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Abstract

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JEL Classification: D83, G11, J2

Keywords: Equity market participation, Individual investors

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Broadband Internet and the Stock Market Investments of Individual Investors*

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ABSTRACT

We study the effects of broadband internet use on the investment decisions of individual investors. A public program in Norway provides plausibly exogenous variation in internet use. Our instrumental variables estimates show that internet use causes a substantial increase in stock market participation, driven primarily by increased fund ownership. Existing investors tilt their portfolios towards funds, thereby obtaining more diversified portfolios and higher Sharpe ratios, and do not increase their trading activity in stocks. Overall, access to high-speed internet seems to spur a "democratization of finance", with individuals making investment decisions that are more in line with the advice from portfolio theory.

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I. Introduction

Does internet use spur a "democratization of finance" (Shiller (2007)), meaning improved portfolio choices by households, or does it amplify behavioral biases? Pioneering studies by Barber and Odean (2002) and Choi et al. (2002) suggest the latter: In the 1990s, individuals that adopted online stock trading platforms increased their trading activity and trading costs without any apparent increase in risk-adjusted returns. More recently, social media usage appears, at best, to have mixed effects on the quality of financial decisions (e.g., Hirshleifer et al. (2021), Barber et al. (2021), and Allen et al. (2022)).

We study the effects of the roll-out of high-speed broadband internet on the stock market participation and portfolio choices of individual investors in Norway in the 2000s. In addition to the roll-out, Norway offers extraordinary data opportunities through detailed common stock and equity fund trading records for the entire population, which allows us to estimate the effects of internet use not only within subgroups of investors but also within the broader population. Our two main findings are that increased internet use, induced by the broadband roll-out, leads to a substantial increase in stock market participation, and to increased diversification, Sharpe ratios, and portfolio efficiency (as defined by Calvet et al. (2007)) among existing investors.

Standard asset allocation theory suggests that if markets are complete and agents have constant relative risk aversion (CRRA) utility functions, risk tolerance is the only individual characteristic that determines stock market participation (Merton (1969); Mossin (1968); Samuelson (1969)): A less wealthy individual's portfolio should be a scaled-down version of a more wealthy individual's portfolio.[1] However, entering the stock market involves fixed costs (Vissing-Jørgensen (2002); Campbell (2006)) such as becoming aware of stock market opportunities (Guiso and Jappelli (2005)), setting up an investor account

[1]And if the agent has human capital, even with CRRA, the equity share of financial wealth should depend on the current amount of financial wealth relative to human capital wealth (Bodie et al. (1992)).

and becoming acquainted with trading solutions (Barber and Odean (2001a)), and acquiring financial competence (Lusardi and Mitchell (2014); Lusardi et al. (2017)). On the one hand, it is plausible that faster internet would facilitate these activities and thus increase stock market participation rates. On the other hand, faster internet reduces the cost of leisure-related activities, such as social networking or watching movies, which could crowd out individuals' focus on personal finance. For example, Brown et al. (2020) document that stock market trading activity increases on days with Blackberry outages, consistent with internet use being an attention-diverting activity.

To study the effects of broadband use on portfolio choices, we employ several data sets. Data from the Norwegian Central Securities Depository (NCSD) provide a record of common stock and fund transactions made by all Norwegian individual investors between 2000 and 2010. Each transaction can be linked to register data on investor socio-demographics, including age and gender, income, education, and municipality of residence, allowing us to compare those that experience an expansion of broadband and those that do not. Household balance sheet data allow us to construct measures of wealth and returns to wealth. In secondary analyses, we use data from two nationally representative surveys on internet use to analyze potential channels underlying the main results.

As a source of exogenous variation in internet use, we exploit a program rolled out by the Norwegian government in the 2000s that aimed at ensuring broadband internet access throughout the country. We use the resulting spatial and temporal variation in broadband coverage across municipalities in an instrumental variables (IV) setup: We instrument the share of households with a broadband subscription in a given year with the share of households that are covered by broadband infrastructure.[2]

[2]Existing work that use the Norwegian broadband data, and a very similar empirical methodology, include Bhuller et al. (2013) on the effects of broadband use on sex crime, Akerman et al. (2015) on the effects of broadband on worker productivity, Bhuller et al. (2020) on the effects of broadband on labor market matching, and Akerman et al. (2022) on the effects of broadband on bilateral trade.

We find that broadband internet use leads to increased stock market participation, driven by an increase in the share of the population investing in equity funds; we find no effect of internet use on the share of the population holding common stocks. The effects are economically significant: For every 10 percentage point increase in broadband use the stock market participation rate increases by 0.7 percentage points, that is, about 5.3 percent of the pre-reform mean stock market participation rate. The effects of broadband internet are larger for the least wealthy individuals when measured relative to pre-reform participation rates. Broadband also has a slightly larger effect for less-educated individuals than for those with the most education. These findings suggest that internet use spurs a democratization of finance: Stock market participation increases, particularly among the socioeconomic groups with the lowest participation rates to begin with.

Our second main question is whether broadband internet affects the trading behavior and portfolio efficiency of individuals that are already stock market investors. On the one hand, access to broadband internet reduces the cost of acquiring information about individual companies, which may increase investors' belief that they can beat the market by being well informed and thus lead to increased trading activity and possibly decreased diversification.[3] On the other hand, broadband may provide easier access to information about sound portfolio allocation principles, and thus lead to improved choices. We find that existing investors on average do not increase their stock trading activity following the introduction of broadband, though there is a slight tendency for the most active traders to become even more active. Moreover, existing investors tilt their portfolios towards equity funds, thereby obtaining more diversified portfolios and higher Sharpe ratios, and portfolio efficiency, as defined by Calvet et al. (2007), increases.

To better understand the channels through which internet use leads to increased

[3]For example, the 2007 annual report of DNB, the largest bank in Norway, is a PDF file of about 4 MB. With a 56 kbs dialup, the download takes about 10 minutes, versus 30 seconds with a 1 Mbps DSL broadband connection.

equity market participation without excessive stock trading, we use a nationally representative survey which provides details on households' internet activities. The survey provides some evidence of a direct link between internet use and stock market participation: For example, the share of respondents using the internet to purchase stocks or financial services more than quadruples over the reform period. The survey responses also show a broad trend towards increased use of the internet for information acquisition and learning. In addition, data on firms' internet activities and marketing expenses allow us to document important supply-side responses to increased internet access. In Section VII.C, we present evidence consistent with firms responding to increased internet use among households by supplying the households with more information — through new web pages and online sales platforms, and increased marketing — supply-side effects that may further reduce the cost for households of online information acquisition.

If the introduction of broadband internet eases access to information and improves individuals' financial skills, it could also have effects on other aspects of financial decision-making than equity market participation. In auxiliary analyses, we use household balance sheet data to analyze broader financial outcomes. We find that broadband internet use increases participation in bonds and bond funds and in unlisted stocks. We also find that broadband use increases households' financial wealth and their return on financial wealth. These results corroborate the message from the main analyses: Broadband internet appears to have a beneficial impact on financial decision-making.

Our paper is primarily related to a literature on how internet use affects the portfolio choices of individual investors (e.g., Barber and Odean (2002); Choi et al. (2002); Hirshleifer et al. (2021); Barber et al. (2021); Allen et al. (2022)). For example, Barber and Odean (2002) and Barber et al. (2021) find evidence of excessive stock trading among adopters of online trading platforms, and Allen et al. (2022) document herding and speculation among users of Twitter, Stocktwits, and Reddit's "wallstreetbets" stock forum.

In contrast, we document positive effects of internet use on the stock market participation and portfolio efficiency of individual investors. We believe the reasons why our results differ from the existing literature are relatively straightforward. The existing literature documents detrimental effects of the use of internet platforms that are targeted primarily at making trading easier or more fun, and for this reason likely attract investors with speculative motives. Access to broadband internet, by contrast, eases all internet activities, not just online trading, and affects a broad group of people. While we find some evidence of increased trading activity among the very most active individual investors following the introduction of broadband internet, which is consistent with the existing literature, our survey evidence suggests a much clearer trend towards using the internet for information acquisition and learning over the broadband reform period.

Our paper also relates and contributes to a literature in household finance (see Campbell (2006); Guiso and Sodini (2013); Gomes et al. (2021) for surveys) that tries to understand why, relative to the predictions of the CCAPM and other asset allocation models, too few individuals invest in equity markets — the "participation puzzle" (e.g., Grinblatt et al. (2011); Guiso and Sodini (2013); Campbell (2016)). The literature has suggested several factors that affect stock market participation, including personal wealth (Brunnermeier and Nagel (2008); Calvet et al. (2009); Briggs et al. (2015); Fagereng et al. (2018)), educational attainment (Cole et al. (2014)), computer ownership (Bogan (2008)), and financial literacy (Lusardi and Mitchell (2014); Lusardi et al. (2017)). We contribute to this literature by analyzing the effects of an exogenous reduction in the fixed costs of equity market participation due to faster internet access, and, in line with theoretical predictions, document that participation increases with access to high-speed broadband internet.[4] We also document positive effects of broadband internet on participation rates

[4]Our results line up with a conjecture from the survey article Guiso and Sodini (2013): "Additionally, the increase in stock market participation that has taken place over the past two decades is also consistent with a decline in participation costs. The availability of financial information on the Internet, and the

in other assets, including bonds and bond funds and unlisted stocks.

Finally, our paper speaks to ongoing policy debates on the government expansion or funding of broadband infrastructure (see Internet Appendix Section I.A for recent policy debates, as well as international comparisons of broadband coverage and usage).[5] The introduction of broadband internet constitutes a major policy shift that was enacted in Norway in the 2000s. Our results inform the policy's effects in Norway, with potential applications to other countries. The central finding of our paper is that access to and use of high-speed internet leads to a democratization of finance: Stock market participation increases, and existing investors increase their portfolio efficiency.[6]

The paper proceeds as follows. Section II describes the broadband reform. Section III presents the data. Section IV introduces the empirical methodology, and Section V presents the main results on stock market participation. Section VI presents results for existing investors. Section VII discusses mechanisms, and Section VIII concludes. The Internet Appendix provides additional documentation and analysis.

II. The Reform

We seek to estimate the causal effect of broadband internet use on stock market participation and other financial outcomes. As a source of exogenous variation in internet use, we exploit a program rolled out by the Norwegian government in the 2000s that aimed

expansion of the mutual fund industry have effectively made access to the equity market cheaper." (p., 1454).

[5]For example, in May 2022, following up on campaign trail promises, the Biden administration committed to reducing the cost of high-speed internet for low-income families (White House (2022)).

[6]The prior literature focuses on the effects of internet on education and health (LaRose et al. (2011), Bauerly et al. (2019)), democratic participation (Campante et al. (2017)), economic growth (Czernich et al. (2011)), wage and employment growth (Forman et al. (2012)), productivity for firms (Akerman et al. (2015)), and possible costs including increased sexual crime (Bhuller et al. (2013)), reduced psychological well-being (Kraut et al. (1998)), and internet addiction (Ko et al. (2012)).

at ensuring broadband coverage at a reasonable price throughout the country.

The transmission of broadband signals through fiber-optic cables requires the installation of local access points. During the 2000s, such access points were progressively rolled out in Norway, which generates spatial and temporal variation in broadband coverage. The staged nature of the broadband expansion was in part a result of limited public funding, and in part because Norway is a geographically large and sparsely populated country. Panel A of Figure 1 plots the mean municipality-level broadband coverage rate, and its distribution, at the start of each year between 2000 and 2010.[7] Before 2002, most municipalities have no broadband coverage, but over time the distribution widens, with several municipalities reaching coverage rates of 80 percent by 2006. By 2010, nearly all municipalities have complete coverage for the entire population.[8] Section IV presents evidence that the timing of the broadband expansion is uncorrelated with pre-reform trends in stock market participation, which is key to the validity of our IV strategy.

Panel B of Figure 1 plots the mean broadband user rate, and its distribution, at the start of each year between 2000 and 2010. The figure shows a strong increase in broadband user rates that appears to lag coverage rates by about one year. In Internet Appendix Table IA.XIV, we regress broadband user rates on contemporaneous and lagged coverage rates, and find that households start adopting broadband one year after receiving coverage. Our IV strategy outlined in Section IV incorporates this feature of the data: We use the prior year's coverage rate (z_{kt-1}) as our instrument for the current user rate (i_{kt}), as specified in the "first stage" relationship in equation (3). Internet Appendix Figure IA.6 provides a graphical illustration of the first stage relationship.

[7]We note that fiber-optic (fixed line) broadband is distinct from mobile broadband technology. All our measures of broadband coverage and use are based on fiber-optic broadband coverage and use. See Section III for more details about the broadband coverage and use data.

[8]As all the municipalities reach universal broadband coverage within a relatively short time span, the Norwegian reform cannot be used to study the long-term effects broadband.

III. Data

Our analysis uses several administrative register data sets from Norway. The register data encompass the entire population of individuals and firms in Norway, and can be linked via unique identifiers. The coverage and reliability of Norwegian register data are rated as exceptional in international quality assessments (Atkinson et al. (1995)). Døskeland and Hvide (2011) provide a general description of Norway and the Oslo Stock Exchange (OSE). In terms of representativeness, as shown by Døskeland and Hvide (2011), individual investors in Norway are similar to individual investors in other Scandinavian countries and somewhat less wealthy than those surveyed by the Survey of Consumer Finance in the U.S.[9] Also, apart from a substantial government ownership share in the most valuable listed companies, the OSE is representative of a large number of small and middle-sized stock exchanges in industrialized countries.

A. *Transaction-level data*

To characterize individuals' stock market participation, we collect data on all common stock trades made on the OSE by Norwegian residents between 1993 and 2010 from the Norwegian Central Securities Depository (NCSD), as well as data on all trades made by Norwegian residents in all equity funds and exchange traded funds covered by the NCSD. For each transaction made by an individual investor, the data contain the anonymized identifier of the individual, the date of transaction, the ticker of the security, and the number of shares purchased or sold. We use the transactions data together with a record

[9]Using data from SimilarWeb in April 2022, we find that Norwegians and Americans overlap on about 50% of each country's most-visited websites; Reddit, the subject of several recent papers on American individual investors (e.g., Allen et al. (2022)), is the 14th most-visited site in Norway. Popular Norwegian stock forums during the broadband reform period, such as HegnarOnline, appear similar in both content and activity as their American counterparts, including Reddit's "wallstreetbets".

of initial holdings (at the end of 1993) to construct end-of-year holdings in stocks and equity funds for each individual. Moreover, from the OSE, we obtain daily ticker prices and other company information such as market capitalization and company ID number. Where needed, we supplement this information with data from *Børsprosjektet* at the Norwegian School of Economics (similar to CRSP). All fund prices in the data are expressed in terms of net asset values — that is, net of fund management fees.

While the stock transactions data are exhaustive for trades on the OSE, the fund transactions data from the NCSD only cover about 25 percent of all Norwegian fund customer relationships. For this reason, we supplement the NCSD fund data with data obtained directly from DNB, the main equity fund provider in Norway among those not recording transactions through the NCSD.[10] The DNB data cover another 50 percent of all Norwegian fund customer relationships (see Internet Appendix Section III for details on these data). We cannot merge the NCSD and DNB data because the investor identifiers are not aligned across data sources. In the main analysis, we focus on the stock and fund data obtained from the NCSD. In robustness tests, we show that the main results are similar when using the DNB data rather than the NCSD fund data.

B. Internet data

The internet data set contains a complete record of the share of households that are covered by or subscribe to broadband internet in every municipality over the period 2000–2010. The data on broadband *coverage* come from the Norwegian Ministry of Government Administration. The ministry monitors the coverage of broadband internet, and the suppliers of broadband to end users are required to file annual reports about their coverage rates to the Norwegian Telecommunications Authority. The broadband coverage rates are based on information on the area signal range of the local access points and

[10] DNB was until 2003 known as Den Norske Bank ("The Norwegian Bank").

detailed information on the place of residence of households. In computing the coverage rates, it is taken into account that multiple suppliers may provide broadband coverage to households living in the same area, so that double counting is avoided.

For the years 2000 and 2001, the data on broadband *subscriptions* come from Telenor, the state-owned enterprise that was the sole provider of broadband internet in Norway in this period. For the remaining period, 2002–2010, the data on broadband subscriptions come from the quarterly Internet Survey performed by Statistics Norway, surveying all suppliers of broadband access to end users. The Internet Survey contains information on the total number of households with broadband subscriptions in each municipality.

C. Other data

The socio-demographic data come from administrative registers provided by Statistics Norway and cover all Norwegian residents in the period 1993–2010. The registers contain individual demographic information, such as sex, age, and marital status, socio-economic data, such as years of education, income, and wealth, and geographic identifiers for municipality of residence. The information on educational attainment is based on annual reports from Norwegian educational establishments, and the income and wealth data are collected from tax records and other registers. The data are the same as the ones used by Eika et al. (2020) to study household consumption, income, and wealth.

The firm-level data come from yearly accounting statements submitted by all incorporated firms to the tax authorities in the period 2001–2010. The data include firms' income statements and balance sheets. The data are very detailed: The income statements cover more than 80 unique income or expense items, while the balance sheets cover more than 90 types of assets or liabilities. Using unique firm identifiers, we merge the income statement and balance sheet data with information on the industry and geographic location of each firm from the Central Register of Establishments and Enterprises.

In addition to the register data described above, our analyses use several survey data sets. The survey data sets are described in the text and appendices.

D. Summary statistics

Although most of the data sources provide information at the individual level, the broadband coverage data, the source of exogenous variation, only provide information at the municipality-year level. For this reason, we analyze the effects of broadband internet on stock market participation rates at the municipality level.

The first part of Table I displays the mean of stock market participation at the municipality level, with standard deviations presented in parentheses.[11] We measure stock market participation by the fraction of individuals in a municipality holding any stocks or equity funds at the end of a calendar year, labeled "Holds Any". Stock market participation increases over time, with Holds Any increasing from about 13 percent in 2000 to 18 percent in 2010. The table also shows the fraction of the population holding individual stocks ("Holds Stocks") and the fraction holding equity funds ("Holds Funds"). The increase in Holds Any over the period from 2000 to 2010 is driven primarily by Holds Funds, which increases from 8.6 to 13.9 percent over the period 2000–2010.

The second part of Table I shows means and standard deviations of broadband coverage and broadband user rates. Over the period 2000–2010, the mean broadband user and coverage rates are 27.7 and 61.2 percent, respectively. In 2000, Norway had zero broadband coverage and use. In 2008, mean coverage reached 97.5 percent, increasing further to 99.6 percent in 2010, whereas the mean user rate reached 54 percent in 2008 and 62 percent in 2010. The largest standard deviation in broadband coverage rates across municipalities is observed around 2004, whereas user rates vary the most across

[11]As in our main analyses, the unit of analysis in Table I is municipality-year. In other words, the descriptive statistics in Table I are reported for the average municipality, not the average person.

municipalities during the final four years of the broadband roll-out period.

Finally, the third part of Table I shows socio-demographic variables. The mean educational attainment is 11.6 years, and the after-tax household income is NOK 503,000, or approximately $40,000. The mean unemployment rate is negligible, at just 1%. Both educational attainment and household incomes are slightly increasing over time, while unemployment rates are stable at a low level throughout the period 2000–2010. Internet Appendix Table IA.IV summarizes additional municipality characteristics.

IV. Methodology

The chief goal of our paper is estimate the causal effect of broadband internet use on individuals' stock market participation and other outcomes. Our IV strategy exploits exogenous variation in broadband internet use generated by the gradual expansion of broadband coverage between 2001 and 2010. To make the identifying assumptions of the IV model as transparent as possible, we start out in Section IV.A with the reduced form of the IV model, which regresses stock market participation and other outcomes directly on the instrument, before explaining the IV model in Section IV.B.

A. Reduced form and the exogeneity assumption

The reduced form of our IV model is specified as follows:

$$y_{kt} = \delta z_{kt-1} + \mu_k + \chi_t + \varepsilon_{kt}, \tag{1}$$

where y_{kt} is the stock market participation rate (or some other outcome) for municipality k in year t, z_{kt-1} is the prior year's broadband coverage rate, the instrument, and μ_k and χ_t are municipality and year fixed effects. The parameter δ captures the effect of broadband coverage on the stock market participation rate. This effect is relevant for policy makers that contemplate increasing their broadband coverage, z_{kt-1}.

Identifying assumption: The reduced form coefficient δ can be given a causal interpretation if z_{kt-1}, our instrument, is exogenous — that is, as good as randomly assigned — conditional on municipality and year fixed effects. Controlling for municipality and year fixed effects implies comparing changes in outcomes within municipalities while eliminating common changes over time. Thus, exogeneity can be interpreted as a common trends assumption: In the absence of broadband coverage expansions, municipalities with early and late expansions would, on average, have followed the same trend in outcomes.

Assessing the assumption: The validity of this exogeneity assumption can be evaluated by comparing pre-reform trends in outcomes and characteristics for municipalities with early and late broadband coverage expansions. The test can be bolstered by also comparing pre-reform levels of outcomes and characteristics: While the municipality fixed effects in (1) would account for any time-invariant differences between treated and control municipalities, one might argue that common trends are more likely if the municipalities with early and late expansion were similar in levels. To examine this, we estimate the following regression separately for each year of the broadband expansion, 2001–2010:

$$\Delta z_{kt} = \alpha + [m_{k,2000}]'\beta + \kappa_{kt}, \qquad (2)$$

where $\Delta z_{kt} = z_{kt} - z_{k,t-1}$, and $m_{k,2000}$ is a vector that includes a wide range of municipality characteristics, such as trends and levels in stock market participation, average years of educational attainment, unemployment and urbanization rates, and household incomes, all measured in the pre-reform year 2000.[12] The goal is to assess whether or not municipalities with different broadband coverage expansions looked similar in trends and

[12]We estimate (2) by pooling data from the period 2000–2010 and interacting all the terms in equation (2) with year fixed effects. This procedure provides identical coefficients as when estimating equation (2) year-by-year, but allows us to cluster the standard errors at the municipality level.

levels of their outcomes and characteristics before the expansions.[13]

Figure 2 plots the estimated yearly β coefficients, with associated 95% confidence intervals. Importantly, we do not find evidence of any significant relationship between changes in the instrument and pre-reform levels (Panel A) or trends (Panel T) in stock market participation, or between changes in the instrument and other key determinants of stock market participation, such as household income and education, supporting the exogeneity assumption. We do find, however, that the timing of the broadband coverage expansion is correlated with pre-reform urbanization: More densely populated areas received coverage earlier than less densely populated areas, as evident from Panel H of Figure 2. A potential concern is therefore that our estimates might be biased due to differential underlying trends in stock market participation between urban and rural municipalities. We deal with this concern in several ways. First, in Internet Appendix Figure IA.7 and Internet Appendix Table IA.XIX, we show that urban and rural municipalities followed very similar trends in stock market participation in the years 1994–2000 prior to the broadband coverage expansion. Second, in Internet Appendix Table IA.XX, we show that our estimates are almost identical when estimated separately for urban and rural municipalities and, thereby, allowing for differential time trends between urban and rural municipalities. Finally, in Section V, we report results with and without a large set of time-varying controls, including urbanization, and find that the estimates barely move. Overall, the evidence supports the (conditional) exogeneity of z_{kt-1}.

Another threat to instrument exogeneity would be that the timing of the broadband coverage expansion coincides with other reforms or developments in the financial sector that impact stock market participation. In Internet Appendix Section XV we address three such concerns: i) a pension reform in 2006 that affected private- but not public-sector workers, ii) financial sector growth over the broadband expansion period, and iii)

[13]This is the same diagnostic test as the one used by Bhuller et al. (2013) and Akerman et al. (2015).

expansions in the availability of online banking and trading solutions over the same time period. We find no evidence of any significant relationship between these financial sector developments and the timing of the broadband coverage expansion.

B. IV model and the exclusion restriction

Our IV model has the following first and second stage equations:

$$i_{kt} = \phi z_{kt-1} + \gamma_k + \theta_t + \nu_{kt}, \tag{3}$$

$$y_{kt} = \omega i_{kt} + \alpha_k + \tau_t + \epsilon_{kt}, \tag{4}$$

where i_{kt} is the broadband user rate and α_k and τ_t (and γ_k and θ_t in equation (3)) are municipality and time fixed effects, respectively. The IV parameter ω is given by the ratio of the reduced form coefficient to the first stage coefficient, that is, $\omega = \frac{\delta}{\phi}$, and measures the effect of broadband internet use on stock market participation.

Identifying assumptions: A causal interpretation of the parameter ω in (4) requires that the instrument, z_{kt-1} is exogenous, as defined in Section IV.A. We also have to assume that z_{kt-1} is *excludable* from the second stage (4).[14] This amounts to assuming that lagged broadband coverage affects stock market participation only through its impact on current household broadband use, and not directly in any other way.

Assessing the assumptions: Section IV.A provides evidence supporting the exogeneity assumption. The exclusion restriction may still be violated if, for example, the installation

[14]A third assumption of the IV model, which seems plausible in our setting, is monotonicity, namely, that increased access to broadband makes it weakly more likely that a household adopts broadband (Imbens and Angrist (1994)). A fourth assumption is instrument relevance; that ϕ in equation 3 is non-zero. As shown in Section V, we have a strong first stage. Recent work that estimate similar IV models include Ben-David et al. (2018), Farre-Mensa et al. (2020), and Meling (2021). Bhuller et al. (2013) use an identical IV model as ((3)–4) to study the effects of broadband use on sex crimes.

of broadband has a direct impact on local real estate prices, which in turn impacts stock market participation, or, more subtly, if z_{kt-1} impacts labor productivity and incomes (and, in turn, stock market participation) through broadband adoption at the firm-level. Section VII.A addresses these and other threats to the exclusion restriction. We also note that the instrument affecting some correlate of stock market participation, such as the extent of online information acquisition and learning, through its impact on i_{kt} does *not* violate the exclusion restriction of the IV model. Instead, such effects should be interpreted as mechanisms that help explain the effects of broadband use on stock market participation. Sections VII.B–VII.C discuss possible mechanisms.

While we are primarily interested in the effect of broadband internet use on stock market participation and other outcomes — that is, ω from the IV model in equation (4) — in the following, we also report estimates of the reduced form effect of broadband coverage on stock market participation (δ from equation (1)) and the first stage effect of broadband coverage on broadband internet use (ϕ from equation (3)).

V. Stock Market Participation

In Sections V.A–V.B, we present our main results concerning the effect of broadband internet use on stock market participation. In Section V.C, we present additional results concerning the effect of broadband use on a broader set of financial outcomes.

A. Main results

Column (1) of Table II shows estimates from the IV model (3)–(4) and the reduced form model (1) using the stock market participation rate as the outcome. The estimated first stage coefficient equals 0.11, which means that a 100 percentage points increase in broadband coverage induces an additional 11 percent of the population to adopt broadband internet within the next year. The first stage relationship is strong, with an F-

statistic around 200; weak instrument bias is not a concern. The reduced form is also highly significant, with a coefficient of 0.0078. Taken together, the first stage and reduced form coefficients imply an IV estimate of 0.0698, which means that for every 10 percentage point increase in the broadband user rate (the user rate's standard deviation is 10.06 in 2010, see Table I) the stock market participation rate increases by 0.698 percentage points, or approximately 5.3 percent of the pre-reform mean stock market participation rate. The effect is highly statistically significant.[15]

In columns (2) and (3) of Table II, we decompose the overall effects on stock market participation into separate effects on stock and fund holding rates. We find that for every 10 percentage point increase in the broadband user rate, the fund holding rate increases by about 0.76 percentage points. In contrast, we find no statistically or economically significant effect of broadband use on stock holding rates. Given that the first stage coefficients in columns (2) and (3) are unchanged compared to column (1) of Table II, the reduced form coefficients paint the exact same picture. That is, the large effect of broadband use and coverage on stock market participation appears to be operating primarily through an increase in the fund holding rate of individual investors.

We challenge the validity of the empirical strategy in two main ways. First, we include in the IV model (3)–(4) a wide range of time-varying municipality controls to see whether the main results are driven by changes in municipality characteristics other than broadband coverage, such as urbanization, household income, or educational attainment. Although slightly smaller upon the inclusion of control variables, the estimated effects

[15]The estimates in Table II are based on a balanced panel of municipality-year level observations, which means that the estimated effects pertain to the average municipality. One might also be interested in the effects for the average Norwegian, which can be obtained by weighting the municipality-year observations by their population counts. Doing so, we find an IV estimate of 0.17. Excluding the four largest cities from the estimation sample reduces the population-weighted IV estimate to 0.12, which suggests that our IV results are stronger in the most populous municipalities.

are contained within the 95% confidence interval of the baseline estimates and remain positive and highly statistically significant.[16] Second, we interact the municipality fixed effects with a linear time trend and include these interactions in the IV model. Thus, we allow the broadband expansion to be correlated with differential underlying time trends in stock market participation across municipalities. Again, we find significant effects of broadband use on stock market participation, suggesting that the main results are not driven by differential underlying trends in stock market participation.

While a common robustness test in the literature, the inclusion in column (5) of Table II of municipality-specific time trends is somewhat contentious. The issue is that the municipality-specific trend may not only eliminate possible bias due to different underlying trends across municipalities — it may also be controlling away parts of the treatment effect. This is simply because the linear time trends in the outcome may in part be driven by the actual treatment effect. Indeed, the IV estimate in column (5) of Table II (0.0287) is outside the 95% confidence interval of the baseline IV estimate in column (1) (0.0698). In Internet Appendix Section XII, we follow Bhuller et al. (2013) in estimating municipality-specific trends exclusively using data covering years *prior* to the expansion of broadband internet. For each municipality k we first obtain a trend estimate, $\hat{v}_k$. We then extrapolate pre-expansion time trends into our IV specification by including $\hat{v}_k t$ as a covariate in both the first and the second stage equations, which will take into account any variation in our instrument that reflects pre-existing trends in the outcome. The results presented in Internet Appendix Section XII show that accounting for pre-trends in

[16] Column (4) of Table II controls for a comprehensive list of municipality characteristics, all measured with little error using register data (see Internet Appendix Section II for details). One might still be concerned that unobserved control variables would, upon inclusion, drive the estimated effect in column (4) to zero. Following the approach in Oster (2019), we find that the results are robust to selection on unobservables, in the sense that selection on unobservables must be more than proportional to selection on observables for the bias-adjusted effects to be zero or switch signs.

this way has very little impact on our estimates. In particular, we obtain an IV estimate of 0.0704 which is very similar to the baseline IV estimate of 0.0698.

A potential concern relates to the coverage of the NCSD data with respect to fund holdings. While providing nearly exhaustive coverage of individuals' stock trades, the NCSD fund trade data is less exhaustive, covering trades by about 25 percent of all fund customer relationships in Norway (see Section III for details). Most notably, the NCSD data do not cover the fund trades made by clients at DNB, the largest bank in Norway, which accounts for about 50 percent of all fund customer relationships. In the final column of Panel B of Table II, we estimate the IV model using fund trading rates from the DNB data as the outcome. Similar to the main results, we find that the effect of broadband use on fund holding rates as measured in the DNB data is positive and statistically significant.[17] Hence, the main results are not specific to the fund customer relationships covered by the NCSD data, but seem to apply more broadly.

B. *Effect heterogeneity*

Following Imbens and Angrist (1994), we interpret the main IV estimates in Table II as the effect of broadband internet use on stock market participation for the part of the population that is induced to use broadband internet as a direct result of the broadband reform.[18] It is possible that the large IV estimates in Table II result from a strong response among a particular subgroup, such as young males. We now estimate the effects of broadband use for subgroups by age, sex, and educational attainment.

To estimate the effects of broadband use for subgroups, we use data from a yearly

[17] We note that the DNB and NCSD databases cover different individuals, which means that coefficient estimates from the two samples are not directly comparable. Unlike the NCSD data, the DNB data do not include detailed sociodemographic characteristics, which means that we cannot in a credible way use covariate balancing (matching) techniques to construct comparable estimation samples.

[18] This is often referred to as a local average treatment effect, or LATE; see Imbens and Angrist (1994).

nationally representative survey on broadband user rates. The survey includes details on broadband internet use, as well as individual characteristics such as age, sex, and educational attainment (see Internet Appendix Section IV for details) for more than 1,000 individuals each year in the period 2001–2010. Using this survey, we first re-construct the user rate i_{kt} from (3) separately for subgroups by age, sex, and educational attainment. For each of the subgroups, we are able to calculate i_{kt} for around 40 percent of the 4,220 municipality-year observations in the full sample. Then, we estimate the IV effect ω from equation (4) separately for each of the subgroups, using all municipality-years with non-missing i_{kt}'s. The results are presented in Panel A of Table III. The estimates are positive across sociodemographic groups with some heterogeneity: Relative to pre-reform stock market participation rates, the effect of a 100 percentage point increase in broadband use on stock market participation is slightly larger for males (39 percent) than for females (29 percent), and larger for younger (59 percent) than for older (34 percent) individuals. The effects are reasonably similar across education groups (30 percent, 43 percent and 27 percent for low, medium and high education groups, respectively).

The IV effects in Panel A of Table III are estimated based on the municipality-year observations for which the survey allows us to calculate subgroup-specific broadband user rates. To assess whether the results are robust to changes in the estimation sample, we also estimate subgroup-specific reduced form effects (which does not require subgroup-specific broadband user rates) of broadband coverage on stock market participation, using the full sample of municipality-year observations. The results, reported in Panel B of Table III, show that the full-sample reduced form estimates broadly line up with the restricted-sample reduced form estimates in Panel A, supporting the conclusion that broadband internet has a positive effect on stock market participation across socioeconomic groups.[19]

[19]The reduced form effect heterogeneity in Panel B of Table III is also broadly similar to the effect

We are also interested in how the effect of broadband internet on stock market participation varies with individuals' wealth and income. We do not observe broadband user rates broken down by wealth or income. For this reason, in Figure 3, we present (full-sample) reduced form estimates of the effect of broadband coverage on stock market participation separately for subgroups by wealth (Panel A) and income (Panel B). Across all wealth and income levels, we find that broadband coverage has a positive and statistically significant effect on stock market participation. Relative to pre-reform participation rates, the effects are largest for low-wealth and low-income individuals.

Overall, the introduction of broadband internet appears to have a positive impact on stock market participation rates across socioeconomic groups — and a relatively stronger impact for younger, less-educated, lower-income, lower-wealth individuals, who have the lowest stock market participation rates (and likely the lowest financial literacy) to begin with — suggesting that broadband spurs a "democratization of finance".

C. *Broader financial outcomes*

Sections V.A–V.B focus on the effects of broadband internet use on stock market participation as measured using NCSD data on ownership of common stock and equity funds. We now estimate the effects of broadband internet on a broader set of financial outcomes. To this end, we supplement the NCSD data with administrative tax records which give end-of-year household balance sheets for the population of Norwegian residents, including information about various asset holdings, insurance policies, and pension plans. Internet Appendix Section VII provides more detail on the balance sheet data.

In Internet Appendix Table IA.IX, we find that broadband internet use increases individuals' participation in bonds and bond funds as well as in unlisted stocks. By

heterogeneity documented for the IV model in Panel A. In particular, in both the reduced form and IV model we find stronger effects of broadband for younger and less educated individuals.

contrast, we do not find evidence of any significant relationship between broadband use and the take-up of life insurance or private pension plans, suggesting that the financial effect of broadband use primarily is centered on direct investment decisions. While we do not have sufficient precision to detect a significant impact of broadband use on households' total wealth, in Internet Appendix Table IA.X we find that broadband use increases households' financial wealth and their historical returns on financial wealth.

These results corroborate the message from the main analyses: Broadband use appears to positively impact portfolio allocation and outcomes for individual investors.

VI. Effects for Existing Investors

We now analyze the effect of broadband internet on existing investors. On the one hand, access to high-speed broadband internet reduces the cost of acquiring information about individual companies, which may increase investors' belief that they can beat the market by being relatively better informed and thus lead to increased trading activity and decreased diversification. Broadband internet also decreases the time cost of trading, an effect that could be important for the most active traders. On the other hand, increased access to broadband internet might improve financial decision-making if the internet is used to collect information on how to diversify or form better portfolios.

We do not observe broadband user rates broken down by past trading activity. To assess the effect of broadband on the trading activity of existing investors, we therefore estimate the reduced form effects given by δ in equation (1). As explained in Section IV, the parameter δ has a causal interpretation and can be estimated without broadband user data. The estimated effect of broadband coverage on the trading activity of existing investors is presented in Table IV. The results reported in the first four columns of Panel A show a positive and statistically significant effect of broadband on fund buying among existing investors, and no significant effect of broadband on fund selling, stock buying, or stock selling.[20] Taken together, these results imply that broadband coverage should lead to an increase for existing traders in the portfolio share of funds as opposed to individual stocks. This is confirmed in the fifth column of Panel A Table IV.

In Panel B of Table IV, we analyze the effects of broadband coverage on measures of portfolio efficiency adopted from Calvet et al. (2007). We first consider the return loss, that is, the average return an individual loses by choosing their actual portfolio rather than a position combining the benchmark portfolio with cash to achieve the same risk level (see equation (10) in Calvet et al. (2007)).[21] In the first column of Panel B, we find a negative and statistically significant effect of broadband coverage on the return loss. The estimates in the next three columns of Panel B are based on the decomposition of the return loss in equation (11) of Calvet et al. (2007). We find that broadband coverage decreases all three components of the return loss — the portfolio weight in risky assets, the standard deviation of the risky assets chosen by the individual, and the relative Sharpe ratio loss, with the effects on the risky asset share and the relative Sharpe ratio loss being statistically significant.[22] In the final two columns of Panel B, we report estimates of the effects of broadband coverage on two other measures of portfolio risk, the Sharpe ratio and the portfolio idiosyncratic risk share. The portfolio idiosyncratic risk share is the share of portfolio variance that can be attributed to idiosyncratic risk, as opposed to systematic risk, and is calculated following equations (1)-(3) in Calvet et al. (2007). We find that broadband coverage increases the Sharpe ratio and decreases the

[20] In Internet Appendix Section XIII, we also find no evidence of any significant effect of broadband coverage on stock portfolio turnover, an alternative measure of stock trading activity.

[21] The mean return loss across individual-years is about 0.31%. The distribution of return losses is comparable to the distribution reported by Calvet et al. (2007), with a slightly fatter right tail.

[22] The relative Sharpe ratio loss captures diversification losses by comparing individuals' Sharpe ratios to the Sharpe ratio of the Morgan Stanley Capital International All Country World Index (MSCI ACWI), see equations (7)-(8) in Calvet et al. (2007). Individuals' Sharpe ratios are calculated based on excess returns relative to the Norwegian Central Bank's overnight deposit rate.

idiosyncratic risk share. Overall, the estimates reported in Panel B of Table IV show that increased access to broadband internet leads to more diversified portfolios and improved outcomes for existing investors. To give a sense of the economic magnitudes of the effects, the mean pre-reform Sharpe ratio in our sample is about 15.5 percent. A 100 percentage point increase in broadband coverage increases the Sharpe ratio by about 0.25 percentage points the year after, column (5) of Panel B shows, or about 1.6 percent of the pre-reform mean. If we assume a first-stage coefficient of 0.15 for the group of existing investors — slightly larger than the 0.11 first stage coefficient for the average person in Table II — these reduced form effects would imply an IV estimate of approximately 0.016. In other words, a 100 percentage point increase in the broadband user rate increases the Sharpe ratio by 1.6 percentage points, or about 10 percent of the pre-reform mean.

While columns (3) and (4) of Panel A in Table IV show that the average existing investor does not increase his stock trading activity following increased access to broadband, it could be that the most active ones do, as documented by Barber and Odean (2002) and Choi et al. (2002) in the context of individual investors' adoption of online trading platforms. To assess this possibility, we first group all investors into 20 (nationwide) ventiles based on their stock trading activity in the previous year. Then, we calculate the average number of trades within a given ventile-municipality-year. Finally, we re-estimate the effect δ from equation (4) twenty times, each time using a different ventile's average number of stock trades as the outcome. Intuitively, this approach involves comparing stock trading activity between existing investors that (i) currently experience different broadband coverage shocks but (ii) in the previous year belonged to the same trading activity ventile, conditional on municipality and year fixed effects.

Panel A of Figure 4 presents the estimates of δ for each of the ventiles. Across the trading activity distribution, there are uniformly weak effects of broadband coverage on current stock trading. The exception is at the very top: For the top 10 percent of the past trading activity distribution, we find positive effects of broadband coverage on stock trading. The estimated coefficient for the top ventile is large, but statistically insignificant. For the 19th ventile, the effect is borderline statistically significant (p-value = 0.051). To assess the robustness of this result, in Panel B of Figure 4 we re-estimate the ventile-specific δ's using the log of the mean number of stock trades as the outcome, and find that the effects of broadband on the trading activity of the most active investors are no longer economically or statistically significant. We conclude that there may be an increase in stock trading activity among the most active existing investors.

Overall, we find positive effects of increased access to broadband internet among existing investors: They increase their equity fund portfolio shares and their Sharpe ratios. We also do not find evidence of increased stock trading activity among existing investors, except possibly at the very top of the trading activity distribution.

VII. Mechanisms

While exogeneity of the instrument, z_{kt-1}, is sufficient for a causal interpretation of the reduced form effects reported in Tables II–III, the IV estimates reported in the same tables can only be interpreted as causal effects of households' broadband use on stock market participation under the exclusion restriction that increased broadband coverage affects stock market participation only through the broadband adoption of households, and not directly in any other way. Section VII.A below addresses threats to the exclusion restriction; Sections VII.B–VII.C discuss potential mechanisms, that is, effects on stock market participation that do operate through households' broadband use.

A. Threats to the exclusion restriction

One possibility is that the estimated effect of broadband coverage on stock market participation results from broadband adoption at the firm level rather than at the household level. Broadband adoption at the firm level could lead to increased productivity and wages of the firms' workers and increase stock market participation through an income effect.[23] Using the same methodology as in Sections V–VI, we assess whether broadband coverage affects labor income reported to the tax authorities. The results reported in Internet Appendix Section XVII suggest that broadband does not have a significant impact on labor incomes. Thus, it seems unlikely that the observed effect of broadband coverage on stock market participation is driven by income effects. We also note that column (4) of Table II shows that our results are robust to controlling for a comprehensive list of time-varying municipality characteristics, including household incomes.

Another possibility is that through a combination of firm- and household-level broadband adoption, increased broadband coverage could allow skilled workers to work from home, creating more time for leisure activities such as getting acquainted with stock market opportunities. This mechanism is likely to be more prevalent for high- than low-skill workers if, for example, low-skill workers do physical tasks that require on-site presence while high-skill workers can perform their jobs remotely. But at least relative to pre-reform participation rates, our results are equally strong for individuals with low education (Table III) which makes this mechanism unlikely to explain our results.

A third possibility is that the installation of broadband internet, an amenity, could have a direct causal impact on local real estate prices and thus increase stock market participation through a loosening of household budget constraints. To address this concern, we follow the methodology of Eika et al. (2020) and construct measures of each household's real estate wealth using data on transactions in real estate, information on the characteristics of each property, and detailed housing price indices. Using the same methodology as in Sections V–VI, we then assess whether broadband coverage impacts

[23]Akerman et al. (2015) find that firm-level broadband adoption increases the productivity of high-skill workers and decreases the productivity of low-skill workers, but they do not report the total effect.

household real estate wealth. The results reported in Internet Appendix Section VII.B show that broadband coverage does not have a significant impact on household real estate wealth, which makes also this mechanism unlikely to explain our results.

A final and perhaps subtler possibility is that the instrument, lagged broadband coverage, z_{kt-1}, affects stock market participation not only through current household broadband use, i_{kt}, but also through its impact on lagged use, i_{kt-1}. This would violate the exclusion restriction of the IV model (3)–(4), which imposes that lagged broadband coverage affects stock market participation only through current use. In Internet Appendix Section X, we expand the IV model to allow for dynamics both in the first- and second-stage equations, and find that controlling for lagged broadband use has little impact on the estimates, supporting the exclusion restriction of the IV model.

B. *Household internet activities*

We now explore channels through which household broadband adoption may increase stock market participation. A nationally representative survey on household internet activities allows us to provide evidence on the link between households' internet adoption and their stock market participation. The survey is administered by Statistics Norway and each year has more than 1,000 respondents that give detailed information about whether or not they have access to the internet, and how they use the internet.[24] The survey covers each year over the period 2003–2010, which allows us to study how households used the internet throughout the broadband reform period.

Online trading. One survey question is of particular relevance: Whether respondents have used the internet to purchase stocks and/or financial services. Panel A of Figure 5

[24]In the percentages reported below, we include in the estimation sample all the respondents to the survey, also the respondents that report not having internet access. Note also that the survey used in the current subsection is distinct from the one used in Section VI. Internet Appendix Section IV and Internet Appendix Section V provide more details on each of the surveys.

plots the share of respondents with affirmative answer to this question before (2003) and after (2010) the broadband reform.[25] In the pre-reform period, a very small percentage of the respondents (less than 2 percent) used the internet to purchase stocks or other financial services. After the reform, more than six times as many (12 percent) respondents reported that they use the internet to purchase stocks or other financial services. The relative increase in the online purchasing of stocks or financial services is considerably larger than for the use of online banking, also shown in Panel A of Figure 5, which was fairly common (at 49 percent) even before the broadband reform. Hence, in percentage terms there was a strong increase in the use of the internet to purchase stocks and/or financial services, even compared to other personal finance activities.[26]

To explore whether the increase in the online purchasing of stocks or financial services is related to the broadband reform, in Panel B of Figure 5, we plot the share of respondents that have purchased stocks or financial services online against broadband coverage in the previous year. The analysis is at the regional level (there are 7 regions) as the survey contains information about respondents' region of residence, but not their municipality of residence.[27] The figure shows a strong positive association between broadband coverage and the tendency to purchase stocks or financial services online; the correlation between online stock/financial purchasing and broadband coverage is about 0.8, statis-

[25] In 2003, the first year of the survey, the average municipality-level broadband internet coverage was about 20%, as shown in Figure 1, Panel A. In 2010, the average broadband coverage was about 99.9%.

[26] As shown in Internet Appendix Section XV.C, the major banks in Norway introduced online banking services in the 1990's, before the broadband reform. While smaller in relative terms than the increase in the online purchasing of stocks or financial services, the share of survey respondents reporting that they use the internet for banking increased materially, from 46% to 81%, from before to after the broadband reform. In Internet Appendix Section VIII, we find that bank customers reduced their frequency of physical bank visits in favor of online banking over the same period.

[27] In Panel B of Figure 5, there are 7 geographical regions $\times$ 8 survey waves = 64 observations. We do not have sufficient statistical power to estimate the IV model (3)–(4) at the regional level.

tically significant at the 1 percent level, and a linear regression of online stock/financial purchasing on broadband coverage yields a slope of 0.11, also statistically significant at the 1 percent level.[28] These results suggest that the observed increase in online purchasing of stocks or financial services may be related to the broadband reform.

Online information acquisition. Why would access to faster internet lead to increased stock market participation and other beneficial outcomes? As suggested by the theoretical literature, entering the stock market involves fixed costs such as becoming aware of stock market opportunities (Guiso and Jappelli (2005)) and acquiring financial competence (Lusardi and Mitchell (2014); Lusardi et al. (2017)). It is plausible that faster internet facilitates these activities and thus increases stock market participation. However, the internet also facilitates leisure activities such as social networking or watching movies, which could reduce the time spent on information acquisition and learning.

While the survey does not ask whether respondents have used the internet to learn about personal finance, it broadly supports that the internet increasingly was used for information acquisition and learning during the sample period. For example, information acquisition about health — which, like personal finance, is important for long-term outcomes — increased from 29 percent in the pre-reform period to 45 percent post-reform, as shown in Panel A of Figure 5. Post-reform, about 54 percent of the respondents answered that they have "Consulted the internet with the purpose of learning", but this question was not asked pre-reform. Panel A also shows the pre-post change for other forms of online information acquisition and learning. The variable "Other info. acq." is the share of respondents that confirms having used the internet to acquire information about

[28] As additional evidence, in Panel D of Figure 5, we plot for the genders and three age groups the change from pre- to post-reform in the online purchasing of stocks or financial services against the subgroup-specific reduced form effect of broadband coverage on stock market participation from Table III. The figure shows that the subgroups with the largest causal effects on stock market participation are also the ones with the largest before-after changes in online purchasing of stocks or financial services.

goods and services, the labor market, travel and accommodation, or have taken an online course.[29] This variable increases from 67 percent pre-reform to 84 percent post-reform. Taken together, this evidence supports a broad trend towards increased internet-based information acquisition and learning during the broadband reform period.

The before-after changes in online information acquisition documented in Figure 5 may not be driven by the broadband reform but rather by secular trends in how households interact with the internet. In Internet Appendix Section XVIII, we use data from a different survey about household media use, which includes information about respondents' municipality of residence. This allows us to estimate the baseline IV model (3)–(4) using proxies for information acquisition as the outcomes. While the survey in Internet Appendix Section XVIII is not as detailed as the one studied in Figure 5, we can construct two measures of online information acquisition at the municipality-year level: The shares of respondents that have used the Internet to "Check facts" or "Read the news". The results in Internet Appendix Section XVIII show that broadband internet increases the time individuals spend acquiring information online by reading the news and checking facts, though only the former effect is statistically significant.

Other effects of household internet use. In addition to increasing online information acquisition, the introduction of broadband is likely to impact a wide range of other household activities. For example, using the same survey as in Figure 5, we find that the shares of respondents that have used the internet to purchase food/take-out or to gamble also increased over the broadband reform period, from 0% and 1% to 3% and 6%, respectively (see Statistics Norway (2022) for summary statistics for other internet activities). Existing papers also show that increased internet use may have a wide range of adverse effects, such as increased sexual crime (Bhuller et al. (2013)), reduced psy-

[29]The fraction of affirmative answers to each of these questions before and after the broadband reform were: travel (40%, 60%), labor market (16%, 20%), education (5%, 5%), goods/services (62%, 79%).

chological well-being (Kraut et al. (1998)), and internet addiction (Ko et al. (2012)), as well as benefits in terms of improved education and health (LaRose et al. (2011), Bauerly et al. (2019)), and democratic participation (Campante et al. (2017)). To the extent that these activities impact stock market participation, we cannot exclude the possibility that reform-induced changes to these activities may in part shape the observed effects of broadband use on stock market participation. We note that column (4) of Table II shows that our main results are robust to controlling for a comprehensive list of time-varying municipality characteristics, including measures of education, income, health, public sector spending, industry compositions, and welfare dependency, which does not support that reform-induced changes to these variables are driving our main results.

C. Firm responses to household internet use

Section VII.B presents evidence consistent with households increasing their online information acquisition and learning from before to after the introduction of broadband internet. One would expect firms to ramp up their online presence and marketing in response, and thus further reduce the costs for households of online information acquisition and learning. We assess this hypothesis by using two data sources.

First, we use data from a nationally representative survey of *firms'* ICT usage. The survey is administered by Statistics Norway and each year has about 3,000 firms that give detailed information about whether they have access to internet and how the firm uses the internet. Compliance is exceptionally high, at around 95%, due to heavy fines for non-compliance. The survey covers the years 2001–2010, which allows us to study how firms used the internet before, during, and after the broadband reform. In Internet Appendix Figure IA.4, we find that firms increase their online presence — by adding online sales platforms and web pages — from before to after the broadband reform. Internet Appendix Section VI provides additional detail and analysis.

Second, we use detailed tax returns data for the population of Norwegian firms (explained in more detail in Internet Appendix Section XIX), which allow us to measure firms' marketing-related costs. Using the same methodology as in Sections V–VI, we assess whether broadband impacts firms' marketing expenses (the data do not allow us to distinguish whether these costs are from online or other forms of marketing). In Internet Appendix Table IA.XXVII, we find that the introduction of broadband leads to a significant increase in firms' spending on marketing as a share of total costs, consistent with firms ramping up their marketing in response to increased broadband use by households.

We are also interested in how financial institutions changed their online information provision in response to increased internet use by households. The survey in Internet Appendix Section VI has insufficient coverage of financial firms. The tax returns data in Internet Appendix Section XIX cover all firms, including financial ones, but financial firms in Norway are mostly clustered in the largest cities, which leaves little variation to estimate the IV model. However, two pieces of anecdotal evidence suggest important responses also among financial firms. First, in 2005 DNB, the largest bank and fund provider in Norway, launched a comprehensive Save Smart marketing campaign specifically for its fund products, motivated by "... intensifying competition for customer savings", the bank citing "trading via the Internet and other electronic channels" as sources of intensified competition in the savings market (DNB (2005), pages 10 and 68). According to DNB, the campaign was "... very well received by the market". Second, in Internet Appendix Section IX, we find that major financial institutions in Norway significantly expanded their offerings of fund products over the broadband reform period. Taken together, the evidence suggests that financial institutions increasingly pushed their fund products in response to increased internet use by their customers.[30]

[30]To further explore the idea that financial institutions respond to increased household internet use by increasingly pushing fund products through online channels, we wrote a script to scrape information from Norwegian financial institutions' web pages using Wayward Machine, a web service that provides snap-

The results above and in Section VII.B suggest that shifts in both household demand and firm supply of online information may be important to understand why broadband internet use increases stock market participation. Further supporting an information channel, we find that the effects of broadband on stock market participation are relatively stronger for individuals with lower income and wealth, that is, the individuals that likely have the least information and financial literacy to begin with.

VIII. Conclusion

The internet has greatly improved the opportunities for individual investors to gather information and easily connect to financial markets. This paper combines plausibly exogenous variation in broadband internet use with detailed register data to study the effects of broadband internet use on stock market participation and trading behavior. We find that broadband use leads to increased stock market participation, to improved portfolio allocation for existing investors, and to increased participation in bonds, bond funds, and unlisted stocks. We do not find adverse effects of internet use; for example, access to high-speed internet does not lead to excessive stock trading among existing investors, except possibly for the very most active investors. Overall, the introduction of broadband internet seems to spur a democratization of finance, with households making investment decisions that are more in line with the advice from portfolio theory.

Why would high-speed internet lead to increased participation rates and improved portfolio efficiency? As suggested by the theoretical literature, entering financial markets involves fixed costs such as becoming aware of stock market opportunities and acquiring financial competence, and it is plausible that high-speed internet would facilitate these activities and thus reduce fixed costs. Survey evidence broadly supports this interpreta-

shots of historical web pages. Unfortunately, the coverage of the Wayward Machine proved significantly too thin to allow us to perform any reliable quantitative analysis.

tion: Over the broadband expansion period, we observe a broad trend towards increased internet-based information acquisition and learning. Heterogeneity analyses also point towards an information acquisition channel: Compared to pre-reform stock market participation rates, the effects of broadband on stock market participation are stronger for younger, lower-income, and lower-wealth individuals, who have the lowest stock market participation rates and likely the lowest financial literacy to begin with.

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IX. Tables

Table I. Summary Statistics

This table shows means of equity market participation rates, broadband internet use and coverage rates, and municipality characteristics over the time period 2000–2010. The data are at the municipality-year level. Internet Appendix Section II provides details on variable construction and also presents summary statistics for additional control variables. Standard deviations are presented in parentheses.

	Overall	2000	2002	2004	2006	2008	2010
Equity market participation:							
Holds any (%)	16.02	13.13	14.72	14.19	16.18	18.00	18.03
	(5.87)	(5.23)	(5.33)	(5.22)	(5.75)	(6.18)	(5.84)
Holds fund (%)	11.81	8.65	10.08	9.95	12.20	13.99	13.93
	(6.17)	(5.38)	(5.54)	(5.47)	(6.06)	(6.51)	(6.13)
Holds stock (%)	6.40	6.33	6.94	6.31	6.12	6.27	6.38
	(2.51)	(2.54)	(2.63)	(2.49)	(2.40)	(2.45)	(2.40)
Internet use and coverage:							
User rate (%)	27.69	0.00	0.08	6.10	31.93	53.97	61.87
	(25.83)	(0.00)	(0.60)	(6.98)	(11.86)	(10.37)	(10.06)
Coverage rate (%)	61.22	0.00	10.90	39.17	85.92	97.51	99.60
	(41.51)	(0.00)	(22.68)	(30.04)	(12.18)	(4.73)	(1.09)
Control variables:							
Unemployment rate (%)	1.45	1.34	1.56	1.99	1.50	0.82	1.21
	(0.80)	(0.69)	(0.78)	(0.83)	(0.76)	(0.50)	(0.57)
Education (in years)	11.61	11.27	11.39	11.52	11.64	11.78	11.84
	(0.46)	(0.42)	(0.42)	(0.42)	(0.42)	(0.43)	(0.43)
Household income (000's)	503.14	483.10	489.62	484.43	514.31	521.88	514.83
	(42.99)	(41.70)	(38.97)	(36.12)	(39.50)	(41.73)	(40.50)
Students (%)	0.11	0.12	0.12	0.11	0.11	0.11	0.10
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)
Poverty rate (%)	0.05	0.06	0.05	0.05	0.05	0.04	0.05
	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Urban residence (%)	0.50	0.48	0.49	0.49	0.49	0.50	0.50
	(0.28)	(0.27)	(0.27)	(0.28)	(0.28)	(0.28)	(0.28)
Public sector (%)	0.27	0.26	0.27	0.26	0.26	0.27	0.29
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Services sector (%)	0.31	0.29	0.30	0.30	0.30	0.31	0.33
	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.05)	(0.04)
Private services sector (%)	0.08	0.07	0.07	0.07	0.07	0.08	0.08
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)
Distance to center (in KMs)	0.82	0.87	0.85	0.82	0.82	0.80	0.80
	(0.73)	(0.75)	(0.73)	(0.70)	(0.71)	(0.74)	(0.75)
Travel time (in minutes)	0.16	0.20	0.15	0.15	0.16	0.15	0.15
	(0.12)	(0.16)	(0.12)	(0.12)	(0.12)	(0.11)	(0.11)
Roads (in KMs)	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	4220	422	422	422	422	422	422

Table II. Equity Market Participation

Panel A shows estimates of ω and ϕ from the IV model (3)–(4) as well as δ from the reduced form model (1). The outcome variables are the equity market participation rate (Holds Any), the stock holding rate (Holds Stocks), and the fund holding rate (Holds Funds), all measured using data from the NCSD. Panel B shows estimates from three robustness tests. The first column of Panel B shows estimates from IV and reduced form models which include controls for time-varying municipality characteristics. See Internet Appendix Table IA.IV for details about the control variables. The second column of Panel B shows estimates from IV and reduced form models which include controls for time-varying municipality characteristics as well as municipality-specific linear time trends. The third column of Panel B shows estimates from the baseline IV and reduced form models using Holds Funds as measured in the DNB data as the outcome variable. All regressions are based on 422 municipalities $\times$ 10 years $= 4,220$ observations. Standard errors are clustered at the municipality level and presented in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Panel A. Main Results			Panel B. Robustness		
	Holds Any	Holds Stock	Holds Fund	Holds Any	Holds Any	Holds Funds
IV Estimate	0.0698***	-0.0062	0.0764***	0.0486***	0.0287***	0.0248**
	(0.0169)	(0.0075)	(0.0173)	(0.0152)	(0.0077)	(0.0099)
Reduced Form	0.0078***	-0.0007	0.0085***	0.0057***	0.0034***	0.0028**
	(0.0018)	(0.0008)	(0.0018)	(0.0018)	(0.0010)	(0.0011)
First Stage	0.1116***	0.1116***	0.1116***	0.1168***	0.1185***	0.1116***
	(0.0079)	(0.0079)	(0.0079)	(0.0077)	(0.0047)	(0.0079)
Controls	No	No	No	Yes	Yes	No
Muni. trends	No	No	No	No	Yes	No
DNB data	No	No	No	No	No	Yes
N	4220	4220	4220	4220	4220	4220

Table III. Trader Heterogeneity

Panel A presents subgroup-specific estimates of ω and ϕ from the IV model (3)–(4) as well as δ from the reduced form model (1). Equity market participation rates for subgroups by age, gender, and educational attainment are calculated using data from the NCSD. Broadband user rates for each of the subgroups are calculated using the survey described in Internet Appendix Section IV. In Panel A, the estimation sample includes the subset of municipality-year observations for which we observe both equity market participation and subgroup-specific broadband user rates. Panel B presents subgroup-specific estimates of δ from the reduced form model (1). In Panel B, the estimation sample includes all 4,220 municipality-year observations in the main sample. In both panels, the pre-reform equity market participation rate is measured in 2000. Standard errors are clustered at the municipality level and presented in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Panel A. IV, RF, FS Using Survey Data							
	Age bins:			Gender:		Education:		
	16-34	35-54	>54	Male	Female	Low	Medium	High
IV Estimate	0.0597***	0.0630**	0.0581**	0.0610***	0.0267**	0.0169**	0.0807**	0.0643
	(0.0215)	(0.0287)	(0.0276)	(0.0224)	(0.0110)	(0.0075)	(0.0382)	(0.0627)
Reduced Form	0.0134***	0.0130***	0.0122***	0.0125***	0.0061***	0.0056**	0.0124***	0.0062
	(0.0037)	(0.0048)	(0.0032)	(0.0031)	(0.0021)	(0.0024)	(0.0037)	(0.0041)
First Stage	0.2247***	0.2063***	0.2101***	0.2046***	0.2282***	0.3300***	0.1542***	0.0957
	(0.0589)	(0.0606)	(0.0776)	(0.0509)	(0.0574)	(0.0699)	(0.0579)	(0.0714)
N	1731	1926	1209	2144	1987	1491	1975	1421
Pre-reform mean	0.1005	0.1858	0.1706	0.1544	0.0905	0.0561	0.1853	0.2377
	Panel B. RF Using Full Data							
	Age bins:			Gender:		Education:		
	16-34	35-54	>54	Male	Female	Low	Medium	High
Reduced Form	0.0116***	0.0144***	0.0041**	0.0091***	0.0064***	0.0061***	0.0122***	0.0060**
	(0.0030)	(0.0033)	(0.0019)	(0.0021)	(0.0016)	(0.0015)	(0.0028)	(0.0026)
N	4220	4220	4220	4220	4220	4220	4220	4220
Pre-reform mean	0.1005	0.1858	0.1706	0.1544	0.0905	0.0561	0.1853	0.2377

Table IV. Effects for Existing Investors

This table presents estimates of δ from the reduced form model (1). In the first four columns of Panel A, the outcomes are the fractions of existing investors — that is, investors with positive stock or fund holdings in the previous calendar year — that buy or sell equity funds or stocks in a given municipality-year. In the fifth column of Panel A, the outcome is the average fraction of existing investors' portfolios that is invested in stocks as opposed to equity funds. In Panel B, the outcomes are the return loss (RLoss), risky asset weight (RWeight), standard deviation of risky assets (SD), relative Sharpe ratio loss (RSRL), Sharpe ratio (SRatio), and idiosyncratic risk share (IdioShare) of existing investors' portfolios, calculated following Calvet et al. (2007). Regressions are based on 422 municipalities $\times$ 10 years $= 4,220$ observations. Standard errors are clustered at the municipality level and presented in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Panel A. Trading Activity

	Funds		Stocks		
	Buy	Sell	Buy	Sell	Stock Share
Reduced Form	0.0068*	0.0004	-0.0013	-0.0030	-0.0308***
	(0.0040)	(0.0005)	(0.0026)	(0.0028)	(0.0089)
N	4220	4220	4220	4220	4220

Panel B. Portfolio Efficiency

	RLoss	RWeight	SD	RSRL	SRatio	IdioShare
Reduced Form	-0.0034***	-0.0187***	-0.0419	-0.0057***	0.0025***	-0.0031**
	(0.0008)	(0.0038)	(0.0284)	(0.0021)	(0.0009)	(0.0015)
N	4220	4220	4220	4220	4220	4220

X. Figures

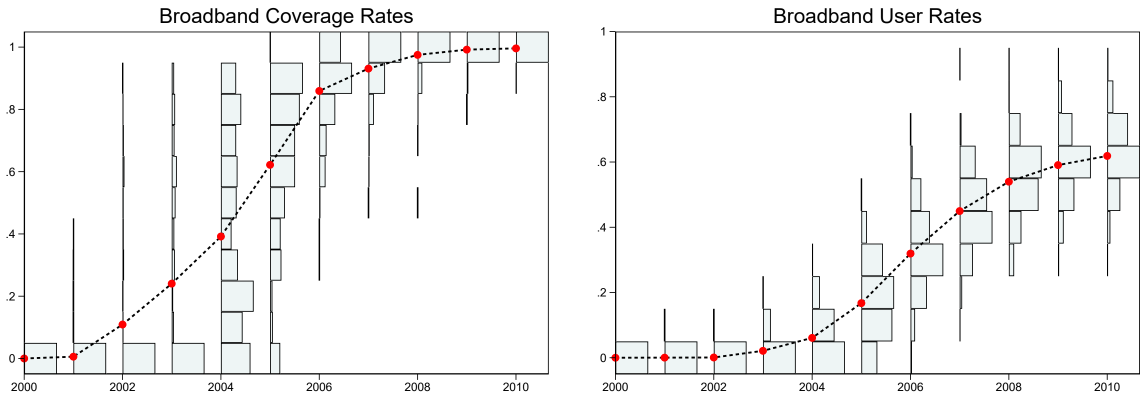


Figure 1. Broadband coverage and user rates, 2000–2010. This figure shows the overall mean and distribution of broadband coverage rates (Panel A) and user rates (Panel B) across municipalities for each year during the period 2000–2010.

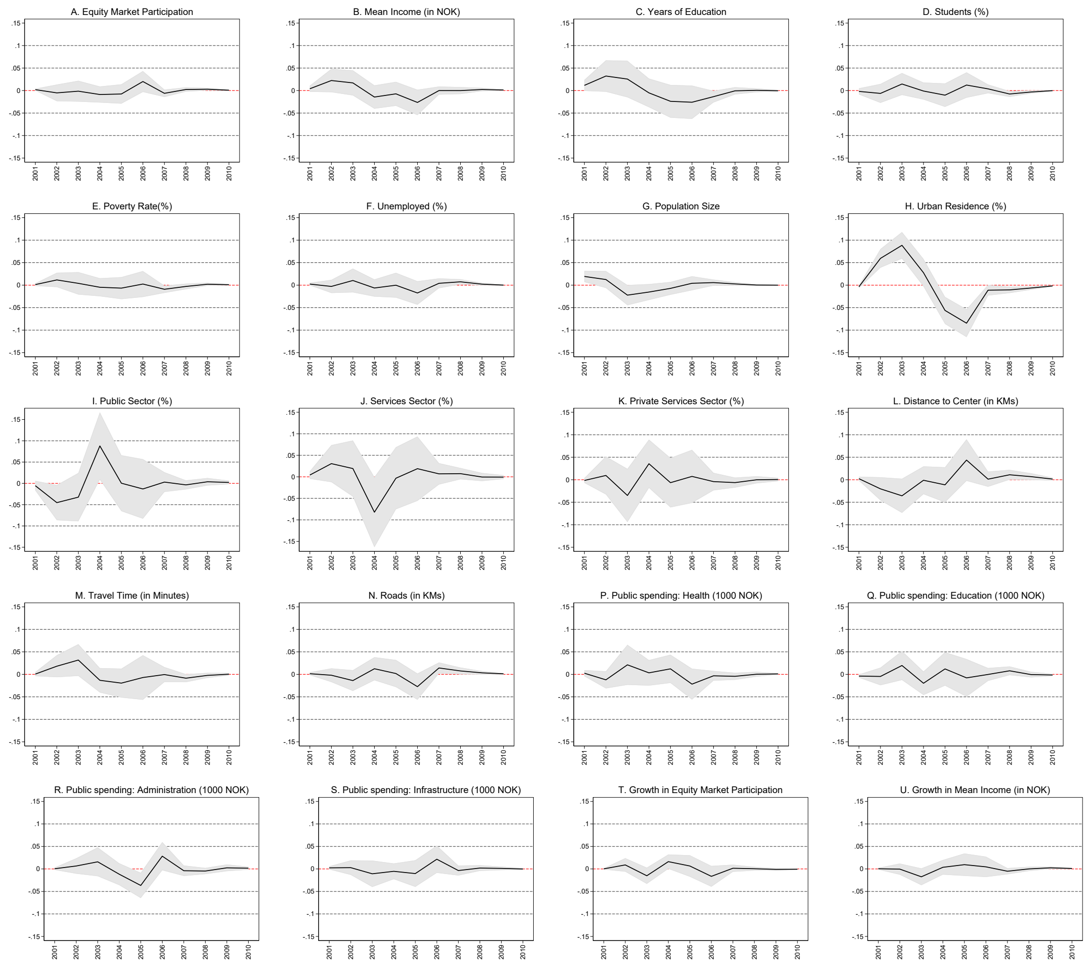
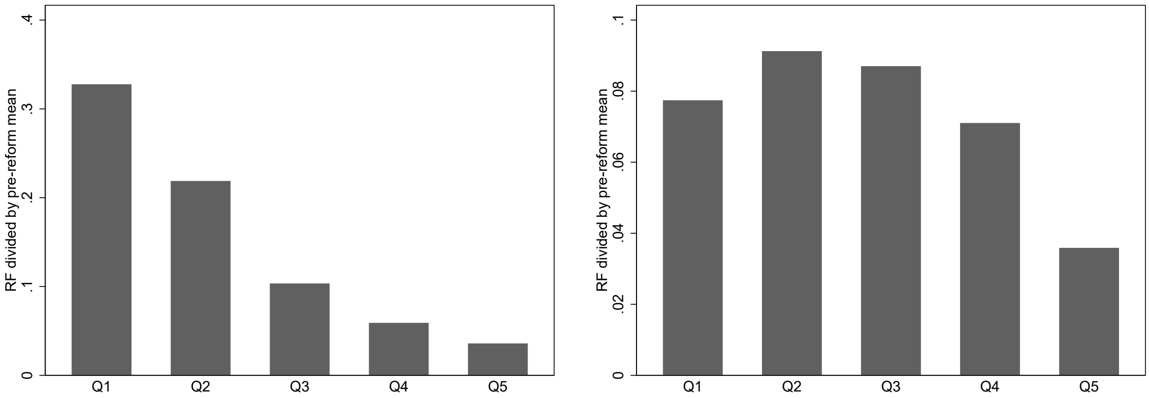


Figure 2. Timing of broadband roll-out and baseline covariates. This figure shows calendar year-specific estimates of β (along with the associated 95 percent confidence intervals) from equation (2), a regression of the change in municipality-level broadband coverage rates, Δz_{kt}, on baseline municipality characteristics, as measured in the pre-reform year 2000. For comparability across panels, all baseline municipality characteristics have been scaled by their respective standard deviation. Internet Appendix Section II provides an overview of the variable definitions.



Panel A. Effects by wealth

Panel B. Effects by income

Figure 3. Effects on stock market participation, by wealth and income. This figure shows reduced form effects of broadband coverage on equity market participation rates. For each year, we first rank each individual into quintiles based on their wealth (Panel A) or income (Panel B) in the previous year. Individuals in Q1 have the lowest wealth or income, individuals in Q5 have the highest. We then calculate the equity market participation rate within each quintile. Finally, we estimate the reduced form coefficient δ from equation (4) for each quintile, using the respective quintile's equity market participation rate as the outcome variable. The quintile-specific estimates of δ are scaled by the quintile's pre-reform stock market participation rate. Internet Appendix Tables IA.XV–IA.XVI present the unscaled regression coefficients along with the corresponding confidence intervals.

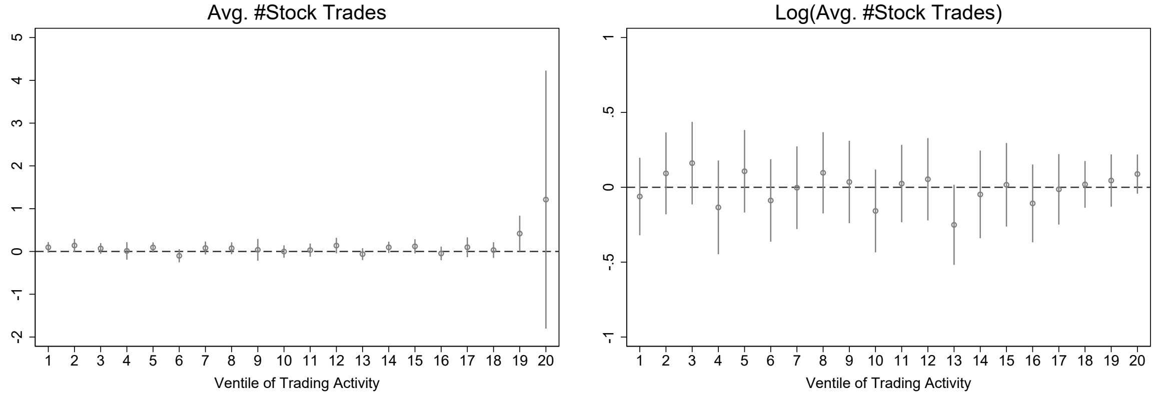
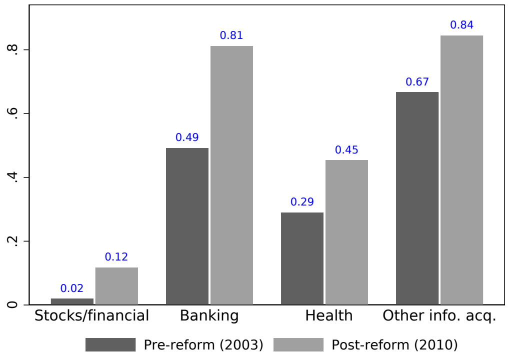
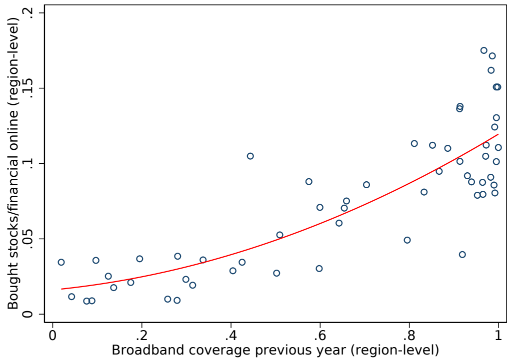


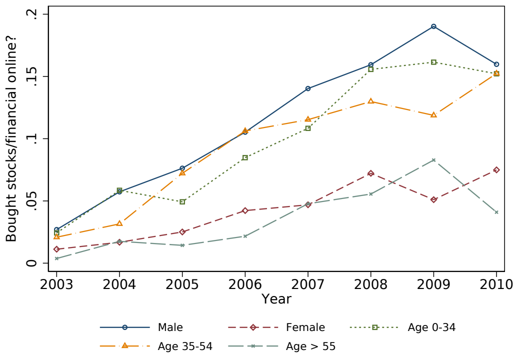
Figure 4. Effects on stock trading, by past trading activity. This figure shows reduced form effects of broadband coverage on the trading activity of existing investors, along with the associated 95 percent confidence intervals. For each year, we first rank each existing investor into 20 ventiles based on the number of trades in the previous year (individuals without stock or fund holdings in the previous calendar year are excluded from the sample). We then calculate the mean number of stock trades (the outcome in Panel A) and the log of the mean number of stock trades (the outcome in Panel B) within each ventile-municipality-year observation. Finally, we estimate the reduced form coefficient δ from equation (4) twenty times, each time using a different ventile's mean number of stock trades or log mean number of stock trades as the outcome variable.



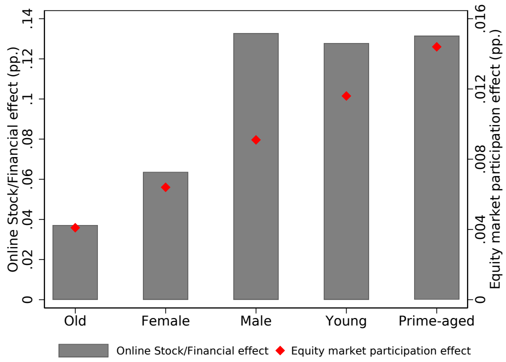
Panel A. Internet activities



Panel B. Online stock/financial over coverage



Panel C. Online stock/financial over time



Panel D. Effects in survey and register data

Figure 5. Survey evidence. This figure presents summary statistics from a yearly survey on how individuals interact with the internet. Internet Appendix Section V provides more details on the survey. For the years 2003 (first survey wave) and 2010 (post-reform), Panel A presents the share of respondents answering "Yes" to whether they have recently used the internet for the purposes of purchasing stocks or financial services, online banking, searching for information about health, or for other forms of information acquisition and learning ("Other info. acq."). "Other info. acq." equals one if the respondent has recently searched the internet for information about goods, services, health, travel and accommodation, the labor market, or have taken an online course (in any subject). For all years 2003–2010, Panel B plots the share of respondents in a given geographical region that report having purchased stocks or financial services online against the previous year's broadband coverage in the respondent's region. There are 7 geographical regions $\times$ 8 years = 64 observations in Panel B. For all years 2003–2010, and separately by sex and age, Panel C plots the share of respondents that report having purchased stocks or financial services online. Finally, Panel D shows the absolute change from 2003 to 2010 in the share of respondents that report having purchased stocks or financial services online (from Panel C) as well as the subgroup-specific reduced form effect δ of broadband coverage on equity market participation rates (from Table III).

Internet Appendix for "Broadband Internet and the Stock Market Investments of Individual Investors"

Hans K. Hvide, Tom G. Meling, Magne Mogstad, and Ola Vestad

This document provides supplementary material for the article "Broadband Internet and the Stock Market Investments of Individual Investors".

I. International Comparisons

In the main text, we study the effects of broadband internet use on stock market participation using a reform in Norway that progressively rolled out broadband coverage throughout the country. In this appendix, we describe broadband use across the world (Appendix I.A) and in the United States (Appendix I.B), provide cross-country analyses of the relationship between broadband use and stock market participation (Appendix I.C), and provide an overview of international broadband reforms (Appendix I.D).

A. Broadband use around the world

Our international data on broadband subscription rates come from the International Telecommunication Union (ITU). In Figure IA.1, we present time-series of broadband subscription rates from 2000–2017 for select countries.[31] Following its broadband coverage expansion between 2001–2010, Norway quickly increased its broadband subscription rate from 0 in 2000 to about 35 per 100 capita in 2010, at the time the highest subscription rate among the sampled countries. Other high-income countries have since caught up, with France, Norway, Germany, Canada, and the U.K. by 2017 having the highest subscription rates — all in the range 30 to 45 broadband subscriptions per 100 capita — followed by the United States at about 30 subscriptions per 100 capita. Among lower-income countries broadband use remains low throughout the period 2000–2017. For example, in 2014, China, India, and Mexico all had fewer than 15 subscriptions per 100 capita. By 2017,

[31]The data are collected from publicly available reports prepared by ITU. Note that the ITU user rates are not directly comparable to those presented in the main text for Norway. The ITU figures are constructed as the number of broadband subscriptions per 100 inhabitants in each country-year, regardless of how many users are connected to each subscription. The Norwegian data, by contrast, are constructed as the share of households that use broadband internet, taking into account that several persons within the same households may be using the same broadband subscription.

China's subscription rate had increased to 25 per 100 capita.

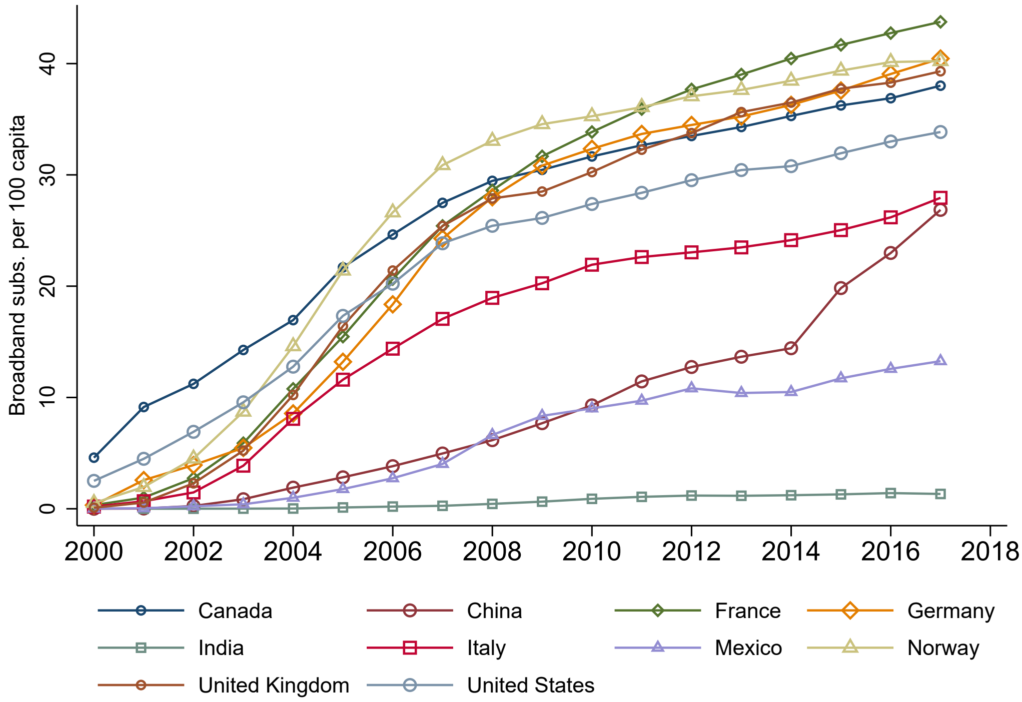


Figure IA.1. Broadband subscription rates by country. This figure presents for ten countries the yearly number of broadband internet subscriptions per 100 inhabitants in the period 2000–2017. The data are collected from public reports by the ITU. Note that the ITU user rates are not directly comparable to those presented in the main text for Norway. The ITU figures are constructed as the number of broadband subscriptions per 100 inhabitants in each country-year, regardless of how many users are connected to each subscription. The Norwegian data, by contrast, are constructed as the share of households that are covered by or use broadband internet, taking into account that several persons within the same households may be using the same broadband subscription.

B. Broadband coverage and use in the United States

To provide a closer look at broadband coverage and use in the United States, we use data from the Federal Communications Commission (FCC). We collected yearly broadband coverage and user rates from publicly available FCC reports.[32] Unlike the ITU

[32]See https://www.fcc.gov/reports-research/reports/broadband-progress-reports. The Commission regulates interstate and international communications by radio, television, wire, satellite, and cable in

broadband use data analyzed in Internet Appendix Section I.A, which give the total number of broadband subscriptions divided by the total number of residents, the FCC reports an "adoption rate" as the total number residential connections to fixed broadband at a given speed divided by the total number of households in the area with access to advertised broadband service at that speed (i.e., the coverage rate). In Table IA.I, we find that in urban US areas, broadband coverage rates were close to 100% throughout the entire period 2010–2018. In rural areas, by contrast, coverage rates were significantly lower — starting at around 70% and only increasing to about 90% by 2018. Broadband user ("adoption") rates are also considerably lower in rural than urban areas, with user rates in 2018 at 67.4% and 78.1% respectively. Table IA.I suggests that there is scope to increase broadband coverage and use in the United States.

Table IA.I. Broadband in the United States

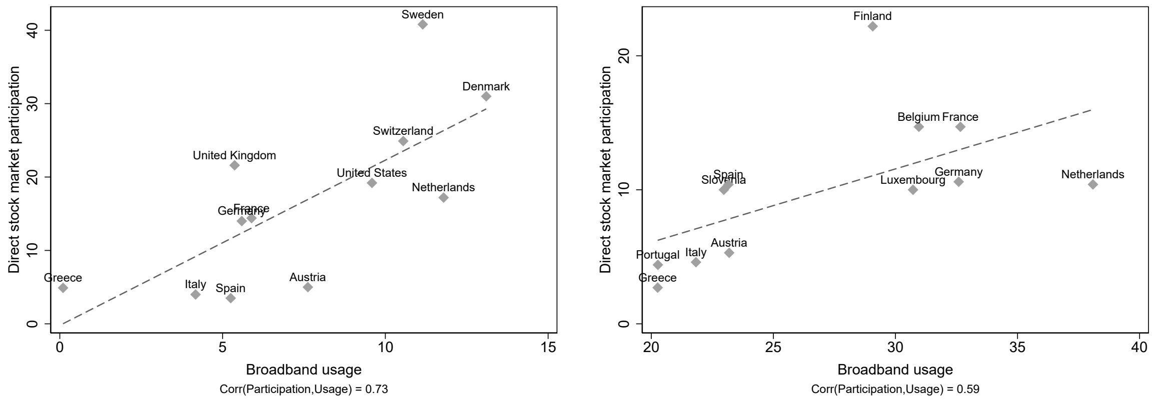
This table presents yearly broadband coverage and user rates in the United States from 2010 to 2018. The broadband coverage and user rates are calculated separately for All Americans, Urban Americans, and Rural Americans. The coverage rate is defined as the total number of households in an area with access to advertised broadband service at a given broadband speed. The user rate is defined as the total number of residential connections to fixed broadband area at a given broadband speed divided by the coverage rate. Mbps is the minimum broadband speed required to be defined as having broadband coverage or use. Observe that the speed requirement has been increased during the sample period. The data are collected from reports by the Federal Communications Commission.

	Coverage rates				**User rates**		
Year	All	Urban	Rural	Mbps	All	Urban	Rural
2010	91.6	97	71.8	3	33.6		18.9
2011	95	99	79	3		45	37
2012	96	99	81	3		55	47
2013	96	99	80	3	62	65	57
2014	93.7	98.2	75.1	10	56	60.7	49.7
2015	94.3	98.4	77.7	10	62.2	67	55.8
2016	95.8	98.9	83.3	10	66.3	71	60.3
2017	96.9	99.1	88.1	10	69.7	74.7	63.4
2018	97.4	99.1	90.6	10	73.3	78.1	67.4

all 50 states, the District of Columbia and U.S. territories. The FCC is the federal agency responsible for implementing and enforcing communications law and regulations in America.

C. Broadband use and stock market participation

Sections I.A–I.B show significant variation in broadband user rates across countries. Here, we relate the country-level variation in broadband user rates to country-level variation in stock market participation. In Figure IA.2, we plot stock market participation rates over broadband user rates for twelve OECD countries. Stock market participation rates come from Guiso et al. (2008) (Panel A) or the ECB (2013) (Panel B). In both panels, we find a strong positive relationship between broadband use and stock market participation. The correlations are 0.73 and 0.59 when using the Guiso et al. (2008) and ECB (2013) data, respectively. The IV estimates of our paper suggest that the positive relationship between broadband use and stock market participation may be causal.



Panel A. Guiso et al. (2008) stock data

Panel B. ECB (2013) stock data

Figure IA.2. Cross-country stock market participation and broadband use. Panel A plots for 12 countries the stock market participation rate over the broadband user rate, where stock market participation rates are collected from Guiso et al. (2008) and are measured in 2003. Panel B plots for 12 countries the stock market participation rate over the broadband user rate, where stock market participation rates are collected from the ECB (2013) and are measured in 2010. Guiso et al. (2008) measure stock market participation as the share of households that have direct investments in either listed and unlisted stocks. The ECB (2013) measures stock market participation as the share of households that have direct investments in listed stocks (see the column labeled "Shares (Publicly Traded)" in Table 2.4 in ECB (2013)). In both panels, broadband user rates are measured in the same year as the stock market participation rates and are collected from publicly available reports prepared by the OECD, see https://www.oecd.org/sti/broadband/broadband-statistics/ for details. The OECD broadband user rate is defined as the number of broadband subscriptions per 100 capita.

D. International broadband policy changes

Sections I.A–I.B show that several countries around the world, including the United States, have yet to reach universal broadband coverage and use. Table IA.II provides an overview of recent or planned reforms to broadband infrastructure in select countries. The overview is based on information from the International Telecommunication Union (ITU). Several countries are planning to expand their coverage or improve their broadband speed in the near future, the table shows. For example, in May 2022, the Biden administration committed to reducing the cost of high-speed internet for low-income families in the United States (White House (2022)); a policy start date has not been set.

Table IA.II. International Broadband Policy Changes

Data collected from "Broadband Situations in Rural and Remote Areas" by the ITU, Table 4.2. For countries with several policy changes reported in the ITU overview, we pick the policy with the highest target speed. The policy year is the year in which a given policy was officially adopted; the target year is the year in which the country in question is expected to reach the target coverage rate of the target broadband speed. The policy changes in this table may reflect updates to existing broadband infrastructure; the policy years do not necessarily indicate the country's first broadband reform.

Country	Policy year	Target speed	Target coverage	Target year
Austria	2012	100Mbps	99%	2020
Brazil	2010	1Mbps	70%	2014
Canada	2014	5Mbps	-	2019
China	2013	12Mbps	-	2022
Denmark	2013	100Mbps	100%	2020
EU	2010	30Mbps	100%	2020
France	2011	100Mbps	100%	2022
Germany	2009	50Mbps	75%	2014
India	2012	2Mbps	100%	2015
Japan	2010	100Mbps	100%	2015
Saudi Arabia	2006	512kbps	100%	2013
South Africa	2013	100Mbps	100%	2030
United Kingdom	2010	2Mbps	100%	2015
United States	2010	100Mbps	85%	2020

II. Variable Construction

In this appendix, we provide additional details on both outcome variables and the control variables used in Table II of the main text. In the top panel of Table IA.III, we define the stock market participation, and internet use and coverage rate variables. In the bottom two panels, we define the control variables used in Panel B of Table II. In Table IA.IV, we present summary statistics of the municipality-level control variables. Variables that are defined in Table IA.III but not summarized in Table IA.IV, including unemployment rates, education, and income, are summarized in Table I.

Table IA.III. Variable Definitions

Variable	Description
Equity market variables	
Holds Any	Share of households residing in a given municipality at the end of year t, who hold stocks or equity funds. Growth in Holds Any, considered in Figure 2 of the main text, is defined as the change in Holds Any from 1999 to 2000.
Holds Funds	Share of households residing in a given municipality at the end of year t, who hold equity funds.
Holds Stocks	Share of households residing in a given municipality at the end of year t, who hold stocks.
Internet variables	
User rate t	Share of households residing in a given municipality at the beginning of year t, who are subscribing to broadband internet (with access speed at or above 256 kilobits per second).
Coverage rate t	Share of households residing in a given municipality at the beginning of year t, who can have access to broadband internet (with access speed at or above 256 kilobits per second).
Covariates of equity market participation and portfolio selection	
Demographic factors	
Urbanization	Percentage share of the population in a given municipality residing in a densely populated locality at the beginning of year t.
Immigrants	Percentage shares of the immigrant and non-western immigrant populations residing in a given municipality belonging to the age-groups 16–21, 22–24, 25–34, 35–44, 45–54, 55–66, and 67 or above at the beginning of year t.
Females	Percentage shares of the female population residing in a given municipality belonging to the age-groups 16–21, 22–24, 25–34, 35–44, 45–54, 55–66, and 67 or above at the beginning of year t.
Age groups	Percentage shares of the population residing in a given municipality belonging to the age-groups 16–21, 22–24, 25–34, 35–44, 45–54, 55–66, and 67 or above at the beginning of year t.
Students	Percentage share of the population aged 16 and above residing in a given municipality that is registered as students at the beginning of October each year t.
Divorced	Percentage share of the population aged 16 and above residing in a given municipality that is registered as divorced or separated at beginning of year t.
College or university	Dummy variable set equal to one if there is a registered college or university located in the municipality in year t.
Socioeconomic factors	
Income	Average after-tax disposable income earned during year t by individuals aged 16–59 years residing in a given municipality. Growth in Income, considered in Figure 2 of the main text, is defined as the proportional change in Income from 1999 to 2000.
Poverty	Percentage share of population having income during year t below half of the median equivalent after-tax income in a given municipality, when the equivalent income is calculated using the OECD equivalence scale.
Unemployment	Percentage share of the population aged 16–59 residing in a given municipality that is registered as fully unemployed at beginning of year t.
Welfare dependency	Percentage share of the population aged 16–59 residing in a given municipality that is registered as recipients of social economic assistance at beginning of year t.
Education	Average years of schooling in the age-group 16–59 residing in a given municipality at the beginning of year t.
Covariates of broadband	
Industry composition	
Services	Percentage share of the population aged 16–59 employed in the services sector at the beginning of year t.
Services, private	Percentage share of the population aged 16–59 employed in the private services sector at the beginning of year t.
Public sector	Percentage share of the population aged 16–59 employed in the public sector at the beginning of year t.
Public services provision	
Total spending	Per capita spending on municipal public services in year t (in NOK).
Administration	Per capita spending on municipal administration in year t (in NOK).
Education	Per capita spending on municipal schools and other educational institutions in year t (in NOK).
Health services	Per capita spending on municipal health care services in year t (in NOK).
Supply factors	
Travel time	Average travel time in minutes to municipal center at the beginning of year t.
Distance	Distance in kilometers to municipal sub-center at the beginning of year t.
Road networks	Distance in kilometers covered by municipal roads at the beginning of year t.
Infrastructure	Per capita spending on municipal infrastructural maintenance (incl. roads, pipes and tunnels) in year t (in NOK).

Table IA.IV. Summary Statistics

This table shows means of time-varying municipality characteristics over the time period 2000–2010. The variables are defined in Table IA.III. Variables defined in Table IA.III but not summarized below are summarized in Table I.

	Overall	2000	2002	2004	2006	2008	2010
Pop. aged 16–21	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Pop. aged 22–24	0.03	0.04	0.04	0.04	0.03	0.03	0.04
Pop. aged 25–34	0.11	0.13	0.12	0.12	0.11	0.10	0.10
Pop. aged 35–44	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Pop. aged 45–54	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Pop. aged 55–66	0.14	0.12	0.13	0.14	0.15	0.15	0.16
Pop. aged 67–	0.23	0.16	0.19	0.21	0.23	0.26	0.28
Immigrant pop. aged 16–21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Immigrant pop. aged 22–24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Immigrant pop. aged 25–34	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Immigrant pop. aged 35–44	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Immigrant pop. aged 45–54	0.01	0.00	0.01	0.01	0.01	0.01	0.01
Immigrant pop. aged 55–66	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Immigrant pop. aged 67–	0.01	0.00	0.00	0.00	0.01	0.01	0.01
Non-western immigrant pop. aged 16–21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-western immigrant pop. aged 22–24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-western immigrant pop. aged 25–34	0.01	0.00	0.00	0.01	0.01	0.01	0.01
Non-western immigrant pop. aged 35–44	0.01	0.00	0.00	0.00	0.01	0.01	0.01
Non-western immigrant pop. aged 45–54	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Non-western immigrant pop. aged 55–66	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Non-western immigrant pop. aged 67–	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Female pop. aged 16–21	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Female pop. aged 22–24	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Female pop. aged 25–34	0.05	0.06	0.06	0.06	0.05	0.05	0.05
Female pop. aged 35–44	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Female pop. aged 45–54	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Female pop. aged 55–66	0.07	0.06	0.06	0.07	0.07	0.07	0.08
Female pop. aged 67–	0.12	0.09	0.10	0.11	0.13	0.14	0.15
Disability	0.02	0.02	0.02	0.02	0.02	0.02	0.01
Welfare	0.01	0.01	0.02	0.02	0.02	0.01	0.01
Divorced	0.08	0.08	0.08	0.08	0.08	0.08	0.08
College or university	0.11	0.12	0.12	0.11	0.10	0.10	0.14
Public spending: Total	55.76	50.64	50.44	51.54	53.71	56.43	79.18
Public spending: Administration	5.89	4.12	5.06	5.68	5.64	6.01	6.91
Public spending: Education	14.12	13.35	12.76	12.74	12.96	12.89	25.58
Public spending: Infrastructure	6.61	7.06	7.02	6.85	7.05	7.30	2.32
Public spending: Health	19.96	18.72	17.98	18.20	19.12	20.37	30.38

III. Fund Data From DNB

In the main text, we use stock and fund transactions data from the Norwegian Central Securities Depository (NCSD) to calculate holding rates at the municipality-year level. While the stock transactions data from the NCSD are exhaustive for trades on the Oslo Stock Exchange, the fund transactions data from the NCSD only cover about 25% of all Norwegian fund customer relationships. For this reason, we supplement the NCSD fund data with data obtained directly from DNB, the largest Norwegian bank and the main equity fund provider among the institutions that do not record their transactions through the NCSD. Here, we provide details on the fund transactions data from DNB.

A. About the DNB data

The fund transactions data from DNB cover all individuals who traded equity funds through DNB at least once in the period 2000–2010 and contain detailed information on all transactions in funds traded through DNB in the same period, with unique identifiers for both the individual traders and the funds. The data contain more than 14 million transactions by 941,068 unique individuals. For each transaction, we observe the price, the date of the transaction, and the type of transaction (buy/sell). For each of the 130 funds, we observe the type of fund (equity fund, bond fund, or mixed fund) and its risk classification (seven categories). In addition to the fund and transaction level information, we also observe each trader's municipality of residence, age (in bins), and sex.

B. Summary statistics

Table IA.V presents summary statistics from the DNB funds data, after aggregating the data from the transaction level to the investor-year level. We restrict attention to investor-years with at least one fund trade. In a given year, there are between 150,000 and 270,000 unique investors with at least one fund trade. Around half of the investors are male. Most investors are old (60+) or prime-aged (40–60) and, in a typical year, less than 20% are young (20–40). Both the age and the sex compositions are fairly stable across years. The yearly trade value (not inflation-adjusted) varies between NOK 38,000 and 83,000, or about $4,750–$10,375, spread out across an average of 4 to 7 transactions. Trading activity measured in the number of transactions is highest in the years leading up to the financial crisis in 2007; the lowest recorded mean number of trades, at 3.89, is in 2008, down from a high of 7.43 in 2007.

Table IA.V. Overview of DNB Data

This table shows summary statistics from the DNB funds data. The underlying data are at the investor-year level and, for the purposes of this table, we only keep investor-years with at least one fund trade. The four leftmost columns show the shares of DNB investors in a given year that are male, young (20–40), prime-aged (40–60), or old (60+). (The DNB data only provide investors' ages in ten-year bins.) The next three columns show investors' mean yearly trading value and their yearly number of trades, as well as the total number of unique investors with at least one trade in a given year.

	Male	Young	Prime	Old	Value	#Trades	#Investors
2000	0.49	0.11	0.31	0.57	38716.39	4.89	151011
2001	0.47	0.14	0.34	0.51	39789.83	5.75	230486
2002	0.47	0.14	0.32	0.53	36718.87	6.13	241325
2003	0.46	0.15	0.33	0.50	42521.45	6.32	207490
2004	0.48	0.15	0.33	0.50	41195.17	6.18	240924
2005	0.48	0.15	0.32	0.50	89251.92	6.58	268749
2006	0.48	0.17	0.32	0.44	79326.59	7.40	271193
2007	0.48	0.18	0.32	0.43	64342.67	7.43	286876
2008	0.49	0.18	0.32	0.43	83791.17	3.89	206612
2009	0.50	0.20	0.34	0.37	51840.49	4.47	140551
2010	0.50	0.20	0.34	0.37	57128.68	4.44	150973

IV. Media Use Survey

In the main text, we use an instrumental variable model to explore the effects of broadband internet use on equity market participation and find that broadband use increases equity market participation. In additional analyses, we use data from the Media Use Survey to estimate heterogeneous effects for subgroups by age, sex, and education. Here, we provide additional details on the Media Use Survey.

A. *About the Media Use Survey*

Since 1991, Statistics Norway has conducted annual surveys on individuals' access to and consumption of media. The surveys are cross-sectional, with representative samples of about 2,000-3,000 individuals drawn from the population aged 9-79. Respondents are interviewed about a wide array of topics related to their access to and consumption of media, including questions on whether the individual had access to dial-up or broadband internet. We received anonymized extracts from these survey data sets for the years 2000–2010, with information on the respondents' age, sex, educational attainment, and municipality of residence. Following Bhuller et al. (2013), we exclude respondents that report not having a PC installed in their home and thus focus on broadband adoption among individuals that actually have the means to adopt broadband. We also exclude individuals that are younger than 16 in the survey year.

B. *Summary statistics*

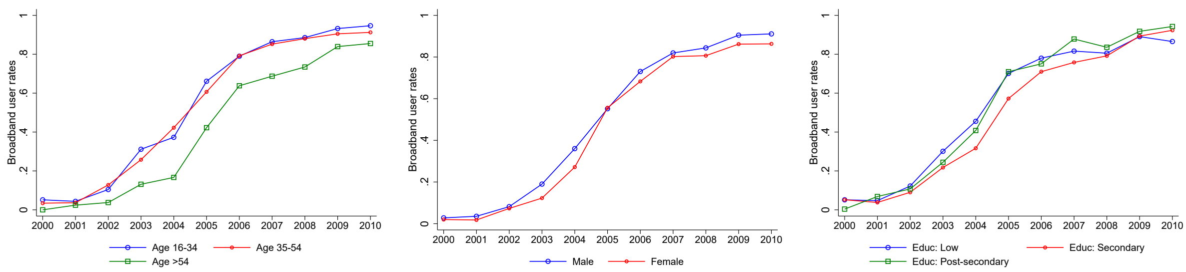
Table IA.VI provides summary statistics from the Media Use Survey. After excluding respondents that do not have access to a computer, we are left with between 1,150 and 1,500 respondents each year between 2000 and 2010. In a typical year, 50 percent of the respondents are male. Across all respondents, 35-40 percent are young (16–34 years), 40 percent prime-aged (35–54 years), and 20-25 percent are old (> 55 years). About 25 percent of the respondents are low-educated (≤10 years), 35 are high-educated (>13 years), and the remaining 40% have completed between 11 and 13 years of education (medium-educated). Over time, the average respondent becomes slightly older while the sex and education compositions remain fairly stable.

Figure IA.3 summarizes broadband user rates by age, sex, and education. Over the broadband reform period 2000–2010, broadband user rates increase sharply across all subgroups. Older individuals seem to adopt broadband internet at a somewhat slower pace than younger individuals.

Table IA.VI. Overview of Media Use Survey

This table shows summary statistics from the Media Use Survey. The first seven columns show the shares of respondents in a given year that are male, young, prime-aged, old, or have low, medium, or high education. The rightmost column reports the number of respondents in a given survey wave.

	Male	Young	Prime	Old	Low Educ	Med Educ	High Educ	*N*
2000	0.524	0.416	0.457	0.127	0.275	0.357	0.368	1173
2001	0.520	0.405	0.457	0.139	0.259	0.404	0.338	1191
2002	0.520	0.415	0.424	0.161	0.257	0.415	0.328	1236
2003	0.520	0.410	0.423	0.167	0.250	0.419	0.331	1211
2004	0.515	0.422	0.407	0.171	0.221	0.431	0.348	1240
2005	0.506	0.408	0.409	0.183	0.237	0.405	0.358	1327
2006	0.527	0.384	0.411	0.205	0.252	0.388	0.360	1371
2007	0.510	0.368	0.408	0.224	0.208	0.442	0.350	1362
2008	0.501	0.333	0.437	0.230	0.212	0.425	0.363	1395
2009	0.523	0.355	0.399	0.246	0.221	0.398	0.381	1437
2010	0.508	0.341	0.394	0.265	0.185	0.429	0.386	1481



Panel A. Age   Panel B. Sex   Panel C. Education

Figure IA.3. Subgroup-specific broadband user rates. This figure presents evidence on subgroup heterogeneity in broadband internet user rates over the sample period 2000–2010. Subgroup-specific user rates are calculated using the Media Use Survey described in Internet Appendix Section IV. Panel A plots broadband user rates for three age bins. Panel B plots broadband user rates separately for males and females. Panel C plots broadband user rates for three education groups.

V. ICT Usage by Households Survey

In the main text, we show that broadband internet use increases individuals' equity market participation. To inform this finding, we use data from the ICT Usage Survey, which provides details about how households interacted with the internet during the broadband reform period, 2000–2010. Here, we provide more details on the Survey.

A. About the ICT Usage Survey

Since 2003, Statistics Norway has conducted annual surveys on individuals' access to and use of information and communications technology (ICT). The surveys are cross-sectional, with representative samples of more than 1,000 individuals drawn from the population aged 16-79. Respondents are interviewed about a wide array of topics related to their access to and use of ICT, including questions on whether the individual has used internet and broadband for particular purposes such as online banking and stock trading. We received anonymized extracts from the ICT Usage Survey data sets for the years 2003 to 2010, with information on the respondents' age, sex, and educational attainment.

B. Summary statistics

Table IA.VII provides summary statistics from the ICT Survey. There are between 1,150 and 1,250 responses each year between 2003 and 2010. In a typical year, 50% of the respondents are male. Across all respondents, about 30-35% are young (16–34 years), 40% are prime-aged (35–54 years), and 25% are old ($>$ 55 years). Over time, the respondents become slightly older on average while the share of males stays fairly stable across the full period 2003–2010.

Table IA.VII. Overview of ICT Usage Survey

This table shows summary statistics from the ICT Usage Survey. The first four columns show the shares of respondents in a given year that are male, young (16–34), prime-aged (35–54 years), and old (>54 years). The rightmost column gives the number of respondents in a given year.

	Male	Young	Prime	Old	N
2000	0.488	0.372	0.394	0.219	1216
2003	0.488	0.372	0.394	0.219	1216
2004	0.499	0.345	0.400	0.240	1188
2005	0.497	0.359	0.396	0.235	1188
2006	0.525	0.336	0.378	0.270	1195
2007	0.507	0.298	0.394	0.294	1210
2008	0.493	0.298	0.412	0.273	1120
2009	0.494	0.277	0.413	0.291	1161
2010	0.500	0.272	0.414	0.289	1014

C. Survey questions: Online stock/financial purchases

In Figure 5 of the main text, we summarize a variable Stock/financial$_{it}$ to gauge the extent to which respondents to the ICT Usage Survey used the internet to purchase stocks and/or financial services before, during, and after the Norwegian broadband reform period. Here, we detail how Stock/financial$_{it}$ is constructed. For respondent i in survey wave t, Stock/financial$_{it}$ equals one if for the question *"What types of goods or services did you buy or order over the Internet for private use in the last 12 months? Tick all that apply."* the box

– Share purchases, insurance policies and other financial services,

is ticked. Stock/financial$_{it}$ equals zero for respondents that do not tick this box. In Figure 5 of the main text, we summarize the mean of Stock/financial$_{it}$ for each survey wave over the period 2003–2010. The exact wording of the question above is taken from the 2010 survey wave. Note that the wording is slightly different in the 2003 survey wave compared to the later waves, 2004–2010. In 2003, respondents are asked whether they have *ever* purchased stocks or financial services online while in the 2004–2010 waves, respondents are asked whether they have done so in the past 12 months. As a result, in

Figure 5 of the main text, we are likely to underestimate the increase in $\text{Stock/financial}_{it}$ from before (2003) to after (2010) the broadband reform.

D. Survey questions: Online information acquisition and learning

In Figure 5 of the main text, we also summarize three variables Health_{it}, $\text{OnlineBanking}_{it}$ and OtherInfoAcq_{it} to gauge the extent to which, respectively, respondents to the ICT Usage Survey used the internet to search for information about health, for online banking, or to engage in other forms of online information acquisition and learning before, during, and after the Norwegian broadband reform. Here, we detail how these three variables are constructed. For respondent i in survey wave t, we focus on the question *"For which of the following activities did you use the Internet in the last 3 months for private purpose? Tick all that apply."* and check whether any of the following boxes are ticked (our variable names are in parentheses):

– Finding information about goods or services ($\text{Goods/Services}_{it}$).

– Using services related to travel and accommodation (Travel_{it}).

– Looking for a job or sending a job application (JobMarket_{it}).

– Doing an online course in any subject (Education_{it}).

– Internet banking.

– Seeking health-related information (e.g., injury, disease, nutrition, improving health).

Constructing our variables, we set Health_{it} equal to one if the final box is ticked, and zero otherwise, $\text{OnlineBanking}_{it}$ is set equal to one if the second to last box is ticked, and zero otherwise, and finally, OtherInfoAcq_{it} is set equal to one if any of the first four boxes are ticked, and zero otherwise. In Panel A, Figure 5 of the main text, we summarize the means of Health_{it}, $\text{OnlineBanking}_{it}$ and OtherInfoAcq_{it} before (2003) and after (2010) the broadband reform. Note that the exact wording of the questions above comes from the 2010 survey wave. The 2003 survey asked three separate questions about online education: whether the respondents have taken i) formal education online, ii) continuing education online, or iii) other courses online related to job opportunities. In 2003, we set Education_{it} equal to one if the subject answers "Yes" to either of these questions. In 2010, we set Education_{it} equal to one if the respondents answers "Yes" to "Doing an online course in any subject." The results in Panel A, Figure 5 of the main text are robust to omitting Education_{it} from the definition of OtherInfoAcq_{it}.[33]

[33]The share of respondents with $\text{Education}_{it} = 1$ in 2003 and 2010 are 5% and 5%, respectively. For the remaining questions not individually summarized in Figure 5, the corresponding pre-post figures are: $\text{Goods/Services}_{it}$ (62%, 79%), Travel_{it} (40%, 60%), JobMarket_{it} (16%, 20%).

VI. ICT Usage by Firms Survey

In the main text, we show that broadband internet use increases stock market participation. To inform this finding, we use data from the ICT Usage by Firms Survey, which details how firms interacted with the internet during the broadband reform period, 2000–2010. Here, we provide more details on the ICT Usage by Firms Survey.

A. About the ICT Usage by Firms Survey

Since 1999, Statistics Norway has conducted annual surveys of firms' access to and use of information and communications technology (ICT). The surveys are cross-sectional, with random samples of about 4,000 firms (stratified by industry and firm size) drawn from the full population of firms. Compliance is exceptionally high, at about 95%, as Statistics Norway can impose coercive fines for non-compliance. Firms are asked about a wide range of topics related to their access to and use of ICT, including whether the firm uses broadband technology (and which type of technology it uses), whether the has a marketing website, and whether it has an online sales platform. We received anonymized extracts from the ICT Usage by Firms Survey for the period 2001–2010.

B. Summary statistics

Table IA.VIII provides summary statistics from the ICT Usage by Firms Survey. There are between 3,100 and 4,400 responses each year in the broadband expansion period 2001– 2010. In 2001, the average number of employees among the sampled firms is 107, and the median is 29. Over time, the sampled firms have become slightly larger, with mean and median employment increasing to 143 and 52, respectively, in 2010.

Table IA.VIII. Overview of ICT Usage by Firms Survey

This table shows summary statistics from the ICT Usage by Firms Survey. For each year 2001–2010, we present the mean, standard deviation, minimum, 25th, 50th, and 75th percentile, and the maximum of respondents' employment, as well as the total number of respondents (N).

	Mean	SD	Min.	p(25)	Median	p(75)	Max.	N
Employees (year = 2001)	107.56	351.64	5.00	11.00	29.00	95.00	8929.00	3372
Employees (year = 2002)	90.85	284.40	5.00	10.00	25.00	82.00	8257.00	3313
Employees (year = 2003)	95.60	519.13	5.00	10.00	25.00	78.00	23076.00	3186
Employees (year = 2004)	105.81	504.02	5.00	10.00	26.00	80.00	21297.00	3004
Employees (year = 2005)	107.92	458.01	5.00	11.00	29.00	91.00	20580.00	2724
Employees (year = 2006)	115.91	375.04	5.00	11.00	28.00	91.00	12690.00	4279
Employees (year = 2007)	114.71	303.74	5.00	11.00	30.00	97.00	6998.00	4410
Employees (year = 2008)	159.82	671.01	10.00	21.00	53.00	124.00	25507.00	3312
Employees (year = 2009)	151.51	572.87	10.00	20.00	51.00	121.00	20325.00	3361
Employees (year = 2010)	143.88	401.21	10.00	21.00	52.00	114.00	8535.00	3429

C. Survey questions: Online presence

In the main text, we summarize the two variables Webpage_{jt} and OSale_{jt} to gauge the online presence of firms before, during and after the Norwegian broadband reform period, 2001–2010. Here, we detail how Webpage_{jt} and OSale_{jt} are constructed. For firm j in survey wave t, Webpage_{jt} equals one if the firm answers yes to the question "Does the firm have a webpage?", and zero otherwise. Similarly, OSale_{jt} equals one if the firm answers yes to the question "Did the firm receive online orders this year?", and zero otherwise. Figure IA.4 plots Webpage_{jt} and OSale_{jt} before (2001) and after (2010) the broadband reform. We find a significant increase in firms' online presence during the broadband reform period: Webpage_{jt} increases from 0.72 in 2001 to 0.85 in 2010, and OSale_{jt} almost doubles over the same time period, increasing from 0.22 to 0.35.

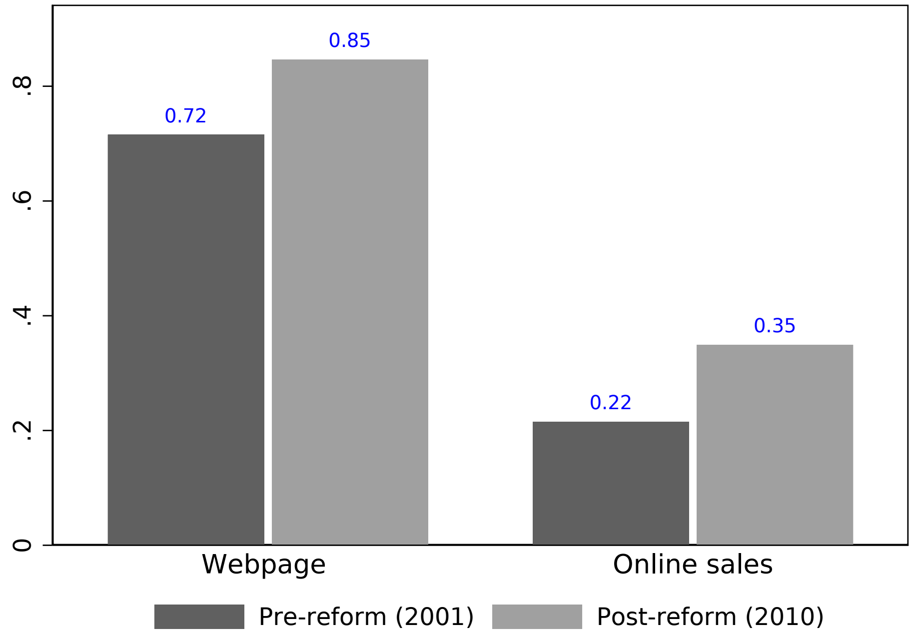


Figure IA.4. Firms' online presence before and after broadband. This figure plots the share of firms in the ICT Survey of Firm that before (2001) and after (2010) the broadband reform answer "Yes" to the question about having a web page ($\text{Webpage}_{jt} = 1$) or to having received online orders ($\text{OSale}_{jt} = 1$).

VII. Broader Financial Outcomes

The main text shows that broadband internet use increases stock market participation and improves portfolio efficiency, plausibly driven by improved access to information. If broadband internet eases access to information and improves individuals' financial skills, it may also have effects on other aspects of financial decision-making. In this appendix, we combine a large number of administrative databases from Statistics Norway to explore the effects of broadband internet on a broader set of financial outcomes. The data used and variables studied in this appendix are identical to those used in Eika et al. (2020), who provide considerable detail on the sample and variable construction.

A. Additional asset classes

In Table II of the main text, we use data from the Norwegian Central Securities Depository (NCSD) to explore the effects of broadband internet coverage and use on stock market participation rates as measured by ownership in equity funds and publicly traded stocks. To explore the effects of broadband internet on participation rates for a broader set of assets, we use administrative tax records on households' (end-of-year) holdings in bonds and bond funds and unlisted stocks not covered by the NCSD data. In Table IA.IX, we find that broadband coverage and use increases participation rates in bonds and bond funds as well as in unlisted stocks (private equity).

B. Wealth components and their returns

The results of our paper suggest that the internet has a broad impact on household investment decisions, increasing both equity market participation (Table II) and participation in bond markets and private equity (Table IA.IX). Portfolio measures that focus exclusively on common stock and equity fund holdings, such as those analyzed in Table

Table IA.IX. Effects on Participation in Bond Funds, Bonds, Private Equity

This tables shows estimates of ω and ϕ from the IV model (3)–(4) as well as δ from the reduced form model (1). The outcomes are the share of the population that own bond funds, bonds, and unlisted stocks/private equity, all measured using the same household balance sheet data as described in Eika et al. (2020). All regressions are based on 422 municipalities $\times$ 10 years $= 4,220$ observations. Standard errors are clustered at the municipality level and presented in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Bond funds	Bonds	Unlisted stocks
IV Estimate	0.0217***	0.0185***	0.0140**
	(0.0048)	(0.0064)	(0.0071)
Reduced Form	0.0024***	0.0021***	0.0016*
	(0.0005)	(0.0007)	(0.0008)
First Stage	0.1116***	0.1116***	0.1116***
	(0.0079)	(0.0079)	(0.0079)
N	4220	4220	4220

IV, may fail to appreciate the broader, cross-asset impact of the internet. As an attempt to remedy this, we follow some of the approaches in Bach et al. (2020) and Eika et al. (2020) and use complete information on household balance sheets to construct measures of households' total (gross) wealth, real estate wealth, and financial wealth, as well as their historical returns. Eika et al. (2020) provide detailed accounts of how each wealth component is calculated from the administrative data. As in Bach et al. (2020), the historical return on wealth is simply the period-specific change in (gross, financial or real estate) wealth divided by the beginning-of-period (gross, financial or real estate) wealth. In Table IA.X, we find positive effects of broadband use on the returns to total and financial wealth, but no effect on the returns to real estate wealth. We do not find evidence of any significant effects of broadband use on the natural logarithms of total wealth or real estate wealth, but we do find that a 100 percentage point increase in broadband use increases financial wealth by 13% (p-value = 0.12). We note that real estate wealth on average constitutes about 60% of total household wealth.

Table IA.X. Wealth and Return-on-Wealth

This tables shows estimates of ω and ϕ from the IV model (3)–(4) as well as δ from the reduced form model (1). In Panel A the outcomes are the logarithms of mean gross wealth (Gross), real estate wealth (RealEst), and financial wealth (Fin), and in Panel B the outcomes are the mean return on gross wealth (GrossR), real estate wealth (RealEstR), and financial wealth (FinR), all measured using the same household balance sheet data as described in Eika et al. (2020). Return measures are winsorized at the top and bottom 1%. All regressions are based on 422 municipalities $\times$ 10 years = $4,220$ observations. Standard errors are clustered at the municipality level and presented in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Panel A. Wealth			Panel B. Return-on-wealth		
	Log(Gross)	Log(RealEst)	Log(Fin)	GrossR	RealEstR	FinR
IV Estimate	0.0447	-0.0103	0.1365	0.0508***	0.0080	0.0533***
	(0.0520)	(0.0522)	(0.0890)	(0.0093)	(0.0111)	(0.0115)
Reduced Form	0.0050	-0.0012	0.0152	0.0057***	0.0009	0.0059***
	(0.0059)	(0.0058)	(0.0101)	(0.0010)	(0.0012)	(0.0012)
First Stage	0.1116***	0.1116***	0.1116***	0.1116***	0.1116***	0.1116***
	(0.0079)	(0.0079)	(0.0079)	(0.0079)	(0.0079)	(0.0079)
N	4220	4220	4220	4220	4220	4220

C. *Insurance, pensions, and mortgages*

Insurance policies, pensions, mortgages, and other financial products are increasingly sold through the internet. Compared to the pre-internet model of buying such products in a physical bank location, one may expect to see higher take-up of financial products and perhaps improved choices, because the internet allows the consumer to search the market more effectively. (Indeed, in Internet Appendix Section VIII, we find a considerable decrease in the frequency of physical bank visits from before to after the introduction of broadband internet in Norway.) We take two steps to explore this idea.

First, we use detailed information from the tax returns of the population of Norwegian residents in the period 2001–2010. We construct LifeIns_{kt} and PrivPens_{kt} as the shares of residents in municipality k in year t that report having life insurance or a private pension, respectively. As a crude proxy for mortgage rates (we do not observe loan-level data), we first calculate for each resident the yearly interest payment (which we observe on the tax form) and divide it by the total mortgage (which we also observe on the tax form), and calculate IntRate_{kt} as the municipality-year median of this ratio.

Second, we estimate the IV model in equations (3)–(4) using LifeIns_{kt}, PrivPens_{kt}, and IntRate_{kt} as the outcome variables. The results are presented in Table IA.XI. We find that broadband coverage and use leads to a decrease in IntRate_{kt}, consistent with consumers making improved choices in the credit market. However, we find no evidence of any statistically significant effects of broadband internet coverage or use on the take-up of life insurance policies (LifeIns_{kt}) or personal pension plans (PrivPens_{kt}).

Table IA.XI. Take-Up of Other Financial Products

This table shows estimates of ω and ϕ from the IV model (3)–(4) as well as δ from the reduced form model (1). The outcomes are the share of households with life insurance (LifIns) or private pension plans (PrivPens) and the median of household interest payments relative to the household's debt (IntRate), all measured using the household balance sheet data described in Eika et al. (2020). All regressions are based on 422 municipalities $\times$ 10 years $= 4,220$ observations. Standard errors are clustered at the municipality level and presented in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	LifeIns	PrivPens	IntRate
IV Estimate	-0.0006	-0.0035	-0.0042**
	(0.0128)	(0.0038)	(0.0016)
Reduced Form	-0.0001	-0.0004	-0.0005**
	(0.0014)	(0.0004)	(0.0002)
First Stage	0.1116***	0.1116***	0.1116***
	(0.0079)	(0.0079)	(0.0079)
N	4220	4220	4220

VIII. Physical Bank Visits

The introduction of broadband internet may affect how individuals interact with the banking system. To gauge bank customers' behavioral responses to the introduction of broadband, we use data from the Online Banking Survey (*Nettbankundersøkelsen* in Norwegian), a yearly and nationally representative survey administered by TNS Gallup and financed by Finance Norway, an industry organization for the financial industry in Norway. The survey asks questions about bank customers' access to and use of banking services, including online banking, telephone banking, mobile banking, physical bank visits, online shopping, and credit card use. Survey responses, based on approximately 1,000 interviews each year, are collected from Finance Norway (2010) and tabulated in Tables IA.XII–IA.XIII. Tables IA.XII shows that the share of bank customers that report physical bank visits "Every 14" days more than halved over the period 2002–2010, and the share that reports "Never" visiting the bank more than doubled. Table IA.XIII shows a considerable increase among bank customers in "online banking" and other online activities, such as "online shopping" and "online information searches".

Table IA.XII. Physical Bank Visits

This table shows the share of respondents to Nettbankundersøkelsen reporting that they visit a physical bank location every 14 days, every 6 months, or never, for each survey wave 2002–2010. Nettbankundersøkelsen is a yearly, nationally representative survey administered by TNS Gallup and financed by Finans Norge. The survey covers the following topics: Bank customers' access and use of banking services including online banking, telephone banking, mobile banking, physical bank visits, online shopping, and credit card use. The data are collected from Finance Norway (2010).

	2002	2003	2004	2005	2006	2007	2008	2009	2010
Every 14 days	24	21	23	16	17	16	12	11	11
Every month	27	28	27	26	25	21	22	17	15
Every 6 months	44	45	44	48	48	53	55	62	61
Never	5	6	6	10	10	10	11	10	13

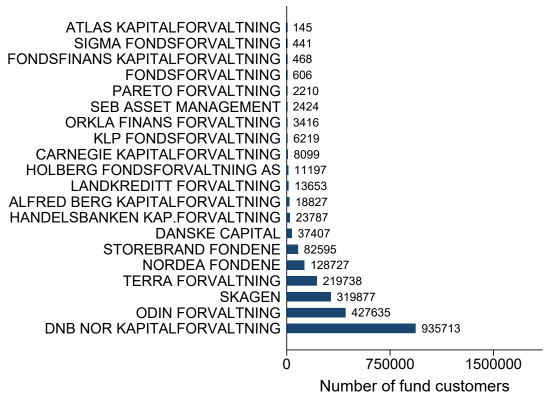
Table IA.XIII. Customer Use of Online Banking, Others

This table shows the share of respondents to Nettbankundersøkelsen reporting that they use the internet for the purposes of banking, shopping, information acquisition, email, direct messaging, gaming, and social media. Nettbankundersøkelsen is a yearly, nationally representative survey administered by TNS Gallup and financed by Finans Norge. The survey covers the following topics: Bank customers' access and use of banking services including online banking, telephone banking, mobile banking, physical bank visits, online shopping, and credit card use. The data are collected from Finance Norway (2010).

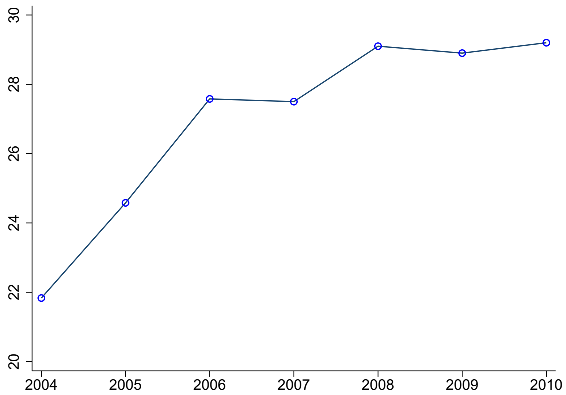
	Online activities						
	Banking	Shopping	Info	Email	Chat	Gaming	Social media
2000	17						
2001	30	21	51				
2002	36	22	49	49			
2003	47	30	60	50			
2004	55	41	61	63			
2005	59	48	63	61	15		
2006	66	48	62	63	22		
2007	68	45	66	68	35	14	
2008	73	55	72	73	31	19	
2009	81	61	76	75	33	19	
2010	79	71	83	82	41	27	50

IX. Supply of Fund Products

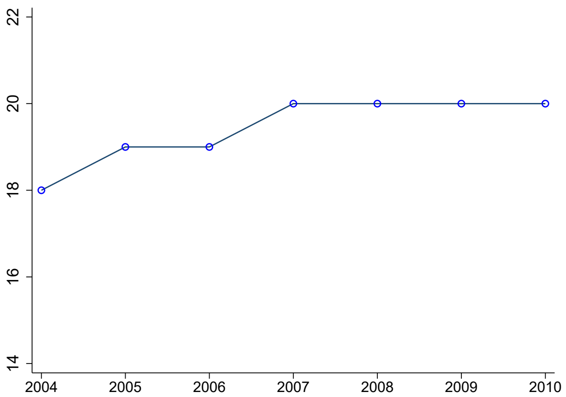
Here, we explore whether Norwegian fund providers modified their supply of fund products over the broadband reform period, 2001–2010. We use data from the Norwegian Fund and Asset Management Association (NFAMA), the industry organization for fund providers in Norway. For each year 2004–2010, the NFAMA publishes data on each member's customer count as well as the number of unique fund products each provider offers to its customers. While membership in the NFAMA is voluntary, we note that the main Norwegian fund providers, including DNB, Odin, and Skagen, are members and thus included in the NFAMA data; we do not observe customer counts or fund product offerings for foreign fund providers. Figure IA.5 summarizes the data. Panel A ranks the sampled fund providers by customer count in 2010. As explained in the main text, DNB is by far the largest fund provider in Norway. Panel B shows that fund providers expanded their product offerings over the broadband reform period, the mean number of fund products per provider increasing from 22 in 2004 to almost 30 in 2010. The total number of fund providers remained fairly stable over the same period, Panel C shows. As a result of expanded offerings from existing fund providers, Panel D shows that the total number of fund products offered increased over the reform period.



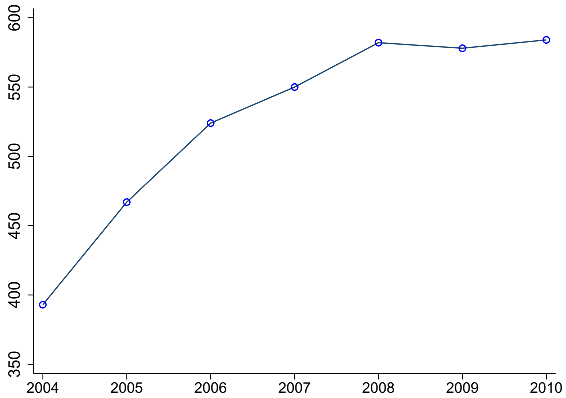
Panel A. #Fund customers in 2010



Panel B. Mean #fund products per provider



Panel C. Total #unique fund providers



Panel D. Total #fund products across all providers

Figure IA.5. Supply of Fund Products, 2004–2010. Panel A shows customer counts for each fund provider in 2010. Panel B shows the mean number of fund products across all fund providers for each year 2004–2010. Panel C shows the total number of unique fund providers for each year 2004–2010. Panel D shows the total number of fund providers across all fund providers for each year 2004–2010. The data are collected from NFAMA and can be found at https://vff.no/historisk-statistikk.

X. Timing of Broadband Adoption

In equation (3) of the main text, we propose a first stage relationship between broadband coverage and broadband use that assumes that households adopt broadband one year after receiving coverage. In Table IA.XIV, we present separate first stage estimates using the contemporaneous, once-lagged, and twice-lagged broadband coverage rate as the explanatory variable. We also present estimates from a regression where all three coverage lags are included simultaneously. The results suggest that households indeed start adopting broadband internet around a year after receiving coverage.

In Figure IA.6, we provide a graphical illustration of equation (3). Following Bhuller et al. (2013), we plot residuals from regressions of broadband user and coverage rates on municipality and year fixed effects in event-time surrounding each municipality's strongest growth in coverage. To mimic the lag structure in equation (3), we re-center the data so that both cause and effect occur at time 0: For the coverage rate, time 0 represents the year with the strongest growth in the coverage rate; for the user rate, time 0 represents the year after the strongest growth in coverage. The results in Figure IA.6 are consistent with the regression estimates in Table IA.XIV. In particular, both coverage and use increase sharply in time 0, which, given the re-centering of the data, again suggests that households start adopting broadband around a year after receiving coverage.

We note that both Table IA.XIV and Figure IA.6 suggest that the effect of broadband coverage on use is not only lagged but also increasing over time: In column (4) of Table IA.XIV twice-lagged coverage has a positive and independent effect on broadband use conditional on once-lagged coverage; in Figure IA.6, broadband use peaks about two years after the coverage shock. Internet Appendix Section XVI discusses the implications of such first stage dynamics for IV identification, and shows the robustness of our IV estimates to expanding equation (3) with additional coverage lags and leads.

Table IA.XIV. Timing of Broadband Adoption

Columns (1)–(3) report estimates from separate regressions of broadband user rates (i_{kt}) on the contemporaneous (z_{kt}), once-lagged (z_{kt-1}), and twice-lagged (z_{kt-2}) broadband coverage rate. All regressions include municipality and time fixed effects. Column (4) reports estimates from a regression of i_{kt} on z_{kt}, z_{kt-1}, z_{kt-2}, and municipality and time fixed effects. All regressions are based on 422 municipalities × 10 years = 4,220 observations. Standard errors are clustered at the municipality level and presented in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Use	Use	Use	Use
Current coverage	0.0181**			-0.0137
	(0.0088)			(0.0088)
Lagged coverage		0.1116***		0.0685***
		(0.0079)		(0.0059)
Twice-lagged coverage			0.1380***	0.1065***
			(0.0083)	(0.0077)
N	4220	4220	4220	4220

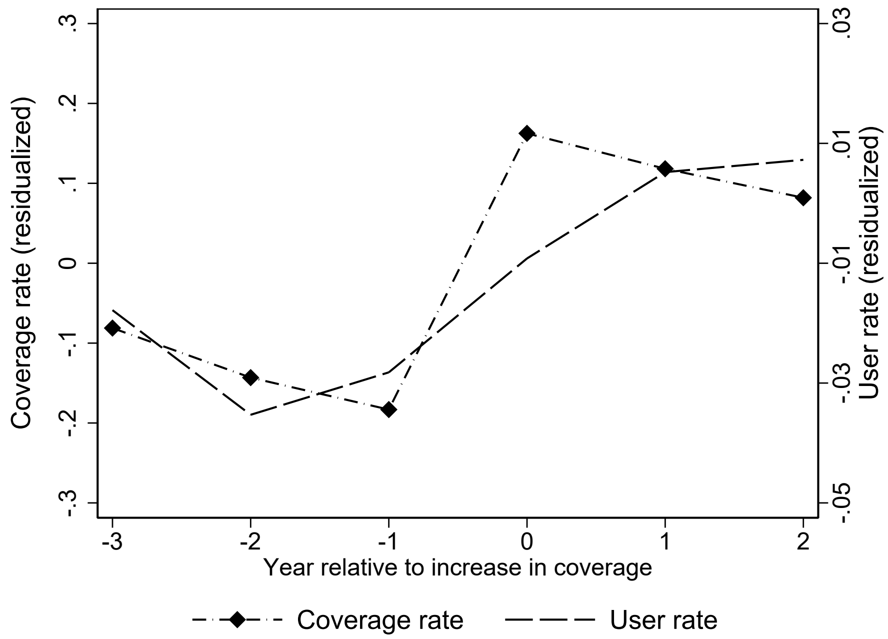


Figure IA.6. Graphical illustration of the first stage, equation (3). To mimic the lag structure in the first stage equation (3), we re-center the data so that both cause and effect occur at event-time 0: for the broadband coverage rate, event-time 0 represents the year with the strongest growth in the coverage rate; for the broadband user rate, event-time 0 represents the year after the strongest growth in the coverage rate. To mimic the identifying variation used in equation (3), the plotted variables are residuals from regressions on municipality and time fixed effects.

XI. Effect Heterogeneity by Wealth and Income

Figure 3 in the main text presents reduced form estimates of the effect of broadband coverage on stock market participation separately by quintiles of wealth and income. The estimates presented in Figure 3 are scaled by pre-reform stock market participation rates. In Tables IA.XV–IA.XVI below, we present the underlying, unscaled reduced form regression coefficients, along with the pre-reform means and relative effects.

Table IA.XV. Heterogeneous Effects by Wealth

This tables shows subgroup-specific estimates of δ from the reduced form model (1). Equity market participation rates, the outcome, are calculated separately by quintiles of wealth using data from the NCSD. "Pre-reform mean" is the mean of the outcome in the year 2000. "Relative effect" is δ divided by the pre-reform mean. All regressions are based on 422 municipalities $\times$ 10 years $= 4,220$ observations. Standard errors are clustered at the municipality level and presented in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Quintile of wealth				
	Q1	Q2	Q3	Q4	Q5
Reduced Form	0.0040***	0.0101***	0.0114***	0.0093***	0.0113***
	(0.0014)	(0.0025)	(0.0028)	(0.0029)	(0.0027)
N	4220	4220	4220	4220	4220
Pre-reform mean	0.0121	0.0463	0.1101	0.1582	0.3171
Relative effect	0.3274	0.2185	0.1031	0.0588	0.0356

Table IA.XVI. Heterogeneous Effects by Income

This tables shows subgroup-specific estimates of δ from the reduced form model (1). Equity market participation rates, the outcome, are calculated separately by quintiles of income using data from the NCSD. To circumvent the practical issue that Q1 has large numbers of both high-wealth pensioners and low-wealth unemployed people, when constructing quintiles we restrict attention to individuals with positive labor income. The baseline stock market participation is slightly higher for this group compared to the population. "Pre-reform mean" is the mean of the outcome in the year 2000. "Relative effect" is δ divided by the pre-reform mean. All regressions are based on 422 municipalities $\times$ 10 years = $4,220$ observations. Standard errors are clustered at the municipality level and presented in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Quintile of income				
	Q1	Q2	Q3	Q4	Q5
Reduced Form	0.0089***	0.0120***	0.0135***	0.0152***	0.0116***
	(0.0022)	(0.0031)	(0.0041)	(0.0044)	(0.0044)
N	4220	4220	4220	4220	4220
Pre-reform mean	0.1152	0.1311	0.1550	0.2137	0.3246
Relative effect	0.0774	0.0912	0.0870	0.0710	0.0358

XII. Controlling for Extrapolated Pre-Trend

In columns (4) and (5) of Table II, we challenge the validity of the empirical strategy in two ways. First, we include in the IV model (3)–(4) a wide range of time-varying municipality controls to see whether the main results are driven by changes in municipality characteristics other than broadband coverage, such as urbanization rates, household income, or educational attainment. Second, we interact the municipality fixed effects in equations (3)–(4) with a linear time trend and include these interactions in the IV model. Thus, we allow the broadband roll-out to be correlated with different underlying time trends in stock market participation across municipalities.

While a common exercise in the literature, the inclusion in column (5) of Table II of municipality-specific linear trends is potentially contentious. The issue is that the municipality-specific trend may not only eliminate possible bias due to differential underlying trends across municipalities — it may also be controlling away parts of the treatment effect. This is simply because the linear time trends in the outcome may in part be driven by the actual treatment effect. Indeed, the estimates in column (5) of Table II are not contained within the 95% confidence intervals of the baseline estimate in column (1). To avoid this issue, in Table IA.XVII, we follow Bhuller et al. (2013) in estimating municipality-specific trends using data covering the period *prior* to the broadband expansion. For each municipality k we first obtain a trend estimate, $\hat{v}_k$, using data from the period 1994–2000. We then extrapolate pre-expansion trends into our IV model by including $\hat{v}_k t$ as a covariate in both the first and second stage equations, which will take into account any variation in our instrument that reflects pre-existing trends in the outcome. The results presented in Table IA.XVII show that accounting for pre-trends in this perhaps more proper way has very little impact on our estimates. Particularly, we obtain an IV estimate of 0.0704, almost identical to the baseline estimate of 0.0698.

Table IA.XVII. Controlling for Extrapolated Trend

Column (1) replicates the baseline estimates from Table II of ω and ϕ from the IV model (3)–(4) as well as δ from the reduced form model (1). Column (2) adds $\hat{v}_k t$, the municipality-specific time trend estimate from the pre-broadband expansion period 1994–2000, as a covariate in both the first and the second stage equations of the IV model. The outcome is the equity market participation rate as measured using the NCSD data. All regressions are based on 422 municipalities $\times$ 10 years $= 4,220$ observations. Standard errors are clustered at the municipality level and presented in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Holds	Holds
IV Estimate	0.0698***	0.0704***
	(0.0169)	(0.0170)
Reduced Form	0.0078***	0.0079***
	(0.0018)	(0.0018)
First Stage	0.1116***	0.1115***
	(0.0079)	(0.0079)
Baseline	Yes	
Control for pre-trend		Yes
N	4220	4220

XIII. Portfolio Turnover

In Table IV of the main text, we explore the effects of broadband coverage on the trading activity of existing investors, as measured by the fraction of existing investors that buy or sell stocks in a given municipality-year. In the current appendix, we explore the effects of broadband coverage on portfolio turnover for the same group of investors.

Following Barber and Odean (2001b), we define portfolio turnover $Turnover_{it}$ for individual i in year t as $\frac{TurnoverBuy_{it}+TurnoverSell_{it}}{2}$. $TurnoverBuy_{it}$ equals the total value of stock buys divided by the individual's total stock portfolio value at the end of the previous year. $TurnoverSell_{it}$ is defined analogously.[34] We then calculate the average of $Turnover_{it}$, $TurnoverBuy_{it}$, and $TurnoverSell_{it}$ at the municipality-year level, and estimate the reduced form model in equation (1) using the municipality-year averages as the outcomes. The results are presented in Table IA.XVIII. As in Table IV, we do not find evidence of any significant effect of broadband coverage on the average stock trading activity of existing investors.

[34]For individuals with small portfolios, $Turnover_{it}$, $TurnoverBuy_{it}$ and $TurnoverSell_{it}$ have very skewed distributions — all three turnover measures tend to be either zero (no trades) or 1 (the entire portfolio is turned over). Therefore, when calculating turnover, we exclude individuals with portfolio values below NOK 5,000 (about \$500).

Table IA.XVIII. Portfolio Turnover

This figure presents estimates of δ from the reduced form model (1). The outcome is the stock portfolio turnover of existing investors, as measured following Barber and Odean (2001b) separately for all trades, buy trades, and sell trades. All regressions are based on 422 municipalities $\times$ 10 years $= 4,220$ observations. Standard errors are clustered at the municipality level and presented in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Portfolio turnover for ...		
	Buys/Sells	Buys	Sells
Reduced Form	0.0078	0.0105	0.0052
	(0.0067)	(0.0097)	(0.0078)
N	4220	4220	4220

XIV. Exogeneity: Urban and Rural Trends

As explained in Section IV, our IV coefficients can be given a causal interpretation if lagged broadband coverage — the instrument — is both exogenous (conditional on fixed effects) and excludable from the second stage equation (4), while our reduced form coefficients only require instrument exogeneity to be given a causal interpretation. Since we control for municipality and time fixed effects, in our setting exogeneity boils down to assuming common trends in the absence of the broadband reform: If the timing of the broadband expansion is related to differential underlying trends in stock market participation and other outcomes across municipalities, our instrument would not be exogenous, and our IV and reduced form coefficients would both be biased.

Panel H of Figure 2 shows that the timing of the broadband expansion is correlated with municipality-level urbanization rates as measured in the pre-reform year 2000. In particular, more densely populated municipalities received coverage earlier than less densely populated ones. Thus, our main results in Section V–VI may be biased due to differential underlying trends in stock market participation between high- and low-coverage municipalities, with the underlying trends being driven by urbanization or some unobserved characteristic common to urban municipalities. We gauge this threat to exogeneity by exploring whether urban and rural municipalities followed different trends in their stock market participation in years prior to the broadband reform.

Reassuringly, Figure IA.7 shows that urban and rural municipalities followed very similar trends in stock market participation in the years 1995–2000. Table IA.XIX reports regression estimates that also show no evidence of a relationship between urbanization and pre-reform trends in stock market participation, supporting the exogeneity assumption. That urban and rural municipalities are balanced in terms of *pre*-reform trends does not, however, guarantee the validity of our empirical design: Urbanization rates could be correlated with *post*-reform shocks to stock market participation unrelated to the broadband expansion, which would also violate exogeneity. To address this concern, we modify our main IV specification in equations (3)–(4) in two ways. First, we include an interaction between the time fixed effects and an Urban indicator, and thus allow urban and rural municipalities to follow differential trends (and experience differential shocks) in the post-reform period. The resulting estimates, presented in column (2) of Table IA.XIX, are almost identical to the baseline IV estimates (reproduced in column (1)). Second, we estimate the IV model separately for urban and rural municipalities, and find almost identical estimates for the two samples. Overall, the evidence suggests that neither pre-reform trend differentials between urban and rural municipalities nor post-reform shocks correlated with urbanization rates are driving our results. We also note that column (4) of Table II shows that our results are robust to controlling for a comprehensive list of time-varying municipality characteristics, including the urbanization rate.

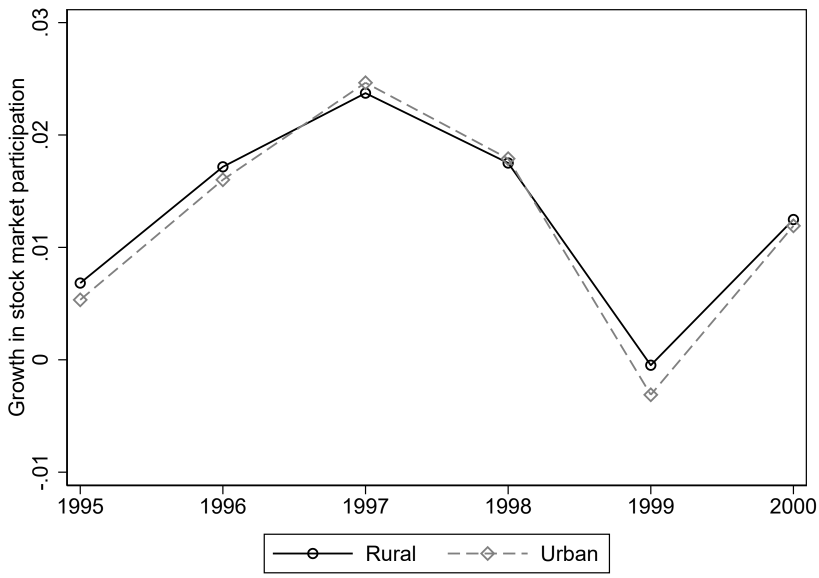


Figure IA.7. Pre-Expansion Trends in $HoldsAny$**.** This figure plots the mean yearly growth rate in stock market participation rates ($\Delta HoldsAny_{kt}$) separately for municipalities with above-median (Urban) and below-median (Rural) urbanization rates as measured in the year 2000.

Table IA.XIX. Balance Test: Pre-Expansion Trends in *HoldsAny*

This table shows estimates of β from the following regression: $\Delta HoldsAny_{k2000} = a + \beta \text{Urban}_{k2000} + \epsilon$, where Urban_{k2000} equals one for municipalities with above-median urbanization rates in the year 2000, and zero otherwise. The outcome, $\Delta HoldsAny$, is the growth in municipality k's stock market participation rate, *HoldsAny*, from either 1999, 1998, 1997, 1996, 1995, or 1994, to 2000. There is one observation for each of the 422 municipalities. Standard errors are presented in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Growth in Holds Any over horizon ...					
	2000-1999	2000-1998	2000-1997	2000-1996	2000-1995	2000-1994
Urban_{k2000}	-0.0006	-0.0032	-0.0028	-0.0019	-0.0030	-0.0045
	(0.0010)	(0.0020)	(0.0026)	(0.0036)	(0.0045)	(0.0051)
N	422	422	422	422	422	422

Table IA.XX. Robustness: Allowing For Urban_{k2000}-Specific Trends

Column (1) replicates the main estimates of ω and ϕ from the IV model (3)–(4) as well as δ from the reduced form model (1). Column (2) adds the term $\text{Urban}_{k2000} \times \alpha_t$ to the baseline IV model, where α_t are year fixed effects. Columns (3) and (4) estimate the baseline IV model separately for municipalities with above ($\text{Urban}_{k2000} = 1$) and below ($\text{Urban}_{k2000} = 0$) median urbanization rates as measured in 2000. In all columns the outcome is the equity market participation rate calculated using data from the NCSD. All regressions are based on 422 municipalities $\times$ 10 years $= 4,220$ observations. Standard errors are clustered at the municipality level and presented in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Holds	Holds	Holds	Holds
IV Estimate	0.0698***	0.0693***	0.0726*	0.0656**
	(0.0169)	(0.0258)	(0.0389)	(0.0325)
Reduced Form	0.0078***	0.0059***	0.0054*	0.0067**
	(0.0018)	(0.0021)	(0.0028)	(0.0029)
First Stage	0.1116***	0.0850***	0.0742***	0.1023***
	(0.0079)	(0.0103)	(0.0102)	(0.0217)
Baseline	Yes			
Control for $\text{Urban}_{k2000} \times a_t$		Yes		
Split sample: $\text{Urban}_{k2000} = 1$			Yes	
Split sample: $\text{Urban}_{k2000} = 0$				Yes
N	4220	4220	2110	2110

XV. Exogeneity: Concurrent Reforms and Trends

As explained in Section IV, our IV coefficients can be given a causal interpretation if lagged broadband coverage — the instrument — is both exogenous (conditional on fixed effects) and excludable from the second stage equation (4), while our reduced form coefficients only require instrument exogeneity to be given a causal interpretation. Since we control for municipality and time fixed effects, in our setting exogeneity boils down to assuming common trends in the absence of the broadband reform: If the timing of the broadband expansion is related to differential underlying trends in stock market participation and other outcomes across municipalities, our instrument would not be exogenous, and our IV and reduced form coefficients would both be biased. Here, we discuss and address three possible violations of the exogeneity assumption.

A. Private sector pension reform, 2006

The first is the introduction in 2006 of a mandatory occupational pension scheme, which affected workers in private sector firms (without prior pension coverage) but not workers in the public sector. This nation-wide reform might challenge the exogeneity of our instrument if municipality-level developments in public versus private sector employment coincided with the expansion of broadband coverage. We address this concern in two steps. First, using matched employer-employee data from the period 2001–2010 with indicators for whether a firm belongs to the private or public sector, we generate PrivEmpShare_{kt}, the private sector employment share in municipality k in year t. Then, we estimate δ from equation (1) using PrivEmpShare_{kt} as the outcome. The results in Table IA.XXI show no evidence of any significant relationship between our instrument and developments in private sector employment share, supporting the exogeneity assumption. We also note that column (4) of Table II shows that our results are robust to controlling for a comprehensive list of time-varying municipality characteristics, including among others measures of industry composition and public services provision.

B. Financial sector expansions, 2001–2010

The second threat to the exogeneity assumption is geographical developments in the market for financial services, such as the local introduction of new bank branches with professional financial advisers, that coincide with the gradual expansion of broadband internet. We address this concern in two steps. First, using matched employer-employee data from the period 2001–2010 with industry information and indicators for the geographic location of establishments, we generate FinPresence$_{kt}$, an indicator for whether a "top-5" financial institution has local presence in municipality k in year t, as defined as having at least one worker stationed there. Top-5 financial institutions are identified in the year 2000 as the five financial institutions with the highest worker count among the subset of financial institutions that survive throughout the broadband reform period 2001–2010. Then, we estimate δ from equation (1) using FinPresence$_{kt}$ as the outcome. The results in Table IA.XXI show no evidence of any significant relationship between our instrument and FinPresence$_{kt}$, supporting the exogeneity assumption.

Table IA.XXI. Concurrent Trends and Reforms

This tables shows estimates of δ from the reduced form model (1). The outcomes are the municipality-year level private sector employment share ($PrivEmpShare_{kt}$) and an indicator $FinPresence_{kt}$ for whether a top-5 financial institution has local presence in a given municipality-year, as defined as having at least one worker stationed there. Top-5 financial institutions are identified in 2000 as the financial institutions with the highest worker count among the subset of financial institutions that survive throughout the broadband roll-out period 2001–2010. All regressions are based on 422 municipalities $\times$ 10 years = $4,220$ observations. Standard errors are clustered at the municipality level and presented in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	PrivEmpShare	FinPresence
Reduced form	0.0015	-0.0332
	(0.0046)	(0.0214)
N	4220	4220

C. Online banking and trading solutions, 2001–2010

The third concern is that online banking and online trading solutions were introduced *during* the broadband coverage expansion, 2001–2010, in a pattern that happens to coincide with the geographical expansion of broadband coverage. To address this concern, we use historical data on the introduction of online banking and trading solutions in Norway. We focus on the major banks and introduction events covered by annual reports and media; the list is not exhaustive. Table IA.XXII shows that major banks in Norway introduced web pages and online banking already in the late 1990s — *before* the broadband reform. Table IA.XXIII shows that online trading solutions were also introduced before broadband. In particular, specialized online trading platforms, such as NetFonds, entered in the mid-1990's, while major banks and discount brokers (e.g., eTrade) added online platforms in 1999 in conjunction with a salient event in Norwegian stock markets, namely, that the Oslo Stock Exchange, the national monopoly exchange, went fully electronic. Overall, the evidence suggests that the online banking and trading infrastructures were in place before the expansion of broadband coverage started in 2001.

Table IA.XXII. Timeline: Bank Web Pages, Online Banking

This table lists when major banks in Norway added web pages and online banking services. The list is based on web page and online banking events covered by the media, and is not exhaustive.

1996	Sparebanken Hedmark og Landsbanken AS, first to provide online banking.
1996	DNB adds web page, information on the bank as well as an interactive services ranging from real estate to the calculation of taxes and mortgage costs.
1997	Sparebanken NOR adds web page and online banking.
1997	Kreditkassen (later Nordea) adds online banking.
1998	Storebrand adds online banking.
1999	DNB adds online banking for its retail customers, offering account information and domestic payment services (w/ online stock trading).
2000	Skandiabanken enters, pure online bank (w/ online stock trading).

Table IA.XXIII. Timeline: Online Trading Platforms

This table lists the entry year of online trading platforms as well as major banks' introductions of online trading platforms. The list is based on events covered by the media, and is not exhaustive.

1996	NetFonds online trading platform enters.
1997	Kreditkassen (later, Nordea) online trading platform enters.
1999	Key event: Oslo Stock Exchange moves to fully electronic trading.
1999	Stocknet online trading platform enters.
1999	DNB adds online trading platform (DNB Markets).
1999	E-trade online trading platform enters (Storebrand customers have access).
1999	Sparebanken NOR online trading platform enters.
2001	Nordnet Norge online trading platform enters.
2002	Terra, representing >80 local savings banks, adds online trading.

XVI. Exclusion Restriction: Dynamics

Our baseline IV model assumes that households adopt broadband one year after receiving broadband coverage, as specified by the first stage relationship:

$$i_{kt} = \phi z_{kt-1} + \gamma_k + \theta_t + \nu_{kt},$$

where i_{kt} is the broadband user rate in municipality k in time t, z_{kt-1} is the prior year's broadband coverage rate, and γ_k and θ_t are municipality and time fixed effects. In column (4) of Table IA.XIV, we document that twice-lagged broadband coverage, z_{kt-2}, positively impacts i_{kt} conditional on z_{kt-1}. While one might be concerned that z_{kt-2} (or further leads or lags) are "omitted variables" in the first stage regression, we note that if two instruments Z_1 and Z_2 are exogenous, then any linear combination of Z_1 and Z_2 is equally valid as an instrument. That is, for any constants c_1 and c_2, $\tilde{Z} = c_1 Z_1 + c_2 Z_2$ is a valid instrument, including $c_1 = 1$ and $c_2 = 0$, which omits one of the two instruments. In other words, omitting an *exogenous* instrument — in our setting, a broadband coverage lead or lag — does not violate the exogeneity assumption of the IV model.[35]

However, a potential concern is that our instrument, z_{kt-1}, may affect stock market participation not only through its impact on current broadband use, i_{kt}, but also through an impact on i_{kt-1}. The impact of z_{kt-1} on i_{kt-1} may be direct (z_{kt-1} impacts i_{kt-1} conditional on i_{kt}) or indirect (z_{kt-1} impacts i_{kt-1} through its correlation with z_{kt-2} or further lags). Either way, if z_{kt-1} affects outcomes through i_{kt-1}, then the exclusion

[35]The intuition is as follows: If the instruments Z_1 and Z_2 are correlated and both affect some treatment D, then the first stage effect that results from regressing D on Z_1 is indeed "biased" in the sense that it captures both the direct effect of Z_1 and an indirect effect of Z_2 through its correlation with Z_1. However, the corresponding reduced form also captures the combined effects of Z_1 and Z_2, and the omitted variable bias terms in the first stage and reduced form cancel out in the second stage, which is the ratio of the reduced form to the first stage.

restriction of the IV model would be violated. In Table IA.XXIV, we address this concern in two ways. First, we include additional leads and lags of the instrument as controls in both the first and second stage equations of the IV model. Second, we extend our IV model to include i_{kt-1} as an additional endogenous variable and z_{kt-2} as an extra instrument. The results reported in Table IA.XXIV show that our IV estimates are robust to allowing for dynamics both in the first and second stage of the IV model.

Table IA.XXIV. Controlling for First- and Second-Stage Dynamics

Column (1) replicates our baseline estimates of ω and ϕ from the IV model (3)–(4) as well as δ from the reduced form model (1). The outcome is the equity market participation rate (Holds Any) measured using data from the NCSD. Columns (2)–(4) expand the first-stage and second-stage equations (3)–(4) with leads and lags of the instrument, z_{kt}. In column (5), we add i_{kt-1} as an additional endogenous regressor in equation (2) and z_{kt-2} as an extra instrument (i.e., multiple first-stages). All regressions are based on 422 municipalities $\times$ 10 years $= 4,220$ observations. Regressions that include leads of the instrument only have 8 years of observations (because the data do not include broadband coverage rates after 2010). Standard errors are clustered at the municipality level and presented in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Holds	Holds	Holds	Holds	Holds
IV (Instrument: z_{t-1}, z_{t-2})					0.0523**
					(0.0266)
IV (Instrument: z_{t-1})	0.0698***	0.0895***	0.0899***	0.0529**	
	(0.0169)	(0.0261)	(0.0227)	(0.0232)	
RF (Instrument: z_{t-1})	0.0078***	0.0072***	0.0074***	0.0043**	
	(0.0018)	(0.0019)	(0.0017)	(0.0018)	
FS (Instrument: z_{t-1})	0.1116***	0.0809***	0.0819***	0.0812***	
	(0.0079)	(0.0081)	(0.0073)	(0.0075)	
Controls for z_{t+2}	No	Yes	No	Yes	Yes
Controls for z_{t+1}	No	Yes	No	Yes	Yes
Controls for z_{t-2}	No	No	Yes	Yes	No
Controls for z_{t-3}	No	No	Yes	Yes	Yes
Controls for i_{t-1}	No	No	No	No	Yes
N	4220	3376	4220	3376	3376

XVII. Exclusion Restriction: Income Effects

While exogeneity of the instrument z_{kt-1} is sufficient for a causal interpretation of the reduced form coefficients reported in Tables II–III, the IV coefficients reported in the same tables can only be interpreted as causal effects of individuals' broadband use on stock market participation under the additional exclusion restriction that increased broadband coverage affects stock market participation *only* through the broadband adoption of individuals, and not in any other way. Broadband adoption at the firm level could lead to increased productivity and wages of the firms' workers (Akerman et al. (2015)) and increase stock market participation through an income effect.[36] In Table IA.XXV, we estimate baseline reduced form model using measures of household income, debt, and bank deposits as the outcomes. We find no statistically or economically significant effect of broadband coverage on household income, debt, or bank deposits. Overall, it seems unlikely that the main results are driven by increases in household incomes. We also note that column (4) of Table II shows that our results are robust to controlling for a comprehensive list of municipality characteristics, including household incomes.

[36]We note that income effects that operate directly via household broadband adoption would not violate the exclusion restriction of the IV model, but would instead represent mechanisms through which broadband use affects stock market participation. For example, individuals might use their own internet connection to attain formal education that increases their productivity at work and their labor incomes. Inconsistent with this mechanism, in Table IA.XXV we find no evidence of income effects.

Table IA.XXV. Income Effects

This table shows estimates of δ from the reduced form model (1). The outcomes are household income, debt, and bank deposits. All outcomes are first averaged across households at the municipality-level, then transformed with the natural logarithm. All regressions are based on 422 municipalities $\times$ 10 years = $4,220$ observations. Standard errors are clustered at the municipality level and presented in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Log(Income)	Log(Debt)	Log(Deposits)
Reduced Form	0.0010	0.0053	-0.0111
	(0.0052)	(0.0117)	(0.0126)
N	4220	4220	4220

XVIII. Mechanisms: Other Information Acquisition

In Figure 5 of the main text, we present descriptive evidence consistent with households increasing their online information acquisition from before to after the broadband expansion. In the current appendix, we supplement the analysis in Figure 5 with evidence from the Media Use Survey (described in Internet Appendix Section Appendix IV). The Media Use Survey includes information about respondents' municipality of residence, which allows us to estimate the baseline IV model in equations (3)–(4) using proxies for information acquisition as the outcomes. We construct two variables at the municipality-year level: The share of survey subjects that respond "Yes" to having used the Internet to "Check facts" or "Read the news". In Table IA.XXVI, we estimate equations (3)–(4) using Check Facts and Read News as the outcomes. The results show that broadband increases the time individuals spend acquiring information by reading the news and checking facts, though only the former effect is statistically significant.

Table IA.XXVI. Effects for Check Facts and Read News

This table shows estimates of ω and ϕ from the IV model (3)–(4) in the main text as well as δ from the reduced form model (1). The outcomes are the share of respondents to the Media Use Survey answering "Yes" to having used the Internet to "Check facts" or "Read the news". Broadband user rates are calculated using the Media Use Survey. We only keep municipality-year observations with non-missing internet activity and broadband use data. Standard errors are clustered at the municipality level and presented in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Check facts	Read news
IV Estimate	0.3352	0.5065**
	(0.2523)	(0.2477)
Reduced Form	0.0674	0.1018**
	(0.0509)	(0.0478)
First stage	0.2010***	0.2010***
	(0.0440)	(0.0440)
N	2785	2785

XIX. Mechanisms: Firms' Marketing Efforts

In the main text, we show that the introduction of broadband internet leads to an increase in online information acquisition among households. In this appendix, we investigate whether *firms* respond to the increase in household information acquisition by increasing their marketing efforts. Our analysis proceeds in two steps.

The first step is to obtain a measure of the extent of marketing by firm j in year t; Marketing_{jt}. To this end, we use detailed income statements submitted by limited liability companies as part of the tax return. In addition to a wide range of earnings items and other cost items, we observe each firm's "sales and advertisement cost", a measure of yearly marketing expenses. Included in the accounting item "sales and advertisement cost" are sales costs (e.g., costs associated with stands, events, or other product promotions) and costs associated with online or other ads (e.g., Facebook, radio, or television ads), printed ads (e.g., newspaper ads), and marketing articles (e.g., coffee mugs with the firm's logo). While the subcategories may be of individual interest, we only observe the sum of these marketing-related expenses. We construct Marketing_{jt} as the "sales and advertisement cost" divided by the total operating cost, i.e., a cost share.

The next step is to estimate the effect of broadband on Marketing_{jt}. We start with an unbalanced panel of the population of Norwegian firms observed over the years 2001–2010. We do not observe broadband use for the population of firms and, therefore, focus on the reduced form effect of broadband coverage in firm j's municipality on Marketing_{jt}. In column (1) of Table IA.XXVII, we estimate equation (1) using the unbalanced population panel. In column (2) of Table IA.XXVII, we again estimate equation (1) using firm-year level data but restrict attention to firms that are present in the sample during the entire reform period 2001–2010. In column (3), we collapse the data to the municipality-year level, thus more closely resembling the regression weights in the main analysis, and estimate equation (1) using the municipality-year data. In all three columns, we find that increased broadband coverage increases firms' marketing-related expenses.

Table IA.XXVII. The Effect of Broadband on Firms' Marketing Expenses

This table shows estimates of δ from the reduced form model (1). The outcome is the firm's "sales-and-advertising costs" divided by total costs. In column (1), the estimation sample is an unbalanced sample of all firms in Norway that are active (have at least one worker) and for which we observe the geographical location of the firm headquarter. In column (2), we retain only the firms that are alive throughout the period 2001–2010. In column (3), we collapse the estimation sample in column (1) to the municipality-year level. Standard errors are clustered at the municipality level and presented in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

	Marketing cost share		
	(1)	(2)	(3)
Reduced form	0.0013***	0.0012***	0.0008*
	(0.0004)	(0.0004)	(0.0004)
Firm weights	Yes	Yes	
Balanced firm panel		Yes	
Municipality weights			Yes
N	656667	108905	4218