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Can a European wealth tax close the green investment gap?

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ABSTRACT

This paper analyses the European Commission's assessment of investment needs as implied by the EU's Paris commitment. We find that official estimates of the green investment gap until 2050 are likely to seriously understate actual investment required. Against this backdrop, we assess the potential of a European wealth tax to close this investment gap. In doing so, we first provide a detailed estimate of the wealth distribution across 22 EU member countries and then develop a microsimulation model for recurring wealth taxes in these countries. The model is based on household survey data from the HFCS, but compensates for missing observations at the top of the wealth distribution by means of a Pareto model. Taking different tax designs into account, we generally find a substantial revenue potential that could contribute significantly to closing currently existing green investment gaps. We also find that compensating for the 'missing rich' is essential for sensibly evaluating progressive tax designs.

1. Introduction

The climate crisis the world is facing is getting more serious every day. The sixth IPCC assessment report (IPCC, 2022) finds that current national commitments would likely result in 2.8 °C of global warming by the end of the 21st century. This is far more than the Paris commitment of limiting global warming to 1.5 °C above preindustrial levels. If policies were implemented in line with the most optimistic IPCC scenario class (SSP1–1.9), it is estimated that between the years 2041 to 2060 the likely range of average global surface temperature increases would be between 1.2 °C to 2.0 °C (IPCC, 2021, WG I – SPM, Table SPM.1). These scenarios (SSP1–1.9) assume that global emissions peak, at the very latest, by 2025 and sharply decline to net-zero by 2050. The median estimate of the global carbon budget remaining at the beginning of 2022, in line with limiting global warming to 1.5 °C with no or limited overshoot, ranges from 320 $GtCO^2$ (for a greater than 67% chance to stay below 1.5 °C) to 420 $GtCO^2$ (for a greater than 50% chance) (CONSTRAIN, 2021; IPCC, 2021, Table SPM.2). Overall, the IPCCs scientists' message is clear:

> "*The remaining carbon budget is small, every tonne of CO_2 emissions adds to global warming, and emissions must fall to net zero by mid-century in order for us to avoid the most dangerous climate change.*"
>
> Constrain (2021, p. 26)

In other words, keeping the 1.5 °C goal alive requires fast and far-reaching action. This includes substantial green infrastructure investment dedicated to decarbonising our societies' energy systems alongside a fundamental re-orientation of our modes of provisioning towards more sustainability and lower resource use. The current policy debate and existing political strategies to address climate change do not take either into account to the required extent. Using the EU27 as a case study this paper shows that current strategies, most importantly the EU's Fit for 55 framework (European Commission, 2021), are grossly underestimating the scale of required investments.

Against this backdrop, our analysis focuses on different forms of wealth taxation to close this green investment gap. Progressive forms of wealth taxation are an attractive policy tool, especially from the perspective of climate change policies, for several reasons: First, they represent an effective tool to reduce current high levels of inequality (Advani et al., 2020; Piketty, 2020; Saez and Zucman, 2019) and have some potential to balance regressive side effects from abandoning fossil fuels as our primary source of energy. Second, they generate much needed revenues for implementing targeted climate change policies, while putting the burden only on those members of society who are in a privileged material position to deal with the negative consequences of climate change. Third, they come with positive secondary effects: for

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one, the administrative infrastructure underlying a wealth tax, such as ownership registers are highly effective in combating organised crime and corruption domestically as well as globally which in turn increases the world's ability to cooperate. For another, taxing top income and wealth holders also reduces the carbon intensity of our current societies since emissions increase along the income and wealth distribution (Ivanova and Wood, 2020; Barros and Wilk, 2021; Nielsen et al., 2021; Theine et al., 2022). While the magnitude of these secondary effects is difficult to assess and, hence, somewhat contested (e.g. Apostel and O'Neill, 2022), there is little doubt that these side-effects of a wealth tax will generally be beneficial.

Notwithstanding these attractive properties, there is only little research on wealth taxes in the context of financing climate change policies. While wealth taxes have been suggested as a primary means for a more sustainable economic policy in the past (Buch-Hansen and Koch, 2019), the current literature lacks (a) concise and reliable estimates of actual wealth holdings at the top of the wealth distribution as well as (b) suitable estimates for revenues to be attained from a wealth tax and their juxtaposition to currently existing investment gaps. This juxtaposition seems crucial from an applied perspective as a wealth tax would instantly increase governmental capabilities to actively push for a socio-ecological transformation in terms of providing new and upgrading existing forms of foundational infrastructure.

One of the reasons for limited research on wealth taxation is a longstanding result from neoclassical economic theory which states that the optimal capital tax rate is zero (Atkinson and Stiglitz, 1976; Chamley, 1986; Judd, 1985) and therefore wealth and capital income taxes are undesirable. The models yielding these results assume an equal distribution of wealth conditional on labour income (Atkinson and Stiglitz, 1976) and an infinitely elastic supply of capital with respect to the tax rate (Chamley, 1986, Judd, 1985). The increase in conditional and unconditional wealth inequality over the last decades, triggered a series of papers which suggest positive optimal tax rates even in a neoclassical setting after relaxing these assumptions (Guvenen et al., 2019; Saez and Stantcheva, 2018; Piketty and Saez, 2013a, 2013b; Aiyagari, 1995). The intuition that wealth taxes yield positive growth effects in addition to more equal distributional outcomes has been around for much longer in the Post-Keynesian tradition (e.g. Ederer and Rehm, 2021). In addition to these theoretical perspectives, the Organisation for Economic Co-operation and Development (OECD) has called for its member countries to use taxes on capital to raise revenues without hampering fragile economies after the 2009 financial crisis as well for the recovery from the pandemic (Rawdanowicz et al., 2013; OECD, 2020). A recommendation which has been echoed by the IMF (IMF, 2021) as well as several economists who argue in favour of wealth taxes to raise public revenues and to reduce historical or newly emerging inequalities (Piketty, 2014; Landais et al., 2020; Saez and Zucman, 2019; Advani et al., 2020). For an informed debate about wealth taxes, policymakers and the public require not only theoretical considerations but also realistic revenue estimations of such taxes. The challenge is that such estimates hardly exist in the literature because suitable data on the distribution of wealth is scarce.

This paper aims to partly fill the outlined gaps in the literature and makes a fourfold contribution. First, we provide a detailed estimate of the wealth distribution in the European Union as well as for 22 member states, based on a consistent method. Second, we analyse recurring wealth taxes instead of one-off policies. This addresses a gap in the literature where the focus on one-off policies seems primarily motived by methodological (Advani et al., 2020; Apostel and O'Neill, 2022)[1] or political (Advani et al., 2020)[2] considerations. Third, we assess the role of key design choices such as the tax exemption threshold and degree of progressivity on revenue potential and administrative feasibility. Finally, we compare our revenue estimates with estimates of current investment gaps to answer the question to what extent a European wealth tax could contribute to bridging the gap between necessary and feasible investments.

Our findings can be summarized as follows. First, net wealth is distributed extremely unequally in the EU. The most affluent 1% of households own 32% of total EU net wealth. The flip side of this extreme wealth concentration is that progressive wealth taxes exhibit high revenue potentials. Second, a combination of clever design choices, more resources and better infrastructure for the EU's tax authorities would make a European net wealth tax practically feasible. Third, although green investment gaps in the European Union and globally are large and most likely underestimated by policy makers, a (progressive) wealth tax could make an essential contribution towards closing this gap. Also, the distributional impact of a wealth tax is superior to established alternatives for public financing like the uptake of public debt, which makes a wealth tax a ‘win-win’ policy tool that allows to improve ecological as well as distributional aspects at the same time.

The remainder of the paper is structured as follows. Section 2 relates investment gaps and wealth taxation by critically assessing current studies on existing investment gaps in the EU. Section 3 discusses the difficulties involved in accurately measuring the distribution of wealth among households and presents the strategy we apply to tackle these challenges. We then present a breakdown of the wealth distribution across the EU22. Eventually, Section 4 presents the different tax models and the corresponding revenue estimates, while Section 5 discusses key implementation issues.

2. The EU's green investment gap

The European Union's climate strategy has undergone several revisions in the past. This section provides an overview of current developments and focuses on the assessment of investment requirements in the EU's energy system.

In October 2018 the IPCC published its special report on limiting global warming to 1.5 °C (IPCC, 2018) and concluded that reaching this goal would require global CO^2 emissions to reach net zero by 2050. The ‘A Clean Planet for All’ climate strategy of the European Union at that time (European Commission, 2018), did not include a 2050 net zero goal. The successor strategy the ‘European Green Deal’ (European Commission, 2019a) which was announced in December 2019 acknowledged this discrepancy between the 1.5 °C goal and the current policy framework and adopted a net zero target for the EU by 2050. The current ‘Fit for 55’ set of policy and legislative proposals (European Commission, 2021) sticks to the 2050 net zero goal while the intermediate 2030 goals for (a) CO^2 emission reductions (−55% relative to 1990), (b) the share of renewables in energy production (40%) and (c) energy efficiency improvements (40%) have become more ambitious. It is the 2050 net zero target together with these 2030 intermediate goals which form the basis for the European Commission's (henceforth ‘EC’) assessment of the required infrastructure investments over the next 30 years (European Commission, 2020, Table 46). Using several interlinked models of the economy and the energy system[3] the EC relies on the

[1] The argument is that only a back-dated one-off tax avoids changes in households' behaviour and therefore second round effects which are difficult to assess.

[2] The authors argue that in the UK context other ways exist to increase the progressivity of the tax system which are easier to implement than a recurring wealth tax.

[3] See Section 9.3.1.1 in EC (2020).

estimates summarized below.

In the decade from 2011 to 2020 the EU27 invested on average €683 billion annually into the energy system across all relevant industries and sectors ('historic' in Table 1). At the same time, the EC estimates that under the current policy framework ('baseline' in Table 1) investment spending will increase by €264 billion to €947 billion annually in the 2021–2030 decade. This baseline path is estimated to deliver a 41% reduction in greenhouse gas emissions compared to their 1990 levels and lead to 33% renewable share in energy production by 2030. In contrast, policies aiming to satisfy the Fit for 55 targets would require €1055 billion of annual investment spending between 2021 and 2030 ('policy scenario' in Table 1). Thus, the EC estimates that only €108 billion of annual investment spending is required above and beyond what will be achieved due to the current policy framework.[4] Going beyond 2030, the EC estimates that the total energy system requires investments of €1196 billion annually in the two decades between 2031 and 2050, which is €513 billion above the historic average but only €215 billion above the baseline scenario consisting of the continuation and implementation of current policies. Table 1 summarises these estimates.

Despite the substantial volume of estimated investment requirements, these estimates are likely to underestimate the actual requirements of a 1.5 °C compliant climate policy path for the EU. Firstly, the EU's climate strategy is squarely focussed on achieving net zero emissions by 2050. This ignores the fact that the 2050 net zero goal established by the IPCC's special report on limiting global warming to 1.5 °C (IPCC, 2018) is a global average. Given vast differences in countries' economic, technical, and social capabilities, the world's richest regions are required to decarbonise faster than the average. In addition, the EU and its member countries have been emitting greenhouse gasses for much longer and at much higher rates than most low- and middle-income countries and have thus contributed more to the problem over time, when measured in cumulative emissions per capita. Since climate change requires unprecedented cooperation, such considerations of fairness and historical responsibilities will be crucial in international negotiations. The implication of varying capabilities and historical responsibilities is that, as one of the world's richest regions, the EU needs to decarbonise substantially before 2050 (Anderson et al., 2020). This in turn means higher investment rates over a shortened time span and thus higher investment gaps compared to current policies and historic trends.

The second reason why the EU's current estimates of its investment requirements are too low is that they leave no room for errors. The Fit for 55 strategy aims for a precision landing and hitting net zero in 2050. This approach ignores the inherent uncertainty in both, the highly complex foundations and potentially non-linear developments of global heating as well as the complex interdependencies that characterize current economic systems of provisioning. This inherent complexity is also reflected in related models, which come with huge error bands: for example, estimates of the remaining global carbon budget consistent with limiting global warming to 1.5 °C range from 820 $GtCO_2$ to 220 $GtCO_2$ depending on the likelihood with which the temperature goal is achieved (ranging from 17% to 83%, respectively).[5] In addition, variations in non-CO_2 emissions can increase or reduce the remaining carbon budget by 200 $GtCO_2$ (IPCC, 2021, Table SPM.2). Moreover, the IPCC's (IPCC, 2018, page 17) as well as the EC's (European Commission, 2020) 1.5 °C scenarios both rely on carbon dioxide removal (CDR) either in the form of afforestation or technological solutions. Since large scale CDR "is subject to multiple feasibility and sustainability constraints" (IPCC, 2018, p. 17) relying on it is a risky strategy. Given that climate change is a highly risky long-term bet, humanity only will make once – akin to what evolutionary theory calls an 'extinction problem', a cautious or 'maxi-min' approach to climate change requires available room for errors and setbacks and thus increasing the ambition from the start (e.g. Costanza, 1989).

Third, the sectoral breakdown of the EC's estimates reveals that the investment figures employed by the EC are in many cases inconsistent with detailed sector-specific assessments. The most significant discrepancy emerges with respect to the insulation requirements of residential and non-residential buildings. Table 2 provides a breakdown of the EC's estimate of the investment gap in the buildings sector (residential and tertiary sector). According to these estimates reaching the 55% emissions reduction target by 2030 would require increasing historic investment rates of €125 billion annually to €286 billion annually, decreasing to €262 billion annually for the two decades up to 2050. The purpose of these expenditures would be to increase annual energy savings by means of renovations (European Commission, 2020, Fig. 52). However, this path would not result in a carbon neutral building sector in 2050, which is pointed out by a detailed and more in-depth study of the housing sector conducted by the EC (European Commission, 2019b). The latter argues that current annual reduction rates in energy use would need to treble in order to achieve a climate neutral building sector by 2050 which would induce additional investment spending of €490 billion annually above historic trends (European Commission, 2019b).

In addition, the EC assumes – in line with many investment estimates in the literature – that technological progress arises exogenously, hence, the costs of the required research and development are not accounted for (Fisch-Romito and Guivarch, 2019). Furthermore, many low investment estimates in the literature do not actually achieve net zero by 2050 and thus require fewer emission reductions and less investment. The International Renewable Energy Agency (IRENA) for example plans for 10Gt/year of CO_2 emissions by 2050 in its Global Renewable Energy Outlook 2020 (IRENA, 2020). Even attaining this modest goal, which falls well below the Paris-aims, would require Europe to invest $145 billion annually into its power sector. Another example is Fisch-Romito and Guivarch (2019) who estimate investment requirements in the transport sector but assume a remaining carbon budget from 2020 onwards of 1370Gt of CO_2 which is incompatible with limiting warming to 1.5 °C and will limit warming to 2 °C with only a 50% likelihood.

Overall, this discussion points out that the European Union needs to step up its efforts and ambitions to credibly contribute towards the global 1.5 °C goal. A credible effort means putting the required green infrastructure in place much faster and on a wider scale than currently planned. Funding these infrastructure projects will require, to a large extent, public revenues and policy makers should think about how to close the resulting investment gap at least partially. This is where the major contribution of this paper lies. We provide a detailed analysis of an underused and underexplored policy tool that would be highly effective: a progressive wealth tax.

3. Measuring household wealth in Europe

Providing a definition of household wealth is a necessary starting point for any discussion on the distribution of wealth. This paper focuses on net wealth – we are looking at the value of all assets minus outstanding liabilities. For the sake of readability, we use wealth and net wealth synonymously and explicitly employ the term gross wealth when referring to the value of assets before subtracting liabilities. Furthermore, the revenue estimations presented in the next section are based on household data and thus assume that the tax subjects are households. We will come back to these definitions when introducing the tax simulations.

[4] See Table 46 in EC (2020). For simplicity we only consider the baseline (BSL) and ALLBNK scenario. The latter includes emissions from international shipping and aviation.

[5] For a greater than 67% chance the corresponding budget is 320 GtCO2 and for a greater than 50% chance the remaining carbon budget is 420 GtCO2 from 2022 onwards.

Table 1
EU27 total energy system investment gap decomposition.

	Investment in total energy system (billion Euros, 2015 prices)	2011–2020 average	2021–2030 average	2031–2050 average
(1)	**historic** annual investment	683		
(2)	annual investment: **baseline**		947	981
(3)	annual investment: **policy scenario**		1055	1196
= (2)–(1)	Gap between baseline and historic trend		264	298
= (3)–(2)	Gap between policy and baseline		108	215
= (3)–(1)	Gap between policy and historic trend		371	513

Source: European Commission (2020), Table 46, the policy scenario depicted here is ALLBNK which includes emissions from international shipping and aviation.

Table 2
EU residential and tertiary sector investment gap decomposition.

	Investment in residential and service buildings (billion Euros, 2015 prices)	2011–2020 average	2021–2030 average	2031–2050 average
(1)	**historic** annual investment	125		
(2)	annual investment **baseline**		224	194
(3)	annual investment **policy** scenario		286	262
= (2)–(1)	Gap between baseline and historic trend		99	69
= (3)–(2)	Gap between policy and baseline		62	68
= (3)–(1)	Gap between policy and historic trend		161	137

Source: European Commission (2020) Table 46, the policy scenario depicted here is ALLBNK which includes emissions from international shipping and aviation.

3.1. Data sources and methodological approach

This study uses data from the ECB's Household Finance and Consumption Survey's (HFCS) third wave which covers 22 EU countries.[6] Wealth survey data can suffer from serious underrepresentation of wealth especially at the top of the distribution for two reasons. First, there is an inherent *median-bias* in drawing random samples from heavy-tailed distributions, which also applies to surveying private wealth holdings (Eckerstorfer et al., 2016). Second, and probably more importantly, more affluent households do participate in such surveys with a lower probability, which causes a selection bias dubbed as 'non-response bias' that affects most wealth survey data (Kennickell and McManus, 1993; Kennickell, 2017a; Kennickell, 2017b; Vermeulen, 2016; Schröder et al., 2022). Some central banks (like the US Fed) and some countries in the HFCS (most importantly France and Spain) address the problem of lower participation among affluent households by deliberately including a disproportionately large number of affluent households in the gross sample. The result is that the net sample will include a sizeable number of households from the tail of the distribution even if the overall rejection rate among the wealthy is high. This technique is called oversampling and crucially requires sample stratification to consider ex ante available information on household wealth, before the data collection starts. For this reason, tax data (e.g. on wealth or capital income) is typically seen as a key requirement to successfully implement oversampling.[7] In the context of the HFCS, each participating country carries out the data collection itself. The ECB only provides a standardised framework determining what type of data are collected, as well as the broad methodological approach (ECB, 2017). Crucially, however, there is no unified approach to oversampling across participating countries. As a result, the extent to which individual country data capture the tail of the distribution varies considerably. This can be seen when comparing the mean of the richest 5 observations across the 22 countries which participated in the third wave of the HFCS. For France, which implements stringent oversampling based on tax data, the mean of the richest 5 observations is €189 million. For the Netherlands the corresponding value is €8 million and for Germany it is €31 million.

To adequately deal with the apparent under-representation of affluent households in many countries, this paper follows the approach of Eckerstorfer et al. (2016) and Vermeulen (2018) to address the under-representation of high-net-worth households in the HFCS (see also Wildauer and Kapeller, 2021 for an operative guide). This means that we first add observations from journalists' rich lists to the survey data and then fit a type I Pareto distribution to the tail of the data where the length of the Pareto tail is determined by an algorithm that searches for the best fit (following the spirit of Clauset et al., 2009). After the Pareto tail is estimated, it is used to extrapolate the part of the distribution above a net wealth threshold of €4 million.[8] This extrapolated tail is combined with the lower body of the survey data to construct an amended data set, which is used to estimate the wealth tax models discussed below.

While rich list observations are not available for all countries in our sample,[9] we aimed at a consistent approach for correcting for the under-representation of wealthy households in the top 1% of the distribution. In order to achieve this, we first calculated total net wealth held by the richest 1% of households after applying the Pareto model for those ten countries where rich list data were available ($Top1_{Pareto}$). In a second step we estimated the proportional increase in wealth held by the top 1% ($Top1_{Pareto}/Top1_{HFCS}$) conditional on the effective oversampling rate of the top 1% (EOR_{Top1}) and the overall response rate ($RESP$) by means of a simple regression model. We made use of these results to correct the wealth holdings of the households comprising the top 1% in the remaining countries based on available information on effective oversampling and response rates.[10]

We will not repeat the details of the estimation, but rather suggest the interested reader to consult the Online Appendix as well as the more

[6] Austria, Belgium, Croatia, Cyprus, Germany, Estonia, Finland, France, Greece, Hungary, Ireland, Italy, Lithuania, Luxembourg, Latvia, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, and Spain (wave 2)., representing 90.8% of EU27 GDP in 2017.

[7] Other forms of oversampling exist and rely on information such as excessive electricity consumption (Cyprus in the HFCS) or ownership of listed companies (German Socio-economic Panel).

[8] We report the results of two robustness checks in the Appendix. First, we test the robustness of our results with respect to the choice of the extrapolation threshold and secondly, to using a Generalized Pareto distribution instead of a type I distribution.

[9] We have rich list observations for Austria, Belgium, Cyprus, France, Germany, Greece, Italy, Netherlands, Portugal, Slovenia, and Spain.

[10] A cruder approach could have been to correct the top wealth brackets of those countries for which no rich lists are available simply based on the average correction of the 10 countries for which rich lists were available. However, conditioning on the effective oversampling and general response rate allowed us to take into account differences in survey quality across countries.

specialized literature such as Wildauer and Kapeller (2021) for an easily accessible introduction.

3.2. Descriptive statistics

This section summarises the results obtained from fitting the Pareto models to the data and compares the amended data sets including the Pareto tail with the raw sample data. Table 3 contains the results for the 22 EU countries in our sample. Fitting a Pareto tail to the data for those countries for which rich list data are available leads to a considerable upward revision of the wealth holdings of the richest 1% of households. The upward revision is reflected by an increase in the top 1% wealth share as well as by a (corresponding) increase in the total wealth holdings. In the case of Germany, for example, the raw survey data report total net wealth of €9394 billion and a top 1% wealth share of 19% and zero billionaires. After adding the Pareto tail, total net wealth increases to €12,520 billion, a top 1% wealth share of 38% and an estimated number of 211 billionaires. The fact that the raw data do not include any billionaires is an obvious indication of the under-reporting of wealth held by the most affluent households. For the data set as a whole (EU22) our approach leads to an increase of aggregate net wealth from €35.7 trillion to €43.6 trillion and the top 1% share increases from 18% to 32%. We provide a fully tabulated summary of the wealth distribution for the EU22 in the Appendix (see Table A4 for average wealth per percentile, Table A5 for percentile cut-offs and Table A6 for total wealth in each percentile). The Online Appendix contains equivalent tabulations for all 22 countries in our sample. It is important to keep in mind that these point estimates are subject to substantial statistical uncertainty, an issue which we address in Appendix A1.

Table 4 puts our results into perspective and compares them with other available information of the top tail of the wealth distribution in Europe. The challenge is that high quality distributional data of household wealth in Europe other than HFCS data are scarce. One exception is Germany, where the German Institute for Economic Research (DIW) produced a data set on household wealth, using publicly available information on German shareholders to oversample high-net-worth individuals (Schröder et al., 2020, 2022). The explicit goal of the sample design was to adequately observe the top tail of the wealth distribution. Based on this data set the DIW estimates the top 1% wealth share to be 35.3%, which is well in line with our results. The same holds for the top 5% and top 10% share (Table 4). When it comes to the number of billionaires in Germany, the *Manager Magazin* publishes a German rich list and for the year 2017 it included 170 billionaires. Given that many of the list entries represent entire family clans, representing more than 1 household, our estimate of 211 billionaires is again well aligned with the available exogenous information on the richest households in Germany. The World Inequality Database (WID) also provides estimates of top 1% wealth shares for Germany (Albers et al., 2022; Blanchet and Martínez-Toledanoz, 2022). For the year 2017 the WID's estimate of 28% is significantly lower than ours (38%). The reason for this discrepancy lies in the fact that WID's estimate is based on Albers et al. (2022), who aim to produce a long time series of wealth distribution data and, hence, cannot use the recent high-quality estimates of Schröder et al. (2022), which come without a time series dimension. This leaves Albers et al. (2022) with survey data which goes back in time longer but does a poor job in covering the tail of the wealth distribution. Since they only homogenously rescale their underlying survey data to match national account aggregates, but do not apply a Pareto correction to the tail, their estimates are likely to substantially underestimate the degree of wealth concentration in Germany, as supported by the recent findings of Schröder et al. (2022) and our discussion above.

Another country for which additional information on the top tail of the wealth distribution is available outside the HFCS is France. Garbinti et al. (2020) for example report top wealth shares for France in 2014 of 55.3% for the top 10%, 43.1% for the top 5% and 23.4% for the top 1%. Our corresponding results are 55.9%, 43.9% and 27.5% respectively (Table 4). When it comes to the number of French billionaires, the magazine *Challenge* reports 68 French billionaires in 2017 in comparison with 79 billionaires according to our estimates. Since the *Challenge* list includes family clans as well, these two results are again well aligned.

Krenek and Schratzenstaller (2018) estimate wealth holdings in Europe and focus on closing the gap between the total financial assets reported in the HFCS compared to national accounts data. Their final estimate of total net wealth across the 22 countries in our sample is €49,599bn compared to our estimate of €43,629 billion (Table 4). This demonstrates that aiming to close the under-reporting gap at the top of the distribution might not be enough to correct for the general under-reporting of wealth in household surveys, which would lead to a downward bias in our results. Compared to Krenek and Schratzenstaller (2018) the estimates of the total net wealth in our sample are conservative since they are roughly €6 trillion lower.

Blanchet and Martínez-Toledanoz (2022) estimate that the top 1% wealth share for Europe as a whole is 26%, which contrasts with our estimate of 32%. This difference stems firstly from the significant difference in the German top 1% wealth share in this paper and Blanchet and Martínez-Toledanoz (2022) as discussed above. Given Germany's size, the thickness of the German tail of the wealth distribution has a substantial impact on the thickness of Europe's tail. Second, Blanchet and Martínez-Toledanoz (2022) do not use a Pareto model to correct for underreported wealth in survey data but simply rescale all observations such that the survey aggregate matches national account aggregates. While this approach resolves some aspects of underreporting in wealth survey data, it is not well-suited for obtaining a detailed picture of the tail of the wealth distribution but is likely to underestimate wealth concentration at the top.

Finally, if we compare the number of billionaires in our amended data set including the Pareto tail with the raw survey data and the national rich lists we use, we find that our Pareto model produces 461 billionaires across the 10 countries in our sample for which we could obtain rich list data. This compares with zero billionaires in the raw survey data and with 431 billionaires on the 10 national rich lists.

Overall, Table 4 demonstrates that the approach taken in this paper to address the under-representation of high-net-worth households in survey data, and in the third wave of the HFCS in particular, yields plausible and robust results. Comparing key measures of wealth concentration based on the Pareto-amended data with several other data sources indicates that our model is well in line with these alternative data sources.

4. The revenue potential of a European net wealth tax

This section presents the rationale behind the wealth tax models we study, explains how the revenue estimates are obtained, and provides core results, including estimates of the likely upper and lower bounds of our estimates.

4.1. Tax models

Our analysis covers four different models of wealth taxation: a classical proportional model (flat tax), two progressive taxation schemes (one mildy, one strongly progressive) and a final one inspired by arguments for an absolute wealth cap (Buch-Hansen and Koch, 2019; Piketty, 2020).

Model I (flat tax model) serves as a simple and easy to understand baseline. It exhibits a constant tax rate of 2%, starting for net wealth holdings above €1 million. This €1 million threshold leaves 97% of European households exempt. The constant tax rate means that a billionaire household is taxed in the same way as a millionaire household. The tax rate of 2% is low compared to average rates of return on wealth as will be shown in greater detail below. If tax rates are below the rate of return, the tax can be paid out of the resulting capital income and the concentration of wealth will not decrease and will potentially

Table 3
Wealth distribution in Europe.

	Raw survey data			Pareto model		
	Total wealth (€bn)	Top 1% share (% of total wealth)	Billionaires	Total wealth (€bn)	Top 1% share (% of total wealth)	Billionaires
Austria*	985	23%	0	1525	47%	44
Belgium*	1789	16%	0	2127	29%	22
Cyprus*	152	22%	0	207	46%	7
Germany*	9394	19%	0	12,520	38%	211
Estonia	66	25%	0	91	45%	0
Spain*	4568	20%	0	4649	21%	8
Finland	553	14%	0	623	24%	0
France*	7097	17%	0	8207	28%	79
Greece*	391	9%	0	458	21%	1
Croatia	159	19%	0	213	39%	0
Hungary	292	20%	0	358	35%	0
Ireland	678	15%	0	787	27%	0
Italy*	5468	12%	0	6787	27%	57
Lithuania	108	15%	0	133	31%	0
Luxembourg	203	20%	0	263	38%	0
Latvia	36	19%	0	43	33%	0
Malta	68	17%	0	90	38%	0
Netherlands*	1450	21%	0	1813	36%	25
Poland	1278	14%	0	1641	33%	0
Portugal*	668	23%	0	724	29%	7
Slovenia*	119	15%	0	129	21%	0
Slovakia	192	12%	0	242	31%	0
EU22	**35,713**	**18%**	**0**	**43,629**	**32%**	**461**

* Rich list information was available and used to fit the Pareto tail. Sources: Household Finance and Consumption Survey and authors' calculations.

Table 4
Assessing the model fit.

German top wealth shares	Raw survey*	Survey + Pareto*	Schröder et al., 2020*
Top 1%	18.6%	37.7%	35.3%
Top 5%	40.8%	55.2%	54.9%
Top 10%	55.4%	66.3%	67.3%
French top wealth shares	Raw survey*	Survey + Pareto*	Garbinti et al., 2020*
Top 1%	17.1%	27.5%	23.4%
Top 5%	35.5%	43.9%	43.1%
Top 10%	49.2%	55.9%	55.3%
	Raw survey**	**Survey + Pareto****	Krenek and Schratzenstaller, 2018**
Total wealth EU22	35,713	43,629	49,599
	Raw survey	**Survey + Pareto**	**National rich lists**
Billionaires in the EU22	0	461	431

*% of total wealth holdings, **€bn. Source: raw survey estimates are from the HFCS's third wave and the survey + pareto results are based on the authors' calculations (eg. Table 3).

increase further over time. This means the flat tax model is not expected to be able to reduce current levels of wealth inequality.

Model II (mildly progressive model) exhibits a progressive structure which means the tax rate increases with net wealth. A billionaire household faces a higher tax rate than a millionaire household. The tax rate starts at 1% on net wealth beyond €1 million (leaving 97% of the population exempt), increases to 2% beyond €2 million (corresponding to richest 1% of all EU22 households, which is roughly 1.9 million households)[11] and finally increases to 3% on net assets beyond €5 million (corresponding to the richest 0.3% of all EU22 households, which is roughly 550,000 households). Even though tax rates now increase with net wealth, they remain well below the typical return on wealth. Thus, model II is only expected to slow down the tendency of increasing wealth inequality but is not expected to reverse such trends.

Model III (strongly progressive model) also exhibits a progressive structure. However, in contrast to model II, tax rates increase faster and are likely to be close to or above actual rates of return on wealth, at least for the higher tax brackets. In addition, model III starts at a higher threshold: a rate of 2% applies to net assets beyond €2 million which means 99% of all households are exempt. The rate increases to 3% beyond €5 million (richest 0.3% or 550,000 households), 5% beyond €10 million (richest 0.1% or 220,000 households), 7% beyond €50 million (richest 0.01% or 23,000 households), 8% beyond €100 million (richest 0.005% or 9000 households) and the final bracket levies a rate of 10% on net assets beyond €500 million (richest 0.001% or 1200 households).[12] The tax rates in the highest brackets of this model are similar to the rates of returns reported in the literature for recent decades. For example, Jordà et al. (2019) estimate the average rate of return on equities between 1980 and 2015 at roughly 9% on average, Fagereng et al. (2020) use Norwegian tax data and show that the rate of return on net wealth is above 10% at the 90th percentile. Bach et al. (2020) use Swedish tax data and estimate the return in excess of the Swedish interest rate to be 8% for the richest 0.01% of tax subjects. This means the strongly progressive model III is expected to facilitate a reversal of current trends towards greater wealth inequality at least when considering the share of wealth held by the richest 1% of households.

[11] Differences from the tables reported in the Appendix are due to rounding.

[12] We rounded these numbers and they should be interpreted as noisy estimates.

Model IV (wealth cap model) represents a fundamentally different approach by introducing an effective maximum level of wealth and by defining tax brackets based on multiples of average wealth. Here we follow the model proposed by Thomas Piketty (2020). Piketty suggests a tax of 0.1% for wealth holdings beyond half the average (which is roughly €260,000 based on the Pareto tail amended data), a rate of 1% for holdings beyond twice the average, 2% for net wealth beyond 5 times the average, going up to 60% beyond 1000 times the average and 90% beyond 10,000 times the average, which is equivalent to €2.6 billion. Due to the skewed nature of the wealth distribution, Piketty's wealth cap model would still leave 59% of all households exempt (although taxation already starts at half of average wealth). It is characterised by high marginal tax rates for top wealth holders, that are substantially above the rate of return on net wealth and thus would be expected to sharply reduce current wealth inequality. Model IV introduces an effective maximum level of wealth (cap) at 1000 times the average (€260 million). Table 5 summarises the four models.

4.2. Revenue estimation

We apply these four tax models to data from the ECB's Household Finance and Consumption Survey (HFCS) on the 22 EU countries in our sample. The HFCS provides information about household gross wealth across five different categories: the first is real estate assets, which includes the main residence and any other real estate assets. The second asset category includes the value of self-employed and non-self-employed privately held businesses. The third category consists of current and savings accounts. The fourth category collects financial assets such as bonds, stocks and private pension wealth held directly or in managed accounts. The fifth category includes any other assets such as cars and other valuables. Net wealth is calculated as the difference between the value across all asset categories minus all outstanding liabilities such as mortgages, car loans, consumer loans etc.

Tax revenues are calculated in the following way: taking a household with net wealth of €1,100,000 and the flat tax model (model I) with an exemption threshold of €1 million and a tax rate of 2% as an example, this household would be taxed at €2000 per year. If the threshold went up to €2 million, this household would be fully exempt. The revenue estimates in Table 6 are the results of equivalent calculations for all observations in our sample, which are then scaled up to the actual population size of the country. Revenues are estimated for all four tax models in four different ways: first, we simply use the raw survey data which do not adequately capture the tail of the wealth distribution (column 1). Secondly, we estimate tax revenues based on the Pareto tail amended survey data (column 2). Third, we use the Pareto amended survey data with a reduced the tax base (i.e., household net wealth) to account for potential tax evasion (column 3). Fourth, we use the Pareto amended survey data and a strongly reduced tax base due to very intense tax evasion (column 4). Roughly spoken the first two columns are mainly dedicated to illustrating the impact of the Pareto-correction on estimated tax revenues, while the third column represents a cautious estimate taxing potential evasion into account. Finally, the fourth column can be understood as a form of 'lower-bound estimate' assuming that available estimates on the propensity for tax evasion are too optimistic.

To quantify the degree of tax evasion of tax subjects we rely on established estimates in the literature (Bach and Beznoska, 2012). We calculate the potential revenues by factoring in evasion in two manners; in column 3, we reduce the tax base of each tax subject in the following manner: real estate assets by 20%, financial assets by 24%, directly held companies by 13% and any other assets by 100%. To simulate a strong evasion reaction by tax subjects we double the reduction factors for financial assets (48%) and directly held companies (26%). This approach is also consistent with the more recent literature (Brülhart et al., 2016; Jakobsen et al., 2020; Seim, 2017). In contrast to Apostel and O'Neill (2022) we do not model tax evasion based on Jakobsen et al. (2020) findings because our application is not directly comparable. Jakobsen et al. (2020) find a strong expansion in taxable wealth due to the abolition of the Danish wealth tax from 1989 onwards. However, this result most likely is not based on a reversion of historic tax evasion but Jakobsen et al. (2020) interpret their findings as the result of increased saving efforts of wealthy households manifesting over decades. Instead, we are incorporating a correction of the tax base for likely evasion effects.

Table 5
Tax models I to IV.

	Model I "flat tax"	Model II "mildly progressive"	Model III "strongly progressive"	Model IV "wealth cap"	
Approach	Flat rate	Progressive rate – slowing growth of inequality	Progressive rate – reducing inequality	Progressive rate – introducing a wealth cap	
% of population exempt	97%	97%	99%	59%	
Tax brackets		Tax rates		Tax brackets	Tax rates
from €1 million €1 million ≈ top 3% or 5.4 million households	2%	1%		0.5 times av. wealth	0.1%
from €2 million €2 million ≈ top 1% or 1.9 million households		2%	2%	2 times av. wealth	1%
from €5 million € 5 million ≈ top 0.3% or 550,000 households		3%	3%	5 times av. wealth	2%
from €10 million €10 million ≈ top 0.1% or 220,000 households			5%	10 times av. wealth	5%
from €50 million €50 million ≈ top 0.01% or 23,000 households			7%	100 times av. wealth	10%
from €100 million €100 million ≈ top 0.005% or 9000 households			8%	1000 times av. wealth	60%
from €500 million €500 million ≈ top 0.001% or 1200 households			10%	10,000 times av. wealth	90%

Average wealth in the EU22 is €260,000 (based on Pareto tail amended data). The tax brackets for model IV therefore start at €130,000 (0.5 times average); €520,000 (2 times the average); €1.3 million (5 times the average); €2.6 million (10 times the average); €26 million (100 times the average); €260 million (1000 times the average) and €2.6 billion (10,000 times the average).

Table 6
Tax revenue estimates for models I to IV.

		(1) Raw survey data	(2) Survey data + Pareto tail	(3) Survey data + Pareto tail + evasion	(4) Survey data + Pareto tail + strong evasion
	in billion €	117	271	192	164
Model I	in % of GDP	1.0%	2.3%	1.6%	1.4%
flat tax	in % of gov rev	2.1%	5.0%	3.5%	3.0%
	in billion €	103	316	224	190
Model II	in % of GDP	0.9%	2.7%	1.9%	1.6%
mildly progressive	in % of gov rev	1.9%	5.8%	4.1%	3.5%
	in billion €	88	505	357	303
Model III	in % of GDP	0.7%	4.3%	3.0%	2.6%
strongly progressive	in % of gov rev	1.6%	9.3%	6.6%	5.6%
	in billion €	249	1837	1281	1081
Model IV	in % of GDP	2.1%	15.5%	10.8%	9.1%
wealth cap	in % of gov rev	4.6%	33.7%	23.5%	19.9%

Estimated tax revenues for models I to IV, reported in billion € (2017 prices), in % of 2017 GDP and in % of total government revenue for the EU22 (Austria, Belgium, Croatia, Cyprus, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Luxembourg, Latvia, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, and Spain). The tax bands and the corresponding rates are presented in Table 5. Source: Own calculations and HFCS.

4.3. Results

Our results are presented in Table 6. We provide revenue estimates based on our sample of 22 EU countries in billion Euros (2017 prices), in % of 2017 GDP (€11,862 billion) and in % of general government total revenue (2017). Table 6 contains the point estimates. We present confidence intervals in Appendix A1.

Three general observations emerge from Table 6: first, the results show that raising substantial revenues of more than 1.5% of GDP (€180 billion) with a net wealth tax is possible even after taking potential tax evasion into account (columns 3 and 4 of Table 6). Second, opting for highly progressive tax rates would allow governments to raise substantially more: 3% of GDP (€350 billion) with model III and 11% of GDP (€1280 billion) with Piketty's wealth cap model. These are significant volumes given that these are estimates of annual revenues.[13] In comparison, the EU's Covid recovery fund is equal to €750 billion over 10 years or roughly €75 billion annually. Put differently, the estimated revenues of the strongly progressive model III amount to €300 billion annually, which is roughly the same amount the EU currently plans to hand out in the form of grants as part of the Covid recovery fund over a period of four years. Third, only a small fraction of the population would be taxed. Households with net wealth beyond €1 million represent the richest 3% of all households across the 22 EU countries in our sample, and households with net wealth beyond €2 million represent the richest 1% of all households in the EU22.

Despite the efforts in this paper, our data are still suffering from an under-representation of extremely wealthy households, since for those countries where no rich lists were available[14] we only upscaled average wealth within the top 1%, which does not yield billionaire observations or observations with net-wealth holdings of hundreds of million for those countries. The implication is that the reported wealth tax revenues are still likely to underestimate the true revenue potential. In particular, revenue estimates for models III and IV are most seriously affected by this constraint as they tax multimillionaire households more than models I and II.

Finally, Table 6 contains a seemingly paradoxical result: when using the raw survey data (column 1), the flat tax model I (threshold €1 million) yields annual revenues of €117 billion compared to €88 billion by the strongly progressive model III (threshold €2 million). This result vanishes as soon as the Pareto tail is added to the data and the under-representation of wealthy households is at least partially considered. In columns 2, 3 and 4, the strongly progressive model III always yields higher estimates than the flat tax model I. This highlights the problem of under-reporting in the raw survey data and the importance of correcting for the 'missing rich' to obtain a realistic assessment of different tax models.

Comparing the results in this study with recent revenue estimates in the scientific literature yields the following picture: Revenue estimates of a European net wealth tax range from 1.05% of GDP (Landais et al., 2020) to 1.47% of GDP (Krenek and Schratzenstaller, 2018). The former suggest a mildly progressive tax of 1% on net wealth holdings in excess of €2 million, which is roughly the top 1% of households in the EU27. For net wealth beyond €8 million a 2% tax rate is applied and beyond €1 billion a tax rate of 3%. The mildly progressive model II is most comparable to Landais et al.'s proposal and yields estimated revenues of 1.9% of GDP. Given the more progressive nature of model II compared to Landais et al., the results are very similar. The only other study of a European net wealth tax (Krenek and Schratzenstaller, 2018) applies a tax rate of 1% beyond net wealth of €1 million and 1.5% beyond €1.5 million. Based on this revenue estimates of 1.5% of GDP are obtained. In comparison the flat tax model I in this study is also estimated to yield revenues of 1.5% of GDP.

We test the robustness of our revenue estimates in two ways. First, we use different thresholds beyond which the survey data is replaced by the estimated Pareto tails. Instead of €4 million which we used for our baseline results reported above, Table A2 in the Appendix reports revenue estimates based on extrapolation thresholds of €2 million and the 100th percentile cut-off. The revenue estimates are only marginally affected by changing these modelling assumptions. Second, we also fit a Generalized Pareto distribution to the survey data instead of a type I distribution. This allows us to relax the assumption of scale invariance in the wealth distribution, which is implicit in the type I model. Table A3 in the Appendix reports the results and shows that this alternative approach provides results broadly in line with our baseline.

5. A well-designed European net wealth tax to fund green investments

Where do our results leave us with respect to our research question: Can a European wealth tax close the green investment gap? And which other design features should be taken into account? If we take the official estimates of the gap between historical and required investment activity as a lower bound, the EU faces an average annual gap of €476

[13] For the wealth cap model (model IV), a drop in revenues would be expected after the maximum level of wealth is established.

[14] These are Croatia, Estonia, Finland, Hungary, Ireland, Latvia, Lithuania, Luxembourg, Malta, Poland, and Slovakia.

billion until the year 2050.[15] Under the assumption of modest tax evasion (Table 6, column 3) our results suggest annual revenues of €211 billion for a flat tax (44% of the gap), €247 billion for the mildly progressive model (52%), €393 billion for the strongly progressive model (83%) and €1411 billion for the wealth cap model (296%).[16] This shows that a European wealth tax clearly has the potential to make a significant contribution towards closing the EU's green investment gap, especially in a progressive form. Furthermore, we do not think that the public sector should directly fund or subsidise these investments entirely. After all, many of them are improvements of existing assets which will increase their value and benefit their owners. How these costs are shared is a political question which goes beyond the scope of the current paper. Nevertheless, our results clearly indicate that a progressive structure with tax rates increasing with wealth, will make it more likely that the EU can mobilize the public revenues needed to close its green investment gap. As discussed above, a progressive structure is also more likely to yield additional benefits beyond the aim of revenue generation, most importantly reducing wealth concentration (Advani et al., 2020; Piketty, 2020; Saez and Zucman, 2019) and carbon emissions due to the higher energy intensity of affluent household's lifestyle (Ivanova and Wood, 2020; Barros and Wilk, 2021; Nielsen et al., 2021; Theine et al., 2022). Achieving significant reductions in emissions is however likely to require a highly progressive tax structure. Apostel and O'Neill (2022) for example calculate that a 5% tax above €3 million would reduce consumption-based CO_2 emissions in Belgium by less than 1 percentage point. Even if this effect would occur annually, it would only represent a modest contribution to reach net zero targets within Paris conform carbon budgets.

Secondly, a well-designed wealth tax should always value assets at their current market price, independent of a progressive or flat structure. Using historic or estimated values is likely to quickly result in serious undervaluation. Property taxes in many countries serve as a warning example. For some assets, such as bank accounts or publicly traded securities, market values are readily available. Real estate is taxed in some form in many countries already and, as a result, valuations are available. In those cases where real estate taxation is based on historic values, transaction data need to be used to build databases of market valuations which can be used together with expert valuations to calculate taxable wealth. For harder to value assets such as privately held businesses, for which no transaction record or comparable assets exist, tax authorities can rely on two options. On the one hand, the value can be estimated based on a formula taking past profitability, turnover and key business characteristics into account. Switzerland does this successfully and the Internal Revenue Service (IRS) in America uses formulas to value stock options for income taxation purposes (Saez and Zucman, 2019). On the other hand, if a formula-based approach is not feasible, owners can be given the opportunity to pay the tax liability in shares (Saez et al., 2021).

Thirdly, the issue of valuation is closely tied to the broader question of enforcement and to what extent tax authorities are given the tools they need. Starving tax authorities of adequate funding, and not providing them with the adequate tools, is surely more of a political choice than an economic imperative. To enforce a wealth tax, tax authorities need additional resources in terms of staff and funding as well as specialized infrastructure (databases for asset valuations, automatic information exchange with financial institutions, as well as beneficial ownership registries). This infrastructure will not only allow proper enforcement of a net wealth tax but will also be crucial in the more general fight against tax evasion and organised crime (ICRICT, 2019). In addition to this 'fairness dividend', this infrastructure will enable tax authorities to automate the calculation of outstanding tax liabilities to a high degree and issue pre-populated tax statements. Several tax authorities use these practices already and in doing so greatly reduce the administrative burden on tax subjects (OECD, 2006; Saez and Zucman, 2019). Providing tax authorities with the necessary infrastructure will become more important for progressive tax schemes as the incentive to hide asset increases.

Fourth, in addition to imposing reporting duties on domestic financial institutions, the EU should use its size to put pressure on foreign jurisdictions, and tax havens in particular, to provide information on tax subjects holding assets in these jurisdictions (automatic information exchange). The US FACTA agreement demonstrates that such information requirements can be enforced. Overall, the implementation of a European net wealth tax requires some practical problems to be overcome. None of them, however, represent a fundamental or insurmountable obstacle. Establishing effective international collaboration also becomes more important for progressive tax designs as the incentive for setting up offshore accounts increases with higher tax rates.

Fifth, a wealth tax will benefit from implementation at the European level or at least from a consistent implementation at the national level across member states. The reason is that taxing wealth across the EU will increase tax authorities' enforcement power and will reduce the ability for tax evasion. While these are clear benefits of an implementation on the European level, they do not by any means imply that national wealth tax initiatives are not viable. The successful implementation in Switzerland, Norway and Spain demonstrates the converse. Also, the revenue potential at the national level remains high (Heck et al., 2020). All four proposed models share the common feature of a deliberately broad tax base, meaning no exemptions are granted. This simplifies administrative burdens and cross-country implementation, especially in combination with high thresholds.

Finally, what about concerns about the administrative costs of net wealth taxes. Can it be that tax revenues will fall short of the costs? Based on the revenue estimates presented in Section 4.3 it is hard to imagine administrative costs of such magnitudes. Studies which report revenues that fall short of, or are close to, the estimated administrative costs reach this conclusion either because of extremely low tax rates (below 1% annually) or because of unrealistically high estimates for administrative costs. The latter are usually high not because of infrastructure costs but because of the estimated cost of compliance on the side of taxpayers. We deliberately abstain from providing such an estimate. Those countries which successfully levy wealth taxes demonstrate that compliance costs can be kept at a reasonable level. In addition, high compliance costs often stem from deliberate complexity and exemptions making it easier to lower the tax base. As, again, this is mainly a matter of political design it is thus not very convincing to employ such costs as an argument against taxation in the first place. Most importantly, however, having proper infrastructure in place which allows for highly automated assessment of the tax liability and pre-filled tax records has the potential to substantially reduce the administrative burden on tax subjects.

6. Conclusion and discussion

This paper uses the European Union's climate policies as a case study to assess the discrepancy between infrastructure requirements in line with the Paris commitment of limiting global warming to 1.5 °C above preindustrial levels and the current policy framework in the form of the Fit for 55 set of regulatory and legislative proposals. The EC's estimates that in order to reach net zero by 2050 an additional €108 billion of annually investment spending beyond current policies is required between now and 2030 and an additional €215 billion annually are required between 2030 and 2050. We find that these estimates are very likely to underestimate the EU's required contribution towards limiting global warming to 1.5 °C above preindustrial levels because a) the focus

[15] We applied an inflation adjustment of 2.27% to convert the 2015 prices from Table 1 to 2017 prices to make them comparable with the HFCS data based on the implicit deflator of gross fixed capital formation in the EU27 and we averaged the 2020–2030 and 2030–2050 period.

[16] We used the size of the EU22 economy relative to the EU27, which was 90.8% in 2017, to rescale the revenues for the EU22 reported in Table 6.

on 2050 does not take into account the necessity for rich nations to decarbonise faster than the global average; b) the investment requirements for the building and energy sectors are likely to be underestimated substantially and c) these estimates require underlying climate or economic models to err only on the side of caution. Against this background we analyse the potential of a European wealth tax to close the resulting green investment gap. While such revenue estimates are crucial for an informed public debate on the topic, producing realistic estimates is difficult due to the lack of data available on the wealth holdings of the most affluent households in Europe. We address this problem in two steps, first we use the ECB's Household and Finance and Consumption Survey (HFCS) as our primary data source. Second, we model the tail of the wealth distribution with a type I Pareto distribution, which we fit to the survey data. A full tabulation of the wealth distribution in the EU22 can be found in the Appendix and in individual country tables in our Online Appendix. Based on this amended data set we estimate revenues for four different tax designs: a flat tax, a mildly progressive as well as a strongly progressive tax and finally a wealth cap (see Section 4.1 for details).

In descriptive terms, we find that household wealth is highly concentrated among the wealthiest households in the EU22: the richest 1% hold 32% of total net wealth while the poorest half of all households only hold about 4.5% of total net wealth. This means that the ability of the wealthiest households to close the EU's green investment gap is much higher than previously suggested. A wealth tax design which exempts all but the richest 1% or richest 3% of households can be justified not only by their ability to pay but also by the fact that rich households tend to leave larger carbon footprints (Oswald et al., 2020; Chancel and Piketty, 2015). In addition, while highly subjective, many perceive wealth taxes as fair because of their ability to reduce the current concentration of wealth. Hence, they might be a key tool for maintaining public support for the difficult transition towards a society characterised by low resource intensity and carbon neutrality. This latter point becomes especially important if highly regressive energy taxes are required for a successful transition away from fossil fuels. Furthermore, taxing wealth at the top is unlikely to hamper fragile post-Covid recoveries, unlike the generation of revenues via energy or consumption taxes. Lastly, the infrastructure required for implementing and enforcing a European wealth tax, most importantly comprehensive beneficial ownership registries, would be an effective tool for fighting tax evasion, organised crime and illicit financial flows in general.

Our estimates show that a European net wealth tax can raise substantial revenues even when taking tax evasion into account. The high revenue potential is the flip side of the observed high levels of wealth concentration. We consider our estimates to be conservative and probably still an underestimation of the true potential due to the under-representation of rich households, which is still likely to persist to some extent in our data despite applying the best available methods to address it.

Overall, our results suggest that a progressive European net wealth tax with high exemption thresholds between €1 and €2 million and implemented at the European level would be an effective tool to close the EU's green investment gap which is required to credibly uphold the Paris commitment of limiting global warming to 1.5 °C above preindustrial levels.

Lastly, it is important to note that open questions remain when it comes to the issue of precisely measuring wealth inequality in Europe. As discussed in the paper our results imply higher levels of inequality than similar estimates in the World Inequality Database (WID) and specifically in Germany (Albers et al., 2022; Blanchet and Martínez-Toledanoz, 2022). While beyond the scope of this paper, further research on the reliability and improvement of different estimation methods is required: in this context measurement problems in survey data and rich lists, but also in national account aggregates and tax data (e.g. due to tax evasion and poor coverage of fundamental wealth aggregates such as real estate and non-listed business wealth) are of key importance. Undoubtedly, the best way forward would be to improve data collection efforts. Specifically, the HFCS should impose comparable oversampling approaches across countries – here Schröder et al. (2022) provide a promising new route for improving currently existing survey designs.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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Appendix A. Appendix

A.1. Statistical significance

The HFCS comes with a set of 1000 so-called 'replicate weights' which simulate 1000 alternative possible data sets which can be used to calculate standard deviations for the point estimates as well as confidence intervals. We used these replicate weights to calculate 1000 alternative revenue estimates for each entry in Table 6 and thus obtained a range of 1000 possible results. Ordering them from the lowest to the highest result for each model, we then used the middle 95% as our 95% confidence interval. These are reported in Table A1.

Table A1
Confidence intervals for estimated tax revenues (€bn).

		(1)	(2)	(3)	(4)
		Raw survey data	Survey data + Pareto tail	Survey data + Pareto tail + evasion	Survey data + Pareto tail + strong evasion
Model I	UPPER	145	302	215	184
flat tax	**POINT**	**117**	**271**	**192**	**164**
	LOWER	92	247	173	147

(*continued on next page*)

Table A1 (*continued*)

		(1)	(2)	(3)	(4)
		Raw survey data	Survey data + Pareto tail	Survey data + Pareto tail + evasion	Survey data + Pareto tail + strong evasion
Model II	UPPER	134	359	256	219
mildly progressive	**POINT**	**103**	**316**	**224**	**190**
	LOWER	77	282	198	168
Model III	UPPER	121	598	427	362
strongly progressive	**POINT**	**88**	**505**	**357**	**303**
	LOWER	64	435	306	258
Model IV	UPPER	303	2302	1622	1372
wealth cap	**POINT**	**249**	**1837**	**1281**	**1081**
	LOWER	203	1521	1054	888

The rows labelled 'POINT' contain the point estimate from Table 6 and are reproduced here for convenience. The rows labelled 'UPPER' contain the upper bound and the rows labelled 'LOWER' contain the lower bound of the 95% confidence interval we calculated, based on a set of 1000 replicate weights from the HFCS.

While it is expected for some variation to be found in the estimates presented in Table A1, the fundamental result is that even the lower bounds remain substantial in absolute terms. This means that our results strongly suggest that introducing an annual tax on net wealth has the potential to generate substantial revenues. Our lowest estimate for the raw survey data is €64 billion and €147 billion after including the Pareto tail but assuming strong tax evasion. On the other hand, the upper bounds are also substantial. For example, the strongly progressive model III could yield up to €427 billion annually under the assumption of moderate tax evasion.

A.2. Robustness checks

The baseline results reported in the paper are based on wealth data for which observations with net wealth in excess of €4 million were replaced with the estimated Pareto distributions. The table below provides additional revenue estimates when changing this extrapolation threshold from €4 million to the 100th percentile cut-off for each country and setting the threshold to €2 million across all countries. The revenue estimates obtained are not significantly affected by changing the extrapolation threshold.

Table A2
Robustness to extrapolation threshold.

Tax model	Extrapolation Threshold	Raw survey data	Survey data + Pareto tail	Survey data + Pareto tail + evasion	Survey data + Pareto tail + strong evasion
Model I	Top 1%	100%	102%	101%	101%
Model II	Top 1%	100%	100%	99%	100%
Model III	Top 1%	100%	97%	96%	97%
Model IV	Top 1%	99%	92%	92%	93%
Model I	€2 million	100%	99%	98%	99%
Model II	€2 million	100%	99%	98%	99%
Model III	€2 million	100%	98%	98%	99%
Model IV	€2 million	100%	98%	97%	99%

Results are expressed relative to the baseline results reported in Table 6.

In addition to the baseline results reported in the paper, which are based on a type I Pareto model, we also fitted a Generalized Pareto distribution to the tail of the wealth distribution. This allowed us to relax the scale invariance assumption, implicit in type I Pareto distributions. Relaxing scale invariance allows for the possibility of increasing inequality within the tail in contrast to constant inequality within the tail with a type I distribution.[17] While fitting a Generalized Pareto distribution is not the same as a Generalized Pareto interpolation (Blanchet et al., 2022), the latter relies on the assumption of the data following the former. The interpolation approach effectively allows for varying coefficients of the underlying distribution. Table A3 compares the revenue estimates from the baseline (type I) with revenue estimates when fitting a Generalized Pareto distribution to the data. The results are broadly consistent across the different models used.

Table A3
Robustness to Pareto tail model.

Tax model	Pareto distribution	Raw survey data	Survey data + Pareto tail	Survey data + Pareto tail + evasion	Survey data + Pareto tail + strong evasion
	Generalized	117	228	160	138
Model I	Type I	117	271	192	164
flat tax	relative to Type I	100%	84%	84%	84%
	Generalized	103	263	189	162
Model II	Type I	103	316	224	190
mildly progressive	relative to Type I	100%	83%	84%	85%
	Generalized	88	468	345	298
Model III	Type I	88	505	357	303
strongly progressive	relative to Type I	100%	93%	97%	98%
	Generalized	263	2484	1842	1603
Model IV	Type I	249	1837	1281	1081
wealth cap	relative to Type I	106%	135%	144%	148%

[17] Constant inequality within the tail would mean if the top 10% own x% of total tail wealth. The top 10% within the top 10% would also own x% of that, etc. Increasing inequality would refer to a situation where this share increases.

A.3. Additional results

Table A4
Average net wealth per percentile for the EU22 in Euros.

Perc	Raw	Pareto	Perc	Raw	Pareto	Perc	Raw	Pareto
100	3,905,000	8,263,000	67	176,000	177,000	33	31,000	31,000
99	1,488,000	1,654,000	66	169,000	170,000	32	29,000	29,000
98	1,109,000	1,164,000	65	163,000	164,000	31	26,000	26,000
97	913,000	946,000	64	157,000	158,000	30	24,000	24,000
96	782,000	799,000	63	152,000	152,000	29	22,000	22,000
95	703,000	715,000	62	146,000	146,000	28	19,000	20,000
94	636,000	643,000	61	140,000	140,000	27	17,000	18,000
93	580,000	587,000	60	134,000	134,000	26	16,000	16,000
92	539,000	544,000	59	129,000	129,000	25	14,000	14,000
91	504,000	509,000	58	123,000	124,000	24	13,000	13,000
90	470,000	474,000	57	119,000	119,000	23	11,000	11,000
89	444,000	448,000	56	113,000	114,000	22	10,000	10,000
88	419,000	422,000	55	108,000	109,000	21	9000	9000
87	398,000	400,000	54	104,000	104,000	20	8000	8000
86	379,000	381,000	53	100,000	100,000	19	6000	7000
85	359,000	361,000	52	95,000	96,000	18	6000	6000
84	340,000	342,000	51	91,000	92,000	17	5000	5000
83	326,000	327,000	50	88,000	88,000	16	4000	4000
82	312,000	313,000	49	84,000	84,000	15	3000	3000
81	299,000	300,000	48	80,000	80,000	14	3000	3000
80	286,000	288,000	47	76,000	76,000	13	2000	2000
79	275,000	276,000	46	72,000	72,000	12	2000	2000
78	264,000	265,000	45	69,000	69,000	11	1000	1000
77	254,000	255,000	44	65,000	65,000	10	1000	1000
76	244,000	245,000	43	61,000	61,000	9	1000	1000
75	235,000	236,000	42	58,000	58,000	8	0	0
74	227,000	228,000	41	54,000	55,000	7	0	0
73	218,000	219,000	40	51,000	52,000	6	0	0
72	211,000	212,000	39	49,000	49,000	5	0	0
71	204,000	204,000	38	45,000	46,000	4	−2000	-2000
70	197,000	198,000	37	42,000	42,000	3	−5000	−5000
69	190,000	191,000	36	39,000	39,000	2	−15,000	−15,000
68	183,000	184,000	35	36,000	36,000	1	−103,000	−103,000
			34	34,000	34,000			

The total number of households in the EU22 is 168 million and thus each percentile (in column Perc) contains roughly 1.68 million households. The displayed values are estimates and thus to avoid the impression of overstated precision have been rounded to the nearest 1000-euro value. Source: Authors' calculations and HFCS.

Table A5
Percentile cut-offs for the EU22 in Euros.

Perc	Raw	Pareto	Perc	Raw	Pareto	Perc	Raw	Pareto
100	1,874,000	2,153,000	67	172,000	173,000	33	30,000	30,000
99	1,245,000	1,322,000	66	167,000	167,000	32	27,000	28,000
98	1,002,000	1,039,000	65	160,000	161,000	31	25,000	25,000
97	836,000	861,000	64	155,000	155,000	30	23,000	23,000
96	741,000	754,000	63	149,000	150,000	29	20,000	21,000
95	665,000	675,000	62	142,000	143,000	28	19,000	19,000
94	607,000	614,000	61	137,000	137,000	27	16,000	16,000
93	556,000	562,000	60	131,000	132,000	26	15,000	15,000
92	522,000	526,000	59	126,000	126,000	25	13,000	13,000
91	485,000	490,000	58	121,000	121,000	24	12,000	12,000
90	457,000	460,000	57	116,000	116,000	23	11,000	11,000
89	430,000	434,000	56	111,000	111,000	22	9000	9000
88	407,000	409,000	55	106,000	107,000	21	8000	8000
87	388,000	390,000	54	102,000	102,000	20	7000	7000
86	369,000	371,000	53	98,000	98,000	19	6000	6000
85	349,000	351,000	52	93,000	94,000	18	5000	5000
84	333,000	334,000	51	90,000	90,000	17	4000	4000
83	318,000	319,000	50	86,000	86,000	16	4000	4000
82	305,000	307,000	49	82,000	83,000	15	3000	3000
81	293,000	294,000	48	78,000	78,000	14	2000	2000
80	281,000	282,000	47	74,000	74,000	13	2000	2000
79	269,000	271,000	46	71,000	71,000	12	2000	2000
78	259,000	259,000	45	67,000	67,000	11	1000	1000
77	249,000	250,000	44	63,000	63,000	10	1000	1000
76	239,000	240,000	43	60,000	60,000	9	0	0
75	231,000	232,000	42	56,000	56,000	8	0	0
74	223,000	223,000	41	53,000	53,000	7	0	0
73	215,000	215,000	40	50,000	50,000	6	0	0
72	207,000	208,000	39	47,000	47,000	5	−1000	−1000
71	200,000	201,000	38	44,000	44,000	4	−3000	−3000
70	194,000	194,000	37	41,000	41,000	3	−8000	−8000
69	186,000	187,000	36	38,000	38,000	2	−28,000	−28,000
68	180,000	181,000	35	35,000	35,000	1	−6,758,000	−6,758,000
			34	32,000	32,000			

Percentile cut-offs represent the beginning of the percentile. Percentile 1 thus represents the minimum of the data set and percentile 51 represents the median. The total number of households in the EU22 is 168 million and thus each percentile contains roughly 1.68 million households. The displayed values are estimates and thus to avoid the impression of overstated precision have been rounded to the nearest 1000-euro value. Source: Authors' calculations and HFCS.

Table A6
Total net wealth per percentile for the EU22 in billion Euros.

Perc	Raw	Pareto	Perc	Raw	Pareto	Perc	Raw	Pareto
100	6539	13,868	67	296	296	33	52	52
99	2499	2779	66	284	286	32	48	49
98	1865	1953	65	274	276	31	44	44
97	1529	1590	64	264	265	30	40	40
96	1318	1336	63	256	255	29	36	36
95	1180	1205	62	245	246	28	33	33
94	1070	1080	61	235	235	27	29	29
93	974	986	60	225	226	26	26	26
92	905	914	59	216	216	25	23	24
91	848	854	58	207	208	24	21	21
90	788	795	57	199	200	23	19	19
89	747	749	56	190	191	22	17	17
88	696	709	55	182	183	21	15	15
87	675	674	54	175	175	20	13	13
86	635	639	53	167	168	19	11	11
85	604	607	52	161	161	18	10	10
84	571	573	51	154	154	17	8	8
83	546	550	50	146	148	16	7	7
82	524	527	49	143	142	15	5	5
81	503	504	48	135	135	14	5	5
80	479	483	47	128	128	13	4	4
79	464	459	46	121	121	12	3	3
78	443	449	45	115	116	11	2	2
77	422	427	44	109	109	10	2	2
76	414	414	43	103	103	9	1	1
75	394	396	42	97	98	8	1	1
74	381	380	41	91	92	7	0	0
73	367	369	40	86	87	6	0	0
72	355	355	39	82	82	5	0	0
71	342	342	38	76	77	4	−3	−3
70	331	333	37	71	71	3	−8	−8
69	318	321	36	66	66	2	−25	−25
68	308	309	35	61	61	1	−175	−175
			34	56	57			

The total number of households in the EU22 is 168 million and thus each percentile (in column Perc) contains roughly 1.68 million households. Source: Authors' calculations and HFCS.

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ecolecon.2023.107849.

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