Estimating the Elasticity of Intertemporal Substitution using Dividend Tax News[†]

Martin B. Holm **Rustam Jamilov** **Marek Jasinski** **Plamen Nenov**

August 2025

Abstract

This paper proposes a novel approach to estimate the elasticity of intertemporal substitution (EIS) of firm owners using a unique quasi-natural experiment and new theoretical insights regarding the spending response to news about future dividend tax changes. We study the Norwegian dividend tax reform, announced in 2004 and implemented in 2006, which increased the dividend tax rate by 28 percentage points. Leveraging rich administrative data and a dynamic difference-in-differences framework, we find that exposed households increased spending after the reform was announced and reduced it following its implementation. This behavior is only consistent with an EIS above one. Using a structural model, we estimate the EIS to be around 1.6.

JEL Classification: D15, E21, H25.

Keywords: public finance, firm owners, capital income taxation, imputed spending.

[†]We thank Annette Alstadsæter, Anmol Bhandari, Steve Bond, V.V. Chari, Philipp Dörrenberg (discussant), Stefano Eusepi, Andreas Fagereng, Andrea Ferrero, Alexandre Gaillard, Niels Johannesen, Joseba Martinez, Ellen McGrattan, Michael McMahon, Magne Mogstad, Gisle Natvik, Morten Håvarstein, Alan Olivi, Franck Portier, Hélène Rey, Federica Romei, Andreas Schaab, Florian Scheuer, Alp Simsek, Stefanie Stantcheva, Kjetil Storesletten, Paolo Surico, Ludwig Straub, Karen Helene Ulltveit-Moe, John Vella and seminar participants at numerous venues for useful comments and suggestions. We thank Sondre Engebretsen for excellent research assistance. We also thank Janis Berzins and Øyvind Norli for providing us with the Oslo Børs data. This paper should not be reported as representing the views of Norges Bank. The views expressed are those of the authors and do not necessarily reflect those of Norges Bank. This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No. 851891) and the Norwegian Research Council (grant agreement No. 326419). First version: March 2024.

Holm: University of Oslo. Email: m.b.holm@econ.uio.no.
Jamilov: University of Oxford. Email: rustam.jamilov@all-souls.ox.ac.uk.
Jasinski: Statistics Norway. Email: marek.jasinski@ssb.no.
Nenov: Norges Bank. Email: plamen.nenov@norges-bank.no.

1 Introduction

How do firm owners adjust spending in response to news about future dividend tax changes? This behavioral response identifies a key parameter in macroeconomics and finance: the elasticity of intertemporal substitution (EIS). The EIS determines how agents adjust consumption in response to intertemporal price changes. Several influential contributions in macroeconomics and finance assume that the EIS exceeds one, implying that the substitution effect dominates the income effect. For example, Straub and Werning (2020) show that this assumption is needed to replicate the well-known result that the optimal long-run capital tax is zero (Judd, 1985; Chamley, 1986). Similarly, Barro (2009) and Gabaix (2012) find that an EIS above one is necessary for asset prices to decline in response to increased disaster risk. Likewise, Kaplan and Violante (2014) show that the same condition is required for wealthy households to tolerate periods of low liquidity around illiquid asset transactions.

Despite its importance, obtaining credible estimates of the EIS, particularly in relation to unity, remains challenging, with over 2,700 widely varying estimates in the literature (Havránek, 2015). The conventional approach to estimating the EIS, following Hall (1988), regresses consumption growth on future interest rates. The difficulty with that approach lies in isolating time-series variation in future interest rates that is both exogenous to individuals and uncorrelated with interest rates in other periods or with broader economic conditions.

We utilize a novel approach applied to a unique quasi-natural experiment, the 2006 Norwegian dividend tax reform, to address the biases inherent in the conventional method. This reform is particularly relevant for three reasons. First, it was a major and therefore salient reform, raising the dividend tax from 0% to 28%. Second, the reform took place in a data-rich environment. Since both the inheritance and wealth taxes existed in Norway at the time, we have access to administrative data on household and firm balance sheets, allowing us to impute spending reliably, even among firm owners.[1] Third, and most importantly for our approach, the reform was unexpected and there was a substantial delay between its announcement and implementation, providing a clear window to study behavioral responses to *anticipated* dividend income tax changes.

To understand why the delay between the announcement and implementation allows us to estimate the EIS, consider a firm owner who saves within her own firm. If the tax change

[1] Imputed spending is defined from the budget constraint as income not saved. This method has been widely used in the literature (Leth-Petersen, 2010; Fagereng and Halvorsen, 2017; Eika et al., 2020; Fagereng et al., 2021; Holm et al., 2021) and has been shown to be accurate when compared to detailed transaction data (Baker et al., 2021).

is immediate, it functions like a consumption tax, creating no intertemporal distortions because it affects the price of consumption today and tomorrow equally. However, if the reform is pre-announced, it introduces an *intertemporal wedge* between the price of consumption just before and immediately after the reform's implementation. This wedge, in turn, induces the standard income and substitution effects on the agent's consumption decision. Following the general partial identification result of Flynn et al. (2023) adapted to our setting, we show that *if consumption of exposed agents increases in response to the news about the future dividend tax increase, their EIS must be above one*.

We identify the spending effects of the dividend tax announcement and its subsequent implementation using a dynamic difference-in-differences (DiD) approach. We estimate the effect of the reform by comparing the spending trajectories of a treatment group – defined as firm owners receiving dividend income before the reform – with a control group of firm owners with no dividend income. This treatment exposure is plausibly exogenous, as it stems from the pre-reform tax planning of firm owners owning firms with different profitability. Specifically, under the pre-reform tax system, the effective marginal labor tax schedule created distinct incentives for owners of more profitable firms to shift income from wages to dividends. We show that the treatment and control groups exhibit parallel spending trajectories before the reform, consistent with the exogeneity assumption.

Our key empirical finding is that exposed households responded to the reform by increasing spending after the announcement and reducing it after implementation. In terms of magnitudes, relative to the control group, treated households increased their spending by around 6% more in 2004, followed by a persistent decline of roughly 8%. The observed post-announcement spending increase is only consistent with an EIS greater than one. Our empirical results are robust to a wide range of potential confounders, including other concurrent tax changes, owner age and firm life-cycle effects, as well as stock market wealth effects.

To estimate the value of the EIS, we construct a tractable structural model and calibrate it to match the estimated dynamic spending response. Our model builds on the standard two-agent capitalist-worker framework of Campbell and Mankiw (1989) with the addition of dividend tax news shocks following the literature on news and macroeconomic fluctuations (Beaudry and Portier, 2004, 2006). We estimate the EIS to be around 1.6 using an impulse-response matching procedure which matches the empirical difference-in-differences setup. Using bootstrapped confidence bands, we find that the baseline model-implied EIS is statistically different from one at the 95% confidence level. This result does not change after an array of model extensions and sensitivity checks, supporting our assertion that the EIS of firm owners is robustly above unity.

Related literature. Our paper contributes to the large body of work estimating the EIS, where no broad consensus has emerged (Hall, 1988, Hansen and Singleton, 1983, Campbell and Mankiw, 1989, Mankiw and Zeldes, 1991, Attanasio and Weber, 1993, Blundell et al., 1994, Attanasio and Browning, 1995, Beaudry and Van Wincoop, 1996, Vissing-Jørgensen, 2002, Vissing-Jørgensen and Attanasio, 2003, and more recently Gruber, 2013, Cashin and Unayama, 2016, Best et al., 2020, Calvet et al., 2021, Crump et al., 2022, Ring, 2024, among others).[2] Estimates of the EIS vary significantly by data type (aggregate time series, survey, or administrative), empirical method, and sample population, partly due to endogeneity issues and biases from using aggregate time-series variation in rates of return or model misspecification.[3] Our primary contribution is to use the news about a future dividend tax change to identify the EIS. This approach is novel to the literature and reliably signs the EIS relative to unity.

Our use of rich administrative datasets places our paper among a small group of recent empirical studies that estimate the EIS using micro data. Best et al. (2020) examine bunching around loan-to-value mortgage thresholds in the UK, combined with a dynamic model of mortgage refinancing choice. Jakobsen et al. (2020) interpret their estimates of wealth responses to the 1989 Danish wealth tax reform in terms of structural parameters. Ring (2024) uses Norwegian administrative data, focusing on border discontinuities in the pricing of housing used to assess the wealth tax in Norway. Compared with this literature, our study has two advantages. First, we study a large and salient reform such that any optimization frictions that may bias the estimates are less relevant in our setting. Second, as we show in Section 2, the dividend tax reform we study mainly affected one specific future effective interest rate, an almost ideal setting to identify the EIS relative to unity.

We also contribute to a growing literature on the real effects of capital income taxation, particularly dividend income taxation (Harberger, 1962, Hall and Jorgenson, 1967, Feldstein, 1970, Auerbach, 1979, Bradford, 1981, Poterba and Summers, 1983, Cummins et al., 1994, Chetty and Saez, 2005, Auerbach and Hassett, 2007, House and Shapiro, 2008, Chetty and Saez, 2010, Yagan, 2015, Alstadsæter et al., 2017, Zwick and Mahon, 2017, Stantcheva, 2017, Barro and Furman, 2018, Saez and Stantcheva, 2018, Chodorow-Reich et al., 2024). There are two broad views on the effects of dividend taxes on firm investment according to that literature – the "old" view (Harberger, 1962, Feldstein, 1970, and Poterba and Summers, 1983), which argues that corporate income taxes affect the cost of capital of firms, and a "new" view (Auerbach, 1979 and Bradford, 1981), which instead contends

[2] Campbell, 2003, Hansen et al., 2007, Attanasio and Weber, 2010, Havránek et al., 2015, and Havránek, 2015 provide surveys and meta-studies detailing how estimates vary by method and publication bias.

[3] See Bansal et al., 2010, Bansal et al., 2011, Gruber, 2013, and Schmidt and Toda, 2015 on downward biases from time-series data and Yogo (2004) on weak instruments in EIS estimation.

that dividend income taxes are neutral for firm investment decisions and only impact firm valuations. Our theoretical analysis aligns with the "new" view when dividend tax changes are unanticipated. However, we emphasize that when household consumption and firm investment decisions cannot be decoupled, a dividend tax can be distortionary, specifically when the reform is *pre-announced* and the EIS differs from unity. The point that dividend taxes influence behavior primarily when they are expected is also made by McGrattan (2012) in the context of the Great Depression.

2 How responses to dividend tax news identify the EIS

To illustrate how the spending response to news about future dividend taxes depends on the value of the elasticity of intertemporal substitution (EIS), consider an infinitely-lived firm owner who only has access to saving in firm capital:

$$\max_{\{c_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-1/\psi}}{1-1/\psi}$$

subject to

$$k_{t+1} = k_t^{\alpha} + (1-\delta)k_t - (1+\tau_t)c_t,$$

where c_t is consumption, k_t is capital, β is the discount factor, δ is the depreciation rate of physical capital, $\alpha \in (0,1]$ is the returns to scale of the production technology, τ is the dividend tax, and $\psi > 0$ denotes the EIS.[4]

The solution to this problem has to satisfy the Euler equation

$$c_t^{-1/\psi} = c_{t+1}^{-1/\psi} \beta \tilde{R}_{t+1}, \tag{1}$$

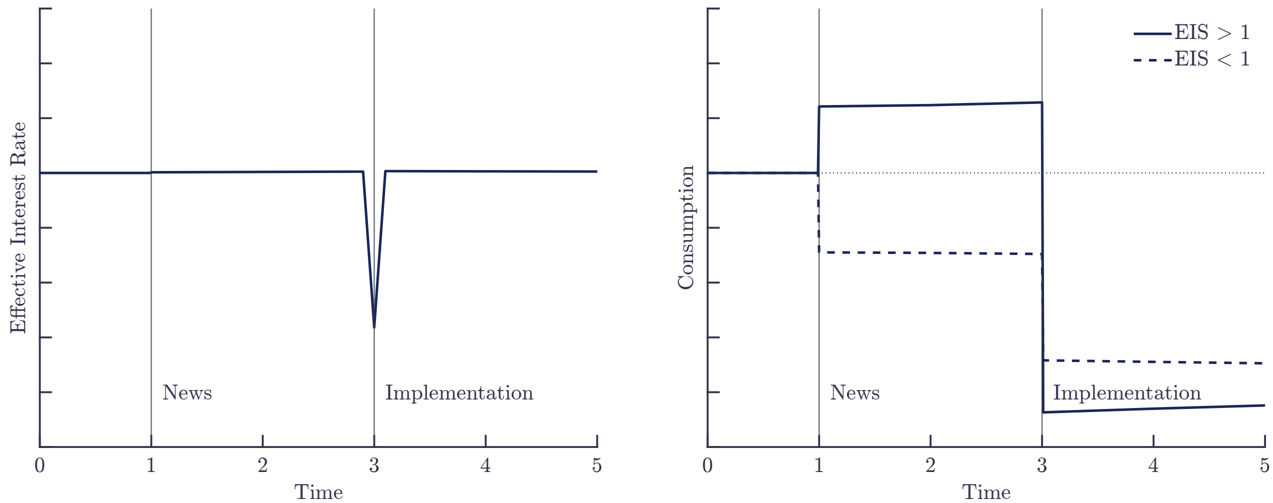
where $\tilde{R}_{t+1}$ is the effective interest rate:

$$\tilde{R}_{t+1} = \left(\frac{1+\tau_t}{1+\tau_{t+1}}\right)\left(\alpha k_{t+1}^{\alpha-1} + (1-\delta)\right). \tag{2}$$

When the dividend tax is constant, it does not affect the effective interest rate. In contrast, an expected change in the dividend tax rate does affect the effective interest rate, resulting in a transitory shift in the effective interest rate for firm owners.

To illustrate this, Figure 1 shows the effective interest rate and consumption responses to a reform that is announced in period 1 and increases the dividend tax from period 3.

[4] Note that this problem is equivalent to the canonical neoclassical growth model with a consumption tax and no labor inputs.



(a) Effective interest rate, $\tilde{R}$.

(b) Consumption, c.

Figure 1: Example consumption and capital paths in response to a future dividend tax increase.

As per equation (2), there is a temporary drop in the effective interest rate when the new dividend tax is implemented. The owner responds to the announced dividend tax by increasing or decreasing consumption *at the time of the announcement*, and thus also by adjusting the level of capital.[5]

The *sign* of the consumption response between the news and implementation of the reform is determined by whether the EIS is greater or less than one. If consumption increases in response to the news about a future dividend tax increase, then the EIS is greater than one. Intuitively, the substitution effect induced by the lower future effective interest rate dominates the income effect. Conversely, if spending decreases before implementation, the EIS is less than one. This approach to signing the EIS relative to unity using news about future rates of return follows from Flynn et al. (2023) and holds more generally. Moreover, in addition to the sign of the EIS relative to unity, the value of the EIS will govern the size of the consumption response between the reform announcement and implementation dates.[6] We apply these two insights to the 2006 Norwegian dividend tax reform to determine both the sign of the EIS relative to unity for households exposed to the reform and its precise

[5]Unless the EIS equals unity, there is also an adjustment in the capital stock, which in turn affects the marginal product of capital and thus the effective interest rate in other periods. When the depreciation rate of capital is relatively low, as is the case in the numerical example in Figure 1, this effect is second-order compared to the direct impact of the dividend tax reform. Note that this indirect effect in the path of the effective interest rate does not impact our approach to identifying the EIS.

[6]With labor income, spending may increase in response to the dividend tax news even if the EIS is below one due to a weakening of the income effect induced by the news. We address this explicitly when estimating the EIS using the structural model in Section 7.

magnitude.

2.1 Robustness

While the model we present is stylized, the comparative statics remain valid in richer models that incorporate multiple assets, return risk, and labor income risk (Flynn et al., 2023). We briefly discuss a few notable extensions, while Section 7 presents a more detailed structural model that maps our empirical estimates to EIS values.

Idiosyncratic business risk. In the data, firm owners face large *returns* risk (see, e.g., Fagereng et al., 2020), which is not accounted for in the framework above. However, as argued by Flynn et al. (2023), idiosyncratic business risk does not pose a challenge to identifying the value of the EIS relative to unity via the inspection of the anticipatory (dis-)saving response to tax news shocks.[7] Intuitively, business risk impacts the risk-adjusted return on wealth but does not change the intertemporal trade-off of the agent in response to the tax news.

Idiosyncratic labor income risk. Unlike business risk, labor income risk could impact the identification of the sign of the EIS relative to unity because it affects the relative strength of substitution and income effects (Farhi et al., 2022; Holm, 2023). In particular, Holm (2023) shows that the substitution effect of interest rate changes weakens in the presence of income risk if the utility function exhibits the *temperance* property.[8] Under the standard and realistic assumption that capitalists' behavior is consistent with decreasing absolute prudence (e.g., power utility), labor income risk does not substantively affect our results because firm owners in our sample are wealthy.[9]

Durable goods. The theory above relies on observing the *non-durable consumption* response to news about the dividend tax to identify the EIS. In the data, we observe *spending*, a measure that also includes durable components such as housing refurbishment and household appliances. The spending response may differ from the consumption response

[7] See Section 4.3 and Proposition 5 in Flynn et al., 2023.

[8] Temperance is defined as a negative fourth derivative of the utility function, $u^{(4)} < 0$. See the Theorem in Eeckhoudt and Schlesinger, 2006. We provide an explicit model of risk in Appendix A.2 to explain this further.

[9] For example, Holm (2023, Corollary 1) shows in a two-period setting that the marginal effect of income risk on the substitution effect is $\frac{1}{8}(1+1/\psi)(2+1/\psi)\frac{1}{C}$ with the power utility function we use here, converging to zero as wealth increases.

and thus impact how we interpret the results. If we assume there is a perfectly competitive durable goods market with no trading friction, buying durable goods is like renting durable goods, and spending and consumption evolve similarly.[10] An alternative is to assume that durable goods are partly irreversible, such that the resale price is below the market price. Generally, because firm owners are permanently poorer due to the dividend tax increase, they should lower their long-run stock of durables. Similarly, trading frictions (e.g., convex adjustment costs) also raise the importance of lower permanent income. Hence, the presence of durable goods may imply that the spending response does not increase as much as the response to non-durable consumption would upon announcement of the reform. This would tend to bias our estimate of the EIS downward.

More general preferences. The sign comparative statics hold for more general preferences (e.g., Epstein-Zin), as shown by Flynn et al. (2023). They also hold for particular non-homothetic preferences used in the macro literature. In Appendix A.1, we specifically demonstrate that the comparative static result holds for non-homothetic preferences, as in Straub (2019). In that environment, however, the EIS does not depend on a single parameter but on a combination of parameters and the level of spending, and may therefore vary depending on changes in that level.

3 The dividend tax reform

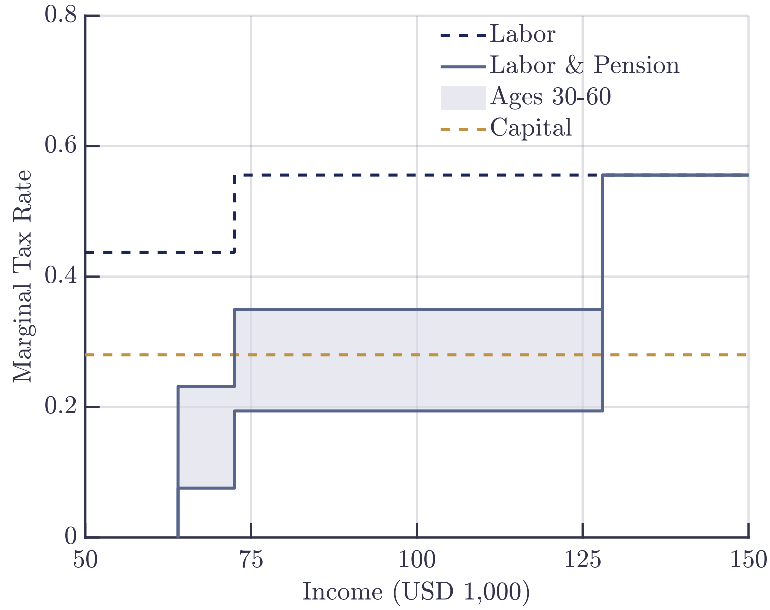
The tax system before 2006. Before 2006, the Norwegian tax system consisted of a progressive labor income tax combined with a flat capital income tax, as illustrated in Figure 2.[11] Wage earners faced a marginal tax rate that increased from around 42% to more than 60%. When including the marginal benefit of the compulsory pension contributions, the effective marginal tax rate for wage earners is substantially lower, with the exact magnitude depending on the individual's valuation of future pension benefits. On the other hand, profits in the firm were taxed at 28% and dividend income was tax-free except temporarily in 2001.[12]

The large difference in effective marginal tax rates between labor and capital income gave some small business owners a strong incentive to classify their own labor income as capital income. Specifically, Figure 2 shows that as income increased, the incentives for firm

[10] Appendix A.3 formalizes this intuition in a simple model.

[11] Appendix B.1 details how we compute the effective marginal tax rates.

[12] The government introduced a temporary dividend tax of 11% only in effect for the 2001 fiscal year (Innstilling til Odelstinget nr. 23, 2000-2001). In our sample period, the corporate income tax remained constant at 28% until it was reduced to 27% in 2014.



Notes: The figure shows effective marginal tax rates for labor and capital income in 2000. "Labor" shows the statutory marginal tax rate on labor income, while "Capital" represents the corresponding rate on capital income. The "Labor & Pension" rate includes the implicit tax from compulsory pension contributions, which are exempt from the wealth tax. The shaded area illustrates that the marginal tax rate (from pensions) varies across individuals, particularly with age of the individual, because it relies on a net present value calculation. Appendix B.1 explains how we construct marginal tax rates.

Figure 2: Effective marginal tax rates in 2000

owners to pay themselves with dividends instead of wages strengthened. For example, for firm owners with income above 12 times the base amount in the Norwegian social security system, also known as "G" (around USD 10,500 in 2000), the effective marginal tax rate on capital income was significantly lower than on labor income, implying that firm owners would find it advantageous to shift income from labor to capital. In 1992, Norway introduced a set of tax rules ("delingsmodellen" in Norwegian) to prevent this, but they were widely circumvented. By 1998, among business owners working in their firms and earning above the threshold where capital income classification was advantageous, 96.5% had structured their business and tax arrangements to avoid the higher wage income tax rate (NOU 2003:9, 2003, p. 239).

The 2006 tax reform. On January 11, 2002, the newly-elected government appointed an expert commission to suggest permanent changes in the tax system motivated by the large difference in marginal tax rates between labor and capital income and the widespread circumvention of the 1992 tax rules regarding income shifting (NOU 2003:9, 2003, p. 11). On February 6, 2003, the government-appointed commission published their findings (NOU 2003:9, 2003). Among the recommendations was the introduction of a 28% dividend tax, raising the effective capital tax rate on firm owners from 28% to 48.2%.[13] At the same time, the commission recommended reducing the top marginal tax rates on wage income to 54.3%. On March 26, 2004, the government officially announced a tax reform that mostly followed the commission's recommendations, introducing a dividend tax and reducing the marginal tax rate on wage income (Stortingsmelding nr. 29, 2003-2004). However, for administrative reasons, the introduction of the dividend tax was postponed to January 1, 2006. Henceforth, we will refer to the publication of the commission's report in February 2003 as the "news" date and January 2006 as the reform "implementation" date.

The reform – once it was officially implemented in 2006 – introduced a 28% personal tax on dividends and capital gains in excess of a threshold amount based on the riskless returns in any given year.[14] Under the previous tax regime, dividends were tax-exempt for any shareholder, while capital gains were almost always applied to a zero base and hence were tax-exempt as well. Firms paid no taxes on dividends and capital gains both before and after the reform.[15] The reform also decreased the top marginal tax on labor income from 64.7% to 54.3%.

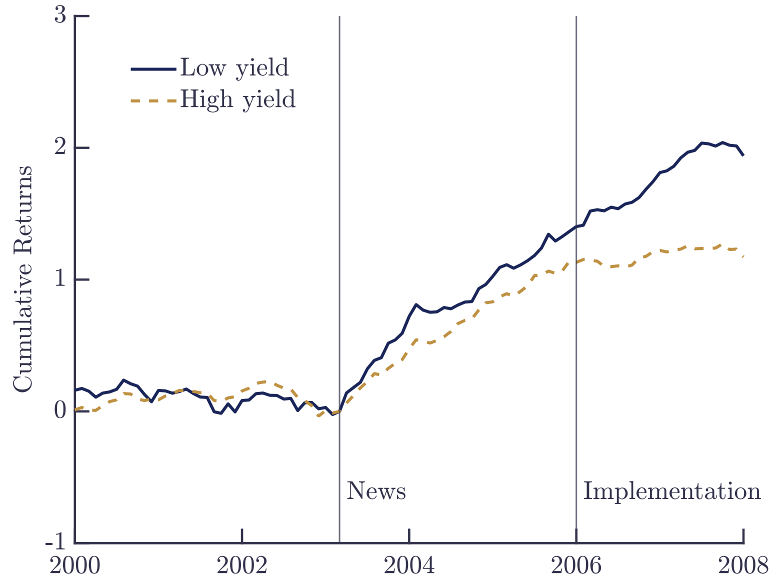
Stock market impact of the reform announcement. To verify that the 2003 reform announcement was unanticipated, we compute the cumulative returns for high- and low-dividend-paying stock portfolios among "small-cap" firms (defined as those below the median market capitalization) using stock-level data from the Oslo Stock Exchange.[16] We focus on small-cap firms for two reasons. First, these firms are similar in size to those in our micro-data analysis. Second, small-cap firms are predominantly owned by individuals based in Norway, making them directly exposed to the dividend tax reform. Figure 3 plots these cumulative returns from January 2000 to January 2008. The empirical stock return patterns from 2000 to 2008 confirm that the announcement was unanticipated, as there is no discernible divergence in portfolio performance prior to the announcement date. Both high- and low-dividend portfolios tracked each other closely until 2003, when the dividend tax reform was announced, after which their returns began to diverge. Divergence

[13] The effective tax rate of firm owners is computed as 48.2% = 28% + (100% − 28%) · 28%.

[14] The annual risk-free rate of return allowance for shareholders/partners (RRA) is computed as the exemption rate multiplied by the sum of the cost price of the share/holding and any unused allowance from previous years. The unused allowance is then carried over to the next year with interest and can be deducted from future dividends and capital gains associated with the same share/holding. The exemption rate for shareholders and partners is the average interest rate on three-month Norwegian Treasury bills in the year for which the allowance is to be calculated. Therefore, the dividend payouts of firms with dividend yields lower than the average yield on 3-month Norwegian Treasury bills fall within the RRA exemption.

[15] During the transition period, stocks could be transferred to a holding company without triggering a capital gains tax.

[16] Appendix B.2 presents details on portfolio construction.



Notes: This figure shows cumulative returns of two portfolios of below-median market-capitalization ("small-cap") firms with high- (above median) vs. low-dividend yields. Appendix B.2 presents details on how the portfolios are constructed.

Figure 3: Cumulative stock returns for high vs. low dividend stock portfolios.

accelerated noticeably during the transition period and after the implementation date.[17]

4 Data

We use data from several Norwegian administrative registries from 2000 to 2014, combined using unique personal identification numbers. The main source is the income and balance sheet statements of all Norwegian households (Statistics Norway, 1993-2019d, "Data om inntekt, skatt, avgift og eiendom"). Because Norway levied wealth, inheritance, and income taxes at the time, the tax authorities collected detailed information on household balance sheets, familial inter vivos transfers, and income statements. Most variables in the income and wealth data are third-party reported by employers, financial intermediaries, or the tax authorities (e.g., assessed housing wealth and private business wealth).

We additionally rely on five data sources to supplement the tax registers. First, we use the housing transaction data when we impute spending (Statistics Norway, 1993-2019a, "Eiendomsregisteret"). Second, we use the stock ownership data to define private business owners (Statistics Norway, 2004-2019e, "Aksjonærregisteret"). Third, we use the income statements and balance sheets of firms to measure dividends and changes in paid-in capital

[17]Figure 3 shows a relatively delayed full capitalization of the dividend tax news into stock prices. This delayed response is consistent with portfolio adjustment frictions by investors (Gabaix and Koijen, 2021).

(Statistics Norway, 2000-2019c, "Brønnøysundregisteret"). Fourth, we use information on family status to construct households, birth year, and home addresses (Statistics Norway, 1964-2019b, "Folkeregisteret"). Fifth, we use the employer-employee register for information on sector of employment (Statistics Norway, 2000-2014, "Aa-registeret"). All values are deflated to real 2011 U.S. dollars.

Imputed spending. The main variable of interest in our study is *imputed spending*, defined from the budget constraint as income not saved. Because the wealth tax is levied at the household level and imputed spending requires measuring saving, imputed spending is defined at the household level. In the analysis below, however, the unit of observation is the individual, where all variables of an individual in a multi-person household are defined as the average value of that variable for the adult population in a household.

We define spending of a household who owns no private businesses (npbo) as

$$\begin{aligned} \text{spending}_{i,t}^{\text{npbo}} &= \text{disp. income}_{i,t} - \text{saving}_{i,t}, \\ &= \text{disp. income}_{i,t} - \text{saving}_{i,t}^{\text{deposits}} - \text{saving}_{i,t}^{\text{debt}} - \text{saving}_{i,t}^{\text{housing}} - \text{saving}_{i,t}^{\text{risky assets}}, \end{aligned} \tag{3}$$

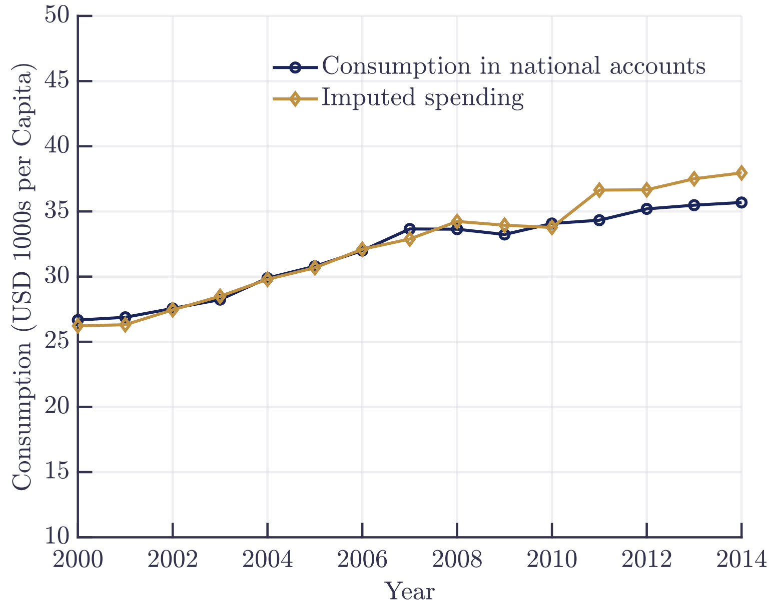
where $\text{saving}_{i,t}^{\text{deposits}}$ is the change in real deposits, $\text{saving}_{i,t}^{\text{debt}}$ is the (negative) change in real debt, and $\text{saving}_{i,t}^{\text{housing}}$ is the (real) net purchases in the housing market, and all of the above are directly observed. The main challenge for this group of households is to compute $\text{saving}_{i,t}^{\text{risky assets}}$, the sum of listed stocks and stock funds, which requires computing the difference in risky assets from one year to the next, net of capital gains. Appendix B.3 presents more details on how we compute saving for each asset class.

The main focus of this paper is the spending response of private business owners (owners of incorporated firms not listed on the public stock exchange) to the dividend tax reform. To impute spending of firm owners, we include income and saving in the private business as part of the owners' income and saving.

We define imputed spending of private business owners as

$$\begin{aligned} \text{spending}_{i,t} &= \text{spending}_{i,t}^{\text{npbo}} + \sum_{f} \left(\text{income}_{i,t}^{f} - \text{saving}_{i,t}^{f} \right), \\ &= \text{spending}_{i,t}^{\text{npbo}} + \sum_{f} \left(\text{dividends}_{i,t}^{f} + \Delta\text{ret. ear.}_{i,t}^{f} - \left(\Delta\text{ret. ear.}_{i,t}^{f} + \Delta\text{paid-in capital}_{i,t}^{f} \right) \right), \\ &= \text{spending}_{i,t}^{\text{npbo}} + \sum_{f} \left(\text{dividends}_{i,t}^{f} - \Delta\text{paid-in capital}_{i,t}^{f} \right). \end{aligned} \tag{4}$$

where spending^{npbo} is defined as spending when we ignore private businesses in equa-



Notes: The figure presents real imputed spending alongside real aggregate consumption data from the national accounts, following the approach of Holm et al. (2021).

Figure 4: Comparison of imputed spending and consumption data from the national accounts.

tion (3). The key observation in equation (4) is that one only needs to keep track of the net flows between the firm and the owner to impute spending of firm owners. In the first line, imputed spending is defined as the sum of spending ignoring the private business and income minus saving in firm f going to owner i. Income in the firm is equal to the sum of dividends and the change in retained earnings. The "active" saving by the firm is defined as the change in retained earnings and the change in paid-in-capital (second line of eq. (4)).[18] Income minus saving in firm f for owner i is thus the dividends net of the change in paid-in capital – the net resource flow from firm to owner.

To apply equation (4), we need to observe how much of each firm an owner holds. We use the ownership register to compute ownership shares, including indirect ownership shares via other firms.[19] As the ownership registry only exists from 2004 we impute the ownership share of owner i in firm f before 2004 using ownership shares from 2004 if the

[18]In our approach, saving in the firm is defined as the change in book value due to active transactions, which in turn equals the sum of the changes in retained earnings and paid-in-capital. Alternatively, one can define active saving in the firm as the change in book value net of capital gains. With this alternative definition, however, one would need to compute capital gains on the firm's assets, which is challenging because firm's asset classes include less information about what the firm owns and thus which prices to apply to each asset class (e.g., ships, rigs, aircraft).

[19]In the ownership registry, we observe all owners of private businesses, both firms and households. The ownership registry thus allows us to compute indirect ownership shares of all firms. We compute indirect ownership shares for households up to layer 10 when we compute ownership shares.

firm existed in the firm registry and the owner had non-zero holdings of non-listed stocks in the tax accounts.[20]

Figure 4 compares imputed spending for the entire population with consumption in the national accounts. Reassuringly, imputed spending tracks consumption in the national accounts closely.[21]

Tax evasion. Our data relies on tax data, which is subject to measurement problems related to tax evasion. This raises two issues when interpreting our results. First, owners of private businesses may use these firms for private consumption. Consumption within the firm is illegal, but likely to be relatively prevalent (Leite, 2024). Systematic tax evasion by exposed firm owners may lead to level differences in imputed spending (if the bias is constant in logs within groups), which is not a problem. An issue arises if the dividend tax reform incentivizes firm owners to shift consumption to within-firm consumption to evade taxes to a larger extent, as suggested and documented in Alstadsæter et al. (2014). However, because this incentive primarily affects behavior after the tax is introduced, it would bias our result only *after* the reform is implemented. In the period between announcement and implementation, the relevant period for identifying the value of the EIS relative to unity, this is a less pertinent issue.

Second, households may evade taxes by hiding wealth abroad, which is also illegal. Because our data relies on administrative data collected by the tax authority, hidden wealth is always an issue, especially among wealthy households (Alstadsæter et al., 2019). A concern is that the latter observed pattern – heightened spending followed by a permanent decline – could be driven by owners hiding wealth before the reform. This would create a measured spending spike followed by a permanent decline if they later spend out of their hidden wealth. To alleviate this concern, we exclude the top and bottom 1% of the spending growth distribution.

Sample restrictions. Our sample spans annual observations from 2000 to 2014. We impose several restrictions. First, we restrict the sample to individuals between 30 and 60 years old in 2000, capturing the prime working and wealth accumulation years. Second,

[20] Our sample is restricted to individuals owning at least 25% of each firm in their private business portfolio, and we observe that 86% of owners maintain the same ownership share after five years.

[21] Baker et al. (2021) compare imputed consumption with transaction data and show that measurement errors are minimal when controlling for individual portfolio holdings and fixed effects for individuals and time. A concern might be that some individuals frequently trade listed stocks, generating large intra-year realized capital gains or losses that we do not observe. However, the mean stock wealth in 2000 for our sample is only USD 2,215, and 65% of individuals change the number of shares in their stock portfolio by less than 20% after five years. To further mitigate concerns about individuals with very large asset holdings and transactions, we exclude those in the top 1% of the wealth distribution in 2000 from our sample.

we exclude households with disposable income below 2G (around USD 21,000) to avoid including those whose consumption patterns may be driven by financial constraints. Third, we limit the sample to households holding at least 25% of every firm in their private business portfolio.[22] Fourth, we retain households with stable imputed spending growth, excluding those with year-to-year log changes in spending in the top or bottom 1% of the distribution to address concerns that spending patterns may reflect tax evasion or asset price revaluations rather than underlying behavior. Fifth, we exclude households that were in the top 1% of the wealth distribution in 2000 to ensure that extreme wealth levels do not disproportionately influence our results. After applying these restrictions, the final sample includes 16,966 individuals in 2000.

5 Econometric methodology

Our econometric specification to estimate the spending responses to the reform announcement is a standard dynamic differences-in-differences model:

$$
\begin{aligned}
c_{i,2000+h} - c_{i,2000} = \alpha + \sum_{h=\underline{h}}^{H} \beta_h \left(D_{i,2000} \times \omega_{2000+h} \right) \\
+ \sum_{h=\underline{h}}^{H} \Gamma'_h \Big(\mathbf{X}_{i,2000} \times \omega_{2000+h} \Big) + \sum_{h=\underline{h}}^{H} \gamma_h \times \omega_{2000+h} + \delta_i + \varepsilon_{i,h}
\end{aligned}
\tag{5}
$$

for $h = \{0, 1, 2, \ldots, 14\}$, where $c_{i,2000+h}$ denotes log imputed spending for individual i in year $2000 + h$, $D_{i,2000} \in \{0, 1\}$ is our treatment variable for individual i in year 2000, ω_t denotes a dummy variable for year t, and $\mathbf{X}_{i,2000}$ contains a set of controls for individual i in 2000, which are interacted with year dummies to allow for time-varying effects. We include year fixed effects, represented by γ_h, to account for aggregate time-varying factors that uniformly impact all individuals, and we add an individual fixed effect δ_i to capture time-invariant individual-specific components. As we explain below, the baseline specification includes pre-reform controls for household non-financial income, along with industry and municipality fixed effects. In addition, we include separate controls for individual and firm age. Standard errors are clustered at the individual level to account for autocorrelation in $\varepsilon_{i,h}$ across observations for each individual.

[22] This restriction also rules out most individuals who own multiple firms (e.g., holding company structures) because they tend to also own ownership shares smaller than 25%.

Treatment definition. We define a household as treated if the mean share of its non-financial income in 2000 and 2002 attributable to dividends from its firm exceeds 30%.[23] We include the years 2000 and 2002 in our treatment definition because dividend payments tend to be lumpy and irregular such that one single payment does not necessarily indicate that the household relied on regular dividend income. Moreover, we exclude 2001 from the definition due to the temporary dividend tax. The control group is defined as private business owners who did not receive any dividend income in 2000 and 2002, including dividend income from listed stocks and mutual funds. Table 1 compares the treatment and control groups in 2000. The two groups are similar in age and labor income. However, treated owners are wealthier, have higher disposable income, and spend more due to substantial dividend earnings from their firms. Additionally, the firms owned by the treated group are larger across several dimensions, including total assets, revenue, number of employees, and value added.[24]

Identification. Identification relies on two key assumptions. First, the reform announcement in 2003 was unexpected, such that households did not adjust their behavior in anticipation of the news about future dividend taxes. As shown in Figure 3, stock returns between 2000 and 2003 exhibit no patterns that would plausibly point to anticipatory effects of the reform's announcement date. Second, we assume that treatment exogeneity or equivalently the parallel trends assumption holds – the control group represents a relevant counterfactual for the treated group's spending *growth* absent the reform.

Conceptually, unconstrained forward-looking agents have similar spending *growth rates* if they have similar preferences and face similar interest rates.[26] We argue that treatment exogeneity holds in our setting, as it stems from the pre-reform tax planning of firm-owners with different permanent incomes generated by the firms they own. As shown in Figure 2, firm-owners' incentives to pay themselves in dividends rather than wage increased in income due to the effective marginal tax schedule they faced. Owners of firms generating higher income (i.e., larger or more productive firms) would have a stronger incentive to pay themselves in dividends before the reform, and thus, be exposed to the reform. On the other hand, owners of firms generating lower income (i.e., smaller or less productive firms) would have weaker incentives to shift income from wages to dividends.

[23] We show in Figure 8c that the exact choice of this threshold is not important.

[24] The sectoral distribution of firms is similar between the two groups, as shown in Table B.1 in Appendix B.4.

[25] The treatment group's average listed-equity holdings is less than USD 4,700. Consequently, dividend income from public assets is negligible, with virtually all dividends arising from their private businesses.

[26] From the consumption Euler equation, $u'(c_t) = \beta(1+r)u'(c_{t+1})$, the consumption growth rates for two individuals are the same, if β, $(1+r)$ and the elasticities of inter-temporal substitution are the same.

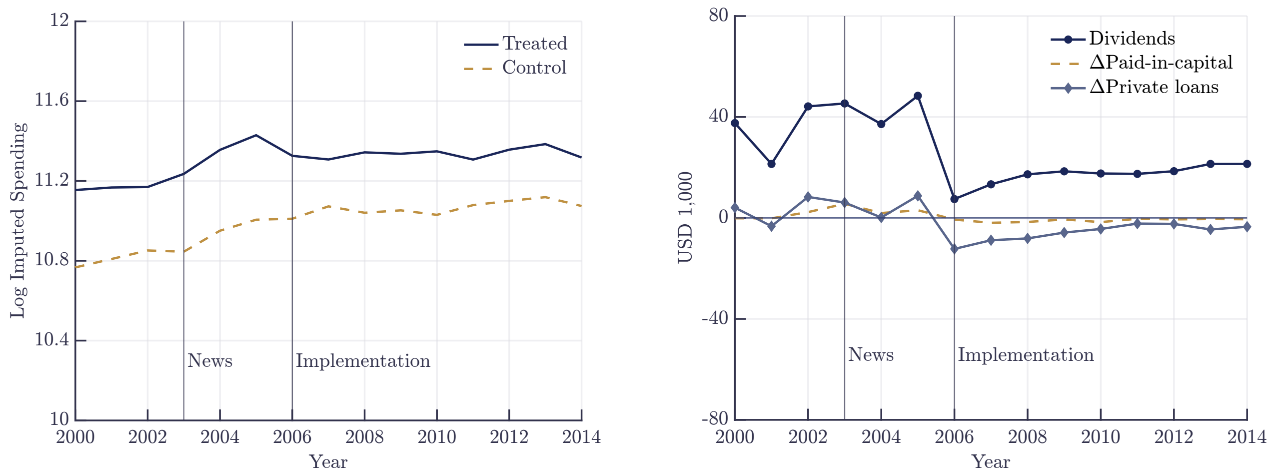
	Control		Treated	
	Mean	S.D.	Mean	S.D.
Panel A: Household Characteristics				
Age	44.42	8.33	47.02	7.93
Number of individuals	13,046	.	3,920	.
Dividend share of net income (%)	.	.	35.21	26.35
Panel B: Household Spending, Income and Wealth				
Spending	47.43	44.76	69.89	77.92
Disposable income	40.54	18.30	79.26	67.30
Labor income	56.02	27.88	58.81	24.90
Dividend income[25]	.	.	37.59	63.56
Net wealth	216.18	366.80	591.64	548.05
Private business wealth	28.99	171.33	198.07	322.55
Panel C: Firm Income Statement, Balance Sheet and Characteristics				
Revenue	581.47	1,489.42	1,507.02	3,280.75
Wages	144.73	407.61	295.36	588.54
Cost of goods purchased	280.90	1,139.15	813.09	2,519.59
Total assets	215.81	1,203.06	660.60	4,017.02
Firm age	7.74	9.47	12.00	11.33
Employees	3.01	6.39	4.94	8.17
Value added per worker	48.53	163.94	101.34	164.00

Notes: We define *treated* as having, on average, more than 30% of non-financial income in the form of dividend income from private businesses in 2000 and 2002. The control group consists of private business owners with no dividend income in 2000 and 2002. Values in Panel B and C are in 1,000 dollars in 2011. Value added per worker is calculated as operating profit plus wages divided by the number of workers.

Table 1: Descriptive statistics in 2000.

Table 1 corroborates the systematic heterogeneity in firm size and productivity between the treatment and control groups. Crucially, Figure 5a shows the mean log spending in the treated and control groups over our sample period. The two groups exhibit similar spending growth in the period before the reform announcement, giving credence to the parallel trends assumption and treatment exogeneity.

Threats to identification. We address specific potential confounders, relating to systematic variation in interest rates or subjective time preferences across the treatment and control groups. Firm owners in the treatment and control groups may face different interest rates due to systematic differences in firm life-cycles. For example, younger firms generate less income and may, in addition, retain more earnings to finance growth, thus delivering higher cash-flows and dividends in the future. Older firms, on the other hand, are more



(a) Log spending in the treatment and control group.

(b) Average dividends, and changes in paid-in-capital and private loans in the treatment group.

Notes: Panel (a) displays the average log imputed spending in the treatment and control groups. Panel (b) shows the average dividends from private businesses to the owner, changes in paid-in capital, and changes in private loans for the treated group.

Figure 5: The evolution of spending, dividends, and changes in paid-in-capital and private loans.

likely to have reached optimal scale and distribute back a steady stream of dividends. If households in the treatment group are disproportionately the owners of older firms, this could bias our estimation of the spending responses. Another concern is that the dividend share of income may vary systematically with the age of owners themselves, which could correlate with differences in spending growth across households due to, e.g., differences in income prospects or portfolio compositions (Fagereng et al., 2017). Consequently, if the exposed households are, on average, older, and older households follow different spending trajectories compared to the younger households, then this could bias our results. To address the concerns with the life cycles of firms and owners, we include eight age bins for both individuals and firms in our empirical specification.[27]

Additionally, there may be confounding effects from three concurrent reforms. First, the concurrent labor income tax reform reduced the top marginal tax rates on wage income during the same period as the dividend tax reform (as detailed in Section 3). This raises the concern that households in the treatment and control groups may have been differentially affected by changes in wage taxation. We include controls for non-financial income, categorized into four bins based on differential changes in marginal tax rates, following

[27] Firms are sorted into eight quantile bins by age, based on their year and owner's birth cohort. Individuals are grouped by year into eight quantile bins by age. The bins are defined using values from the year 2000.

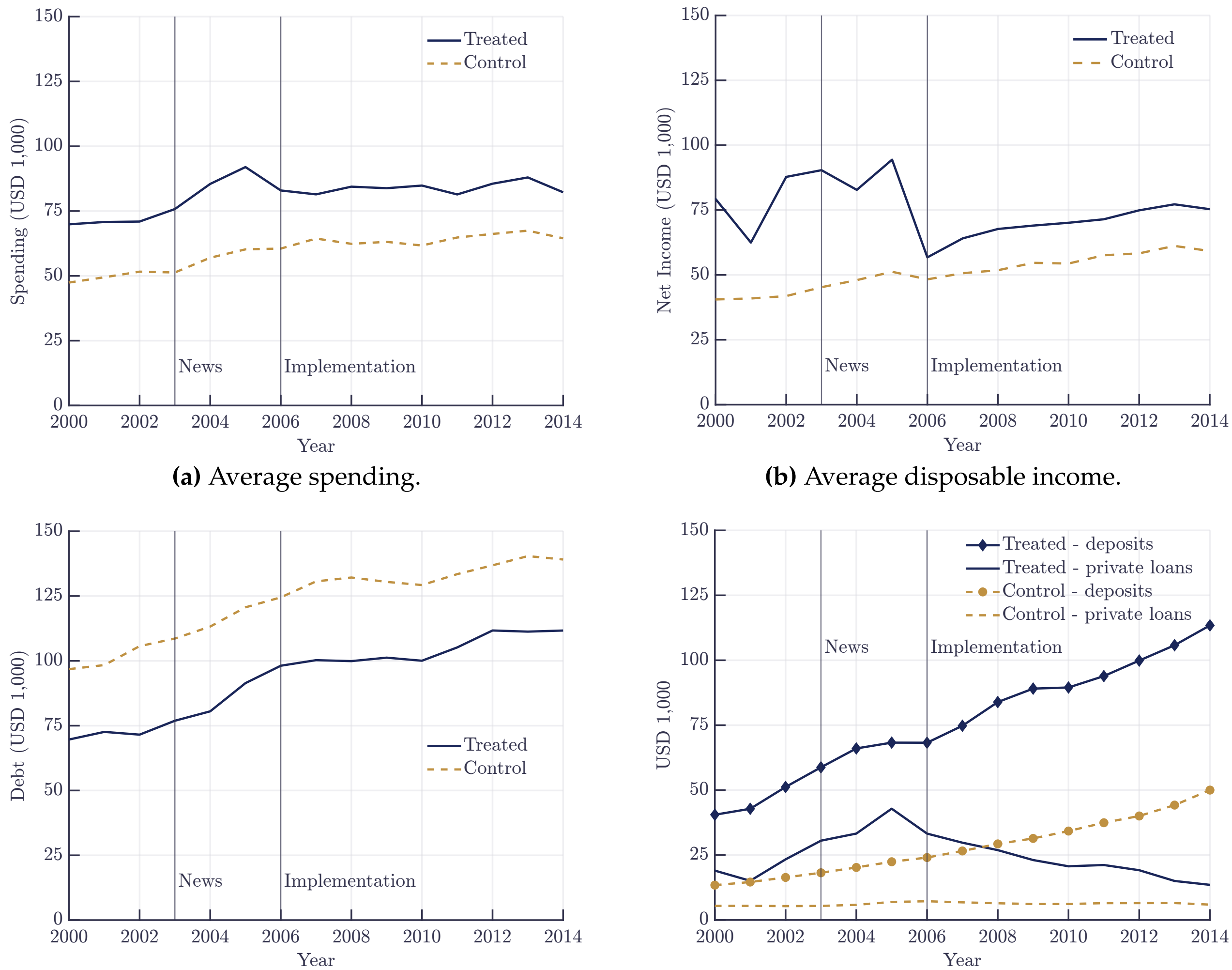
Thoresen et al. (2010, Figure 1) to address this concern.[28] Second, the abolition of the five geographically differentiated payroll tax zones between 2004 and 2006 affected the total tax on wage income (Ku et al., 2020). Households in the treatment and control groups may also differ in their exposure to sectors of the economy and to labor market shocks. To account for potential differences arising from both sectoral exposure and the payroll tax reform, we control for the household's primary employment sector, defined by 2-digit NACE industry codes, and include municipality fixed effects. Third, the 2006 tax reform also included a change in the inheritance tax from a stepped-up to a carry-over basis. Msall and Næss (2025) document that this reform led to more capital gains realization, especially among older individuals. In our sample of relatively young individuals (ages 30-60), this reform has limited impact. Moreover, our specification includes controls for age interacted with year, which alleviates the concern that this reform may confound our results.

Finally, a potential issue is that the exposed households may have experienced a positive stock wealth shock during the 2004–2006 period, as stock prices were rising and dividend income is correlated with stock holdings. If treated households are disproportionately stock-rich, this could bias our estimates. We therefore conduct a robustness exercise that additionally controls for the stock share of household financial wealth as well as gross household wealth.

A remaining concern is that changes in *imputed* spending between the treatment and control groups may be driven mechanically by changes in dividend income. Specifically, owners of firms had incentives to extract dividends from the firm prior to the reform, and if we fail to measure saving well, this may erroneously raise imputed spending. Figure 5b shows the dividends together with the changes in private loans and paid-in capital for the treated group. The treated group consistently paid themselves dividends before 2003, continued to do so at the same level after the news about the dividend tax in 2003, and reduced dividend payments significantly after the dividend tax was introduced in 2006.[29] Hence, the increase in spending of treated households between 2003 and 2006 was not due to an increase in dividend payments. Instead, Figure 6 displays the evolution of decomposed imputed spending of the control and treatment groups, and reveals that the increased spending in 2004 and 2005 in the treatment group is primarily due to an increase in debt combined with somewhat higher disposable income, partly offset by a rise in savings mostly in deposits and private loans.

[28]Specifically, we use three cutoffs for the 2000 non-financial income, corresponding to the 2006 marginal tax thresholds in NOK: 394,000, 750,000, and 936,800.

[29]In addition, they accumulated private loans to the firm and paid-in capital before 2006 and spent the years after 2006 on repaying these private loans and extracting paid-in capital – the two common ways of avoiding the dividend tax.



(a) Average spending.

(b) Average disposable income.

(c) Average debt.

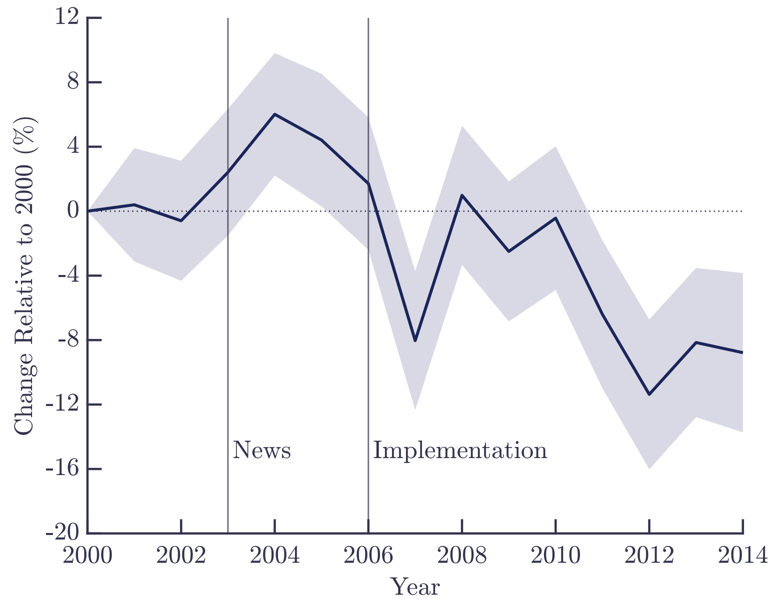
(d) Average deposits and private loans.

Notes: Panel (a) displays the average imputed spending in the treatment and control groups. Panel (b) shows the average disposable income in the treatment and control groups. Panel (c) shows the average debt in the treatment and control groups. Panel (d) shows the average deposits and private loans in the treatment and control groups.

Figure 6: The evolution of spending, disposable income, debt, deposits and private loans in the treatment and control groups.

6 Empirical results

Figure 7 displays the spending response of treated households relative to the control group. Between the announcement and implementation of the reform, spending by treated households increased by approximately 6% relative to the control group. After the reform was implemented in 2006, their relative spending decreased by about 8%. The anticipatory increase in spending following the announcement of the reform is only consistent with an elasticity of intertemporal substitution greater than one. Furthermore, the subsequent



Notes: The figure displays the estimated coefficients of equation (5) with 95% confidence bands computed using standard errors clustered at the individual level.

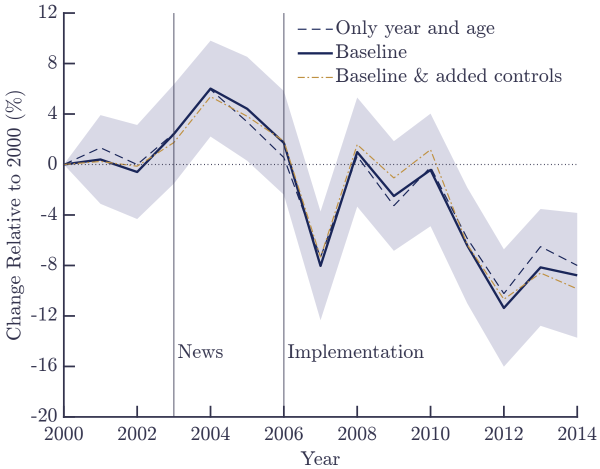
Figure 7: The spending response to the dividend tax reform.

decline in spending after the reform's implementation aligns with a reduction in the permanent income of treated households.

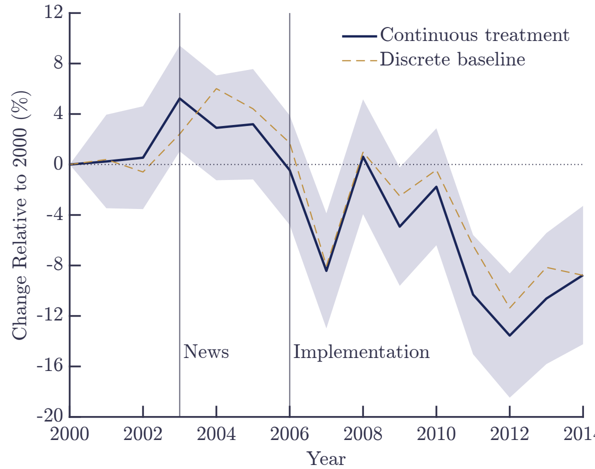
Robustness. Figure 8 presents a number of robustness exercises. First, Figure 8a shows results from two alternative specifications: a simpler model with only year and age fixed effects, and a model that additionally includes eight bins each for the stock share of financial wealth and gross wealth. The results change only marginally.

Second, in our baseline specification, households are defined as treated if their dividend share of income exceeds 30%. As an alternative, we use the dividend share of income as a continuous measure of treatment exposure, capturing varying degrees of exposure across households. This continuous specification leverages the full distribution of dividend shares, including the control group without dividend income, to identify the average treatment effect on the treated (Callaway et al., 2024). The continuous specification is:

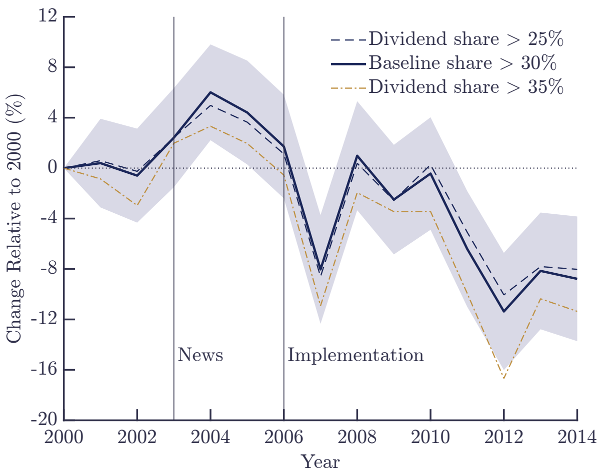
$$
\begin{aligned}
c_{i,2000+h} - c_{i,2000} = \alpha + & \sum_{h=\underline{h}}^{H} \beta_h \Big(\text{exposure}_{i,2000} \times \omega_{2000+h}\Big) \\
& + \sum_{h=\underline{h}}^{H} \Gamma_h' \Big(\mathbf{X}_{i,2000} \times \omega_{2000+h}\Big) + \sum_{h=\underline{h}}^{H} \gamma_h \, \omega_{2000+h} + \delta_i + \varepsilon_{i,h},
\end{aligned} \tag{6}
$$



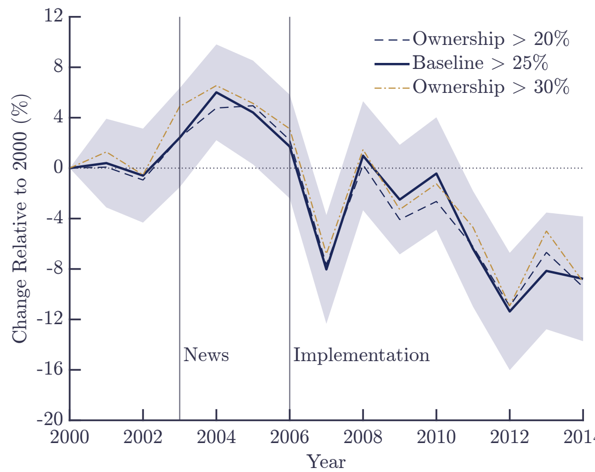
(a) Alternative sets of controls.



(b) Continuous treatment.



(c) Alternative dividend thresholds.



(d) Alternative ownership thresholds.

Notes: The figures display the estimated coefficients of equation (5) with 95% confidence bands computed using standard errors clustered at the individual level.

Figure 8: Robustness of the empirical results.

where $\text{exposure}_{i,2000}$ denotes the average dividend share of household income for household i in 2000 and 2002. To ensure comparability with the baseline specification, we adjust the estimated coefficients to represent the effect of an increase in treatment exposure by 50 percentage points, corresponding approximately to the average exposure (46.97%) of the treatment group in the baseline setup.[30] Figure 8b presents the coefficients from equation (6) alongside the baseline results for the specification with a dividend threshold. The results from this alternative specification remain consistent, showing a positive response

[30]In equation (6), the coefficient β_h denotes the marginal effect of an increase in exposure on consumption growth. We adjust the measure exposure such that one unit corresponds to a 50 percentage points increase in exposure.

following the announcement and a negative response after the reform's implementation.

Third, Figure 8c displays results when varying the treatment threshold for the average dividend share of income to 25% and 35%, respectively, illustrating that the results do not change materially. Fourth, in our sample restrictions we require owners to hold ownership shares above 25% in all private businesses they own. In Figure 8d, we display robustness to this restriction by either relaxing it (20%) or tightening it (30%). The results remain unchanged.

Taking stock Overall, we find that news about a future dividend tax increase induced a positive spending response among households who relied on dividend income before the news. Following the reform's implementation, this group experienced a persistent decline in spending. The observed front-loading of spending in anticipation of lower future post-tax income is consistent with an elasticity of intertemporal substitution (EIS) greater than one when interpreted through the lens of the parsimonious model in Section 2. The following section shows that this conclusion also holds in a richer structural model.

7 Structural approach

7.1 Model

To estimate the EIS, we now construct a structural, general equilibrium model that is closely aligned with our empirical setup. We consider two groups of households: a fraction λ of households, referred to as *capitalists*, who represent the firm owners in our sample exposed to the reform, and a fraction $1-\lambda$ of *workers*, who represent the control group of firm owners earning only labor income from the firm. Both groups have the same preferences and supply labor exogenously. Capitalists can save only in firms' shares, while workers can save only in a risk-free bond. Additionally, capitalists are subject to a dividend tax with imperfect pass-through. Moreover, capitalists have access to transitory tax avoidance opportunities, allowing them to postpone the incidence of the dividend tax.

Capitalists. Capitalists are denoted by k and $C_{k,t}$ is their consumption in period t. Consumption is taxed at the rate $\tau_{d,t}$, and actual realized spending is

$$\varphi(C_{k,t}) = C_{k,t}(1+\tau_{d,t})^{\kappa}, \tag{7}$$

where $\kappa \in [0,1]$ is a parameter that governs how much a change in the tax rate affects the relevant tax rate for capitalists. κ is a reduced-form parameter capturing the existence of other assets such that a change in the dividend tax rate does not fully affect the relevant effective interest rate because capitalists can switch to other assets.[31]

Dynamically, capitalists maximize the discounted utility flow from consumption subject to a sequence of constraints:

$$\max \mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \frac{C_{k,t+j}^{1-1/\psi} - 1}{1 - 1/\psi} \quad \text{s.t.} \quad S_{k,t+1} P_t \leq (1 - \tau_{k,t}) N_k + S_{k,t}(D_t + P_t) - \varphi(C_{k,t}) + T_{k,t}, \tag{8}$$

where $\beta \in (0, 1)$ is the subjective discount factor, N_k is labor supply, $S_{k,t}$ are claims on firms, P_t is the market value of those claims, D_t are dividends paid by firms to capitalists, $\tau_{k,t}$ is the proportional labor income tax, and $T_{k,t}$ is a lump-sum tax or subsidy.

Utility maximization subject to the sequence of period budget constraints implies the standard Euler equation for firm shares:

$$1 = \mathbb{E}_t \left[\beta \left(\frac{C_{k,t+1}}{C_{k,t}} \right)^{-1/\psi} \left(\frac{1 + \tau_{d,t}}{1 + \tau_{d,t+1}} \right)^{\kappa} \frac{D_{t+1} + P_{t+1}}{P_t} \right], \tag{9}$$

where the crucial parameter of interest is ψ, the EIS.[32][33]

Tax avoidance opportunities. Following the literature on income taxation, we assume that capitalists have access to tax avoidance opportunities (Piketty and Saez, 2013; Piketty et al., 2014). These opportunities are available upon arrival of the news but disappear every period with an exogenous (i.i.d.) probability $1 - \theta$. As a result, following a tax news shock, a share θ of capitalists (temporarily) avoids the new dividend tax. Over time, the economy converges to the steady state under the new tax regime where all capitalists face the new tax.[34] This assumption serves two purposes. First, it describes a relevant feature of the 2006 dividend tax reform in which owners could postpone the incidence of the dividend tax increase by extracting dividends tax-free before the reform was implemented. Second,

[31]In Appendix A.4, we show that in a model where capitalists have access to other assets with returns strictly below the return on capital in the firm, the effective interest rate given the tax news has a lower bound equal to the return on these alternative assets.

[32]The absence of arbitrage implies the existence of a unique stochastic discount factor $\Lambda_{t,t+1}$ that prices the assets in the economy. $\Lambda_{t,t+1}$ is defined in terms of consumption of the capitalists because they own all firms and are the marginal investor: $\Lambda_{t,t+1} \equiv \beta \left(\frac{C_{k,t+1}}{C_{k,t}} \right)^{-1/\psi}$. Together with the usual transversality condition, by forward substitution the pricing equation for shares can be obtained as: $P_t = \mathbb{E}_t \sum_{j=t+1}^{\infty} \Lambda_{t,j} D_j$.

[33]Because we assume that there is no risk in the model, our results would not change with recursive utility (Kreps and Porteus, 1978; Epstein and Zin, 1989, 1991; Weil, 1990).

[34]Our modeling choice builds on the literature on deviations from full information and rational expectations (FIRE) by assuming an i.i.d. disappearance of tax avoidance opportunities (Mankiw and Reis, 2002; Reis, 2006a,b; Auclert et al., 2020; Carroll et al., 2020).

it smooths the model-implied spending response to the tax news shock, in line with the data.

Workers. Workers save in risk-free one-period bonds B_t (in zero net supply) that pay an exogenous gross return R^B each period, pinned down by the rate of time preferences. The maximization problem is:

$$\max \mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \frac{C_{w,t+j}^{1-1/\psi} - 1}{1 - 1/\psi} \quad \text{s.t.} \quad C_{w,t} + \frac{B_{t+1}}{R^B} = N_w + B_t, \tag{10}$$

where the solution has to satisfy the Euler equation:

$$1 = R^B \mathbb{E}_t \left[\beta \left(\frac{C_{w,t+1}}{C_{w,t}} \right)^{-1/\psi} \right]. \tag{11}$$

Firms. There is a continuum of perfectly competitive firms of mass one that produce the final good. The production technology is:

$$F(K_t, N_t) = K_t^{\alpha} N^{1-\alpha}, \tag{12}$$

where K_t is capital and N is labor supply (and assumed to be constant). Capital evolves according to $K_{t+1} = I_t + (1-\delta)K_t$ where I_t is investment and δ is the depreciation rate such that K_t is pre-determined at time $t-1$. Firms take the production function and the law of motion of capital as given and decide the dividend payout D_t and investment I_t.

The optimization problem of firms can be written recursively as

$$V(K_t) = \max_{\{D_t, K_{t+1}\}} \left[D_t + \mathbb{E}_t \Lambda_{t,t+1} V(K_{t+1}) \right] \text{ s.t. } D_t + K_{t+1} \leq (1-\delta)K_t + F(K_t, N) - N, \tag{13}$$

where $V(K_t)$ is the market value of the firm and $\Lambda_{t,t+1}$ is the stochastic discount factor of the capitalists. The first-order condition with respect to K_{t+1} is

$$\mathbb{E}_t \Lambda_{t,t+1} \underbrace{\left(\frac{1 + \tau_{d,t}}{1 + \tau_{d,t+1}} \right)^{\kappa} \left[F_k(K_{t+1}, N) + (1-\delta) \right]}_{\text{Net Return on Investment } R_t} = 1. \tag{14}$$

Government. We assume that the government collects tax income and rebates it back through lump-sum transfers:

$$T_{k,t} = \tau_{d,t} D_t + \tau_{k,t} N_k. \tag{15}$$

Aggregation and market clearing. Since only capitalists own firms, the holdings of each asset holder are pinned down solely by the share of capitalists in the economy: $S_t = S_{t+1} = \frac{1}{1-\lambda}$. Labor market clearing in our environment is trivial and equates the weighted average of endowments to the production function input N: $N = \lambda N_w + (1-\lambda) N_k$. Similarly, aggregate consumption is determined by: $C_t = \lambda C_{w,t} + (1-\lambda) C_{k,t}$. The resource constraint is $Y_t = C_t + I_t$, which is also the goods market clearing condition.

Tax processes. The government has at its disposal two policy instruments: the tax on dividends τ_d and the tax on capitalists' labor endowment τ_k. These instruments are assumed to follow the following exogenous stochastic processes:

$$\begin{aligned} \log \tau_{d,t} &= \log \tau_{d,t-1} + \sigma_d \varepsilon_{d,t-j}, \\ \log \tau_{k,t} &= \log \tau_{k,t-1} + \sigma_k \varepsilon_{k,t-j} \end{aligned} \tag{16}$$

where $\varepsilon_{d,t-j}$ and $\varepsilon_{k,t-j}$ are drawn from $\mathcal{N}(0,1)$.[35] The stochastic processes capture the news component of the dividend tax reform. It was announced j periods before the tax was implemented, which we set equal to two periods to mimic the 2006 dividend tax reform.

Definition 1. *A rational expectations general equilibrium, given tax policy innovation shocks* $\{\varepsilon_{d,t}, \varepsilon_{k,t}\}$ *and the tax policy processes, is defined as a set of policies for (i) capitalists:* C_k *and* S_k*; (ii) policies for workers:* C_w *and* B_w*; (iii) policies for firms:* K *and* D*; (iv) firm market value* $V(K)$*; (v) and aggregate prices* Λ *and* R^b*, such that: all policies solve the respective agents' optimization problems,* $\Lambda_{t,t+1} = \beta \frac{U'(c_{k,t+1})}{U'(c_{k,t})}$*, and all markets clear at any given time t.*

7.2 Estimation

We estimate the model using the method of simulated moments. First, we externally calibrate a set of parameters. Next, we simulate a dividend tax increase from 0% to 28%, announced two years in advance. Because the capitalists in our model represent the treated owners while the workers represent the control group, the differential consumption response of capitalists and workers in response to the announced reform maps directly

[35] The shock processes are assumed to be unit root. In practice, we compute impulse responses to very persistent shocks, with autocorrelation of all shock processes set to 0.9999.

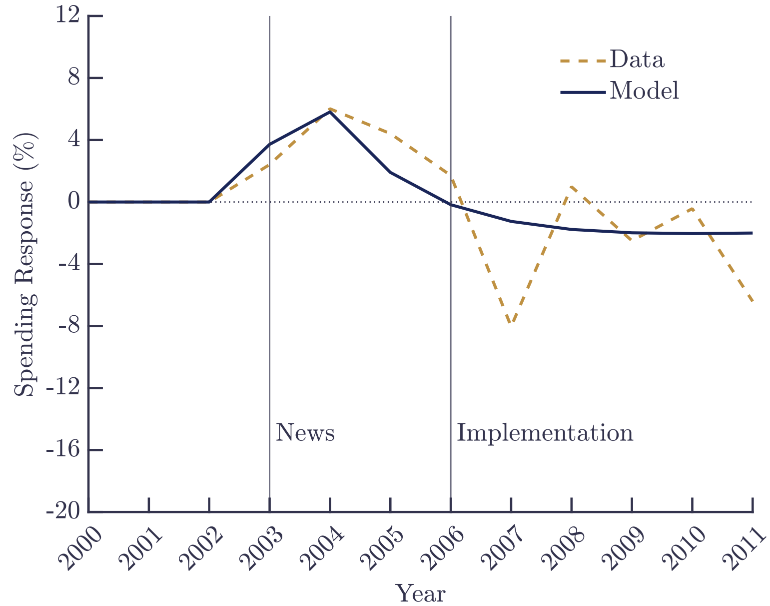
Parameter	Value	Description
λ	0.990	Share of workers
β	0.980	Discount factor
δ	0.075	Depreciation rate
α	0.330	Capital share
N	0.300	Labor endowment
σ_d	0.280	St. dev., capitalist dividend tax news
σ_l	0.104	St. dev., capitalist labor tax news

Table 2: Externally set model parameters.

to our empirical difference-in-differences estimates. We estimate the model's remaining parameters, including the EIS, by minimizing the distance between the experiment in the model and the empirical difference-in-difference results.[36]

External parameters. Table 2 lists the externally calibrated parameters. The frequency of our calibration is annual. The subjective discount factor and depreciation rates are set to $\beta = 0.98$ and $\delta = 0.075$, respectively. The fraction of capitalists $1 - \lambda$ is set to 0.01, which corresponds to the share of business owners in the data. The capital share α is set to 0.33 and labor endowments $N = N_k = N_w$ are set to a standard value of 0.3. We calibrate the standard deviations of the dividend and labor tax shocks to represent the institutional details of the Norwegian tax reform with $\sigma_d = 0.28$ and $\sigma_l = 0.104$. These two shocks map to the Norwegian 2003-2006 experience of a simultaneous increase in the dividend tax rate and reduction of the marginal labor income tax rate for the highest income bracket.

Estimation results. Figure 9 shows the model-generated consumption response of capitalists relative to workers. The implied EIS (ψ) is 1.59, a value significantly greater than unity. The model-implied spending response closely follows the data: the spending differential increases after the announcement and then gradually declines after implementation. The corresponding values of $\bar{\kappa}$ and $\bar{\theta}$ are 0.02 and 0.56, respectively. This suggests that through the lens of the structural model, there exist alternative financial assets that capitalists can save in (a low κ) and engage in relatively high transitory tax avoidance (a high θ). The latter points to high levels of private-business intertemporal tax shifting.



Notes: This figure shows the differential response of spending in the model (straight line) and the data (dashed line) in response to the tax reform. Differential spending in the model is defined as consumption by capitalists less consumption by workers. Differential spending in data is defined accordingly in Section 5.

Figure 9: Matched model responses to the dividend tax news shock.

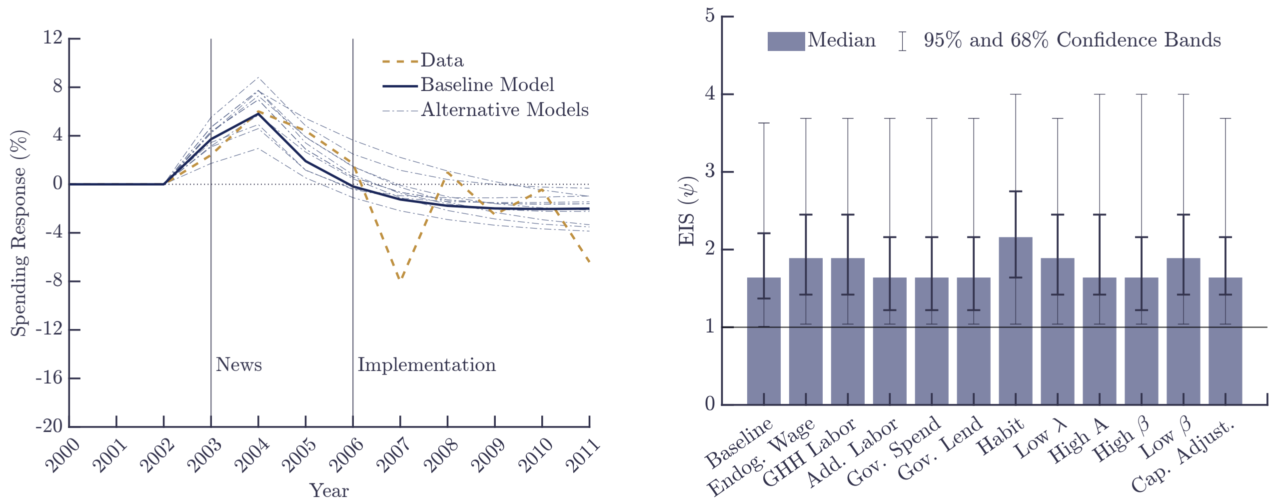
7.3 Robustness

To explicitly account for coefficient uncertainty in the estimated spending response, we conduct a bootstrapping exercise in which we compute the EIS using 10,000 independent draws from the empirically estimated spending response coefficients. Results are summarized in Panel (b) of Figure 10. For the baseline model, the median EIS is 1.64 and the 95% confidence interval is [1.01, 3.63]. Thus, the estimated EIS is robustly above unity.

To account for possible model mis-specification, we consider several extensions of the baseline framework and run additional sensitivity checks. We repeat the same bootstrapping procedure for every extension. First, we allow the wage rate, W_t, to be determined competitively, rather than being set exogenously at unity, as in the baseline. Second, labor supply is endogenized in two alternative ways: by assuming that utility is additively separable in consumption and labor, and by assuming non-separability between consumption and leisure in the spirit of Greenwood et al. (1988).[37] Third, we consider two alternative

[36] Appendix C.1 provides details on our numerical procedure.

[37] An important literature has related the EIS to intertemporal labor supply elasticities in various dynamic settings (Chetty, 2006). To first order, in a simple model with separable utility, one can show that the labor elasticity can be derived by assigning values to the marginal propensity to earn out of non-labor income, the EIS, and the consumption-to-labor-income ratio. In the case of capitalists, if the former is around -0.2 and the latter is roughly 1, then an EIS of 1.6 implies a labor elasticity of 0.4. This value aligns with the microeconomic estimates, which range from 0.26 to 0.54 (Chetty et al., 2011).



(a) Consumption response in alternative models.

(b) EIS estimates in alternative models.

Notes: Panel (a) plots relative spending responses to the Norwegian tax reform in the baseline and the alternative models, as described in the text. Panel (b) reports median EIS values as well as 68% and 95% bootstrapped confidence intervals implied by each alternative model. Model versions, from left to right, correspond to: the baseline, endogenous wages, endogenous GHH labor supply, endogenous additively separable labor supply, fiscal rule with government spending instead of lump-sum taxes, fiscal rule with government bond lending instead of lump-sum taxes, habit formation instead of heterogeneous tax incidence, high share of capitalists, high aggregate productivity, high discount factor, low discount factor, and capital adjustment costs.

Figure 10: Model robustness.

fiscal rules for the re-distribution of surpluses along the transition path following dividend tax news shocks: government spending and lending abroad via one-period bonds. Fourth, as an alternative way of generating smooth transition dynamics following the tax news shock, we introduce internal habit formation into the consumption problem of the capitalists in the spirit of Christiano et al. (2005). Fifth, we consider an alternative parameterization of the share of workers, λ. Sixth, aggregate productivity, which is normalized to unity in the baseline, is set to a higher value. Seventh, to allow for the possibility that capitalists are either more patient *or* less patient than workers in our model, we set the β of capitalists first to a larger and then to a smaller number, while keeping the β of workers unchanged. Finally, we extend the baseline model by incorporating capital adjustment costs, as described in Hayashi (1982), and allow the price of capital, Q_t, to deviate from unity.[38]

Figure 10 reports all the results in two stages. First, in Panel (a) we plot relative spending responses implied by all the alternative models that we have described above. Every pattern is qualitatively indistinguishable from the baseline case and tracks the data well. Second, in Panel (b) we report the median values of ψ implied by each model with

[38]Appendix C.2 provides further details and derivations for every model robustness test.

the 68% and 95% bootstrapped confidence bands. The EIS is consistently above unity in all of our robustness exercises.

Additional results. We present and discuss several supplementary results in the Appendix. First, Appendix C.3 provides a decomposition of the total response to a dividend tax news shock into partial and general equilibrium effects. Second, Appendix C.4 presents all model impulse responses, including those of aggregate variables. Third, in Appendix C.4, we consider three alternative parameterization approaches: we set the EIS to a counterfactually low value of 0.1 to illustrate how the model-implied consumption response looks in this case, set $\theta = 0$ to highlight the importance of tax avoidance opportunities for generating the empirically-consistent shape of the spending response, and set $\kappa = 1$ to emphasize that low reform pass-through is very important for matching impulse responses quantitatively. Fourth and finally, Appendix C.4 presents impulse responses for a surprise tax shock, as opposed to a tax news shock. In all of these sensitivity checks, our main results do not change and key assumptions are validated.

8 Conclusion

This paper has proposed a novel approach for the estimation of the elasticity of intertemporal substitution. We estimate spending responses to *news* about a future dividend tax reform using detailed administrative data and a unique quasi-natural experiment – the Norwegian dividend tax reform of 2006. We find that the exposed households increased spending in the period between the announcement and implementation of the reform. This behavior is only consistent with an EIS above one. Using a structural model, we estimate the EIS to be around 1.6.

Our approach identifies the EIS for a specific subgroup of the population – firm owners. These are households in the top 5% of the wealth distribution. To the extent that the EIS increases with wealth (Browning and Crossley, 2000; Guvenen, 2006; Havránek et al., 2015; Calvet et al., 2021), our estimate is, therefore, more generally relevant for wealthy households. Wealthy households can be disproportionately important in a wide variety of settings, such as capital formation, asset pricing, aggregate spending, and innovation (Akcigit et al., 2016). Our paper, therefore, sheds light on the consumption-saving behavior of an economically-important group of households.

Beyond evidence on the EIS, our estimated spending responses are of independent interest in macroeconomics, as they reflect the approximate effects of a one-time drop in a specific future interest rate. As recently shown by Auclert et al. (2021, 2024), these spending responses are crucial for calibrating and disciplining dynamic macroeconomic models.

References

Akcigit, Ufuk, Salomé Baslandze, and Stefanie Stantcheva, "Taxation and the International Mobility of Inventors," *American Economic Review*, October 2016, *106* (10), 2930–81.

Alstadsæter, Annette, Martin Jacob, and Roni Michaely, "Do Dividend Taxes Affect Corporate Investment?," *Journal of Public Economics*, 2017, *151*, 74–83.

_ , Niels Johannesen, and Gabriel Zucman, "Tax Evasion and Inequality," *American Economic Review*, 2019, *109* (6), 2073–2103.

_ , Wojciech Kopczuk, and Kjetil Telle, "Are Closely Held Firms Tax Shelters?," *Tax Policy and the Economy*, 2014, *28* (1), 1–32.

Attanasio, Orazio P and Guglielmo Weber, "Consumption Growth, the Interest Rate and Aggregation," *Review of Economic Studies*, 1993, *60* (3), 631–649.

_ and _ , "Consumption and Saving: Models of Intertemporal Allocation and Their Implications for Public Policy," *Journal of Economic literature*, 2010, *48* (3), 693–751.

_ and Martin Browning, "Consumption over the Life Cycle and over the Business Cycle," *American Economic Review*, 1995, *85* (5), 1118–1137.

Auclert, Adrien, Bence Bardóczy, Matthew Rognlie, and Ludwig Straub, "Using the Sequence-space Jacobian to Solve and Estimate Heterogeneous-agent Models," *Econometrica*, 2021, *89* (5), 2375–2408.

_ , Matthew Rognlie, and Ludwig Straub, "Micro Jumps, Macro Humps: Monetary Policy and Business Cycles in an Estimated Hank Model," *NBER Working Paper 26647*, 2020.

_ , _ , and _ , "The Intertemporal Keynesian Cross," *Journal of Political Economy*, 2024, *132* (12).

Auerbach, Alan J, "Wealth Maximization and the Cost of Capital," *Quarterly Journal of Economics*, 1979, *93* (3), 433–446.

_ and Kevin A Hassett, "The 2003 Dividend Tax Cuts and the Value of the Firm: an Event Study," in Alan J. Auerbach, James R. Hines, Jr., and Joel Slemrod, eds., *Taxing Corporate Income in the 21st Century*, Cambridge University Press, 2007, p. 93–126.

Baker, Scott R, Lorenz Kueng, Steffen Meyer, and Michaela Pagel, "Consumption Imputation Errors in Administrative Data," *The Review of Financial Studies*, 2021, *35* (6), 3021–3059.

Bansal, Ravi, Dana Kiku, and Amir Yaron, "Long Run Risks, the Macroeconomy, and Asset Prices," *American Economic Review*, 2010, *100* (2), 542–46.

— , — , and — , "An Empirical Evaluation of the Long-run Risks Model for Asset Prices," *Critical Finance Review*, 2011, *1* (1), 183–221.

Barro, Robert J., "Rare Disasters, Asset Prices, and Welfare Costs," *American Economic Review*, 2009, *99* (1), 243–64.

— and Jason Furman, "Macroeconomic Effects of the 2017 Tax Reform," *Brookings Papers on Economic Activity*, 2018, *2018* (1), 257–345.

Beaudry, Paul and Eric Van Wincoop, "The Intertemporal Elasticity of Substitution: an Exploration Using a Us Panel of State Data," *Economica*, 1996, *63* (251), 495–512.

— and Franck Portier, "An Exploration into Pigou's Theory of Cycles," *Journal of Monetary Economics*, 2004, *51* (6), 1183–1216.

— and — , "Stock Prices, News, and Economic Fluctuations," *American Economic Review*, 2006, *96* (4), 1293–1307.

Best, Michael Carlos, James S Cloyne, Ethan Ilzetzki, and Henrik J Kleven, "Estimating the Elasticity of Intertemporal Substitution Using Mortgage Notches," *Review of Economic Studies*, 2020, *87* (2), 656–690.

Blundell, Richard, Martin Browning, and Costas Meghir, "Consumer Demand and the Life-cycle Allocation of Household Expenditures," *Review of Economic Studies*, 1994, *61* (1), 57–80.

Bradford, David F, "The Incidence and Allocation Effects of a Tax on Corporate Distributions," *Journal of Public Economics*, 1981, *15* (1), 1–22.

Browning, Martin and Thomas F Crossley, "Luxuries Are Easier to Postpone: a Proof," *Journal of Political Economy*, 2000, *108* (5), 1022–1026.

Callaway, Brantly, Andrew Goodman-Bacon, and Pedro H. C. Sant'Anna, "Difference-in-differences with a Continuous Treatment," *Working Paper*, 2024.

Calvet, Laurent E, John Y Campbell, Francisco Gomes, and Paolo Sodini, "The Cross-section of Household Preferences," *Working Paper*, 2021.

Campbell, John Y, "Consumption-based Asset Pricing," *Handbook of the Economics of Finance*, 2003, *1*, 803–887.

— and Gregory Mankiw, "Consumption, Income, and Interest Rates: Reinterpreting the Time Series Evidence," *NBER Macroeconomics Annual*, 1989, *4*, 185–216.

Carroll, Christopher, Edmund Crawley, Jiri Sracalek, Kiichi Tokuoka, and Matthew White, "Sticky Expectations and Consumption Dynamics," *Americal Economic Journal: Macroeconomics*, 2020, *12* (3), 40–76.

Cashin, David and Takashi Unayama, "Measuring Intertemporal Substitution in Consumption: Evidence from a VAT Increase in Japan," *Review of Economics and Statistics*, 2016, *98* (2), 285–297.

Chamley, Christophe, "Optimal Taxation of Capital Income in General Equilibrium with Infinite Lives," *Econometrica*, 1986, *54* (3), 607–622.

Chetty, Raj, "A New Method of Estimating Risk Aversion," *American Economic Review*, December 2006, *96* (5), 1821–1834.

_ , Adam Guren, Day Manoli, and Andrea Weber, "Are Micro and Macro Labor Supply Elasticities Consistent? A Review of Evidence on the Intensive and Extensive Margins," *American Economic Review*, May 2011, *101* (3), 471–75.

_ and Emmanuel Saez, "Dividend Taxes and Corporate Behavior: Evidence From the 2003 Dividend Tax Cut," *Quarterly Journal of Economics*, 2005, *120* (3), 791–833.

_ and _ , "Dividend and Corporate Taxation in an Agency Model of the Firm," *American Economic Journal: Economic Policy*, 2010, *2* (3), 1–31.

Chodorow-Reich, Gabriel, Matthew Smith, Owen M Zidar, and Eric Zwick, "Tax Policy and Investment in a Global Economy," *NBER Wokring Paper 32180*, 2024.

Christiano, Lawrence J., Martin Eichenbaum, and Charles L. Evans, "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy," *Journal of Political Economy*, 2005, *113* (1), 1–45.

Crump, Richard K, Stefano Eusepi, Andrea Tambalotti, and Giorgio Topa, "Subjective Intertemporal Substitution," *Journal of Monetary Economics*, 2022, *126*, 118–133.

Cummins, Jason G, Kevin A Hassett, R Glenn Hubbard, Robert E Hall, and Ricardo J Caballero, "A Reconsideration of Investment Behavior Using Tax Reforms as Natural Experiments," *Brookings Papers on Economic Activity*, 1994, *1994* (2), 1–74.

Eeckhoudt, Louis and Harris Schlesinger, "Putting Risk in Its Proper Place," *American Economic Review*, 2006, *96* (1), 280–289.

Eika, Lasse, Magne Mogstad, and Ola L. Vestad, "What Can We Learn about Household Consumption Expenditure From Data on Income and Assets?," *Journal of Public Economics*, 2020, *189*, 104163.

Epstein, L. and S. E. Zin, "Substitution, Risk Aversion, and the Temporal Behavior of Consumption and Asset Returns: a Theoretical Framework," *Econometrica*, 1989, *57* (4), 937–969.

_ and _ , "Substitution, Risk Aversion, and the Temporal Behavior of Consumption and Asset Returns: an Empirical Analysis," *Journal of Political Economy*, 1991, *99* (2), 263–286.

Fagereng, Andreas and Elin Halvorsen, "Imputing Consumption From Norwegian Income and Wealth Registry Data," *Journal of Economic and Social Measurement*, 2017, *42* (1), 67–100.

_ , Charles Gottlieb, and Luigi Guiso, "Asset Market Participation and Portfolio Choice over the Life-cycle," *Journal of Finance*, 2017, *72* (2), 705–750.

__ , **Luigi Guiso, Davide Malacrino, and Luigi Pistaferri**, "Heterogeneity and Persistence in Returns to Wealth," *Econometrica*, 2020, *88* (1), 115–170.

__ , **Martin B Holm, and Gisle J Natvik**, "MPC Heterogeneity and Household Balance Sheets," *American Economic Journal: Macroeconomics*, 2021, *13* (4), 1–54.

Farhi, Emmanuel, Alan Olivi, and Iván Werning, "Price Theory for Incomplete Markets," *Working Paper*, 2022.

Feldstein, Martin S, "Corporate Taxation and Dividend Behaviour," *Review of Economic Studies*, 1970, *37* (1), 57–72.

Flynn, Joel P, Lawrence DW Schmidt, and Alexis Akira Toda, "Robust Comparative Statics for the Elasticity of Intertemporal Substitution," *Theoretical Economics*, 2023, *18* (1), 231–265.

Gabaix, Xavier, "Variable Rare Disasters: an Exactly Solved Framework for Ten Puzzles in Macro-finance," *Quarterly Journal of Economics*, 2012, *127*, 645–700.

__ **and Ralph SJ Koijen**, "In Search of the Origins of Financial Fluctuations: the Inelastic Markets Hypothesis," *NBER Working Paper 02138*, 2021.

Greenwood, Jeremy, Zvi Hercowitz, and Gregory W Huffman, "Investment, Capacity Utilization, and the Real Business Cycle," *American Economic Review*, 1988, *78* (3), 402–417.

Gruber, Jonathan, "A Tax-based Estimate of the Elasticity of Intertemporal Substitution.," *Quarterly Journal of Finance*, 2013, *3* (1), 1 – 20.

Guvenen, Fatih, "Reconciling Conflicting Evidence on the Elasticity of Intertemporal Substitution: a Macroeconomic Perspective," *Journal of Monetary Economics*, 2006, *53* (7), 1451–1472.

Hall, Robert E, "Intertemporal Substitution in Consumption," *Journal of Political Economy*, 1988, *96* (2), 339–357.

__ **and Dale W Jorgenson**, "Tax Policy and Investment Behavior," *American Economic Review*, 1967, *57* (3), 391–414.

Hansen, Lars Peter and Kenneth J Singleton, "Stochastic Consumption, Risk Aversion, and the Temporal Behavior of Asset Returns," *Journal of political economy*, 1983, *91* (2), 249–265.

__ , **John Heaton, Junghoon Lee, and Nikolai Roussanov**, "Intertemporal Substitution and Risk Aversion," *Handbook of econometrics*, 2007, *6*, 3967–4056.

Harberger, Arnold C, "The Incidence of the Corporation Income Tax," *Journal of Political Economy*, 1962, *70* (3), 215–240.

Havránek, Tomáš, "Measuring Intertemporal Substitution: The Importance of Method Choices and Selective Reporting," *Journal of the European Economic Association*, 12 2015, *13* (6), 1180–1204.

_ **, Roman Horvath, Zuzana Irsova, and Marek Rusnak**, "Cross-country Heterogeneity in Intertemporal Substitution," *Journal of International Economics*, 2015, *96* (1), 100–118.

Hayashi, Fumio, "Tobin's Marginal Q and Average Q: a Neoclassical Interpretation," *Econometrica*, 1982, *50* (1), 213–224.

Holm, Martin B, "Monetary Transmission with Income Risk," *The Scandinavian Journal of Economics*, 2023, *125* (2), 441–460.

_ **, Pascal Paul, and Andreas Tischbirek**, "The Transmission of Monetary Policy under the Microscope," *Journal of Political Economy*, 2021, *129* (10), 2861–2904.

House, Christopher L and Matthew D Shapiro, "Temporary Investment Tax Incentives: Theory with Evidence From Bonus Depreciation," *American Economic Review*, 2008, *98* (3), 737–68.

Innstilling til Odelstinget nr. 23(2000-2001), *Innstilling O. Nr. 23 (2000-2001)* 2000.

Jakobsen, Katrine, Kristian Jakobsen, Henrik Kleven, and Gabriel Zucman, "Wealth Taxation and Wealth Accumulation: Theory and Evidence From Denmark," *Quarterly Journal of Economics*, 2020, *135* (1), 329–388.

Judd, Kenneth L, "Redistributive Taxation in a Simple Perfect Foresight Model," *Journal of public Economics*, 1985, *28* (1), 59–83.

Kaplan, Greg and Giovanni L Violante, "A Model of the Consumption Response to Fiscal Stimulus Payments," *Econometrica*, 2014, *82* (4), 1199–1239.

Kreps, David M and Evan L Porteus, "Temporal Resolution of Uncertainty and Dynamic Choice Theory," *Econometrica*, 1978, *46* (1), 185–200.

Ku, Hyejin, Uta Schönberg, and Ragnhild C. Schreiner, "Do Place-based Tax Incentives Create Jobs?," *Journal of Public Economics*, 2020, *191*, 104105.

Leite, David, "The Firm as Tax Shelter: Using Business Resources for Final Consumption," *Working Paper*, 2024.

Leth-Petersen, Søren, "Intertemporal Consumption and Credit Constraints: Does Total Expenditure Respond to an Exogenous Shock to Credit?," *American Economic Review*, 2010, *100* (3), 1080–1103.

Mankiw, Gregory and Ricardo Reis, "Sticky Information Versus Sticky Prices: a Proposal to Replace the New Keynesian Phillips Curve," *Quarterly Journal of Economics*, 2002, *117* (4), 1295–1328.

_ **and Stephen P Zeldes**, "The Consumption of Stockholders and Nonstockholders," *Journal of Financial Economics*, 1991, *29* (1), 97–112.

McGrattan, Ellen R, "Capital Taxation during the Us Great Depression," *Quarterly Journal of Economics*, 2012, *127* (3), 1515–1550.

Msall, Lucy and Ole-Andreas Næss, "Never-Realized Capital Gains," Technical Report, Tech. rep., University of Chicago 2025.

NOU 2003:9, *Nou 2003:9 Skatteutvalget - Forslag Til Endringer I Skattesystemet* 2003.

Piketty, T. and E. Saez, "Optimal Labor Income Taxation," *Handbook of Public Economics*, 2013, *5.*

Piketty, Thomas, Emmanuel Saez, and Stefanie Stantcheva, "Optimal Taxation of Top Labor Incomes: A Tale of Three Elasticities," *American Economic Journal: Economic Policy*, February 2014, *6* (1), 230–71.

Poterba, James M and Lawrence H Summers, "Dividend Taxes, Corporate Investment, and 'q'," *Journal of Public Economics*, 1983, *22* (2), 135–167.

Reis, Ricardo, "Inattentive Consumers," *Journal of monetary Economics*, 2006, *53* (8), 1761–1800.

_ , "Inattentive Producers," *Review of Economic Studies*, 2006, *73* (3), 793–821.

Ring, Marius A K, "Wealth Taxation and Household Saving: Evidence from Assessment Discontinuities in Norway," *The Review of Economic Studies*, 2024.

Saez, Emmanuel and Stefanie Stantcheva, "A simpler theory of optimal capital taxation," *Journal of Public Economics*, 2018, *162*, 120–142. In Honor of Sir Tony Atkinson (1944-2017).

Schmidt, Lawrence and Alexis Akira Toda, "Do You Save More or Less in Response to Bad News? a New Identification of the Elasticity of Intertemporal Substitution," *MPRA Paper No. 78983,*, 2015.

Stantcheva, Stefanie, "Optimal Taxation and Human Capital Policies over the Life Cycle," *Journal of Political Economy*, 2017, *125* (6), 1931–1990.

Statistics Norway, "National Population Register ("Folkeregisteret")," Technical Report, Statistics Norway 1964-2019.

_ , "Ambita Transaction Registry ("Eiendomsregisteret")," Technical Report, Statistics Norway 1993-2019.

_ , "Registry of Tax Returns ("Data om inntekt, skatt, avgift og eiendom")," Technical Report, Statistics Norway 1993-2019.

_ , "The State Register of Employers and Employees ("Aa-registeret")," Technical Report, Statistics Norway 2000-2014.

_ , "Register of Company Accounts ("Brønnøysundregisteret")," Technical Report, Statistics Norway 2000-2019.

_ , "The Shareholder Register ("Aksjonærregisteret")," Technical Report, Statistics Norway 2004-2019.

Stortingsmelding nr. 29(2003-2004), *Stortingsmelding Nr. 29 (2003-2004) Om Skattereform* 2004.

Straub, Ludwig, "Consumption, Savings, and the Distribution of Permanent Income," *Working Paper*, 2019.

_ **and Iván Werning**, "Positive Long-run Capital Taxation: Chamley-judd Revisited," *American Economic Review*, 2020, *110* (1), 86–119.

Thoresen, Thor Olav, Erlend Eide Bø, Erik Fjærli, and Elin Halvorsen, "Skattereformen 2006–har Skattesystemet Blitt Mer Omfordelende?," *Statistisk sentralbyrå*, 2010.

Vissing-Jørgensen, Annette, "Limited Asset Market Participation and the Elasticity of Intertemporal Substitution," *Journal of Political Economy*, 2002, *110* (4), 825–853.

_ **and Orazio P Attanasio**, "Stock-Market Participation, Intertemporal Substitution, and Risk-Aversion," *American Economic Review*, 2003, *93* (2), 383–391.

Weil, Philippe, "Nonexpected Utility in Macroeconomics," *Quarterly Journal of Economics*, 1990, *105* (1), 29–42.

Yagan, Danny, "Capital Tax Reform and the Real Economy: the Effects of the 2003 Dividend Tax Cut," *American Economic Review*, 2015, *105* (12), 3531–63.

Yogo, Motohiro, "Estimating the Elasticity of Intertemporal Substitution When Instruments Are Weak," *Review of Economics and Statistics*, 2004, *86* (3), 797–810.

Zwick, Eric and James Mahon, "Tax Policy and Heterogeneous Investment Behavior," *American Economic Review*, 2017, *107* (1), 217–48.

Online Appendix for "Estimating the Elasticity of Intertemporal Substitution using Dividend Tax News"

Martin B. Holm   Rustam Jamilov   Marek Jasinski   Plamen Nenov

August 2025

Contents

A Theoretical appendix

A.1 Comparative statics with non-homothetic preferences

We illustrate the robustness of the sign comparative statics for the value of the elasticity of intertemporal substitution relative to unity derived in Flynn et al. (2023) for a simple two-period setting with non-homothetic preferences as in Straub (2019).

Suppose that the agent's period t utility function is given by $u_t(c_t) = \frac{c_t^{1-\sigma_t}}{1-\sigma_t}$ ($\ln(c_t)$ if $\sigma_t = 1$). The agent allocates initial wealth a over period $t = 0$ consumption and period $t = 1$ savings a_1. The period $t = 1$ gross return is R, so that period $t = 1$ consumption is $C_1 = RA_1$.

We follow Flynn et al. (2023) and define the aggregator function between period $t = 0$ consumption c and the period $t = 1$ continuation value v as $f(c, v) = u_0(c) + u_1(v)$. Notice that f and $v = c_1$ define a strongly regular environment according to definition 1 in Flynn et al. (2023), as the aggregator f is strictly increasing and twice continuously differentiable with a non-negative cross-partial derivative, and the continuation value v is also strictly increasing and twice continuously differentiable by the properties of a CRRA utility function. Furthermore, the period $t = 1$ consumption c_0 is interior to the budget set given that the CRRA period utility satisfies Inada conditions. Consequently, Theorem 1 in Flynn et al. (2023) applies to our environment. Specifically, we have the following sign comparative static:

$$\text{sgn}\left(\frac{\partial c}{\partial \log R}\right) = \text{sgn}\left(1 - \varepsilon\psi\right),$$

where ψ is the elasticity of intertemporal substitution and ε is the Relative Elasticity of the Marginal Value of Wealth (REMV), an object that measures the impact of wealth effects on the response of consumption.

Following Flynn et al. (2023), we define the elasticity of intertemporal substitution (EIS) as

$$\psi = -\frac{\frac{\partial \log\left(\frac{c}{v}\right)}{\partial \log R}}{\frac{\partial \log\left(\frac{f_c}{f_v}\right)}{\partial \log R}}.$$

Similarly, noting that period $t = 1$ wealth and period $t = 1$ consumption coincide, we define the Relative Elasticity of the Marginal Value of Wealth (REMV) as

$$\varepsilon = \frac{\frac{\partial \log v_a}{\partial \log R}}{\frac{\partial \log v}{\partial \log R}}.$$

For the continuation value defined as $v = c_1$, the value of the REMV is

$$\varepsilon = \frac{\frac{\partial \log v_a}{\partial \log R}}{\frac{\partial \log v}{\partial \log R}} = 1,$$

and we have that

$$\text{sgn}\left(\frac{\partial c}{\partial \log R}\right) = \text{sgn}\left(1 - \psi\right).$$

Hence, the sign of the consumption response to the change in log returns is the same as the sign of the EIS relative to unity. Note, however, that in this case, the EIS is not a single parameter as would be the case with time-invariant preferences but instead depends on the values of both σ_0 and σ_1. Specifically, we can re-write the EIS as

$$\psi = -\frac{\partial \log c/\partial \log R - \partial \log v/\partial \log R}{-\sigma_0 \partial \log c/\partial \log R + \sigma_1 \partial \log v/\partial \log R} = \frac{1}{\sigma_0}\frac{\partial \log c/\partial \log R - \partial \log v/\partial \log R}{\partial \log c/\partial \log R - \frac{\sigma_1}{\sigma_0}\partial \log v/\partial \log R}.$$

Hence, with time-varying values of σ, the EIS is a function of the current level of consumption, the level of returns R, and the CRRA parameters for the period utility functions.

A.2 Model with risk

We now consider the model in Section 2 where capital earns a constant rate R_t and where we include labor income and returns risk. The problem is:

$$\max_{\{c_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-1/\psi}}{1-1/\psi}$$

subject to

$$\begin{aligned} \frac{b_{t+1}}{1+\tau_t} &= \frac{b_t R_t}{1+\tau_t} + y_t - c_t, \\ R_t &\text{ follows a Markov process,} \\ y_t &\text{ follows a Markov process,} \end{aligned}$$

where c_t is consumption, b_t is a real bond, R_t is the return on the bond, y_t is income, β is the discount factor, τ is the dividend tax, and $\psi > 0$ denotes the EIS. The solution to this problem has to satisfy the Euler equation

$$c_t^{-1/\psi} = \beta \left(\frac{1+\tau_t}{1+\tau_{t+1}} \right) \mathbb{E}_t \left\{ c_{t+1}^{-1/\psi} R_{t+1} \right\}. \tag{A.1}$$

Labor income. The first complication is that compared with the model in Section 2, this model has income from sources other than capital. When the model includes other income sources, it is not the EIS relative to unity that governs the sign of the consumption response between announcement and implementation. Instead, it is the EIS relative to a value lower than unity because the income effect is weaker in a model with labor income. Intuitively, the income effect is about changing the value of the present value budget constraint. In a model where the capitalist only has capital income, this can be computed as the change in the net present value of the consumption plan, similar to a wealth effect today. When there is also labor income, the income effect is about how the net present value of the plan of consumption net of labor income is affected.

Risk. The second complication is that the model now includes risk from two sources: labor and capital. The first observation is that the dividend tax term is multiplicative in the Euler equation. Hence, if we compute the first-order approximation around the expected level of labor income and return, the dividend tax affects the owner similarly to a situation with no risk.

Nevertheless, there will be higher-order effects of risk that affect how the owner responds to dividend tax changes. These higher-order effects are determined by how the response to the dividend tax affects the choice between consuming today and tomorrow. Consider an increase in the future dividend tax and assume the owner responds by increasing consumption in the period before the introduction of the dividend tax. This increase in consumption affects the strength of the precautionary saving motive. How much a change in consumption affects the strength of the precautionary saving motive is governed by the curvature of the precautionary saving motive, which is in turn driven by the fourth derivative of the utility function (temperance). This effect weakens with wealth under the reasonable assumption of power utility (or decreasing absolute prudence more generally). We would thus expect risk to play an insignificant role in our empirical setup.

A.3 Model with durable goods

Consider an infinitely-lived firm owner who only has access to saving in a real bond but who consumes both durable and non-durable goods:

$$\max_{\{c_{d,t},c_{n,t}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \frac{\left(c_{n,t}^{\alpha} c_{d,t}^{1-\alpha}\right)^{1-1/\psi}}{1-1/\psi}$$

subject to

$$\begin{aligned} b_{t+1} &= b_t(1+r) - (1+\tau_t)(c_{n,t} + p_{d,t} I_t), \\ c_{d,t+1} &= (1-\delta_d)c_{d,t} + I_t, \end{aligned}$$

where c_n is non-durable consumption, c_d is durable consumption, b_t is a real bond, β is the discount factor, δ_d is the depreciation rate on durable goods, p_d is the price of durable goods, r is the real interest rate, τ is the dividend tax, and $\psi > 0$ denotes the EIS.

Define wealth as the sum of bonds and durable goods: $a_t \equiv b_t + p_{d,t}(1+\tau_t)c_{d,t}$. The budget constraint is then

$$a_{t+1} = (1+r)a_t - (1+\tau_t)(c_{n,t} + \overbrace{p_{d,t}\left(r + \delta_d - \frac{p_{d,t+1}(1+\tau_{t+1}) - p_{d,t}(1+\tau_t)}{p_{d,t}(1+\tau_t)}\right)}^{\hat{p}_{d,t}} c_{d,t}$$

where the relevant price of durable goods is the user cost $\hat{p}_{d,t}$. Suppose the relative price of durables $\hat{p}_{d,t}$ is priced competitively such that it is always constant. In this case, the dividend tax only moves the price of aggregate consumption, not the relative price of non-durable and durable goods. The comparative static with durables is therefore the same as in the model with only non-durable consumption in Section 2.

A.4 Model with portfolio choice

This appendix presents a model of a firm owner who can save in capital and a riskless bond. The firm owner solves

$$\max \sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-1/\psi}}{1-1/\psi}$$

subject to

$$b_{t+1} = (1+r)b_t + y_t + d_t - c_t - e_{t+1}, \tag{A.2}$$

$$k_{t+1} = k_t^{\alpha} + (1-\delta)k_t - (1+\tau_t)d_t + e_{t+1}, \tag{A.3}$$

$$b_{t+1} \geq 0, \quad k_{t+1} \geq 0, \quad e_t \geq 0, \quad d_t \geq 0, \tag{A.4}$$

where b is a bond with constant real return r, k is capital in the firm, y is non-financial income, c is consumption, d is dividends from the firm, and e is resources allocated from the owner to the firm (an equity injection). We assume that $\beta(1+r) < 1$, such that the owner holds no bonds in the steady state.

The first-order conditions of this problem can be summarized by two Euler equations,

$$u'(c_t) \geq \beta(1+r)u'(c_{t+1}), \tag{A.5}$$

$$u'(c_t) = \beta X_{t,t+1} R_{t+1} u'(c_{t+1}), \tag{A.6}$$

where $R_{t+1} = \alpha k_{t+1}^{\alpha-1} + (1-\delta)$ is the return on physical capital and X_t is a tax wedge given by

$$X_{t,t+1} = \begin{cases} \frac{1+\tau_t}{1+\tau_{t+1}} & \text{if } d_t > 0 \text{ and } d_{t+1} > 0 \\ 1 & \text{if } d_t = 0 \text{ and } d_{t+1} = 0 \\ 1+\tau_t & \text{if } d_t > 0 \text{ and } d_{t+1} = 0 \\ \frac{1}{1+\tau_{t+1}} & \text{if } d_t = 0 \text{ and } d_{t+1} > 0 \end{cases}$$

and depends on whether the firm owner chooses to pay dividends or insert equity. This model nests the quantitative model in Section 7 (with $\kappa = 1$ and $\theta = 0$) in the paper if $b_{t+1} = 0$ and $d_t > 0 \; \forall \; t$.

Consider an initial situation in which the firm is of the optimal size, $k^* = \left(\frac{\alpha}{1/\beta-(1-\delta)}\right)^{\frac{1}{1-\alpha}}$, the dividend tax τ is zero, and the firm pays dividends. Suppose the firm owner learns there will be a permanent increase in τ from period $T+1$ onward.

Suppose first that the firm owner has no access to the bond. The owner will then respond as in the illustrative model in Section 2. If the EIS exceeds 1, the owner will increase consumption today and reduce capital. After implementation, the firm owner will gradually accumulate capital to its unchanged steady-state value while consumption is permanently reduced.

The response is different if the owner also has access to a bond. Since $\beta(1+r) < 1$, the owner will still respond by increasing consumption if the EIS > 1. But the response will be quantitatively smaller because the owner can temporarily save in the bond. Specifically, the bond Euler equation (A.5) will hold with equality at T. Therefore, unlike the model without access to saving in bonds, in this case, the effective interest rate that enters the owner's Euler equation is $1 + r \geq X_{T,T+1}R_{T+1}$. The solution is thus to take out capital from the firm in period T ($d_T > 0$) such that $R_{T+1} = (1+r)$, consume c_T and save the remainder in bonds $b_T > 0$. This is achieved by choosing capital $k_t = \left(\frac{\alpha}{\left(\frac{1+\tau_{t+1}}{1+\tau_t}\right)(1+r)-(1-\delta)} \right)^{\frac{1}{1-\alpha}}$. After the reform is implemented, the owner will sell all bonds ($b_{T+1} = 0$) and put these resources back into the firm ($d_{T+1} = 0$ and $e_{T+1} > 0$) . Since $1 + r < 1/\beta$, just like in the case in Section 2, with EIS>1, the owner spends more than income at T, so capital after the equity injection at $T + 1$ is below its steady-state level. Consequently, $R_t > 1/\beta$ for $t > T + 1$, and the owner will accumulate capital going forward ($d_t = 0$).

The key observation is that the presence of the bond implies a limit to how much the effective interest rate $\tilde{R}_{t+1}$ that the owner faces may fall. The interest rate on the bond is the floor for the effective interest rate because if the effective interest rate on capital falls below this level, the owner would prefer to move all capital into bonds. This observation allows us to reinterpret the parameter κ in our structural model in Section 7. Specifically, in that model, we have the dividend Euler equation

$$u'(c_t) = \beta \left(\frac{1+\tau_t}{1+\tau_{t+1}} \right)^{\kappa} R_{t+1} u'(c_{t+1}).$$

Therefore, a value of $\kappa < 1$ captures, in a reduced form way, the possibility to save in other assets, such as bonds or bank deposits, such that $\left(\frac{1+\tau_t}{1+\tau_{t+1}}\right)^{\kappa} R_{t+1}$ equals the gross return on those assets. The presence of other assets thus imposes a floor on the effective interest rate, parametrized by κ in the specific model in Section 7. Specifically, the estimated κ is, through this interpretation, only relevant for the specific empirical setting analyzed in this paper and does not represent a general pass-through parameter.

B Empirical appendix

B.1 Effective marginal tax rates

This appendix explains how we compute the effective marginal tax rates on labor and capital income in Figure 2 for 2000, based on The Ministry of Finance (2000, Table 2.1).

Capital income taxes. The only capital income tax that the owner faces is the flat corporate income tax of 28%.

Labor taxes. For wage income, the base of the system is a flat tax rate of 28% (same as capital income taxes) and a flat tax of 7.8% national insurance contribution (trygdeavgift). In addition, we include an employer's tax (arbeidsgiveravgift) of 14.1%. The "top tax" (toppskatt) then adds progressivity in the marginal tax rates, adding tax of 13.5% on each NOK above 329,000, which increases to 19.5% for each NOK above 762,700. We compute the marginal tax rates as

$$\text{marginal tax rate}_{\text{labor}} = \frac{0.28 + 0.078 + 0.141 + \text{top tax rate}}{1 + 0.141}. \tag{B.1}$$

Additionally, we include the benefit from public pension contributions. The public pension system in 2000 is based on a point system where an individual on the margin earns the following pension points:

$$\text{marginal pension point (MPP)} = \begin{cases} 1 & \text{if income } \in (\text{NOK}49,090,\ \text{NOK}294,540] \\ \frac{1}{3} & \text{if income } \in (\text{NOK}294,540,\ \text{NOK}589,080] \\ 0 & \text{if income } \geq\ \text{NOK}589,080 \end{cases}$$

The pension payment at retirement is defined as the average of the 20 years with the highest pension points accumulated for an individual. Next, the payout depends on how many years an individual has worked, up to 40 years. We assume the individual will work for 40 years and that this one year is one of that person's 20 best years. The marginal effect of a pension point on the annual payment from the social security pension system is then

$$\text{marginal annual pension payout per pension point}(MAPP) = \frac{0.45}{20} = 0.0225. \tag{B.2}$$

Four additional complications play a role. First, pension payments are received in the future, and we therefore need to compute the net present value of pension accumulations.

Second, the pension accumulation is in real units, adjusted annually almost one-for-one with the nominal wage growth. Third, pension payouts are received each year the individual survives and therefore depends on the health and mortality risk of the individual. Fourth, the Norwegian tax system includes a wealth tax but the social security pension wealth is not part of the wealth tax base. Hence, accumulating social security pensions represents an additional advantage for individuals who pay the wealth tax at the margin, compared with saving in private (and taxable) wealth. The net present value of annual pension payment for an individual with age a, retirement age R, expected lifetime T, who faces the real interest rate r, the expected real wage growth rate in the social security system g, and the wealth tax wt is

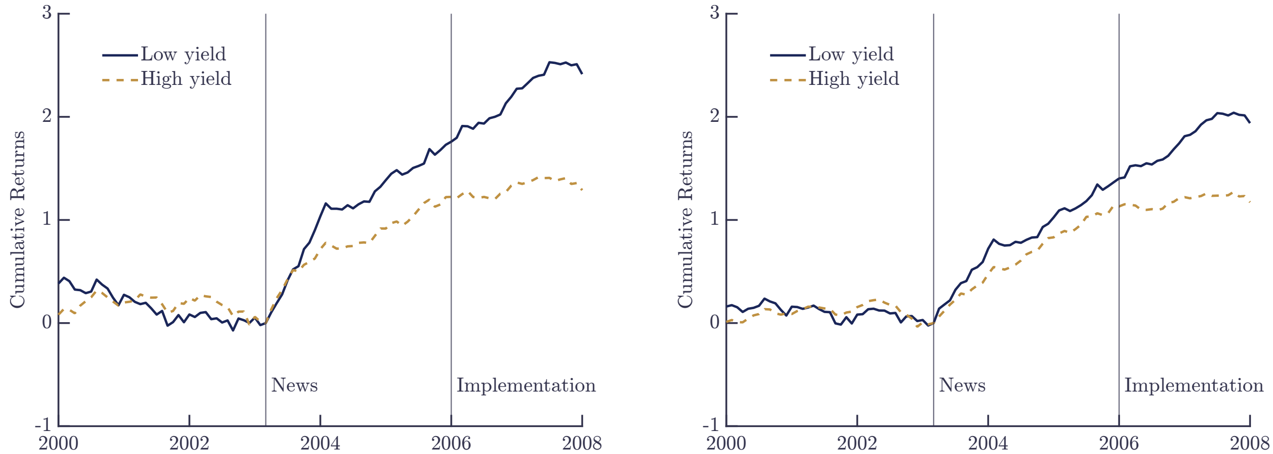
$$\text{NPV}_{\text{annual pension payment}} = e^{-(r-g-wt)(R-age)} \sum_{t=0}^{T} e^{-(r-g-wt)t}. \tag{B.3}$$

The marginal pension tax is then

$$\text{marginal pension tax} = -\text{MPP} \cdot \text{MAPP} \cdot \text{NPV} \tag{B.4}$$

We use a retirement age R of 67, an expected lifetime after retirement T of 20, a real interest rate r of 0.0172, a real wage growth g of 0.025, and a wealth tax wt of 0.011 in the computation. In Figure 2, the shaded area represents variation by age between 30 and 60 years (our sample restriction).

B.2 Stock market analysis details



(a) Low beta. **(b)** Low market capitalization.

Notes: This figure shows cumulative returns for high vs. low dividend stock portfolios among firms with low beta (a) and low market capitalization (b).

Figure B.1: Cumulative stock returns for high vs. low dividend stock portfolios.

Figure 3 in the main text is constructed in the following way. First, we use monthly data on all publicly traded stocks on the Norwegian stock exchange. The data is comparable to CRSP for the USA in that it accounts for stock splits and other similar events. We also have data on dividend payouts with the monthly date for the payment, see Ødegaard (2013) for details. Second, following the standard practice in empirical asset pricing, we remove penny stocks and very expensive stocks by dropping stocks with prices less than NOK 1 or greater than NOK 1000. This amounts to roughly the top and bottom 1% of the price distribution. We also drop the top decile of firms by market capitalization in order to focus on a sample that is more comparable to closely-held businesses that we study in the micro analysis. Third, we compute the dividend yield for each publicly traded stock (based on the ISIN number) on the Norwegian stock exchange using annual dividends data up until the reform. The dividend yield is defined as dividends over the price as of December 2002, i.e. prior to the reform news shock. We double-sort all stocks into portfolios based on the dividend yield (above and below the median) and either the market cap or the market beta. Fourth, we compute portfolio-specific cumulative returns over the period January 2001 - January 2008.

We first perform a two-way sorting based on the market beta and the dividend yield. We construct the market beta for each stock using monthly returns data until and including December 2002. For each stock, we run an OLS regression of excess returns on the excess return of the Norwegian stock market index. When computing betas, we remove regressions with less than 24 observations (two years). Figure B.1a shows the results which indicate a growing premium for low-yield stocks following the reform announcement. We then perform a two-way sorting based on size (market capitalization) and dividend yield. Figure B.1b reports the results, which were also shown in the main text. Excess returns for low-yielding stocks are small or insignificant in the case of high-beta and high-size stocks.

Overall, our findings suggest that the market priced in a premium on low-yield stocks following the announcement of the Norwegian dividend tax reform. The premium was driven by low-beta and low-size firms, which are more likely to represent closely-held businesses that we analyze with the administrative data. In addition, the response of market prices to the news shock was slow, which is consistent with portfolio adjustment frictions by investors (Gabaix and Koijen, 2021). Importantly for our identification strategy, there are no systematic differences in returns before 2003, suggesting once again that the news shock about the future permanent dividend tax reform was not anticipated.

B.3 Imputing spending ignoring private businesses

The first challenge when imputing spending is to define income and saving consistent with the budget constraint. We define income as *disposable income*, the sum of labor income, transfers, business income, capital income, and other income (e.g., inheritances and lottery prizes), net of taxes. We define *saving* as the change in net wealth due to either depositing or withdrawing resources from asset classes. Income, as defined above, is directly observed in the tax accounts. The main challenge in imputing spending is to compute the relevant measure of saving.[1]

The relevant measure of saving using the budget constraint described above is the sum of active depositing or withdrawing of resources into and from all asset classes. The main challenge is that the tax authorities only report total valuations within broad asset classes at the end of the year, and changes in these values could be due to either saving or capital gains. We compute saving within each asset class differently depending on data availability. For nominal assets, such as debt and deposits, saving during the year is directly observed as the change between end-of-year and beginning-of-year values.

For housing, we observe housing transactions in the transaction registry, allowing us to observe the relevant saving measure. Hence, saving is housing is the sum of all housing bought minus all housing sold. Specifically, we do not need to know the estimated valuation of the house from year to year.

For stocks, we compute capital gains on household stocks using the stock ownership register after 2005. This register allows us to observe a household's ownership of specific stocks at the end of each year. We combine this ownership information with price changes in individual stocks to compute capital gains.[2] Before 2005, we only observe total wealth in stocks and impute capital gains for households using capital gains rates from the financial accounts. This approach ensures that capital gains are correct on average but will imply that capital gains for any specific household may be wrong. For stock funds, we use the capital gains rate from the financial accounts to impute capital gains for all years in our sample.

[1] An alternative and consistent way of imputing spending is to include capital gains as part of income and define saving as the change in net wealth. In that case, saving would be directly observed and the challenge would be to compute income. In either case, one must compute a measure of *unrealized* capital gains, which is unobserved in the tax data.

[2] Because we only observe ownership at the beginning and end of the year, we need to impose when the stock was traded to compute capital gains. We assume stocks are traded uniformly during the year. For example, if an individual owned 100 shares of Equinor at the beginning and 50 shares at the end of the year, we assume the individual sells Equinor shares gradually throughout the year.

Imputed spending ignoring private businesses, spending^{npbo}, is computed as

$$\text{spending}_{i,t}^{\text{npbo}} = \underbrace{\text{disp. income}_{i,t} - \text{saving}_{i,t}^{\text{nominal assets}} - \text{saving}_{i,t}^{\text{housing}}}_{\text{observed}} \underbrace{-\text{saving}_{i,t}^{\text{stocks/stock funds}}}_{\text{unobserved}},$$

where the main source of measurement errors comes from the unobserved component, saving in stocks and stock funds.

B.4 Additional empirical results

Industry	**Control (%)**	**Treated (%)**
Agriculture, forestry and fishing	0.96	0.38
Mining and quarrying	1.45	0.28
Manufacturing	9.77	9.16
Electricity, gas, etc	0.43	0.52
Water supply; sewerage, etc	1.13	0.33
Wholesale and retail trade	12.12	13.24
Transportation	28.44	27.32
Accommodation	4.33	2.13
Information and communication	5.57	4.51
Financial and insurance activities	0.25	0.14
Professional, scientific and technical activities	26.12	33.06
Administrative and support service activities	1.22	0.62
Education	2.31	4.13
Human health and social work activities	0.25	0.38
Arts, entertainment and recreation	4.86	2.85
Unknown	0.78	0.95
Total	100.00	100.00

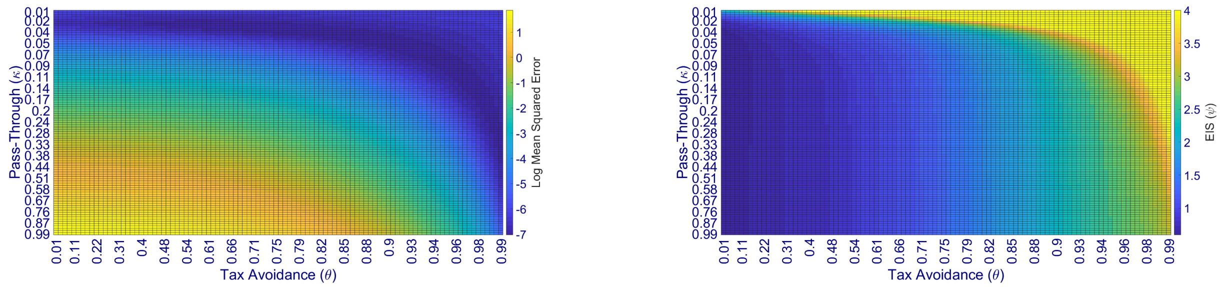
Table B.1: Distribution of firms across sector categories by treatment status in 2000 (%).

C Structural model appendix

C.1 Numerical details for the structural model

Our impulse response matching approach consists of several steps. First, we take the empirically documented differential response of the treated (capitalists) vs. the control (workers) group. For the baseline case, we use the estimates from Figure 7. We calibrate a sub-set of model parameters externally, as reported in Table 2. We then construct a coarse two-dimensional grid for the pass-through parameter κ and the EIS, ψ. The grid for κ is agnostic, ranging from 0.01 to 0.99. The grid for ψ is $[0.1, 4]$, with the lower bound corresponding to the value conjectured by Hall (1988) and the upper bounds being slightly above what is estimated using cross-household differences in after-tax real interest rates (Gruber, 2013). To improve accuracy, all grids are non-linearly spaced, allowing for more points in the region of the parametric space that is most likely to generate low matching errors.

Next, we solve the model for each $\{\kappa, \psi\}$ pair, i.e., for every point on the two-dimensional grid. The grid comprises 100 nodes in each direction. We thus solve the model 10,000 times under different parameter configurations. In every case, we compute and store impulse-response functions to a combination of two news shocks: a positive one-standard deviation news shock to ε_d and a one-standard deviation negative news shock to ε_k. In particular, we are interested in the model-implied estimates of the consumption response of capitalists less the consumption response of workers following the news shocks. This allows us to construct a response matrix under no tax avoidance. Finally, we construct the cum-avoidance response matrix. To this end, we first build a grid for the tax avoidance parameter θ, ranging from 0.01 to 0.99 using 100 non-linearly spaced nodes. For each value of θ on this grid, we compute and store a new response path. This completes the first step of our approach.



(a) Matching Errors

(b) Implied EIS Values

Notes: Panel (a) represents a heatmap of IRF matching errors produced by the calibration procedure over the three-dimensional grid $\{\psi, \kappa, \theta\}$ with tax avoidance intensity and reform pass-through on the horizontal and vertical axes, respectively. Colder colors correspond to lower mean squared errors. Panel (b) presents the corresponding EIS estimates. Warmer colors correspond to higher EIS values.

Figure C.1: Impulse response matching results.

In the second step of our procedure, we locate the point on the grid that minimizes the distance between the empirical and the model-implied spending differentials. In other words, we identify the values of parameters that "match" the empirical impulse responses as closely as feasible. Our candidate model-based sequences are stored in a $10 \times 100 \times 100 \times 100$ array, corresponding to the three-dimensional grid $\{\kappa, \psi, \theta\}$ with nine rows (years).

The targets for the moment matching procedure are as follows. For ψ, which governs the extent of front-loading of spending, we target the differential spending response between capitalists and workers in 2004, which corresponds to the year of the formal announcement of the reform. We then compute the mean squared differences between the moments in the model and data and identify the value of the EIS, $\bar{\psi}$, that delivers the smallest matching error. For κ, which governs the long-run pass-through of the reform, we target the average differential spending response over 2007-2011, the years that correspond to the post-implementation period. We obtain the error-minimizing value of $\bar{\kappa}$ in a similar fashion. Finally, conditional on $\bar{\psi}$ and $\bar{\kappa}$, for θ, which controls the smoothness of the response path, we target the full spending sequence over 2003-2011 and obtain $\bar{\theta}$.[3]

Figure C.1 plots the outcome of this impulse response matching exercise. In Panel (a), we present a heatmap with θ and κ on the x-axis and y-axis, respectively. Each colored square on the map represents a (log) mean-square error between model and data for the corresponding combination of parameters. Panel (b) presents the corresponding estimates of the EIS. From Panel (a) we see that the matching error declines as tax avoidance intensity rises and pass-through falls, i.e., the northeastern region is where the best-fitting

[3]Our results do not change if the search for $\{\bar{\kappa}, \bar{\psi}, \bar{\theta}\}$ is done simultaneously rather than sequentially.

combinations of parameters are. In fact, there is a clearly visible dark-blue patch that showcases the global minimum area. From Panel (b), we observe that this area corresponds to the values of the EIS that are generally in the [1.2, 2.6] interval with the baseline value of 1.6 being the estimate that produces the globally lowest moment matching error.

C.2 Model robustness and sensitivity tests

In this section we detail extensions of the baseline structural model. The first three exercises test the sensitivity of the results to the specification of the labor market. First, we allow for an endogenous wage rate W_t, which was set to unity in the baseline. The competitive wage rate is determined via the marginal product of labor in every period: $W_t = (1-\alpha)K_t^{\alpha}N_t^{-\alpha}$. Second, we endogenize the labor supply of capitalists and workers in two alternative ways. We first assume non-separability between consumption and leisure in the spirit of Greenwood et al. (1988). The first-order condition with respect to labor supply for agent type x is: $(1-\tau_x)W_t = \phi N_{x,t}^{\chi}$, where τ_x is a proportional labor tax only in the case of capitalists. Next, we assume that utility is additively separable in consumption and labor. The first-order condition with respect to labor supply for agent type x is now: $(1-\tau_x)W_t C_{x,t}^{-1/\psi_x} = \phi N_{x,t}^{\chi}$, where τ_x is a proportional labor tax only in the case of capitalists. For separable utility, we fix the EIS of workers to unity and allow the EIS of capitalists to be determined by the impulse response matching procedure as before. Frisch elasticity, $\frac{1}{\chi}$, is set to unity. The labor disutility parameter ϕ is set to a value which guarantees that hours equal 0.3 in the steady state for both types, same as in our benchmark.

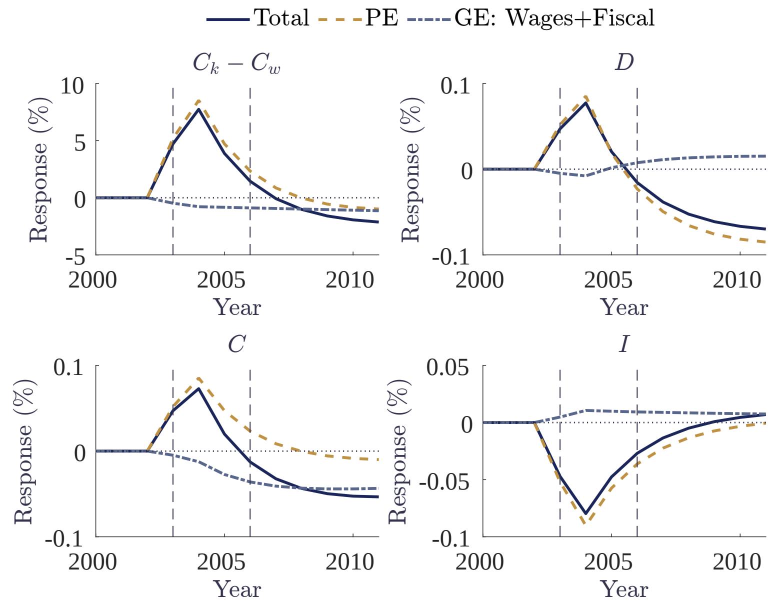
The next two exercises concern government fiscal rules. The baseline model assumes that any fiscal surplus along the transition path following dividend tax news shocks is rebated back to the households. We now test two alternative fiscal plans. First, we assume that the government uses the surplus to finance government spending. The government budget constraint is, in this case, $G_t = \tau_{d,t}D_t + \tau_{k,t}N_{k,t}$. And the resource constraint becomes $Y_t = C_t + I_t + G_t$. Second, we allow the government to lend abroad via one-period bonds at the risk-free rate R^F. The government budget constraint becomes: $\frac{1}{R_t^F}B_{t+1} + \tau_{d,t}D_t + \tau_{k,t}N_{k,t} = B_t$. In equilibrium, the risk-free rate is pinned down by the stochastic discount factor: $R_t^F = \frac{1}{\mathbf{E}_t m_{t,t+1}}$.

An alternative way of generating smooth transition dynamics following tax news shocks is by introducing habits in consumption. We now allow for internal habit formation in the consumption problem of the capitalists in the spirit of Christiano et al. (2005). Tax avoidance opportunities are shut down (θ=0). The stochastic discount factor becomes: $\Lambda_{t,t+1} = \beta\left(\frac{C_{k,t+1}-\zeta C_{k,t}}{C_{k,t}-\zeta C_{k,t-1}}\right)^{-1/\psi_k}$. As with θ in the baseline model, we target the full spending sequence over 2003-2011 and obtain $\bar{\zeta}$.

Next, we test sensitivity of model results to the values of externally calibrated parameters. First, the *share* of capitalists $1-\lambda$ directly controls the mass of agents affected by the reform. In the baseline, we calibrate λ to the data. However, our baseline λ could be argued to be high; although it is Norway-consistent, the external validity of our findings could be questioned if λ is generally lower in other countries. We therefore lower our λ to 0.95. Second, Hicks-neutral total factor productivity, A_t, is increased to 1.01 from the benchmark value of unity. Third, to allow for the possibility that capitalists are either more patient *or* less patient than workers, we set the β of capitalists first to 1.03 and then to 0.93 while keeping the β of workers unchanged.

Finally, in our baseline model the price of capital, Q_t, is always equal to unity. We now extend the model with capital adjustment costs. We follow Hayashi (1982) and assume that the capital accumulation equation can be written as $K_{t+1} = I_t - \frac{\phi}{2}\left(\frac{I_t}{K_t} - \delta\right)^2 K_t + (1-\delta)K_t$. Preferences and technology specifications otherwise do not change. Solution to this extended problem now includes an additional equation: $Q_t = \left[1 - \phi\left(\frac{I_t}{K_t} - \delta\right)\right]^{-1}$ The price of capital is increasing in the ratio of $\frac{I_t}{K_t}$. The first-order-condition of the firms problem with respect to K_{t+1}, in recursive notation, takes on the following form now: $\mathbb{E}\ m'\left(\frac{\varphi_D(D)}{\varphi_D(D')}\right)\left[F_k(A, K', N') + Q'\left(1 - \delta + \phi\left(\frac{I'}{K'} - \delta\right)\frac{I'}{K'} - \frac{\phi}{2}\left(\frac{I'}{K'} - \delta\right)\right)\right] = 1$. With $\phi > 0$ we can generate time-variation in the price of capital, Q_t, in response to the dividend tax reform. Whenever $\phi = 0$, we are back to the benchmark model. In our calibration, we set $\phi = 1$.

C.3 Direct and indirect effects decomposition



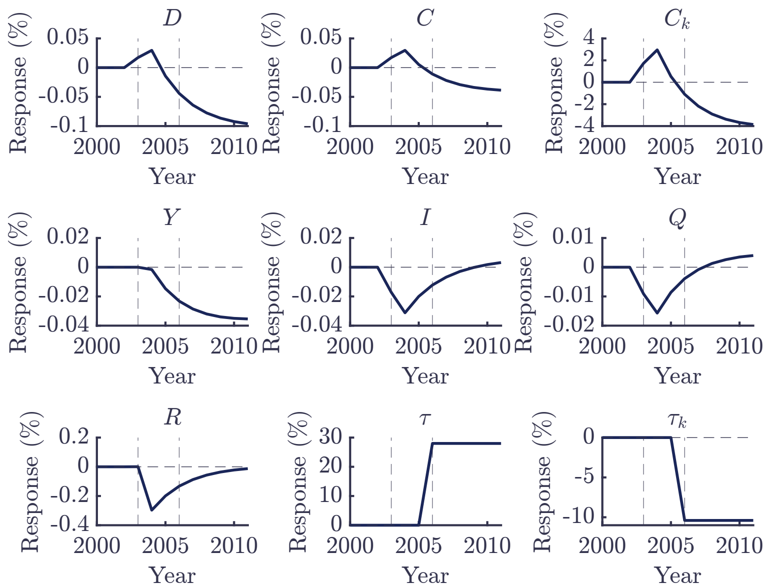
Notes: Decomposition of impulse response functions from the structural model into direct (partial equilibrium or PE) and indirect (general equilibrium or GE) effects.

Figure C.2: Decomposition into direct (PE) and indirect (GE) effects.

To better understand the mechanism that underlies our structural model, in this appendix we produce and report the decomposition of impulse response functions into partial and general equilibrium components. Our approach follows closely the methodology in Kaplan et al. (2018) and Auclert (2019). To this end, we will be considering a version of the model with endogenous GHH labor supply and the fiscal rule characterized by lump-sum rebates of fiscal surpluses to the capitalists. The total response to the dividend tax news shock is comprised of two effects. First, the direct effects (or partial equilibrium) channel captures the reaction to the change in the interest rate, R_t, while keeping wages W_t and transfers $T_{k,t}$ fixed at their steady-state values. Second, the indirect effects channel captures the feedback onto the economy from general-equilibrium changes in W_t and $T_{k,t}$.

Figure C.2 reports the decompositions for the differential response of spending of capitalists less spending of workers ($C_k - C_w$), aggregate dividends, aggregate consumption, and investment. For the differential spending response as well as the other aggregate variables, total responses are driven primarily by the direct effects. In other words, general equilibrium forces are rather mild. This lends further credence to our identification strategy and the close alignment of the model with the empirical estimates, the latter being inherently partial-equilibrium.

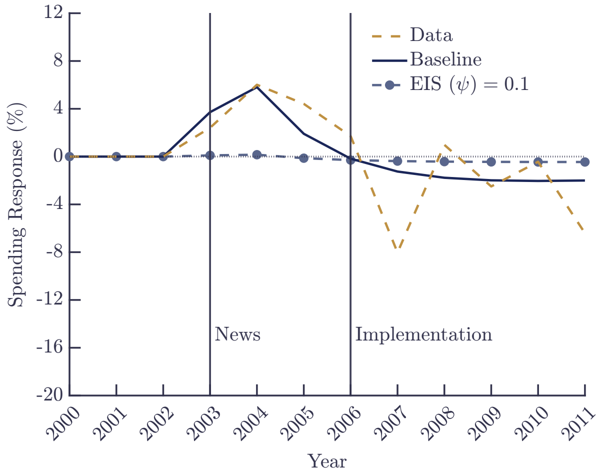
C.4 Additional model results



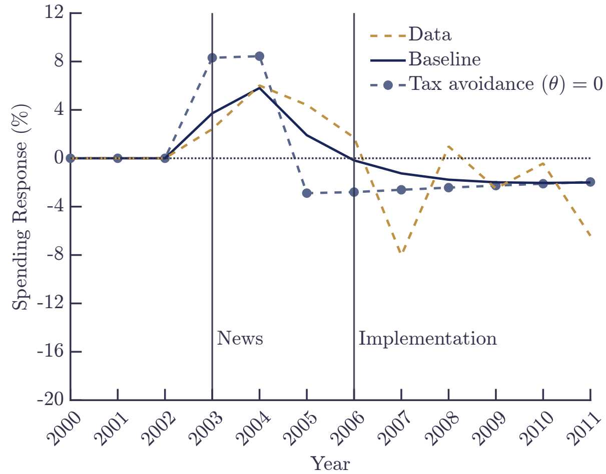
Notes: All impulse response functions from the structural model extended with capital adjustment costs.

Figure C.3: Impulse responses of all variables.

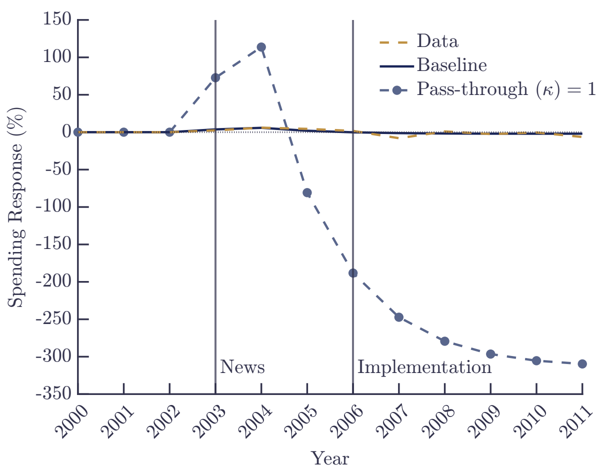
In this section, we present several additional model results that complement the main text. First, we report all impulse response functions from the baseline model extended with capital adjustment costs. Figure C.3 shows the responses to the dividend tax reform of aggregate dividends, aggregate consumption, consumption of capitalists, aggregate output, investment, the price of capital, the interest rate, the tax rate on dividends, and the tax rate on capitalists' labor income. Notice that while the response of capitalists' spending is relatively large, recall that their share in the economy is small and thus the macroeconomic impacts on consumption, investment, and output are less stark. The front-loading of dividends and spending starts immediately as the news of the reform hits in 2003. The macroeconomy then begins to adjust downward as the interest rate that firm owners face falls. Demand for investment goes down, putting downward pressure on the price of capital, leading to a macroeconomic contraction.



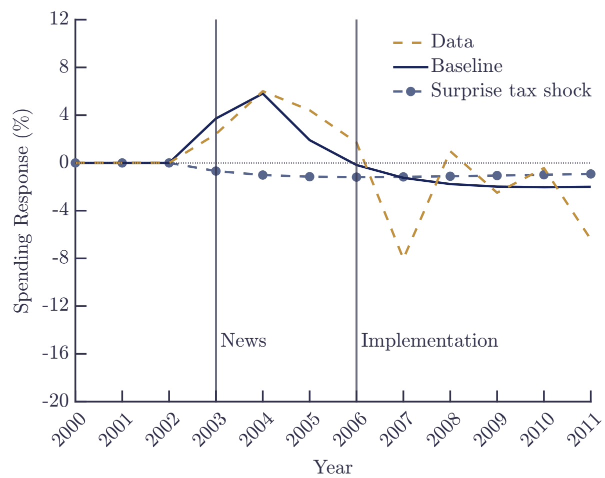
(a) Setting the EIS (ψ) to 0.1.



(b) Setting tax avoidance (θ) to 0.



(c) Setting pass-through (κ) to 1.



(d) The impact of surprise tax shocks.

Notes: Panels (a), (b), and (c) plot relative spending responses implied by alternative parametrizations in which we set $\psi = 0.1$, $\theta = 0$, and $\kappa = 1$, respectively. Panel (d) reports relative spending responses after a surprise tax shock, rather than a news shock.

Figure C.4: Additional model results.

Second, we test whether picking a wrong model with high matching errors produces empirically inconsistent results. Panel (a) of Figure C.4 shows the result when we counterfactually set the EIS (ψ) to 0.1, a very different value from what our calibration suggests but a value that is often referenced in the macro literature. The spending response in this case corresponds to a mean squared error that is at least an order of magnitude above the minimum and such a low EIS fails to match the front-loading of spending before implementation.

Third, panel (b) of Figure C.4 presents relative spending responses from a model with θ equal to 0, corresponding to no tax avoidance in the short run. This shows that the tax avoidance friction does not impact our results qualitatively but is crucial to quantitatively match the relatively smooth response to the tax news shock.

Fourth, panel (c) of Figure C.4 shows relative spending responses from a case with full pass-through, i.e. $\kappa = 1$. The magnitudes of the responses are now much larger, suggesting that low reform pass-through is very important for matching the relative spending response patterns quantitatively. Finally, panel (d) presents impulse responses for a surprise tax shock, rather than a news shock. A surprise shock completely fails to reproduce the increase in spending during the 2003-2006 period.

References

Auclert, Adrien, "Monetary Policy and the Redistribution Channel," *American Economic Review*, 2019, *109(6).*

Christiano, Lawrence J., Martin Eichenbaum, and Charles L. Evans, "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy," *Journal of Political Economy*, 2005, *113* (1), 1–45.

Flynn, Joel P, Lawrence DW Schmidt, and Alexis Akira Toda, "Robust Comparative Statics for the Elasticity of Intertemporal Substitution," *Theoretical Economics*, 2023, *18* (1), 231–265.

Gabaix, Xavier and Ralph SJ Koijen, "In Search of the Origins of Financial Fluctuations: the Inelastic Markets Hypothesis," *NBER Working Paper 02138*, 2021.

Greenwood, Jeremy, Zvi Hercowitz, and Gregory W Huffman, "Investment, Capacity Utilization, and the Real Business Cycle," *American Economic Review*, 1988, *78* (3), 402–417.

Gruber, Jonathan, "A Tax-based Estimate of the Elasticity of Intertemporal Substitution.," *Quarterly Journal of Finance*, 2013, *3* (1), 1 – 20.

Hall, Robert E, "Intertemporal Substitution in Consumption," *Journal of Political Economy*, 1988, *96* (2), 339–357.

Hayashi, Fumio, "Tobin's Marginal Q and Average Q: a Neoclassical Interpretation," *Econometrica*, 1982, *50* (1), 213–224.

Kaplan, Greg, Giovanni L Violante, and Benjamin Moll, "Monetary Policy According to Hank," *American Economic Review*, 2018, *108* (3).

Ødegaard, Bernt Arne, "Empirics of the Oslo Stock Exchange. Basic, Descriptive, Results 1980-2020," *Working Paper*, 2013.

Straub, Ludwig, "Consumption, Savings, and the Distribution of Permanent Income," *Working Paper*, 2019.

The Ministry of Finance, "St.prp. nr. 1: Skatte-, avgifts- og tollvedtak for budsjetterminen 2001," *https://www.regjeringen.no/no/dokumenter/st-prp-nr-1_2000-2001/id137635/*, 2000.