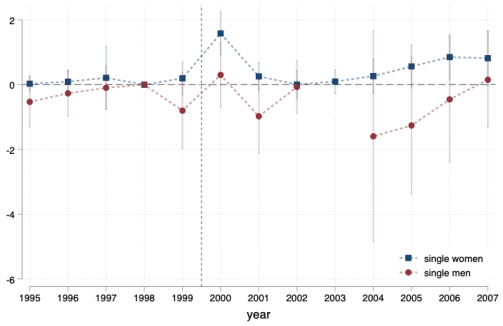
(c) Single vs. married



(d) Sex



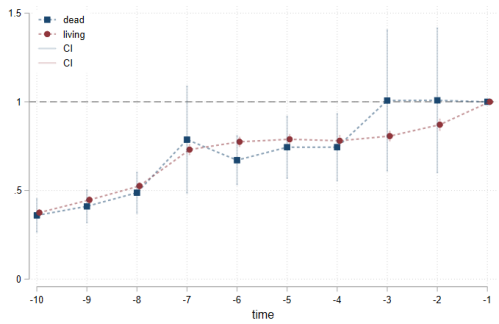
(e) Single women vs. single men



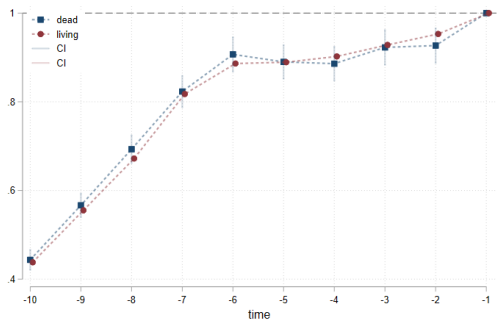
Notes: This figure plots ATT_{levels} defined in equation (14) for annual capital gain realizations calculated using coefficients from the reduced form regression (11) for various subgroups of the sample. The coefficients have percentage change interpretation. Panel (a) divides the post-reform sample whose initial stock of gains (in base year) exceeded $\$2,000$ into 2 groups - those with above median stocks and those below. Panel (b) divides the entire sample into those aged under 65 years and those above. Panel (c) divides the sample by marital status, and Panel (d) by sex. Panel (e) divides the sample into 4 groups using marital status interacted with sex, but plots the coefficients of single individuals only. Robust standard errors are calculated and 95% confidence intervals are plotted in all panels. Single women, individuals with high initial stock of gains, and those aged under 65 years show the greatest sensitivity to tax change.

Figure 12: Trends leading up to death event

(a) Relative mean dollar capital gain realizations of living and dead



(b) Relative mean indicator for non-zero capital gain realizations by living and dead



Notes: This figure traces back all individuals in yearly cross-sectional samples to 10 years prior to the observation year. The observation year is considered as the death event for each sample. Next, all yearly cross-sections are stacked together based on the death event. Finally, this figure plots mean dollar capital gains realization of living and dead group each time period normalized to the year prior to death. Y-axis shows changes in times the base year mean. Panel (a) and Panel (b) respectively show that leading upto the death event, capital gains realizations and propensity to realize of the living and dead groups were on similar trends. The dead did not change their realization behaviour in anticipation of death. Robust standard errors are calculated and 95% confidence intervals are plotted in both panels.

8 Tables

Table 1: Percentage of capital gains that are taxable (inclusion rate) over time in Canada.

Inclusion rate	Years
50%	1972 to 1987
$66\frac{2}{3}$%	1988 to 1989
75%	1990 to 1999
	2000
75%	for gains realized prior to 28-Feb
$66\frac{2}{3}$%	for gains realized from 28-Feb to 17-Oct
50%	for gains realized after 17-Oct
50%	2001 to date

Notes: Canada uses the same progressive tax rates for capital gains income as well as other personal income. However, the amount capital gains income is adjusted lower by applying the inclusion rate. This table shows how this inclusion rate has changed over the years.

Table 2: Regression results for year 2000 - elasticity to tax and net-of-tax rate

	reduced form linear (1)	reduced form poisson (2)	first stage linear (3)	first stage linear (4)	reduced form linear (5)	extensive margin linear (6)
dependent variable	realized gains	realized gains	log effective tax rate	log net of effective tax rate	log realized gains	indicator for realized gains
LIVING x POST (β)	411.0962	0.6669***	0.0130	0.0256***	0.5151***	0.0049
	(938.9306)	(0.2348)	(0.0216)	(0.0025)	(0.1214)	(0.0054)
LIVING (δ)	-3,324.7927***	-1.7689***	0.4436***	-0.0640***	-1.5230***	-0.0033
	(869.0649)	(0.2192)	(0.0153)	(0.0022)	(0.0964)	(0.0037)
POST (λ)	354.8148	0.0848	-0.4421***	0.0778***	0.1928	0.0161***
	(938.1305)	(0.2314)	(0.0216)	(0.0025)	(0.1212)	(0.0053)
wald denominator ($\theta + \gamma$)			-0.4291***	0.1034***		
			(0.0011)	(0.0001)		
wald numerator (ATT)	1.0321***	1.0321***				
	(0.2654)	(0.2654)				
elasticity in year 2000			-2.41***	9.98***		
			(0.55)	(2.27)		

Robust (or bootstrapped for elasticity only) standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: This table presents regression estimates using annual outcomes for the sample year 2000 as post year and year 1998 as base year. Column (1) presents coefficients from the linear regression (11) using outcome in levels. These coefficients are then converted to ATT_{levels} using equation (14). Column (2) presents coefficients from the poisson regression (15) using outcome in levels. These coefficients are also converted to $ATT_{poisson}$ using equation (16). Column (3) and (4) present coefficients from first stage equation (12) when the outcome is log of effective tax rate and log of net of effective tax rates respectively. These coefficients are then used to calculate the Wald denominator given by $\theta + \gamma$. The last row shows the elasticity to tax and net of tax rates using a Wald estimator of the form (13). Column (5) contains coefficients from regression (11) when outcome is in logs. Finally, column (6) presents coefficients from regression (11) when outcome is an indicator of non-zero gains. Number of observations is over 3 million.

Table 3: Elasticity to tax and net-of-tax rate for annual, cumulative and static outcomes

	reduced form ATT_{levels} linear (1)	first stage $\theta + \gamma$ linear (2)	wald elasticity to effective tax rate (3)	first stage $\theta + \gamma$ linear (4)	wald elasticity to net of effective tax rate (5)	extensive margin β linear (6)
dependent variable	realized gains	log effective tax rate		log net of effective tax rate		indicator for realized gains
Panel A: Annual						
2000	1.0321***	-0.4291***	-2.41***	0.1034***	9.98***	0.0049
	(0.2654)	(0.0011)	(0.55)	(0.0001)	(2.27)	(0.0054)
2001	0.1305	-0.4622***	-0.28	0.1142***	1.14	-0.0208***
	(0.2064)	(0.0011)	(0.40)	(0.0001)	(1.60)	(0.0052)
2002	-0.1393	-0.5040***	0.28	0.1194***	-1.17	-0.0265***
	(0.2168)	(0.0011)	(0.42)	(0.0001)	(1.76)	(0.0048)
2003	-0.2473	-0.5192***	0.48	0.1207***	-2.05	-0.0311***
	(0.2473)	(0.0011)	(0.39)	(0.0001)	(1.67)	(0.0052)
2004	-0.3207	-0.5243***	0.61	0.1209***	-2.65	-0.0108**
	(0.4461)	(0.0011)	(0.73)	(0.0001)	(3.16)	(0.0053)
2005	-0.1283	-0.4740***	0.27	0.1154***	-1.11	-0.0046
	(0.5876)	(0.0011)	(0.85)	(0.0001)	(3.48)	(0.0055)
2006	0.5609*	-0.4789***	-1.17*	0.1157***	4.85*	-0.0027
	(0.3021)	(0.0011)	(0.54)	(0.0001)	(2.25)	(0.0054)
2007	0.3179	-0.3799***	-0.84	0.1041***	3.05	0.0002
	(0.3980)	(0.0011)	(0.91)	(0.0001)	(3.32)	(0.0059)
Panel B: Cumulative						
2-years ending in 2001	1.1123**	-0.3965***	-2.81**	0.0978***	11.37**	0.0008
	(0.5601)	(0.0014)	(1.56)	(0.0002)	(6.31)	(0.0056)
3-years ending in 2002	0.2368	-0.4172***	-0.57	0.1015***	2.33	-0.0006
	(0.8082)	(0.0014)	(2.07)	(0.0002)	(8.50)	(0.0056)
4-years ending in 2003	-0.2688	-0.4528***	0.59	0.1067***	-2.52	-0.0052
	(0.8534)	(0.0015)	(1.74)	(0.0002)	(7.37)	(0.0056)
5-years ending in 2004	0.0538	-0.4566***	-0.12	0.1051***	0.51	-0.0031
	(0.6635)	(0.0015)	(1.22)	(0.0002)	(5.29)	(0.0056)
Panel C: Static annual						
post period ending in 2004	0.0658	-0.4948***	-0.13	0.1191***	0.55	-0.0114***
	(0.1593)	(0.0005)	(0.32)	(0.0001)	(1.34)	(0.0022)
post period ending in 2007	0.1499	-0.4780***	-0.31	0.1176***	1.27	-0.0051**
	(0.1754)	(0.0005)	(0.37)	(0.0001)	(1.49)	(0.0020)

Robust (or bootstrapped for elasticity only) standard errors in parentheses

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Notes: Refer to Table 4 notes.

Table 4: Elasticity to tax and net-of-tax rate for 2-year cumulative outcomes

	reduced form ATT_{levels} linear (1)	first stage $\theta+\gamma$ linear (2)	wald elasticity to effective tax rate (3)	first stage $\theta+\gamma$ linear (4)	wald elasticity to net of effective tax rate (5)	extensive margin β linear (6)
dependent variable	realized gains	log effective tax rate		log net of effective tax rate		indicator for realized gains
Cumulative 2 years ending in						
2000	0.8232**	-0.3853***	-2.14**	0.0922***	8.92**	0.0034
	(0.4193)	(0.0014)	(1.22)	(0.0002)	(5.11)	(0.0055)
2001	1.1123**	-0.3965***	-2.81**	0.0978***	11.37**	0.0008
	(0.5601)	(0.0014)	(1.56)	(0.0002)	(6.31)	(0.0056)
2002	0.1653	-0.4387***	-0.38	0.1058***	1.56	-0.0143***
	(0.5178)	(0.0014)	(1.40)	(0.0002)	(5.80)	(0.0052)
2003	-0.5302	-0.4575***	1.16	0.1082***	-4.90	-0.0253***
	(0.7923)	(0.0014)	(1.90)	(0.0002)	(8.03)	(0.0055)
2004	-0.4494	-0.4584***	0.98	0.1080***	-4.16	-0.0081
	(1.0053)	(0.0013)	(2.50)	(0.0002)	(10.59)	(0.0053)
2005	-0.3230	-0.3935***	0.82	0.1018***	-3.17	-0.0095
	(1.3521)	(0.0013)	(3.28)	(0.0002)	(12.68)	(0.0059)
2006	0.7359	-0.3943***	-1.87	0.1012***	7.27	-0.0097*
	(0.9154)	(0.0013)	(2.50)	(0.0002)	(9.74)	(0.0059)
2007	0.1123	-0.3299***	-0.34	0.0952***	1.18	-0.0063
	(1.3327)	(0.0013)	(4.61)	(0.0002)	(15.99)	(0.0062)

Robust (or bootstrapped for elasticity only) standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Notes: Table 3 presents regression estimates using annual, cumulative and static outcomes. Annual and cumulative results use the period ending in 1998 as base period. Column (1) presents ATT_{levels} calculated using equation (14) and coefficients from the linear regression (11) using outcome in levels. Column (2) and (4) present coefficients $\theta+\gamma$ from first stage equation (12) when the outcome is log of effective tax rate and log of net of effective tax rates respectively. Columns (3) and (6) present the elasticity to tax and net of tax rates respectively using a Wald estimator of the form (13). Finally, column (6) presents coefficients from regression (11) when outcome is an indicator of non-zero gains. Panel A contains results when outcomes are measured on an annual basis, and the number of observations for all years combined is 21.1 million. Panel B contains results when n-year cumulative outcomes are used for $n \in [2,5]$ and the specification is a static 2x2 difference-in-difference,and the number of observations for each n-year sample is over 1.6 million. Panel C contains results when annual outcomes are used but years are grouped into 2 groups, with years 2000 to 2007 designated as post-reform years, while years 1995 to 1999 designated as pre-reform years, the specification is a static 2x2 difference-in-difference. Table 4 presents results using 2-year cumulative outcomes ending in each sample year. The number of observations for Table 4 is over 14 million.

Table 5: Marginal value of public funds in the year 2000

	year				
mean realized gains($)	1998	2000	change		tax($)
dead	4000	4356	9%		
living	680	1442	112%		
counterfactual for living, $\mathbb{E}g^0$	680	741	9%	taxed at old rate, $\mathbb{E}T^0(g^0)$	165
				taxed at new rate, $\mathbb{E}T^1(g^0)$	107
				WTP	58
actual gains for living, $\mathbb{E}g^1$		1442		taxed at new rate, $\mathbb{E}T^1(g^1)$	209
				Cost	-44
				MVPF for year 2000	infinite

Notes: This table presents details of how MVPF is calculated using annual outcomes for the year 2000 using equation (17). The next table does the same for all post-reform years in a summarized manner.

Table 6: Aggregate revenue impacts

in dollars

year	mean realized gains living (1)	counterfactual gains living (2)	WTP (3)	Cost (4)	MVPF (5) = (4)/(3)
Annual					
2000	1442	741	58	-44	infinite
2001	667	578	45	32	1.41
2002	470	564	44	58	0.76
2003	489	657	51	76	0.67
2004	697	915	71	103	0.70
2005	1047	1134	88	101	0.87
2006	1228	847	66	11	6.00
2007	1310	1094	85	54	1.57
			508	391	1.30
Aggregate (billion)			4671	3595	1.30
Cumulative 5-year ending in 2004	2717	2635	213	203	1.05

Notes: This table calculates MVPF using annual ATT_{levels} and an average pre-reform effective tax rate of 22.3%, an average post-reform tax rate of 14.5%, when using annual outcomes. Number of treated on average is 1.6 million, which represents an 87% match rate out of a sample that represents 20% of the population. Aggregate impact in columns (3) and (4) is calculated by multiplying the sum of these columns by 5 times the number of treated and dividing by 87%. The last row calculates MVPF using annual ATT_{levels}, an average pre-reform effective tax rate of 21.2%, and an average post-reform tax rate of 13.1%, when using cumulative outcomes over 5 years.

A Appendix

Table A1: Empirical estimates of elasticity of realizations to capital gains tax

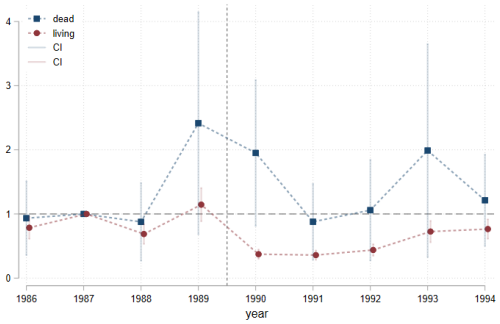
Paper	Elasticity to tax estimate (std. error)	Data	Tax rate	Approach
US estimates				
Agersnap and Zidar (2021)	-0.29 to -0.53 (0.33) (0.26)	state-year aggregate	max combined rate - state	direct projections
Dowd and McClelland (2019)	-0.79 (0.06)	individual daily transactions	combined rate - individual	bunching
Dowd, McClelland and Muthitacharoen (2015)	-0.72 (0.11)	individual tax returns panel	individual mtr*	Type II Tobit model
Bakija and Gentry (2014)	-0.66 (0.21)	state-year aggregate	max combined mtr	diff-in-diff
Bogart and Gentry (1995)	-0.65 (0.19)	state-year aggregate	max combined mtr	diff-in-diff
Burman and Randolph (1994)	-0.18 (0.48)	individual tax returns panel	max combined mtr and individual mtr	generalized Tobit with lagged mtrs
Joint Committee on Taxation (JCT)	-0.68			
Earlier estimates	-0.22 to -3.8			
Canadian estimates				
Lavecchia and Tazhitdinova (2024)	0.02 to 0.59 (0.07) (0.05)	individual tax returns panel	individual mtr	diff-in-diff
This paper	-0.13 to -0.31 (0.32) (0.37)	individual tax returns panel	individual mtr	diff-in-diff

*mtr stands for marginal tax rate Notes: This table summarizes existing empirical estimates of elasticity of realizations to capital gains tax, along with the types of data and empirical approach used.

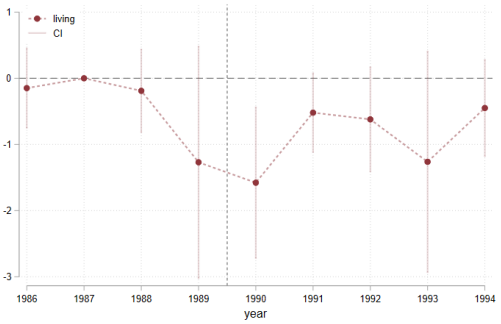
A.1 Additional figures

Figure 13: Reforms that raised tax rates in 1988 and 1990

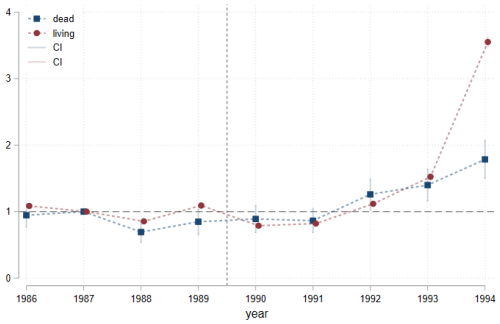
(a) Relative mean dollar capital gain realizations of living and dead



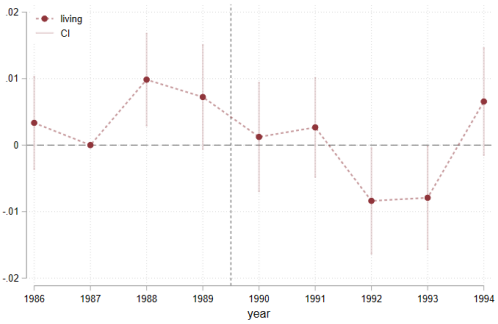
(b) ATT_{levels} using annual outcome of capital gain realizations



(c) Relative mean indicator for non-zero gains by living and dead



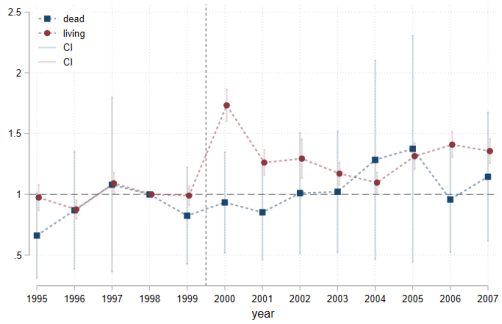
(d) β using annual outcome of indicator for nonzero gains



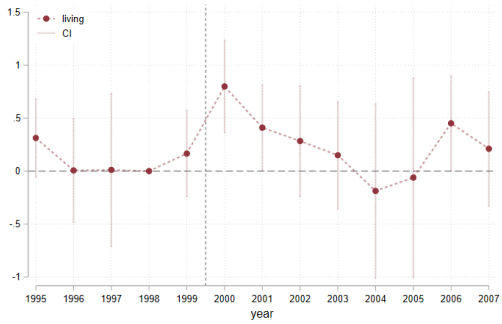
Notes: This figure plots results for 2 tax rate cut events in Canada, one in 1988 and the second in 1990. Both reforms were pre-announced in mid-1987. Panel (a) coefficients represent mean dollar capital gains realization of living and dead group each year, normalized to the base year (1987) means. Y-axis shows changes in times the base year mean. Panel (b) plots ATT_{levels} defined in equation (14) for annual capital gain realizations calculated using coefficients from the reduced form regression (11). The coefficients have percentage change interpretation. The living group makes smaller sized realized gains in 1989 and 1990, but then this response recovers. In 1988 and 1989, the propensity to realize among the living becomes higher, but this response too subsides by 1990. Robust standard errors are calculated and 95% confidence intervals are plotted in both panels.

Figure 14: Other outcomes

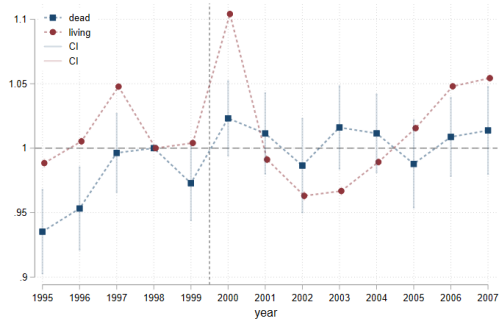
(a) Relative mean dollar capital gain realizations conditional on realizing



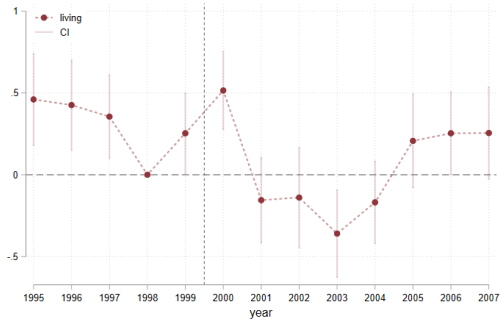
(b) ATT_{levels} using annual outcome conditional on realizing



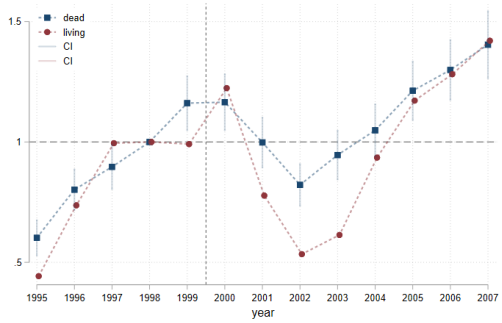
(c) Relative mean log of gains realized



(d) ATT_{logs} using annual outcome in logs



(e) Relative mean indicator for nonzero gains using annual outcome

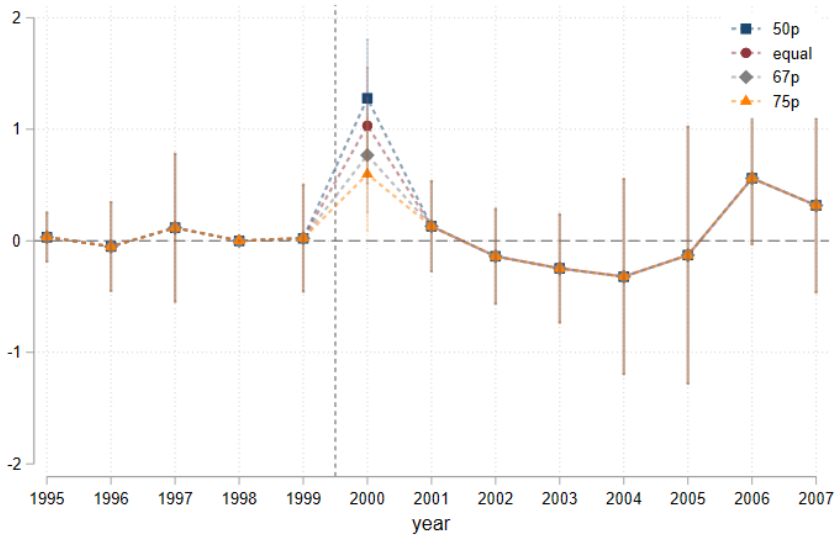


(f) β using annual outcome of indicator for nonzero gains



Notes: Panel (a) coefficients represent mean dollar capital gains realization of living and dead group each year conditional on realizing, normalized to the base year (1998) means. Y-axis shows changes in times the base year mean. Panel (b) plots ATT_{levels} defined in equation (14) for annual capital gain realizations conditional on realizing, calculated using coefficients from the reduced form regression (11). The coefficients have percentage change interpretation. Panel (c) plots mean log of realized gains using annual outcomes, while Panel (d) plots ATT_{logs} which equals the β coefficient estimated from the reduced form regression (11) when the outcome is in logs. Panel (e) plots relative mean indicator for nonzero capital gains realization using annual outcomes, normalized to the base year (1998) means. Panel (f) plots the β coefficient estimated from the reduced form regression (11) when the outcome is an annual indicator for nonzero realizations. Robust standard errors are calculated and 95% confidence intervals are plotted in all panels.

Figure 15: Sensitivity to Inclusion Rate Assumption



Notes: Three different inclusion rates applied to realizations made in the year 2000 depending upon the date of realization (see Table 1). To account for this, Statistics Canada created the T1FF Schedule3 2000 dataset. This dataset provides additional breakup of the realized gain amount. For a portion of taxable realized gains the data shows exactly in which inclusion rate period the gain occurred (the disclosed portion). However, for the portion of taxable gains for which this information is not available (the undisclosed portion), researchers have to make an assumption about the inclusion rate applicable. In this paper, I make following assumptions for dead and living individuals in the year 2000. For dead individuals, the inclusion rate at the undisclosed portion is assumed to be the one that is applicable on their date of death. For living individuals, I assume the same weighted average inclusion rate that I calculate for the disclosed portion of taxable gains also applies to the undisclosed portion. This figure shows the sensitivity of the year 2000 ATT_{levels} to this assumption. The red dot shows the baseline result, which is a weighted average inclusion rate between 50% and 67%.

A.2 Deriving the Value Function

The transition rule for wealth in the dynamic realization problem can be written as a function of x,

$$W'(x) = \left[\, x\,(1+r) \;+\; (1-x)\,(1-\tau\alpha)\,\left(1+(1-\tau)i\,\right)\,\right] W \tag{18}$$

where W' is wealth next period. Similarly, the transition rule for unrealized share can also be written as a function of x,

$$\alpha'(x) \;=\; x \;\cdot \frac{\alpha+r}{1+r} \tag{19}$$

The agent maximizes expected wealth at death and this problem can be represented by the following functional equation,

$$\begin{aligned} J(W,\alpha,r) = \max_{x\in\{0,1\}} \; & x\cdot\left[\,\mu\, W'(1)\,\left(1-\tau\alpha'(1)\right) \;+\; (1-\mu)\,\mathbb{E}J\big(W'(1),\alpha'(1),r'\big)\,\right] \\ & +(1-x)\cdot\left[\,\mu\, W'(0)\,\left(1-\tau\alpha'(0)\right) \;+\; (1-\mu)\,\mathbb{E}J\big(W'(0),\alpha'(0),r'\big)\,\right] \\ & \text{s.t.}\;\; (18)-(19) \end{aligned} \tag{20}$$

The expectation in continuation value terms is on expected return on existing asset in next period. Since the value function is linear in net of tax wealth, we can normalize the value function with beginning net of tax wealth. Let,

$$V(\alpha,r) = \frac{J(W,\alpha,r)}{W(1-\tau\alpha)} \tag{21}$$

Equation (20) can also be written as,

$$\begin{aligned} \frac{J(W,\alpha,r)}{W(1-\tau\alpha)} = \max_{x\in\{0,1\}} \; & x\cdot\frac{W'(1)\,(1-\tau\alpha'(1))}{W(1-\tau\alpha)}\left[\,\mu \;+\; (1-\mu)\,\frac{\mathbb{E}J\big(W'(1),\alpha'(1),r'\big)}{W'(1)\,(1-\tau\alpha'(1))}\,\right] \\ & +(1-x)\cdot\frac{W'(0)\,(1-\tau\alpha'(0))}{W(1-\tau\alpha)}\left[\,\mu \;+\; (1-\mu)\,\frac{\mathbb{E}J\big(W'(0),\alpha'(0),r'\big)}{W'(0)\,(1-\tau\alpha'(0))}\,\right] \end{aligned}$$

From equation (21), $V(\alpha, r) = \frac{J(W,\alpha,r)}{W(1-\tau\alpha)}$, which implies that,

$$V(\alpha, r) = \max_{x\in\{0,1\}} \; x \cdot \frac{W'(1)\,(1-\tau\alpha'(1))}{W(1-\tau\alpha)} \left[\mu \; + \; (1-\mu)\,\mathbb{E}V\big(\alpha'(1), r'\big) \right] + (1-x) \cdot \frac{W'(0)\,(1-\tau\alpha'(0))}{W(1-\tau\alpha)} \left[\mu \; + \; (1-\mu)\,\mathbb{E}V\big(\alpha'(0), r'\big) \right]$$

From (18) and (19),

$$\frac{W'(1)\,(1-\tau\alpha'(1))}{W(1-\tau\alpha)} \; = \; 1 + \frac{(1-\tau)}{(1-\tau\alpha)} r$$

And similarly,

$$\frac{W'(0)\,(1-\tau\alpha'(0))}{W(1-\tau\alpha)} \; = \; 1 + (1-\tau) i$$

which leads to the value function,

$$V(\alpha, r) = \max_{x\in\{0,1\}} \; x \cdot \left(1 + \frac{(1-\tau)}{(1-\tau\alpha)} r\right) \left[\mu \; + \; (1-\mu)\,\mathbb{E}V\big(\alpha'(1), r'\big) \right] + (1-x) \cdot \big(1 + (1-\tau) i\,\big) \left[\mu \; + \; (1-\mu)\,\mathbb{E}V\big(\alpha'(0), r'\big) \right]$$

Denote $\alpha'(1)$ by α' and note that $\alpha'(0) = 0$,

$$\begin{aligned} V(\alpha, r) = \max_{x\in\{0,1\}} \; & \big(1 + (1-\tau) i\,\big) \left[\mu \; + \; (1-\mu)\,\mathbb{E}V\big(0, r'\big) \right] \\ & + \; x \cdot \left[\mu \; \left(1 + \frac{(1-\tau)}{(1-\tau\alpha)} r - \big(1 + (1-\tau) i\,\big)\right) \right. \\ & \left. + \; (1-\mu) \; \left\{ \left(1 + \frac{(1-\tau)}{(1-\tau\alpha)} r\right) \mathbb{E}V\big(\alpha', r'\big) \; - \big(1 + (1-\tau) i\,\big) \mathbb{E}V\big(0, r'\big) \right\} \right] \end{aligned}$$

$$V(\alpha, r) = \max_{x\in\{0,1\}} \; \textit{value from switching to alternative asset} + x \cdot \left[\textit{advantage of holding the existing asset} \right]$$

which leads to eq(3)

$$V(\alpha, r) \;=\; \max_{x \in \{0,1\}} \; C_0 + \; x \cdot \left[\mu \, \Delta_d(\alpha, r) + \; (1-\mu) \, \Delta_a(\alpha, r) \right]$$

where, C_0 is the mortality weighted value of switching to alternative asset, i.e.

$$C_0 = \big(1 + (1-\tau) i \,\big) \left[\; \mu \; + \; (1-\mu) \, \mathbb{E}V\big(0, r'\big) \; \right]$$

and, Δ_d is the advantage of holding in case of death in current period,

$$\Delta_d(\alpha, r) = (1-\tau) \left(\frac{r}{(1-\tau\alpha)} \; - \; i \right)$$

and, Δ_a is the advantage of holding in case of survival in current period,

$$\Delta_a(\alpha, r) = \; \left(1 + \frac{(1-\tau)}{(1-\tau\alpha)} r \right) \mathbb{E}V\big(\alpha', r'\big) \; - \; \big(1 + (1-\tau) i \,\big) \, \mathbb{E}V\big(0, r'\big)$$

A.3 Proof of Proposition 1

Optimal decision rule is given by,

$$\begin{aligned} x^* = 1 \quad & \textit{iff} \quad \mu\, \Delta_d(\alpha, r) + \ (1-\mu)\, \Delta_a(\alpha, r) \ \geq \ 0 \\ 0 \quad & \textit{otherwise} \end{aligned}$$

This means that the agent will choose $x^* = 1$ iff,

$$\begin{aligned} \mu\, \Delta_d(\alpha, r) + \ (1-\mu)\, \Delta_a(\alpha, r) \ &\geq \ 0 \\ \Delta_d(\alpha, r) + \ (1-\mu)\, \Big(\Delta_a(\alpha, r) - \ \Delta_d(\alpha, r)\Big) \ &\geq \ 0 \\ (1-\tau)\left(\frac{r}{(1-\tau\alpha)} \ - \ i\right) \ + \ (1-\mu)\, \Big(\Delta_a(\alpha, r) - \ \Delta_d(\alpha, r)\Big) \ &\geq \ 0 \\ r \ \geq \ (1-\tau\alpha)\, i \ - \ \underbrace{(1-\mu)\, \frac{1-\tau\alpha}{1-\tau}\, \Big(\Delta_a(\alpha, r) - \ \Delta_d(\alpha, r)\Big)}_{\textit{option value of deferral}} \end{aligned}$$

It is optimal to hold the existing asset as long as the expected return on it is not lower than the hurdle rate, r^*. It is optimal to hold iff:

$$r \ \geq \ (1-\tau\alpha)i - \text{option value of deferral} \ \equiv \ r^*$$

where,

$$\text{option value of deferral} \ = (1-\mu)\, \frac{1-\tau\alpha}{1-\tau}\, \big(\Delta_a(\alpha, r) - \Delta_d(\alpha, r)\big)$$

□

A.4 Proof: the advantage to holding is increasing in α and r

The advantage to holding in case of death this period is given by,

$$\Delta_d(\alpha, r) = (1-\tau)\left(\frac{r}{(1-\tau\alpha)} - i\right)$$

This is clearly increasing in α and r,

$$\frac{\partial \Delta_d}{\partial r} = \frac{(1-\tau)}{(1-\tau\alpha)} > 0$$

$$\frac{\partial \Delta_d}{\partial \alpha} = \frac{\tau(1-\tau)r}{(1-\tau\alpha)^2} > 0$$

Moreover, the advantage to holding in case of survival can be expressed as

$$\begin{aligned}\Delta_a(\alpha, r) = &\left(1 + \frac{(1-\tau)}{(1-\tau\alpha)}r\right)\left[C_0 + x'\left[\mu\ \Delta_d(\alpha', r') + (1-\mu)\ \Delta_a(\alpha', r')\right]\right] \\ &- \left(1 + (1-\tau)i\right)\left[C_0 + x''\left[\mu\ \Delta_d(0, r') + (1-\mu)\ \Delta_a(0, r')\right]\right]\end{aligned} \tag{22}$$

where x' is the choice variable in next period conditional on $x = 1$, and x'' is the choice variable next period conditional on $x = 0$. The terms being subtracted on the RHS in the above equation are all independent of α and r. Clearly, $\left(1 + \frac{(1-\tau)}{(1-\tau\alpha)}r\right)$ is increasing in α and r. Moreover, $\Delta_d(\alpha', r')$ is increasing in α and r because,

$$\frac{\partial \Delta_d(\alpha', r')}{\partial \alpha'} > 0$$

and

$$\frac{\partial \alpha'}{\partial \alpha} > 0 \qquad \text{and} \qquad \frac{\partial \alpha'}{\partial r} > 0$$

Future $\Delta_a(\alpha', r')$ will be a weighted sum of such terms that are increasing in α and r., which implies that,

$$\frac{\partial \Delta_a}{\partial r} > 0 \qquad \text{and} \qquad \frac{\partial \Delta_a}{\partial \alpha} > 0$$

And resultantly, the total advantage to holding is also increasing in α and r,

$$\frac{\partial}{\partial \alpha}\left(\mu\ \Delta_d(\alpha, r) + (1-\mu)\Delta_a(\alpha, r)\right) > 0$$

$$\frac{\partial}{\partial r}\left(\mu\ \Delta_d(\alpha, r) + (1-\mu)\Delta_a(\alpha, r)\right) > 0$$

□

A.5 Proof of Proposition 2

Proposition 2 states that the hurdle rate r^* is decreasing in tax rate τ. The advantage to holding is a mortality weighted average of the advantage in case of death or survival in the current period. I will prove this proposition by showing that in both cases the advantage is increasing in τ. In case of death,

$$\Delta_d(\alpha, r) = (1-\tau)\left(\frac{r}{(1-\tau\alpha)} - i\right)$$

$$\implies \frac{\partial \Delta_d}{\partial \tau} = i - \frac{r}{(1-\tau\alpha)} + \frac{(1-\tau)\, r\alpha}{(1-\tau\alpha)^2} > 0 \qquad \textit{when} \quad r \leq (1-\tau\alpha)i$$

Moreover,

$$\frac{\partial}{\partial \alpha}\frac{\partial \Delta_d}{\partial \tau} = \frac{-\tau\, r}{(1-\tau\alpha)^2} + \frac{(1-\tau)\, r\alpha}{(1-\tau\alpha)^3} \cdot 2\tau + \frac{(1-\tau)\, r}{(1-\tau\alpha)^2} > 0 \qquad \forall \tau \leq 1/2$$

The advantage to holding in case of death in current period is increasing in the tax rate; it increases at a higher rate for higher values of α. Finally, note that this result holds even at $\alpha = 0$.

In case of survival, using equation (22),

$$\begin{aligned}
\Delta_a(\alpha, r) \;=\; & \Delta_d(\alpha, r)\; C_0 \\
& + \left(1 + \frac{(1-\tau)}{(1-\tau\alpha)} r\right) \left[x' \left[\mu\; \Delta_d(\alpha', r') + \;(1-\mu)\; \Delta_a(\alpha', r')\right]\right] \\
& - \left(1 + (1-\tau)i\right) \left[x'' \left[\mu\; \Delta_d(0, r') + \;(1-\mu)\; \Delta_a(0, r')\right]\right]
\end{aligned}$$

Since, $\Delta_d(\alpha, r)$ is increasing in τ at $r \leq (1-\tau\alpha)i$, and $\Delta_d(\alpha, r) > \Delta_d(0, r)$, and $\frac{\partial^2 \Delta_d}{\partial \alpha \partial \tau} > 0$, the entire RHS will be increasing in τ if the first term $\Delta_d(\alpha, r)\; C_0$ is increasing in τ. From

equation (4), $\frac{\partial C_0}{\partial \tau} < 0$, which implies that,

$$\frac{\partial}{\partial \tau}\Big(\Delta_d(\alpha, r)\ C_0\Big) \ = \ \underbrace{\frac{\partial \Delta_d(\alpha, r)}{\partial \tau} C_0}_{>0} + \Delta_d(\alpha, r) \underbrace{\frac{\partial C_0}{\partial \tau}}_{<0}$$

But $\Delta_d(\alpha, r) \leq 0$ when $r \leq (1 - \tau\alpha)i$. Therefore,

$$\frac{\partial \Delta_a(\alpha, r)}{\partial \tau} \ > \ 0 \qquad\qquad \text{when } r \leq (1 - \tau\alpha)i$$

Higher advantage to holding pushes the hurdle rate lower, which implies that at higher tax rates, agents will choose to keep holding even worse performing assets and the hurdle rate will be lower. □

A.6 Additional theoretical results

Proposition 8 *The hurdle rate for holding is increasing in the probability of death.*

$$\frac{\partial r^*}{\partial \mu} \ > \ 0 \tag{23}$$

Proof:

The optimum decision rule is:

$$\begin{aligned} x^* = 1 \ &\iff \ \mu \ \Delta_d(\alpha, r) + \ (1 - \mu) \ \Delta_a(\alpha, r) \ \geq \ 0 \\ &\iff \ \Delta_d(\alpha, r) + \ (1 - \mu) \ (\ \Delta_a(\alpha, r) - \ \Delta_d(\alpha, r)) \ \geq \ 0 \end{aligned}$$

We know that $\Delta_d(\alpha, r)$ is independent of μ, and that $\Delta_a(\alpha, r) - \Delta_d(\alpha, r) > 0$. In order to prove that the advantage to holding is decreasing in μ, all we need to prove is that $\Delta_a(\alpha, r)$

is decreasing in μ. From equation (22),

$$\begin{aligned}\Delta_a(\alpha, r) \;=\; & \Delta_d(\alpha, r)\; C_0 \\ & + \left(1 + \frac{(1-\tau)}{(1-\tau\alpha)} r\right) \left[x' \left[\mu\;\; \Delta_d(\alpha', r') + \;(1-\mu)\;\; \Delta_a(\alpha', r')\right]\right] \\ & - \left(1 + (1-\tau) i\right) \left[x'' \left[\mu\;\; \Delta_d(0, r') + \;(1-\mu)\;\; \Delta_a(0, r')\right]\right]\end{aligned}$$

We know that $\Delta_d(\alpha, r)$ is independent of μ and from equation (4), $\frac{\partial C_0}{\partial \mu} < 0$. Meanwhile, $\Delta_d(\alpha, r) > \Delta_d(0, r)$, and $\Delta_d(\alpha, r) < \Delta_a(\alpha, r)$. This implies that the entire RHS is decreasing in μ,

$$\frac{\partial}{\partial \mu} \Delta_a(\alpha, r) < \; 0$$

This implies that,

$$\frac{\partial}{\partial \mu}\; \mu \Delta_d(\alpha, r) + (1-\mu)\Delta_a(\alpha, r) < \; 0 \qquad\qquad \text{at } r = r^*$$

In the proof to Proposition 1, I have already shown that the advantage to holding is increasing in r, which proves that,

$$\frac{dr^*}{d\mu} \;\; < \;\; 0$$

□

Proposition 9 *The hurdle rate for holding is decreasing in the current fraction unrealized gain on existing asset.*

$$\frac{\partial r^*}{\partial \alpha} \;\; < \;\; 0 \tag{24}$$

Proof:

The optimum decision rule is:

$$x^* = 1 \iff \mu\;\; \Delta_d(\alpha, r) + \;(1-\mu)\;\; \Delta_a(\alpha, r) \;\geq\; 0$$

The agent is indifferent at $r = r^* = (1 - \tau\alpha)\, i -$ option value of deferral. In the proof for Proposition 1, I have already shown that the advantage to holding is increasing in α and r, which proves that

$$\frac{\partial r^*}{\partial \alpha} \;<\; 0$$

□

Proposition 10 *When the tax rate on capital income is 0, there is no lock-in effect.*

$$r^* \;=\; i \quad \textit{if} \quad \tau \;=\; 0$$

Proof:

When there is not tax on capital income, the transition rule for wealth becomes,

$$W'(x) = [\, x\,(1+r) \;+\; (1-x)\,(1+i)\,]\,W \tag{25}$$

where W' is wealth next period.

The unrealized gain fraction is no longer relevant to the agent's decision, and it is no longer a state variable. The agent maximizes expected wealth at death, where the per period probability of death is $\mu > 0$. However, μ also does not affect the value function anymore, as the death event is no longer tax relevant.

This problem can be represented by the following functional equation,

$$\begin{gathered} K(W, r) = \max_{x \in \{0,1\}} \left[\mathbb{E} K\big(W'(x), r'\big) \right] \\ \text{s.t.} \;\; (25) \end{gathered} \tag{26}$$

The optimum decision rule is:

$$x^* = 1 \iff r \;\geq\; i$$

The agent chooses whichever asset offers the higher nominal return. Since, the hurdle rate is no longer reduced due to tax considerations, this proves that there is no lock-in effect. □

A.7 Proof of Proposition 6

To see how the hurdle rate in this problem compares to one in a system which allows carry-over basis for unrealized gains at death, one can simply set the parameter $\mu = 0$. The value of switching to alternative asset as well the advantage of holding are both higher when $\mu = 0$. This is because the continuation values receives full weight of 1 and there is no weight on the lower instantaneous value in case of death this period. By setting $\mu = 0$, the problem allows for no tax at death and the next recipient of the asset is assumed to behave just like the original agent and retains the cost basis. The option value of deferral in such a case will be much higher and the hurdle rate lower. Proposition 6 formalizes this result. The normalized value function can be written as,

$$V(\alpha, r) \;=\; \max_{x \in \{0,1\}} \; \big(1 + (1-\tau)i\,\big)\mathbb{E}V\big(0, r'\big) \;+\; x \cdot \Delta_a(\alpha, r)$$

where, Δ_a is the advantage of holding the existing asset,

$$\Delta_a(\alpha, r) = \left(1 + \frac{(1-\tau)}{(1-\tau\alpha)}r\right) \mathbb{E}V\big(\alpha', r'\big) \;-\; \big(1 + (1-\tau)i\,\big)\,\mathbb{E}V\big(0, r'\big)$$

The optimum decision rule is:

$$x^* = 1 \iff \Delta_a(\alpha, r) \;\geq\; 0$$

The hurdle rate in this case is denoted by, $r^*_{carry_over}$, and clearly it will be lower than the hurdle rate in a system with mandatory taxation of unrealized gains at death, $r^*_{mandatory_tax}$, because the option value of deferral in this case is not weighted down by $\Delta_d(\alpha, r) < \Delta_a(\alpha, r)$.

$$r^*_{carry_over} < r^*_{madatory_tax}$$

□

A.8 Proof of Proposition 7

A system that allows step-up in basis feature will also result in a higher advantage to holding, as the death event results in a reset of future α to 0 without incurring any tax on existing α. Modeling a system with step-up in basis would retain $0 < \mu < 1$ parameter values but it will change equation (20) such that in case of death and choice of $x = 1$, there is no tax applied and future α is reset to 0. The value function can be restated as,

$$\begin{aligned} L(W, \alpha, r) = \max_{x \in \{0,1\}} \; & x \cdot \left[\mu \, \mathbb{E}L\big(W'(1), 0, r'\big) \; + \; (1-\mu) \, \mathbb{E}L\big(W'(1), \alpha'(1), r'\big) \right] \\ & + (1-x) \cdot \; \mathbb{E}L\big(W'(0), 0, r'\big) \\ & \text{s.t.} \;\; (18) - (19) \end{aligned}$$

The optimum decision rule is:

$$x^* = 1 \iff \mu \, \mathbb{E}L\big(W'(1), 0, r'\big) \; + \; (1-\mu) \, \mathbb{E}L\big(W'(1), \alpha'(1), r'\big) \; - \; \mathbb{E}L\big(W'(0), 0, r'\big) \; \geq \; 0$$

The hurdle rate in such a system which allows for step-up in basis for unrealized gains at death, $r^*_{step_up}$, will be lower than the hurdle rate in a system with mandatory taxation of unrealized gains at death, $r^*_{mandatory_tax}$, because there is no tax cost associated with choice $x = 1$ in case death occurs in current period. In fact, such an event is attractive as it resets the furtue α to 0 while also allowing tax free accrued gain to be added to market value of wealth. This drives the option value higher.

$$r^*_{step_up} < r^*_{madatory_tax}$$

□