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A global tax on capital to stop the indefinite increase of wealth inequality, really?

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Introduction

Introduction

The year 2014 (2013 for the French version) saw an unexpected book in the ranking of best sellers, both in physical and online stores: *Capital in the Twenty-First Century* from the French economist Thomas Piketty, professor at the Paris School of Economics. The book summarizes years of research and publications of Piketty and his team, presenting several conclusions and backing arguments related to the evolution of income and wealth in different countries throughout the 20th century. The key takeaway of the book is that capitalist economies are skewed towards an indefinite accumulation of capital by the very wealthy, meaning wealth inequalities are only expected to increase with time.

Piketty argues that the 20th century has been marked by exceptional circumstances (two World Wars) causing the massive destruction of capital in Europe and resulting in decreased capital concentration by the very wealthy. This is, *a priori*, not expected to be repeated. He suggests that no economic nor fiscal tool currently exists in our societies that would act against the accumulation of capital by the wealthy. He notes that wealth concentration has risen since the end of World War II in all countries, reaching levels unseen since the end of the 19th century. His proposal to tackle this issue is explained in the 15th chapter of his book, making the case of *"a progressive global tax on capital*[1]*, coupled with a very high level of international financial transparency"* as a way to *"avoid an endless inegalitarian spiral and to control the worrisome dynamics of global capital concentration"*. Although Piketty enjoyed support from many authors, it should be noted that this book raised a substantial number of criticism related to, among others, the methodology and the veracity of the data.[2]

Contextually, amount of literature dealing with economic inequalities has emerged over the past decades. Recently, Anthony B. Atkinson, worldwide acknowledged expert on the subject, professor at Oxford and at the London School of Economics, published a book called *Inequality: What Can Be Done?* (2015). In this book, he presents a set of 15 proposals geared towards tackling inequalities from various angles, and a *property tax* is but one of them. Also in 2015,

[1]That is, a tax on the stock rather than on the flow as it is usually the case.
[2]See for example Weil (2015), Auerbach & Hasset (2015) or Mankiw (2015).

Joseph E. Stiglitz, laureate of the Nobel Prize in Economics and former chief economist at The World Bank, published *The Great Divide* in which he, among others, gives his opinion about how economic inequalities are problematic.[3] This book followed *The Price of Inequality* released in 2012. Combining scientific research and newly available data on income and wealth,[4] several authors are suggesting policies to tackle growing inequalities, both through tax reforms (Piketty's proposal falls in this category) and social initiatives (such as raising minimum wage or unconditional access to quality education).

Going further than research papers, political parties have introduced tackling inequalities as part of their agenda. For example, the *Parti du Travail de Belgique* in Belgium (PTB, 2015) and the *Green Party* in the UK (Sharman & Heatley, 2014) both formally advocate for the introduction of a tax on the possession of net wealth. Actually, the concept of tax on wealth is not completely uncommon. On the one hand, in most European countries, real estates are already taxed through a so-called *property tax.* On the other hand, some countries are already applying a tax close to Piketty's suggestion. France and Spain are examples within the European Union.[5]

Taxing net wealth is hence far from being a new idea introduced by Piketty, since it is often debated on or even implemented in some countries. However, his proposal distinguishes itself from what we see elsewhere in two main ways.

- First, he argues the tax should be global, applied on each and every individual. This requirement is paramount or else individuals would be able to fiscally evade the tax by hiding wealth abroad or physically relocating in other countries. A perfect example being the recent worldwide scandal baptized *Panama Papers* in which more than 11 million documents belonging to a Panamanian law firm have been unveiled in April 2016, incriminating more than 200,000 individuals (including political leaders, athletes, actors etc.) of assets hiding for tax evasion and money laundering purposes.

- Second, no exemption should be applied. The tax is to be on the entire net wealth, defined as the marketable value of all assets, net of all debts.[6] This ensures equity in

[3]For a critical review, see for example The Wall Street Journal (2015).

[4]Comprehensive databases on historical private wealth levels using standardized methodologies across nations are relatively new - and still incomplete -, the OECD Wealth Distribution Database (2016), and the *World Wealth and Income Database* (formerly the *World Top Incomes Database*) of Alvaredo et al. (2016) respectively created in 2015(Murtin & d'Ercole, 2015), and 2011 (Paris School of Economics, 2013) are the two largest sources of such data and both are less than 10 years old.

[5]Even if Spain introduced it as a *temporary measure* and keeps repeating it would abolish it, the tax still exists (Belvins & Franks, 2015).

[6]Piketty uses *capital* and *wealth* interchangeably in his book when referring to the marketable value of all assets. We will only refer to *wealth.*

the administration of the tax and forbids individuals to change their portfolio of assets and/or debts in order to reduce their tax burden (tax avoidance).

For this idea to work in practice, Piketty admits that strong collaboration and cooperation among nations is required so as to exchange information about wealth ownership of individuals worldwide. As a result, he admits himself that his proposal is "utopical", but nevertheless provides a long-term idealistic objective. This is why he suggests that it could first be introduced at a smaller scale, regionally or nationally.

Researchers have elaborated on his idea, trying to estimate the potential impact on specific economic variables. To our knowledge, most of those papers focus on the impact on macro-economic variables such as gross domestic product or employment (see Schuyler (2014) for an example in the United States) while very little has been written on the impact on inequalities themselves. This is where our thesis fills a literature gap by trying to answer the following question:

«Is the introduction of a net wealth tax as defined by Piketty on Belgian residents with the objective of reducing wealth inequalities in Belgium desirable?»

To do so, we break it down in three sub-questions, each representing a distinct part of this thesis.

(1) Should something be done to reduce wealth inequalities in Belgium?

(2) Is a net wealth tax as defined by Piketty an appropriate (theoretical point of view) and viable (practical point of view) tool to reduce wealth inequalities?

(3) What would be the impact of the net wealth tax as defined by Piketty on wealth inequalities and other selected variables?

In order to answer the first question, we start by defining the concept of economic inequality, putting it in its context and review its measurement methods (chapter 1). We then assess whether economic inequalities are harmful to economic growth and if they should be decreased (chapter 2). Finally, we analyze available data in Belgium and other countries to see if they are indeed on the rise (chapter 3).

The second question is answered in two steps. First, we review existing literature about the role of taxation, and look at the various motives for wealth accumulation in order to assess whether wealth possession should be taxed from an economic theory point of view (chapter

4). Second, we analyze if, from a practical point of view, a wealth tax should be introduced. To do this, we analyze case studies of France and Spain, currently having a wealth tax, and then consider what challenges Belgium would have to face if decided to implement such a tax (chapter 5).

We answer the last question by creating a model of individual wealth dynamics (chapters 6, 7 and 8) in which we input data of a sample population replicating Belgium (chapter 9). Finally, we analyze the results created by this model under various hypothesis (states of the world) and look at the impact on wealth inequalities and other selected variables of introducing the tax proposed by Piketty (chapter 10).

We conclude by bringing together the answers to those three sub-questions and formulating recommendations as to whether a tax on net wealth as defined by Piketty should be introduced in Belgium with the objective of reducing wealth inequalities. Throughout the thesis, we aim at fulfilling the triple objective[7] made of scientific (by demonstrating academic rigour, applying a clear methodology and developing innovative thinking and models), managerial (by providing concrete conclusions and recommendations) and societal (by dealing with questions seen by many as critical for the sustainability of the society) contributions.

[7]This triple objective has been suggested by Chantal de Moerloose and Valérie Swaen, professors at the Louvain School of Management.

Part I

Economic inequalities

Chapter 1

Definition, context and measures

1.1 Introduction

This first chapter puts equality in its context by defining it in the framework of this paper (section 1.2) along with the main related concepts (section 1.3) and by explaining the different ways used to measure it (section 1.4).

1.2 Equality

Piketty's (2013)[1] objective with his global tax on net wealth[2] is to *regulate financial crises* and *stop indefinite increase of wealth inequality*. Focusing on the second purpose and to avoid any confusion, let us agree on what wealth inequality is. Throughout this document, we consider wealth inequality as the extent to which individuals in a given society have different levels of wealth. Oppositely, we consider wealth equality as the extent to which individuals in a given society have a same level of wealth. The perfect equality being when all individuals have the same wealth and the perfect inequality being when only one individual detains the entire stock of wealth in the society. We here understand the idea of wealth concentration, paramount element in the study. Although inequality is related to wealth, income, wage, land, social status, skills etc., this paper relates it to only wealth and sometimes income.

1.3 Inequality in its context

Countless authors and papers investigated the questions of poverty, equity or efficiency (Rawls, Sen, Stiglitz, Atkinson, Musgrave and Kaplow being the most famous ones). We

[1]See Piketty (2014) for the English version translated by Arthur Goldhammer and published in April 2014.

[2]As it will be defined later, the net wealth of an individual refers to the value of his assets minus the value of his debts while income is a flow aiming at growing the stock of net wealth.

here make the reader aware of the existence of those questions and how they are related to equality.

1.3.1 Poverty

Individual poverty relates to the absolute level of wealth detained by an individual, without systematically comparing it with the total distribution in the economy as done when studying inequality. An agent is considered as poor if its level of wealth is below a threshold.[3] For example, The World Bank considers as extremely poor (i.e. extreme poverty threshold) an individual living with less than $1.90 a day in purchase parity power terms (The World Bank, 2015).

Imagine two societies. In the first one, everyone has the same wealth. In the second one, there are huge wealth inequalities but the poorest individual has more than any individual from the first society. Which one is "better"? Although we won't answer this question, it highlights that poverty and inequalities are two different concepts, with proper causes, implications and measures (Todaro & Smith, 2012).

1.3.2 Equity

Concept Mankiw & Taylor (2011) define equity as the ability of a society to redistribute wealth among individuals in a an equitable way... Quite tautological, isn't it? Actually, there is no better definition as such, since one must first define what is equitable and what is not before stating any normative judgment, as there is an infinite number of criteria to define equity (Gérard, 2014). For example, putting ourselves in a tax framework (Musgrave, 1959), one could argue that those with the same contributing capacity should be taxed the same way but another could argue that those with the same social benefits should be taxed the same way by the state to be equitable.

Dimensions There are two dimensions to equity: horizontal and vertical (Gérard, 2014). Horizontal equity (HE in the literature) states that similar individuals (e.g. same income) should face the same taxation. Vertical equity (VE) states that individuals with better situation (e.g. more income) should be taxed more, in absolute terms. Basically, its about non discrimination. Note that VE does not state anything about the relative taxation; that is,

[3] Sometimes, the poverty threshold is defined as a function of the distribution. We then talk about relative poverty (Vanderborght, 2014). For example, the European Union defines its income poverty threshold as 60% of the median income.

the tax rate, which can be progressive, proportional or regressive (Gérard, 2014). By definition, those two dimensions are not mutually exclusive.[4]

Link to equality Todaro & Smith (2012) refer to Rawls (1999) and its concept of the *veil of ignorance* according to which what is fair is what one would chose without knowing its own situation, with a *veil* on his eyes (Vanderborght, 2014). Theoretically, in our context, it means that if one person chooses a world with huge inequality among people without knowing if he is rich or poor in this world, then huge inequality is the fair situation. Practically, most people recognize the need of a certain degree of inequality to provide incentives, but to a lesser extent of what is happening now in the world or almost in any country (Todaro & Smith, 2012). Under this paradigm, the current state of the world is therefore not optimal in terms of fairness/equity.

1.3.3 Efficiency

Another important parameter to consider along with HE and VE when discussing tax redistribution is efficiency (Repetti & McDaniel, 1993). Mankiw & Taylor (2011) define efficiency as the ability of a society to generate the best output out of its resources. While equality is concerned with the distribution of the pie, efficiency is concerned with the size of the pie. Okun (1975) highlighted a trade-off - a negative relationship - between equality and efficiency since redistributing resources to reach more equality has a cost (administrative expenses, reduction of incentives etc.) and therefore a negative impact on the size of the pie. As counter argument, we will see later than redistribution can have positive impact on economic growth.

1.4 Measures of equality

The different ways economic inequality has been and is measured have been more or less extensively discussed by many authors, using quite formal approaches. Xu (2004) cites for example Sen & James (1973), Lambert (1989), Chakravarty (1990), Silber (1999) or Atkinson (2000). We here provide a friendly overview of the main metrics.

1.4.1 Properties

A good inequality metrics should follow some specific properties (World Bank Institute, 2005; Haughton & Khandker, 2009).

[4] According to some, there is even a hierarchical relationship between both (Lambert & Yitzhaki, 1995).

- *Mean independence.* The scale of the data (i.e. country with relatively high vs. low individual wealth) should not impact the value of the inequality metric.
- *Population size independence.* The scale of the economy (i.e. country with relatively high vs. low population) should not impact the value of the inequality metric.
- *Symmetry.* A complete wealth exchange between two individuals should not impact the value of the inequality metric.
- *Transfer sensitivity.* A transfer of wealth from the higher tail to the lower tail of the wealth distribution scale should impact the inequality metric in such way that inequality is reduced. This property is known as the Pigou-Dalton principle, from Pigou (1912) and Dalton (1920).
- *Decomposability.* Wealth inequalities between/within subgroups (e.g. age, job etc.) should be easily reflected in the decomposition of the inequality metric. That is, the index should be the sum of the subgroups indexes.
- *Statistical testability.* The significance of variations over time in the inequality metric should be able to be statistically tested, through confidence intervals for example.

1.4.2 Notations

To keep it short for the rest of the section, we now take some time to introduce a few simple notations, adapted from Xu (2004).

Discrete case Let W be the discrete random variable wealth or income, say wealth here. There are n individuals denoted by $i \in \{1, 2, \dots, n\}$ with respective increasingly-sorted wealth $a \leq w_1 \leq w_2 \leq \cdots \leq w_n \leq b$. The probability that the wealth of an individual takes a specific value w (distribution function) is $f(w) = \frac{1}{n}$. The probability that the wealth of an individual i lies between a and w_k (cumulative distribution function) is $F(w_k) = \frac{k}{n}$. This is also the share of population with wealth between a and w_k. The average wealth is $\mu_W = \frac{1}{n}\sum_{i=1}^{n} w_i$, meaning that total wealth is $n \cdot \mu_W$. Finally, the share of total wealth detained by the i first individuals is $L_i = \frac{1}{n \cdot \mu_W}\sum_{j=1}^{i} w_j$. Obviously, $0 \leq F(w_k) \leq 1$ and $0 \leq L_i \leq 1$.

Continuous case *Mutatis mutandis*, the probability that the wealth of an individual takes a specific value w (distribution function) is $f(w)$. The probability that the wealth of an individual i lies between a and w^* (cumulative distribution function) is $F(w^*) = \int_a^{w^*} f(w)\,\mathrm{d}w$. This is also the share of population with wealth between a and w^*. The average wealth is $\mu_W =$

$\int_a^b w \cdot f(w)\ \mathrm{d}w$. Finally, the share of total wealth detained by the individuals with wealth below or equal to w^* is $L(F(w^*)) = \frac{1}{\mu_W} \int_a^{w^*} w \cdot f(w)\ \mathrm{d}w$. Therefore, taking $0 \leq \alpha \leq 1$,

- $L(\alpha)$ gives the share of total wealth detained by the bottom-α of the population;
- $1 - L(1-\alpha)$ gives the share of total wealth detained by the top-α of the population.

We use those same notations to explain the different ways to measure inequality.

1.4.3 Sample distribution

For illustration, we take an example of an economy with 20 individuals whose wealth distribution is detailed in table 1.1, adapted from Todaro & Smith (2012). With this sample discrete distribution of wealth, $n = 20$, $i \in \{1, 2, \cdots, 20\}$, $a = 0.8$, $b = 15$, $w_{10} = 3$, $F(3) = 50\%$ and $L_{10} = 19.8\%$.

1.4.4 Main indicators

Variance, coefficient of variation and relative mean deviation

Atkinson (1970) identified some typical statistical measures of inequality among individuals. Those include variance, coefficient of variation, relative mean deviation, Gini index and standard deviation of logarithms.

Variance Simply, the variance σ_W^2 is defined as the average square deviation to the mean of the variable and it estimated through

$$\sigma_W^2 = \frac{1}{n-1} \sum_{i=1}^{n} (w_i - \mu_W)^2 . \tag{1.1}$$

Applying this to the example leads to $\sigma_W^2 = 18.83$. Alone, this does not provide much information. Compared to another distribution with variance of let's say 20, this would tell that, according to the variance criteria,[5] the distribution in the example is more equal.

Coefficient of variation The variance depends on the scale of the data (see mean independence property). An economy with higher wealth per individual will tend, to *ceteris paribus*, have higher variance. Normalizing the variance σ_W^2 (or the standard deviation σ_W) by the average wealth μ_W erases this pattern. The coefficient of variation, typically noted c_V, is then

[5] As it is explained in section 1.4.5, each method involves a specific ranking criteria, often not straightforward when looking at the formula of the index.

Individual #	Individual wealth (monetaruty unit)	Cumulative wealth (monetaruty unit)	Cumulative share of individuals	Cumulative share of wealth	Fractiles share of wealth		
					Deciles	Quintiles	Quartiles
0	**0**	0	0%	0%	N/A	N/A	N/A
1	**0,8**	0,8	5%	0,8%	1,8%	5,00%	6,9%
2	**1**	1,8	10%	1,8%			
3	**1,4**	3,2	15%	3,2%	3,2%		
4	**1,8**	5	20%	5,0%			
5	**1,9**	6,9	25%	6,9%	3,9%	9,00%	
6	**2**	8,9	30%	8,9%			12,9%
7	**2,4**	11,3	35%	11,3%	5,1%		
8	**2,7**	14	40%	14,0%			
9	**2,8**	16,8	45%	16,8%	5,8%	13,00%	
10	**3**	19,8	50%	19,8%			
11	**3,4**	23,2	55%	23,2%	7,2%		22,1%
12	**3,8**	27	60%	27,0%			
13	**4,2**	31,2	65%	31,2%	9,0%	22,00%	
14	**4,8**	36	70%	36,0%			
15	**5,9**	41,9	75%	41,9%	13,0%		
16	**7,1**	49	80%	49,0%			58,1%
17	**10,5**	59,5	85%	59,5%	22,5%	51,00%	
18	**12**	71,5	90%	71,5%			
19	**13,5**	85	95%	85,0%	28,5%		
20	**15**	100	100%	100,0%			
Total	**100**	N/A	N/A	N/A	100%	100%	100%

Figure 1.1: Sample wealth distribution

Source: Todaro & Smith (2012)

estimated by

$$c_V = \frac{\sigma_Y}{\mu_Y}. \tag{1.2}$$

In the example, we have a coefficient of variation of 0.87. Again, the lower c_V, the more equal the distribution is, according to the "c_V criteria".

Mean deviation and relative mean deviation The purpose of the exponent applied to the deviation in the variance and coefficient of variation calculation is to avoid a null result.[6] Another way to do so is to take the absolute value of each deviation. The mean deviation is and relative mean deviation are respectively estimated with

$$MD = \frac{1}{n}\sum_{i=1}^{n} |w_i - \mu_W| \text{ and } RMD = \frac{\frac{1}{n}\sum_{i=1}^{n} |w_i - \mu_W|}{|\mu_W|}. \tag{1.3}$$

There could be some advantages to those measures, we refer the interested reader to Gorard (2004). Linking this to our example, we have $MD = 3.4$ and $RMD = 0.68$. The lower MD and RMD, the more equal the distribution, according to the underlying criteria.

Standard deviation of logarithms Allowing to easily connect the initial dataset with the concept of normal distribution, a logarithmic transformation is sometimes applied.

Size distributions

The most common way used to compare wealth distributions is to partition the population in fractiles (quartiles, quintiles, deciles, percentiles etc.) according to their wealth (e.g. the first (resp. tenth) decile would be composed by the 10% of population having the least (resp. most) wealth) (Todaro & Smith, 2012) and then

- compare the wealth detained by one or more fractile and the total wealth in the economy;
- compare the wealth detained by one or more fractile and one or more other fractile.

Using previous notations (continuous case of section 1.4.2) and applying them to the example, the ratio of wealth detained by the top 10% to the wealth detained by the bottom 10% is

$$\frac{1 - L(0.90)}{L(0.10)} = \frac{1 - 0.715}{0.018} = \frac{0.285}{0.018} = 15.83. \tag{1.4}$$

[6] Indeed, without the exponent, we end up with $\frac{1}{n-1}\sum_{i=1}^{n}(w_i - \mu_W) = \frac{1}{n-1}\left(\sum_{i=1}^{n}(w_i) - n \cdot \mu_W\right) = \frac{1}{n-1}\left(n \cdot \mu_W - n \cdot \mu_W\right) = 0$.

This means that the top 10% detains more than 15 times the wealth detained by the bottom 10%. Such ratio is massively used by Piketty (2013), along with $1 - L(0.99)$ or $1 - L(0.999)$. Another famous particular case of the size distribution approach is the *Palma* ratio, derived from Palma (2011) and computed as $(1 - L(0.90))/L(0.40)$, or the *Kuznets* ratio comparing the top 20% and bottom 40% wealth (Todaro & Smith, 2012). This approach has been used by Lorenz (1905) to derive its famous curve, subject of the next subsection. Historic values to those shares and rations are given for different countries and points in times in chapter 3.

Gini's ratio of concentration

Probably the most famous aggregate measure of inequality, the GINI index was developed by the Italian mathematician Corrado Gini at the beginning of the twentieth century (Gini, 1912). According to some people, its approach may have actually already been thought of in the 1870's by German researchers (Xu, 2004). He built his index on the concept of Lorenz curve, first appearing in Lorenz (1905).

Lorenz curve The Lorenz curve plots the relationship between the cumulative share of individuals and its detained share of wealth. Formally, each $F(w^*) \in [0, 1]$ (x-axis) is associated to its correspondent $L(F(w^*))$ (y-axis).

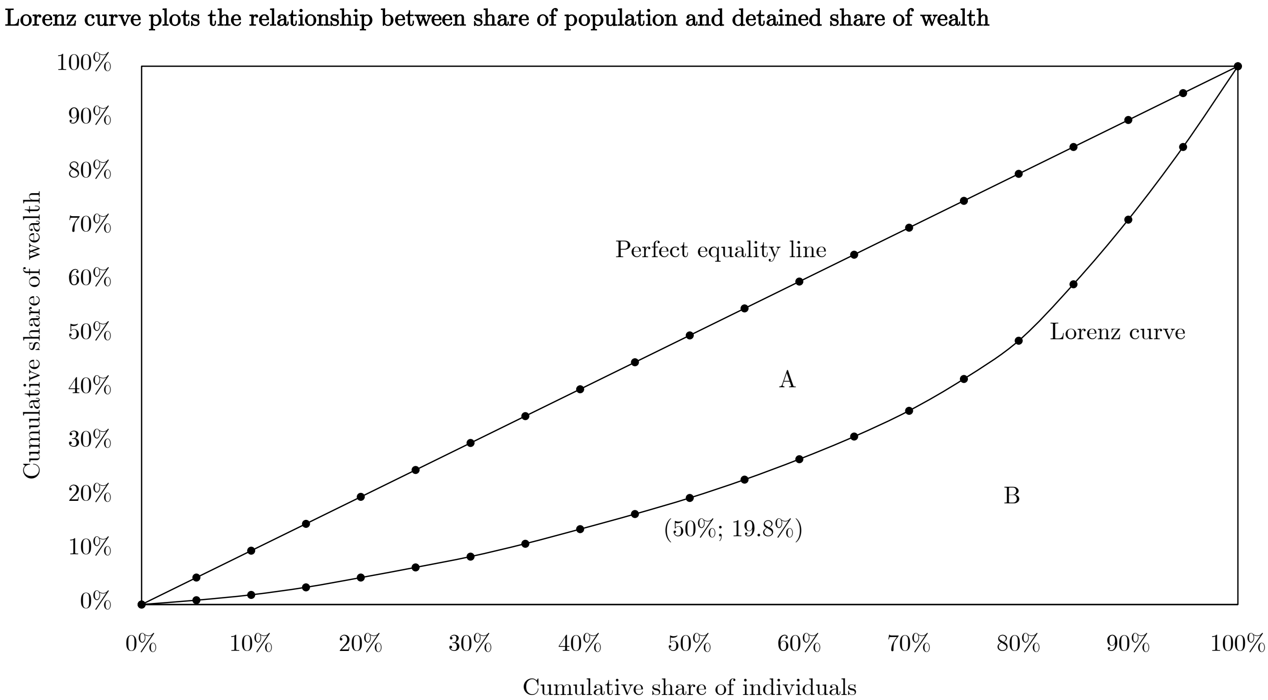


Figure 1.2: Example of Lorenz curve

Source: Todaro & Smith (2012)

Figure 1.2 uses the distribution from the example and shows that 50% of the population detains 19.8% of total wealth. The farther the Lorenz curve from the perfect equality line, the more unequal the distribution. Obviously, it starts in (0%; 0%) and ends in (100%; 100%).

Gini coefficient Let A be the area between the perfect equality line and the Lorenz curve and B the area between the Lorenz curve and the x-axis. Gini (1912) defines his ratio as

$$G = \frac{A}{A+B}. \tag{1.5}$$

As we said, the higher B (the lower A), the more equal the distribution, and the lower G (i.e. a lower coefficient means a more equal distribution). By construction, $0 \leq G \leq 1$. Since the combination of areas A and B constitutes half of the unit box, we have $A + B = \frac{1}{2}$ and, therefore, $G = 1 - 2 \cdot B$. Lots of papers treated the different ways to compute the coefficient. Pyatt (1976), through Xu (2004), showed for example that, in the discrete case, the index can be expressed as

$$G = \frac{\frac{1}{n^2}\sum_{i=1}^{n}\sum_{j=1}^{n}\max(0; w_i - w_j)}{\mu_W}. \tag{1.6}$$

Applying this to the example, we find $G \approx 0.44$, a quite unequal distribution knowing that most equal countries typically have indexes between 0.20 and 0.35 (Todaro & Smith, 2012). As explained in Cowell (1998), a distribution Lorenz-dominates (i.e. is more equal under Lorenz criteria) another if its Lorenz curve is above or at the same level of the other for any cumulative share of individuals.

Critics and extensions A plethora of critics have been raised against Gini's index (see for example Newbery (1970) or Atkinson (1970)). Actually, a plethora of critics have been raised against pretty much all aggregate measures of inequality. One of those is the fact that the index doesn't rank a given set of distributions in the same way an additive utility function[7] would do (Newbery, 1970). Another point is the fact the index doesn't allow easy ventilation to dig deeper and look for the source of inequality. For example, a specific group of people could drive most of the observed inequality. Authors such as Bhattacharya & Mahalanobis (1967), Pyatt (1976) or Lambert & Aronson (1993) develop ways to somehow ventilate the index, along with Theil (1967) who uses information theory concepts to build its eponymous index explained later in this section.

[7]An additive utility function is an aggregate utility function equal to the sum of the individual utility functions.

Atkinson's index

With the objective of including a measure of social acceptability within the inequality measurement index, or, in other words, including the social welfare function in the index as we discuss the relevance in section 1.4.5, Atkinson (1970) suggests the measure of inequality

$$I = 1 - \left[\sum_{i=1}^{n} \left(\frac{w_i}{\mu_W} \right)^{1-\epsilon} f(w_i) \right]^{\frac{1}{1-\epsilon}}. \tag{1.7}$$

where ϵ is a sensitivity parameter ranging from 0 to $+\infty$ catching the concern put on the lower tail of the wealth distribution (the condition of the poorest people), 0 being the level of complete indifference. Indeed, if $\epsilon = 0$, then $I = 1 - \frac{1}{\mu_W} \sum_{i=1}^{n} w_i \cdot f(w_i) = 1 - \frac{\mu_W}{\mu_W} = 0$ and there is then no inequality, according to social preferences summarized in ϵ, which Atkinson interprets as the measure of inequality-aversion. Figure 1.3 represents Atkinson's index[8] of the sample distribution, for different values of ϵ.

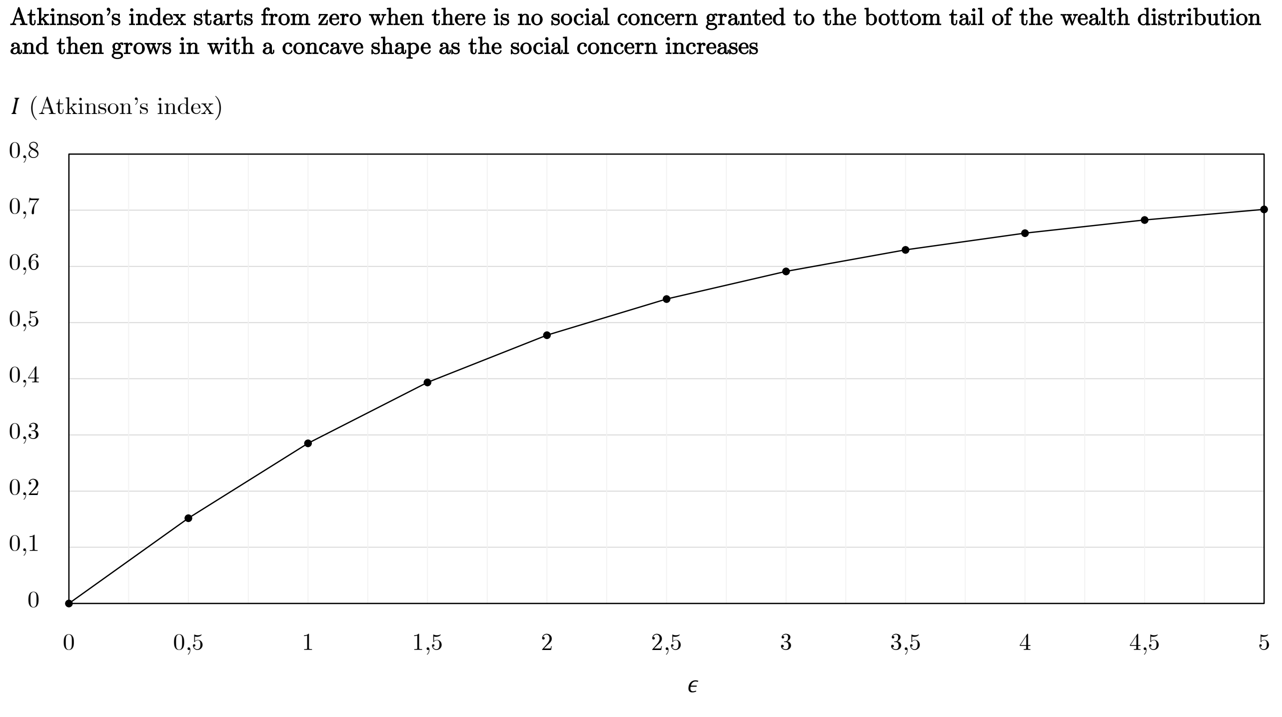


Figure 1.3: Example of Atkinson's index for different values of ϵ

Source: Own calculations

Clearly, the index follows an asymptotic shape in ϵ. If $\epsilon \to +\infty$, I tends to a finite constant. Atkinson calls this the social welfare function approach, which is further pursued by Sen & James (1973) or Cowell (1998), among others.

[8]For $\epsilon = 1$, the formula used is $I|_{\epsilon=1} = 1 - \frac{\prod_{i=1}^{n} y_i^{\frac{1}{n}}}{\mu_Y}$.

Theil's indexes

To overcome the issue of non-decomposability (property 5) inherent to the Gini ratio, Theil (1967) develops a specific index within the family of the generalized entropy (GE) indexes (De Maio, 2007), which satisfies the six criteria (World Bank Institute, 2005) but is quite complex to compute and interpret. The family inherits its name following several concepts borrowed from the information theory such as *information entropy*.[9] The inequality is measured by

$$GE(\alpha) = \frac{1}{\alpha(\alpha-1)}\left[\frac{1}{n}\sum_{i=1}^{n}\left(\frac{w_i}{\mu_W}\right)^{\alpha} - 1\right] \tag{1.8}$$

where α, similarly to Atkinson's ϵ, is such that $0 \leq \alpha \leq +\infty$ and catches the sensitivity of GE to inequality in the lower tail (for low values of α) or higher tail (for high values of α) of the wealth distribution. For the specific cases where α equals 0 or 1, the formula becomes

$$GE(0) = \frac{1}{n}\sum_{i=1}^{n}\ln\left(\frac{\mu_W}{w_i}\right) \text{ and } GE(1) = \frac{1}{n}\sum_{i=1}^{n}\frac{w_i}{\mu_W}\cdot\ln\left(\frac{\mu_W}{w_i}\right). \tag{1.9}$$

$GE(0)$ and $GE(1)$ are respectively Theil's L (high sensitivity granted to the Low tail) and Theil's T (high sensitivity granted to the Top tail) indexes (World Bank Institute, 2005). The main advantage of this aggregate measure is that it can be disaggregated in groups such that total inequality is simply the sum of inequalities within and between groups (Pyatt, 1976), similarly to the ANOVA (analysis of variance), a statistical method aimed at decomposing the variance of a parameter within and between groups (Deprins, 2012).

Other approaches

Other measures of inequality may substitute the ones just presented. One of them, provided by Hoover (1936), is the *Robin Hood* index. Measuring the maximum vertical distance between the perfect equality line and the Lorenz curve, the Robin Hood index can be seen as the share of wealth above the average wealth which has to be redistributed below the average to achieve an equal distribution (De Maio, 2007).

1.4.5 Challenges

Mathematical properties, data and modeling strategy In addition to the common issues such as mathematical properties of each metric, data quantity, data aggregation level (to protect confidentiality, mostly in the upper tails), research question specification and selection of modeling strategy raised by Cowell (1998), another point is worth mentioning.

[9]The *entropy* of a message is a measure of the quantity of information included in the message.

Underlying social welfare/utility function As it has been showed, each of the above formulas leads to different results when applied to the same distribution. Moreover, different methods (often) lead to different ranking of a given set of distributions. That is, distribution A can be more equal than distribution B using one method while B can be considered as more equal than A using another. This critical observation is raised by Atkinson (1970), pointing out the fact that one method actually involves an implied/underlying/inducted/non-stated welfare or utility function. Put another way, one method involves a specific ranking criteria not straightforward when looking at the formula. The ranking criteria differ by methods, otherwise A and B would have been ranked in the same way. The problem is that this criteria may not be in line with what people would agree with (Atkinson, 1970). To go over this issue, he suggests an index of inequality

$$I = 1 - \frac{w_{EDE}}{\mu_W} \tag{1.10}$$

where y_{EDE} is called the *equally distributed equivalent level of income* and defined as the "level of income per head which if equally distributed would give the same level of social welfare as the present distribution" and μ_W is the mean of current distribution. The lower I, the more equal the distribution. Such approach makes impossible to compute I without formally specifying the form of the social welfare function. However, the problem is then to specify the welfare function to be used.

1.5 Conclusion

Equality, poverty, equity and efficiency The question of equality influences and is influenced by other questions. The paper focuses on equality while efficiency will also be measured in the third part when forecasting the impact of Piketty's tax on the total stock of wealth in the economy.

No perfect measurement approach We see that a wide literature appeared over the past century, challenging all measures but not providing one single approach without any known drawbacks. For this reason, we mainly use the size distribution approach, like Piketty, as it is the most common in surveys and reports, along with the so-called GINI index.

Chapter 2

Consequences

2.1 Introduction

Now that we know what inequality actually is, we ask ourselves the question of its implications. The objective here is not to scientifically prove that wealth and/or revenue inequalities are good or bad, which would constitute a whole thesis in itself and certainly more, without even entering into philosophical questions. The goal is to highlight some mechanisms through which inequalities can have a positive or negative impact on (economic) development (section 2.2) and to somehow quantify the impact (section 2.3) so as to make the reader aware of the importance of the subject and the relevance of further analysis.

Wealth inequalities The first concern is to precisely determine the type of inequality we study: money, skills, title etc. For obvious reasons, we focus the analysis on monetary inequality, within which a crucial distinction has to be made between income and wealth (Diaz-Gimenez et al., 1997), the former being one of the flows driving the latter, the stock. As Piketty's suggested tax is applied to the wealth of individuals (Piketty, 2013), we narrow down on the impact of wealth inequalities, while including many arguments originally coming from the income inequalities literature. Indeed, some (many) economic mechanisms and analytic models related to wealth can be applied to income provided some adjustments, and inversely.

We would tend to go even further by stating that what actually ultimately matters is wealth. Take for example A with \$1,000,000 of wealth and \$1,000 of annual income versus B with \$100,000 of wealth and \$10,000 of annual income. Who has the best situation? It would take 100 years for B to reach the same level of wealth of A, assuming no outflows. Kuznets (1955) is one of the first person to open the question of inequality (in this case income inequality) and economic growth.

Consequences, not causes, on economic growth Impact of wealth inequalities on what? Again, for obvious reasons, we narrow the analysis on the impact on economic development, most of the time measured by the gross domestic product (GDP) growth. Although understanding the source of inequalities is probably a *sine qua non* condition to handle the problem in a sustainable way, we do not answer the question *What drives inequalities (causes)?*, as it falls out of our scope. We can however state some of the main explanations: inner talent/skills, family inheritance, luck, network etc.

2.2 Wealth/income inequalities and economic growth

2.2.1 Challenges

A lot of academic papers published in the 1990s was aimed at determining the drivers of economic growth. Combined with adequate data, studies looked at the impact of inequality, mainly income inequality, can have on it (Aghion et al., 1999). Regarding wealth, there was and is still a substantial challenge of data availability, as countries do not tax wealth as often as they tax income, and therefore do not require wealth disclosure from citizens (Piketty, 2013; Bagchi & Sveijnar, 2015). Other challenges on top of data quantity include data quality, choice of indicator of degree of inequality and choice of statistical method (OECD, 2015). As a consequence, academics use proxies: mostly income inequality to estimate wealth inequality (Aghion et al., 1999).

We could briefly ask ourselves the quality of such estimation. As shown by figure 2.1, there is no precise relationship between wealth concentration and income concentration across countries. This shows the need of better country-specific data regarding wealth of individuals. We now have a look at the different mechanisms through which inequalities (concentration) of wealth may have an impact, being either positive or negative, on economic growth.

2.2.2 Paradigms

Summarized by Galor (2009) and pointed out by Shao (2011), three paradigms have been historically used to study the link between income/wealth inequality and economic growth. In order of appearance, there is

- the *classical approach* (1920s) with Keynes arguing a positive relationship between inequality and growth;
- the *neoclassical approach* (1950s) with Solow, Kuznets etc. arguing no significant relationship;

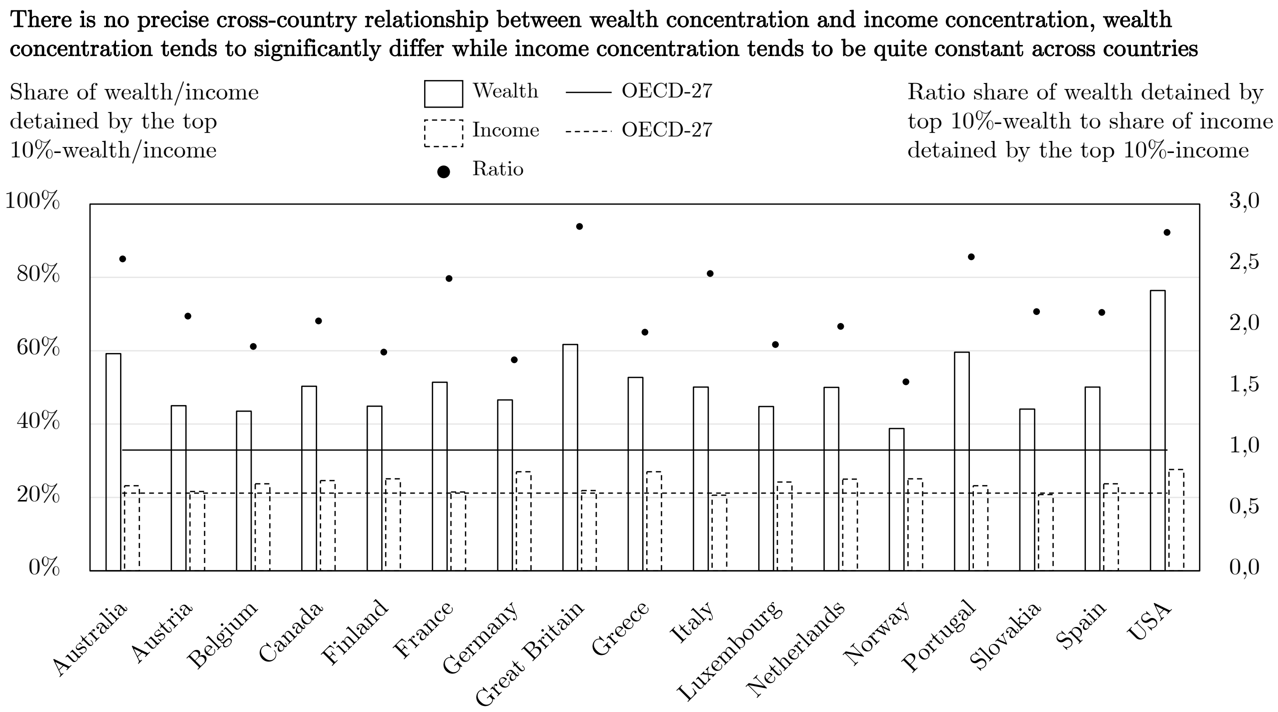


Figure 2.1: Cross-country comparison of wealth and income concentration in selected countries in 2015

Source: OECD (2015), own calculations

- the *modern approach* (1980s) with Romer, Galor & Zeira, Aghion etc. arguing a negative relationship.

We structure the section in mechanisms rather than in paradigms or authors.

2.2.3 Positive impact of inequality

Higher incentives

Probably the first reason one would think about when asking why income and wealth inequalities could be needed is to provide individuals with incentive to upgrade their standards of life by working more, investing and taking risks (Mirrlees, 1971; Lazear & Rosen, 1979; Todaro & Smith, 2012; OECD, 2015). We will see later that, in case of moral hazard context due to limited liability of borrowers, the incentive argument actually becomes a counter-advocate for inequality.

Higher propensity to save, and therefore to invest

Originally from Keynes and pursued by Kaldor (1957) or Bourguignon (2010), an explanation why inequalities are beneficial to growth has to be found in the propensity to save, measured by the savings rate of individuals.

Oversimplifying the approach, let's say that income can either be consumed (without monetary return) or saved/invested (at a positive rate of return). Assuming that the savings rate is positively driven by income, then, at a given total income, the more concentrated the income, the more the investment, the more the capital accumulation and therefore more growth. Easy to understand, this approach is based on the critical assumption that the savings rate increases with income/wealth. As we will see below, there are opposite views to this assumption (Todaro, 1997).

2.2.4 Negative impact of inequality

Hampered social cohesion and education

Social cohesion Inequality may decrease "social stability and solidarity" leading to civil wars and increased power concentration in the hands of people who usually use it at their advantage through lobbying, targeted charity, extortion and nepotism (Todaro & Smith, 2012; United Nations, 2013). Furthermore, the anger of poorer people vis-à-vis inequality may lead them to vote for populist/nationalist governments (Todaro & Smith, 2012), for which history is not a proof of long-term sustainability and growth. Alesina & Perotti (1996) also highlight the negative relationship through reduced investments due to political-uncertainty aversion

Effects of inequality through political connections are studied with more details by Bagchi & Sveijnar (2015) using *Forbes*' data from 1987 to 2007, with a "somewhat subjective" classification on who is politically connected and who is not, concluding a negative impact. One of their illustrating case study is the time when some Russians became rich because their political connections allowed them to go into natural resources businesses at prices below arm's length standards after the fall of the wall. Alesina & Rodrik (1994) or Saastamoinen (2006) come up with similar conclusions.

Education In a recent study, OECD (2015) argues that the social cohesion mechanism is actually not the most relevant to explain lower economic growth, the answer coming from education (Schmitt, 2015). According to the organization, less wealthy people invest less in acquiring and developing skills and knowledge. This gap in skills and knowledge is found to be higher in countries with higher inequalities Peston (2015). On the same vein, Todaro & Smith (2012) argue that unequal societies are biased towards better high-end education accessible only by elite rather than basic education for all.

Unexploited individual productivity

One of the major assumption of the whole neoclassical economy is that the *marginal productivity of investment* or the *rate of return on investment*, decreases with the size of the investment (Aghion et al., 1999). In other words, the individual production function, $f(k_i)$ where i denotes an individual and k_i its capital (being physical or human), is concave: $f''(k_i) < 0$. This mindset is first suggested by Solow (1956) in its publication *A Contribution to the Theory of Economic Growth* by expressing the production (output) of an economy using a *Cobb-Douglas* expression:

$$Y = K^{\alpha}(A \times L)^{1-\alpha} \text{ with } 0 < \alpha < 1 \tag{2.1}$$

where K stands for the stock of capital in the economy, L is the stock of labor in the economy, A is a productivity factor (tied to technology) and α is the capital-elasticity of production. The constraint $0 < \alpha < 1$ is the analytic counterpart of the concavity shape. This simple model has been the starting point of countless of theories on economic growth (see for example Mankiw et al. (1992), Islam (1995) or Gemmell (1995)).

Applying this to individuals, Aghion et al. (1999) show that, in a context of heterogeneity of initial endowment (i.e. different wealth for different individuals) and imperfection of capital markets (i.e. different access to credit for different individuals) as raised by Piketty (1993), productive investment opportunities are unexploited. The rationale is that, if an individual with less wealth is more productive than an individual with more wealth, then the former could leverage his productivity by borrowing. However, if his financing capabilities are limited, he is not able to fully use his advantage. Therefore, some production leaves unrealized.[1] They build on previous aligned results from Galor & Zeira (1993) and Bénabou (1996). This mechanism using the argument of imperfection in credit markets is also included in Saastamoinen (2006), Todaro & Smith (2012) (along with another rationale related to land ownership, pointing out that the most productive farms are middle-size rather than big-size farms) and some others.

Non undertaking of high-yield investment projects

Let us now color this view a bit. The previous rationale is based on the critical assumption of concavity of production function. What if this is not the case in reality? In *Capital in the Twenty-First Century*, Piketty (2013) raises the problem of unequal access to high-

[1] For the interested reader, *Aghion et al.* came up with a growth rate $g_t = \alpha \ln(s) + \ln\left(\int_0^1 (w_{i,t})^{\alpha} di\right)$ where $w_{i,t}$ is the endowment of individual i in t, s is the invested fraction of $w_{i,t}$ ($k_{i,t} = s \times w_{i,t}$) and α is the productivity parameter. Since $0 < \alpha < 1$ because of the concavity of production function assumption, g_t is maximal when $w_{i,t} = w_{j,t}$ for all individuals i and j, that is, when all endowments are equal.

yield investments, saying that the average rate of return actually increase with the wealth as wealthier people will have access to better investments (e.g. complex financial products requiring authorization, offshore financial entities and "real" projects only available to rich people etc.). This is one of the pattern driving Piketty's equation $r > g$ leading to inequalities. This weakens Aghion's approach, but implies on the other hand that some production is also left aside due to the fact that best investment projects are usually not accessible to everyone.

Lack in borrowers' incentives to succeed

According to Aghion et al. (1999), building on Banerjee & Newman (1993) and Aghion & Bolton (1997), the need to borrow generates a disincentive to provide the adequate level of endeavor needed for the completion of an investment project. The rationale can be summarized in two steps.

In case of limited liability, a borrower owning an amount of wealth w and borrowing an amount b for an investment project will never be asked to pay back more than $\max(w, b)$. Consider now two projects for which the respective needs to borrow are b_1 and b_2 such as $w < b_1 < b_2$. The investor does not have much more incentive to succeed with project one or two since he will anyway have to repay w if he fails, the remaining driver of incentive being the expected additional profit from the endeavor two. Actually, as soon as $w < b$, the level of effort committed by the investor is lower than the level of effort the lender expects the investor to provide. This is called, in our context, the *moral hazard*.

The less the initial wealth of the investor, the more he has to borrow, the less he is, on average, inclined to commit huge amount of effort. That being said, redistributing wealth from richer to poorer people would increase the total amount of effort as long as richer people do not fall in the case $w < b$.[2]

Unrealized consumption

In TED (2004), Nick Hanauer, "entrepreneur, venture capitalist, civic activist, philanthropist and author" as stated on his own website, says that the consumption of rich people does not follow the same multiple than the wealth multiple compared to relatively poorer people.

[2] For the interested reader, *Aghion et al.* came up with an amount of effort $e = \sigma - r(\phi - \frac{w}{A})$ supplied by the undertaker of an investment project to maximize its utility, where σ is a measure of output if the project is successful, r is the interest rate to repay to the lender, ϕ is a measure of initial investment, A $(> w)$ is the link between investment and outcome, and w is still the individual wealth. The clear result is that $e < e^* = \sigma$, that is, the effort provided by someone who has to borrow is less than the effort provided by someone who has not to borrow (for who $r = 0$).

However, economic growth is mainly driven by consumption. So, there is a negative effect due to unrealized consumption. We formally note

$$c_i = \lambda(w_i) \times w_i \text{ with } \frac{d\lambda_i(w_i)}{dw_i} < 0 \tag{2.2}$$

where c_i denotes the consumption of individual i, λ_i his consumption multiple and w_i his wealth. Although Mr Hanauer has no academic recognition, this TED talk provides an intuition of the impact of inequality on growth through consumption. This intuition may make sense at first, knowing that GDP (growth) is driven by private consumption (growth) to an extent of more than 50%, as shown by figure 2.2.

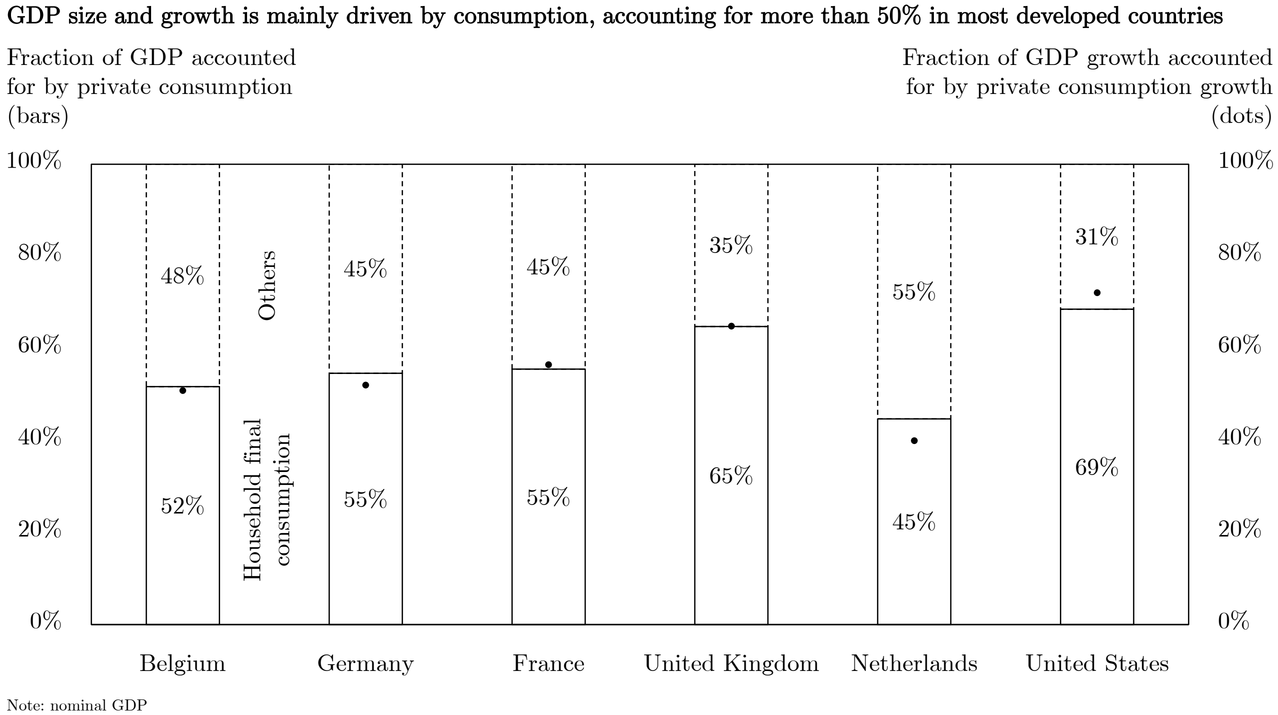


Figure 2.2: Drivers of GDP size (2014) and growth (2000-2014) in selected countries

Source: The World Bank (2015), own calculations

What nevertheless should be confirmed is the negative relationship between wealth w_i and wealth multiple $\lambda(w_i)$. On the one hand, we can think about first necessity goods and services for which there is no particular reason why a rich person would buy much more than a more poor person, in value, except from a price difference coming from premium products. On the other hand, rich people can make discretionary purchases (e.g. luxury cars, Swiss watches etc.) with high impact on individual consumption. This is confirmed by Todaro (1997) explaining that the middle-class usually presents the highest savings rate (and therefore the lowest consumption rate) among the different classes of wealth. Formal academic models of growth including consumption are developed by Corneo & Jeanne (2001) and Peng (2008), amongst others, supporting the conclusion of negative impact.

2.2.5 Other considerations

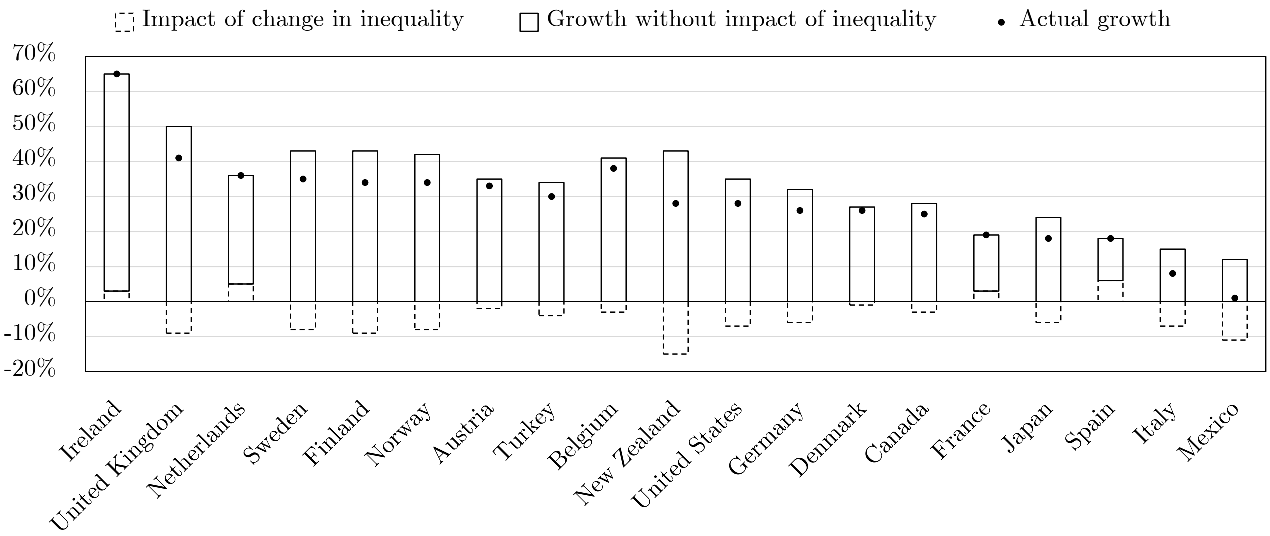
All the models previously detailed are, by definition of a model, simplifying the reality by leaving out some aspects which may actually play in the inequality-growth equation. Other researchers integrate considerations such as the industrial maturity of an economy or the easiness of knowledge transmission (Bandyopadhyay & Basu, 2005), the differences in talents and skills among individuals (Mookherjee & Ray, 2003) or also differences in return of physical capital versus return on human capital (Galor & Moav, 2004). We don't

2.3 Quantification

Before concluding, let's try to put some numbers on the mechanisms and intuitions explained above to get an idea of their magnitude. We here take estimations of the most recent study conducted by OECD (2015), partisan of the view following which less inequality is beneficial. According to it, reducing inequality (income in this case) by one GINI point would result in an increase of 0.15 percentage point in the GDP growth rate (Schmitt, 2015).

According to OECD, increase in income inequalities during 1985-2005 cost at least 4 percentage points of gross domestic product growth in 50% of countries during 1990-2010

GDP per capita growth rate over 1990-2010



Note: Spain, Ireland and France patterns are explained by a reduction of income inequalities before the crisis

Figure 2.3: Cost on 1990-2010 growth of change in income inequality in selected countries during 1985-2005

Source: OECD (2014)

Figure 2.3 depicts the impact of change in income inequality during the 1985-2005 period on the GDP per capita growth in selected OECD countries and shows that at least 4 percentage points of growth during the 1990-2010 period have been lost in more than half of the countries.

2.4 Conclusion

There have been waves of literature successively in favor of, neutral to and against income/wealth inequalities. The present consensus is that they reduce economic growth. One could question this pattern of "waves" in the literature, however we don't open this door here.

Important to notice, the causal relationship takes the form of different mechanisms, implying different levers, both micro- and macro-economic. Attempts to concretely quantify the impact of reduced inequalities rely on huge assumptions though and it is not clear today how much an economy could benefit from it.

Knowing this, we now move on to the historical analysis of income and wealth inequalities, focusing on Belgium, in order to assess whether there is a need of intervention.

Chapter 3

Evolution in the developed world

3.1 Introduction

"Instead of an economy that works for the prosperity of all, for future generations, and for the planet, we have instead created an economy for the 1%" (Hardoon et al., 2016). Whether this is true or not, the questions of income equality, wealth concentration and redistribution have been at the center of political debate for centuries (see Ricardo (1817), Marx et al. (1906), Kuznets (1955), Atkinson (1970) and more recently, Piketty (2013), Dorling (2014) and Atkinson (2015)). While an important topic, this paper is not geared towards analyzing global economic inequalities and distribution, and this chapter focuses solely on analyzing the case for selected developed countries.

We analyze the historical distribution of two variables: income and wealth. We focus the analysis on six countries: the United States, France, the United Kingdom, Germany, the Netherlands, and Belgium. Most of these countries have been chosen due to the high availability of existing data about income, wealth. Among them, Belgium has been chosen because the main purpose of this paper is to shed light on this country.

Understanding the reasons of the evolution of inequalities is out of our scope. We therefore not look into the issues of poverty, education, employment and other social variables that could be linked to unequal distribution of income or wealth within the society.

Diaz-Gimenez et al. (1997) differentiate between income, salary and wealth inequalities as part of economic inequalities. For the sake of simplicity, we divide economic inequalities between income and wealth. We also prefer using size distribution data to the use of any specific aggregate inequality indicator, for the reasons mentioned in chapter 1.

3.2 Income inequalities

Size of income First, we look at how national income has evolved in the six selected countries (section 3.2.1).

Distribution of income Second, we perform two analyses. One, we look how different deciles of the population have seen their income grow in the past 50 years. This gives a snapshot of where the variation in national income comes from. Two, we analyze how the top 10% share in total national revenue has evolved over the same time period. This tells whether revenue is getting more or less concentrated within the highest earners. We consider two variables, namely taxable income and equivalized disposable income (section 3.2.2).

3.2.1 Income size

The variable used is the adjusted net national income (NNI) which is equal to the gross national income (GNI) minus consumption of fixed capital and natural resources depletion.[1] As defined by The World Bank (2016b), GNI is *"the sum of value added by all resident producers plus any product taxes (less subsidies) not included in the valuation of output plus net receipts of primary income (compensation of employees and property income) from abroad"*. Data is in current US$, computed through the world bank *Atlas method*.[2]

The evolution of national income per capita can be seen in graph 3.1. We notice that there has been a clear upward trend in national income per capita, growing from less than $5 000 in 1970 in all countries to more than $35 000 everywhere. Knowing that income per capita has been rising significantly over the past 40 years, we now turn the analysis to the next section and look how this national income is shared among citizens of each country.

A word on the shadow economy Before going further, we think it is good to mention how those data on income at a national level actually reflect the reality. The main gap between them and what happens in the real world is probably the size and importance of the shadow economy. Following Elgin & Oztunalı (2012), the shadow economy is smaller in developed and rich nations than in poor and developing countries, and there is a worldwide trend in reduction of the shadow economy. A summary of the estimation of the size of the shadow economy as a percentage of GDP for the six countries studied can be found in appendix A.2. What

[1] For a formal explanation of the differences between NNI and GNI and an explanation of why NNI has been preferred, refer to appendix A.1.

[2] The Atlas method applies a conversion factor that averages the exchange rate for a given year and the two preceding years, adjusted for differences in rates of inflation between the countries (The World Bank, 2016b).

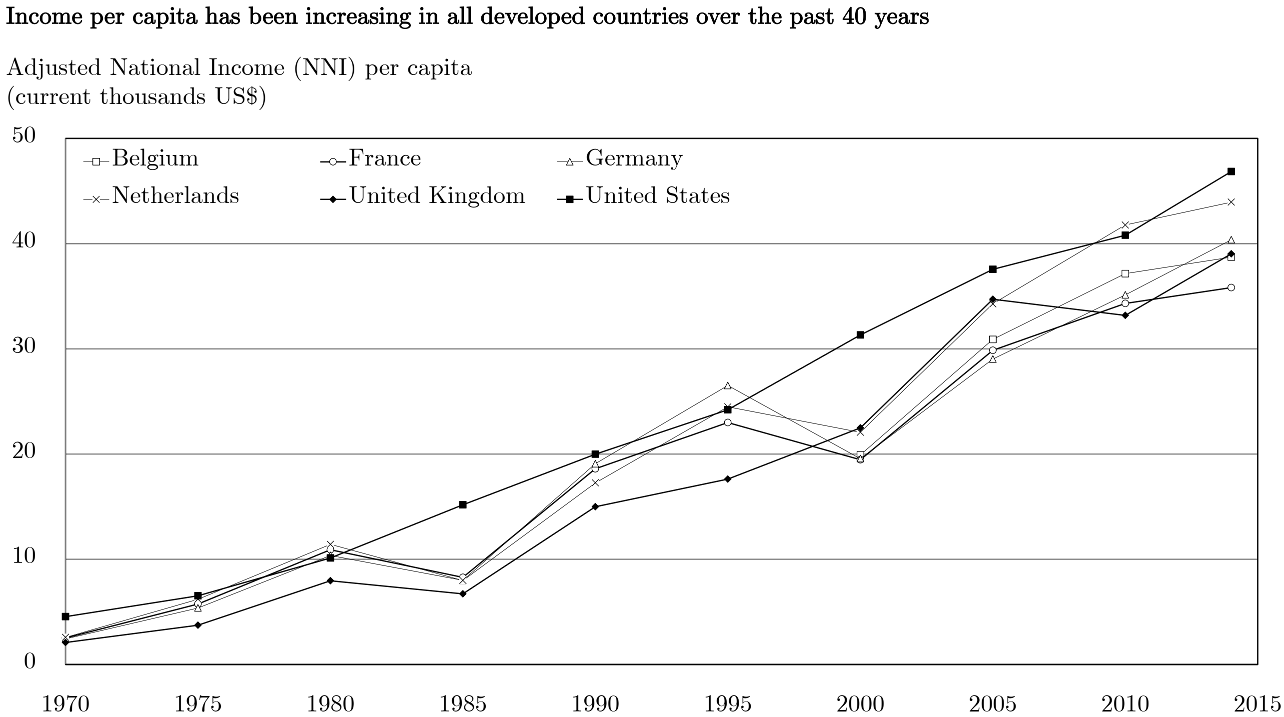


Figure 3.1: Adjusted net national income in selected countries between 1970 and 2014

Source: The World Bank (2016a)

we see is that Belgium has the highest estimate of shadow economy as a percentage of GDP, around 20% in 2010, whereas the United States have the smallest one, around 8%. While substantial, Belgium's estimates stays small compared to estimates in Latin America and Sub-Saharan African for which weighted-averages of estimates of the size of the shadow economy as a percentage of GDP were valued between 35% and 40% in 2009, with a record-high for Bolivia at 63.5% in 2009 (Elgin & Oztunalı, 2012). Although this could represent a significant change in the numbers, mostly in the Belgian case, we however do not include any correction for the potential size of the shadow economy on our data set.

3.2.2 Income distribution

In this section, we look at the distribution of income within the different countries and the evolution of this distribution over time, considering equivalized disposable income and taxable income.

Equivalized disposable income

Equivalized disposable income refers to a household's disposable income within a given year. It is computed as the sum of wages, capital income and transfers from the State; less income taxes and social security; divided by the number of household members converted into equivalized adults, using the so-called *modified OECD scale*.[3] Figure 3.2 shows how equivalized disposable income has evolved in the selected countries between the middle of the 1980s and the end of the 2000s.

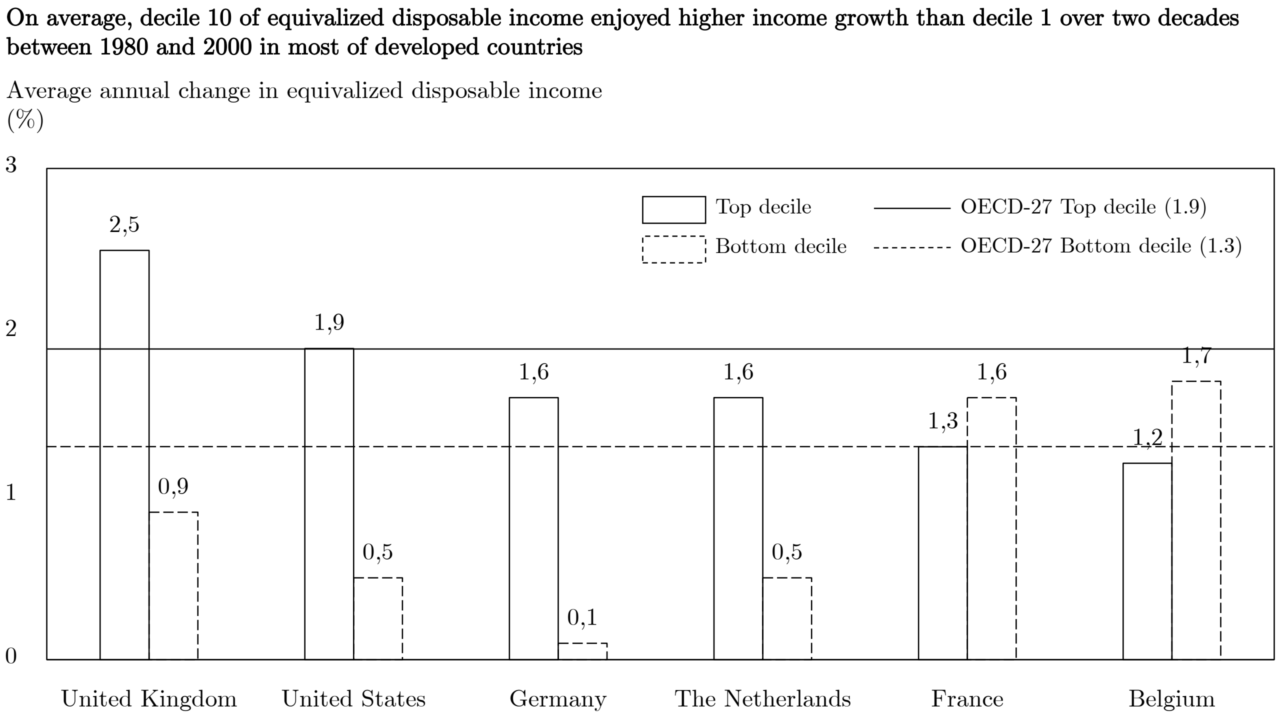


Figure 3.2: Average annual change in equivalized disposable income in selected countries between 1980 and 2000

Source: OECD (2011)

A key takeaway from this data is that for the OECD-27 average, the bottom decile sees its income grow at a slower rate than the top decile, stemming for an average general (except from France and Belgium) increase in inequalities.

In figure 3.3, we look at how the share of national equivalized income of the bottom and the top deciles have changed over the years 1995-2014. Except for Germany and for the UK, the bottom decile has gained ground, winning between 0.5 and 0.7 percentage point in 20 years.

Germany appears to have experienced the strongest increase in income gap as the share of income for the bottom decile has declined while the one of the top decile has increased. Compared to what was concluded in figure 3.2, the top decile has indeed seen its disposable

[3]A value of 1 is assigned to the household head, of 0.5 to each additional adult member and of 0.3 to each child (Haagenaars et al., 1994).

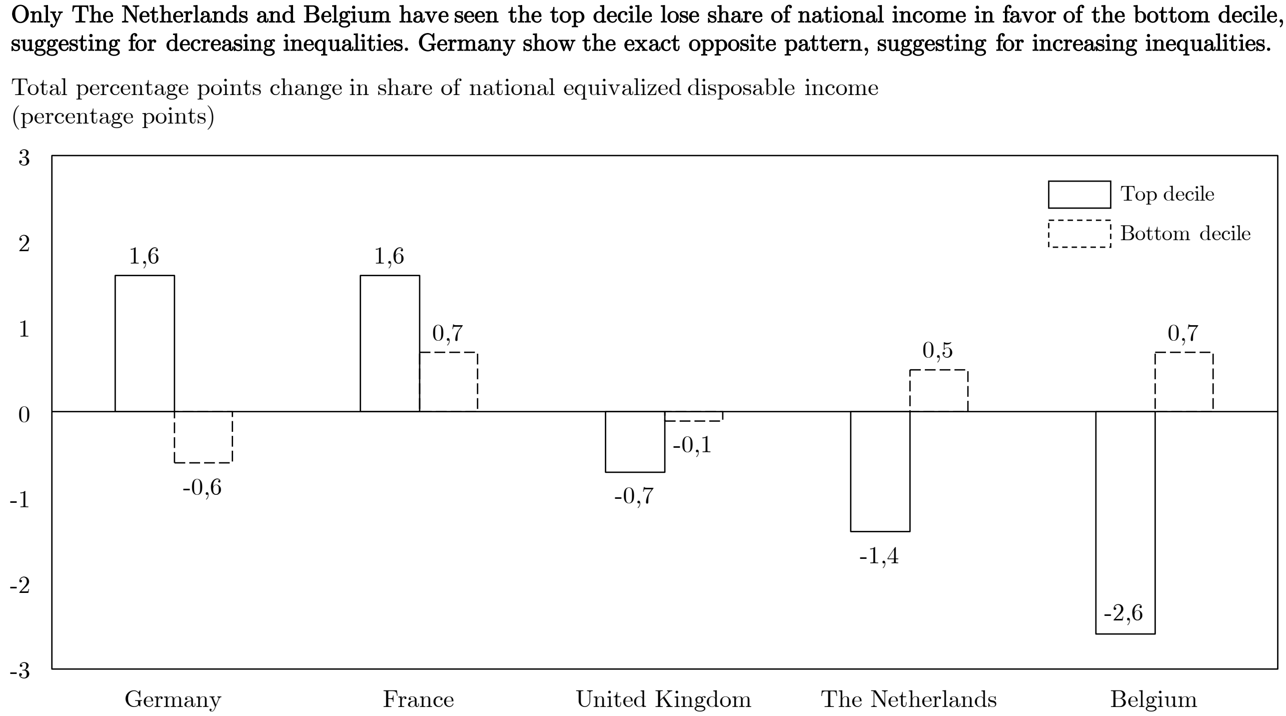


Figure 3.3: Total change in the share of national equivalised disposable income in selected countries between 1995 and 2014

Source: Eurostat (2016)

income grow faster than the bottom one, suggesting this change in share of total income. Belgium and The Netherlands present the exact opposite pattern: it seems that the bottom decile has received a larger share of total income, and the top decile has lost some share.

Taxable income

Taxable income refers to the income taxed through the personal income tax, excluding income taxed separately and deductible expenses(Direction générale Statistique, 2016).

As it can be seen in figure 3.4, the evolution of the share of the top 10% in the total taxable income has followed a U-shape over the past century in most developed countries. France seems to be the only exception where the share of the top decile did not significantly rise over the past 50 years, being at 32% in 1943, climaxing in 1965 at 37.15% and stumbling around 30-33% since then, being at 33% in 2009. It is however good to mention that the top 10% enjoys a significant share of total taxable income: more than 30% in all observed countries, and up to over 45% in the United States.

Let's focus on the last 30 years depicted in figure 3.5. On the one hand, there is a clear distinction between the US, the UK and, lately, Germany as of the increase in income share

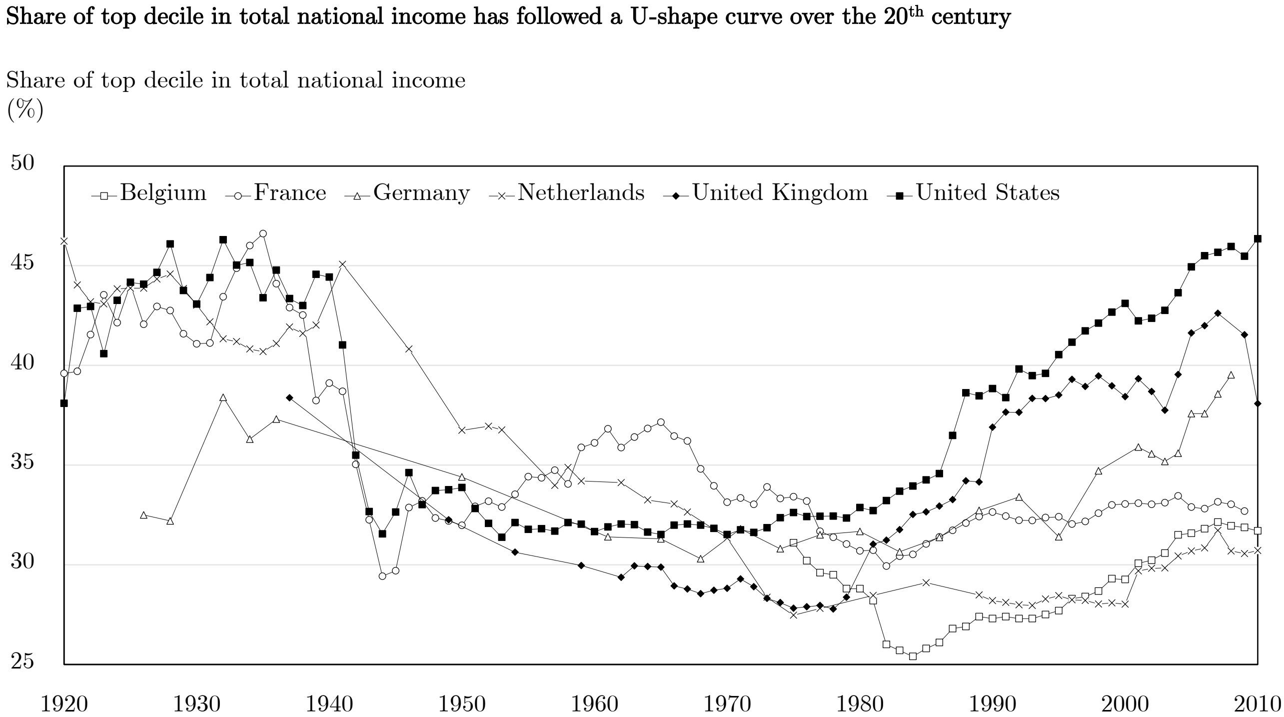


Figure 3.4: Taxable income share of the top 10% in selected countries between 1920 and 2010

Source: Various (see above)

detained the top 10%. Indeed, in 1980, all countries experienced relatively equal top decile share (somewhere between 30-35% of national income for all countries). Since then, the UK and the US rose to levels comparable to what could be seen after the first World War, between 40-45%. Germany followed the same pattern but later, with a rise starting more or less after 1995.

On the other hand, countries from Continental Europe such as France, the Netherlands and Belgium have not seen a rise in the top decile income share since 1945, still recording values between 30-35% of national income. More data is available for the evolution of the top 5%, 1%, 0.1% and 0.01% in Piketty (2013) and we send the reader to it for further analyses. The book however confirms the trend that Anglo-Saxon countries have all experienced a rise in inequalities that has not plateaued yet, whereas countries from Continental Europe have seen the top 10% kept a relatively stable share of national income somewhere between 30 and 35% over the past 20 years.

A word on the data sources Caution should be taken when analyzing these figures.

Fist, various sources are used to obtain historical data for those countries, with the following methodology when choosing them.

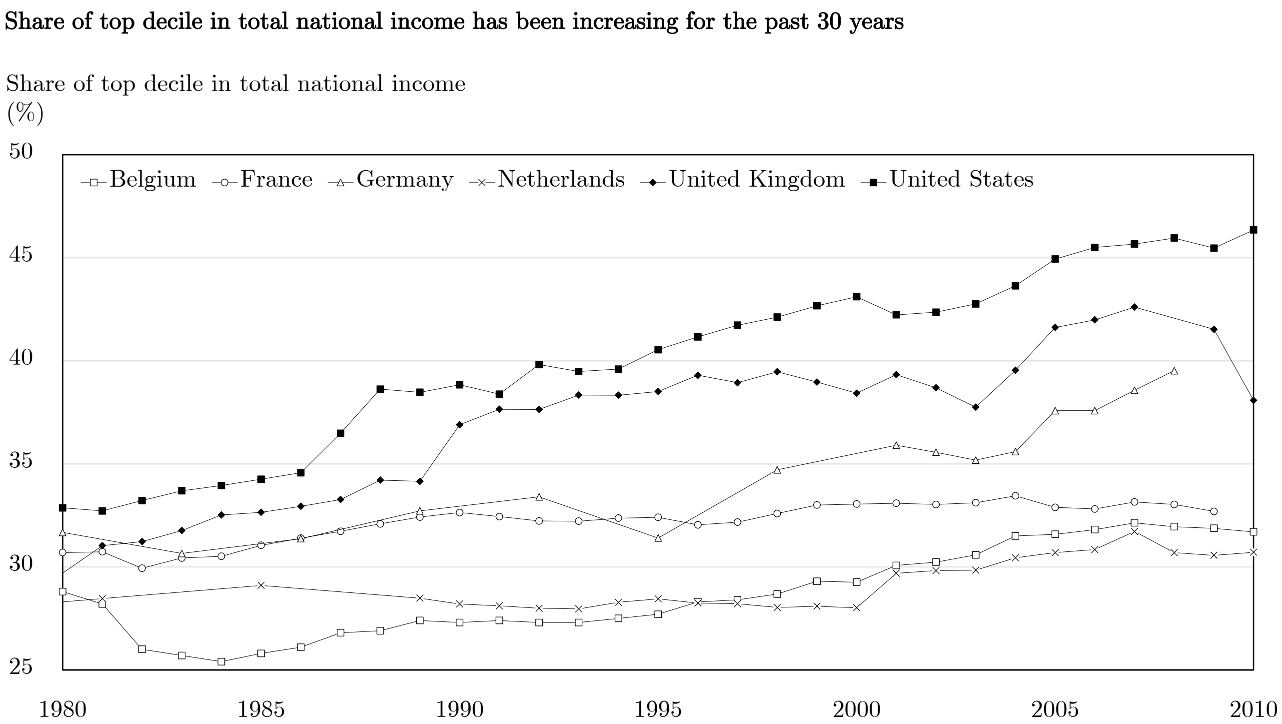


Figure 3.5: Taxable income share of the top 10% in selected countries between 1980 and 2010

Source: Various (see above)

- We use Abbeloos & De Smet (2014) providing data from 1973 till 2011 for Belgium (except 1973-1974), France (except 2010, 2011), United Kingdom (except 1980, 2008) and United States along with data from 1989 till 2011 for the Netherlands.
- Older data points for those 5 countries come from Piketty & Zucman (2014).
- The data related to Germany comes from the online *World Wealth and Income Database* (Alvaredo et al., 2016).

Abbeloos & De Smet (2014) are preferred as they are the only one having done the analysis for Belgium, main focus of this paper. No large discrepancies could however be noted when comparing these three data sources for other countries, which suggests that similar (if not same) methodology has been applied.

Second, this data displays the income as stated on tax returns. However, income tax data is directly linked to the personal income tax definition of a country and is impacted by tax reforms. This poses two issues: one in comparing data over time in a country, and one in comparing data across countries. In particular, consider the Belgian case where capital income is taxed separately from the personal income tax (SPF Finances, 2016b), the Nordic dual income taxation scheme (Nielsen & Sørensen, 1997) and the US comprehensive income tax where gross income is defined as "all income from whatever source derived".[4] Not considering capital income in the definition of taxable income can substantially reduce the considered income of the highest earners (Barthels & Jenderny, 2014). And, as wealth rich individuals tend to have higher capital income than the wealth poor, this means that income inequalities are undervalued for wealthy individuals. Last but not least, tax avoidance and evasion (e.g. undeclared income) also impact the veracity of available fiscal data.

3.2.3 Conclusions on income inequalities

This section was aimed at assessing the evolution of income inequalities in some developed countries over the last century. While income per capita has been rising in the past century in all countries observed, it seems that not everyone benefited the same way from this rise. Data suggests that taxable income has grown more unequal over the past 40 years, a phenomenon mostly experienced in Anglo-Saxon countries. However, equivalized disposable income seems to be distributed more equally than taxable income, suggesting that the redistribution mechanisms in place in most countries do in fact reduce inequalities

Two arguments need to be considered when making this conclusion. First, the unit of analysis is not the same for taxable and equivalized disposable income. The first is per taxpayer, while the second is per equivalized household. In other words, the structure of the household has an impact on the equivalized disposable income and is therefore a 'construit' that needs to be analyzed with caution. The second argument is that data is likely to underestimate income at the top of the distribution, suggesting that real income might be more unequally distributed than the two income variables studied in this section. Overall, we can however conclude that income inequalities are rising in the observed countries over the long term.

3.3 Wealth inequalities

Before looking at how wealth distribution has changed historically, it is good to frame what we mean by wealth. In his book, Piketty uses the ides of wealth and capital interchangeably, which caused many economists to argue that his conclusions where flawed, as those two concepts are different. As defined in Encyclopædia Britannica (2016), capital is "a stock of resources that may be employed in the production of goods and services". They further explain that, "in its broadest possible sense, capital includes the human population; nonmaterial elements such as skills, abilities, and education; land, buildings, machines, equipment of all kinds; and all stocks of goods — finished or unfinished — in the hands of both firms and households." One

[4] See I.R.C. § 61(a) (2006).

can notice here that the capital of a nation therefore does not include any financial element, such as saving accounts or shares of stock-denoted companies. Wealth, on the other hand, does account for "possessions and financial claims" (Encyclopædia Britannica, 2016). Piketty defines capital as “the total market value of everything owned by the residents and government of a given country at a given point in time, provided that it can be traded on some market.” Piketty (2014). Several components are left out of Piketty’s definition, such as human capital (skills, knowledge...). In the remainder of this paper, we refer to wealth in the same way Piketty defined capital, net wealth (or ’net worth’) referring to wealth net of debts.

To analyze the evolution of wealth distribution, we first of all assess how private wealth has been evolving in the past decades both in absolute terms and relative to the economy (section 3.3.1). Then, we look at the distribution of this private wealth within society and see whether private wealth is getting more and more distributed or concentrated (section 3.3.2).

3.3.1 Private wealth size

The stock of private wealth

We start by analyzing how the overall stock of private wealth has changed in the selected developed countries over the period 2000-2015. To do so, we use the data from Shorrocks et al. (2015), which measures individual net worth for 215 countries and defines ’individual net worth’ as the marketable value of financial assets plus non-financial assets less debts of individuals, exactly what we call ’individual net wealth’ throughout the thesis. This data is computed following a three steps methodology.

1. The first step establishes the average level of wealth for each country. The preferred sources for this are national households balance sheets. Although only 17 countries provide full households balance sheets, another 31 provide data points regarding financial assets and debts, but exclude non-financial (or "real") assets.

2. The second step involves constructing the wealth distribution shape within countries. Direct data concerning wealth distribution is available for 135 countries.

3. The third step is about using rich list data to adjust the highest tail (i.e. wealthiest people) of the wealth distribution shape.

It appears that some countries will have more accurate data than others. Concerning the six ones we analyze, only Belgium is considered as ’satisfactory’, while the other five are considered as ’good’ - the highest possible level of data quality. Belgium is classified this way as only financial assets are disclosed in the households balance sheets. Data for Belgium comes both from the *Organisation for Economic Co-operation and Development* database and the *Eurosystem Household Finance and Consumption Survey* (HFCS, European Central Bank (2013b)), for which data in Belgium dates back to 2010.[5] Shorrocks et al. (2015) explain that data of countries for which recent information is not available, Belgium for example, have been estimated this way: real assets have been actualized using house-price growth, financial assets using market capitalization and debts using GDP per capita. Finally, even if the upper tail of the distribution is corrected, it is important to mention that data on the top percentile and, to some extent, decile, is still likely to be inaccurate, due to the reliance on rich lists, which are only estimates.

Using this, we construct figure 3.6 representing the stock of private wealth in the studied countries. The United States have voluntarily been left out, due to the disproportionate stock of private wealth they have: 5.5 times more than the UK, the second largest in the list. The graph shows that private wealth has increased over the past 15 years for each of those countries. Several years have been marked by a drop in stock of private wealth (2005, 2008, 2011, 2015) and the growth rate seems to vary greatly (high during 2001-2004 and 2006-2008, low during 2000-2001 and 2008-2014).

The wealth-to-income ratio

Previously in this paper, we have concluded that national income is increasing. We just concluded that the stock of private wealth is increasing as well. We now look how those two compare in order to quantify the importance of private wealth compared to national income.

Piketty (2013) does the analysis for France and the UK from 1870 till 2010. His conclusion is that national wealth (private wealth combined with public wealth) has been rising since the 1950s up to the level experienced before the first World War. Nowadays, national wealth represents between 4 and 6 times national income. Using the data on private wealth and national income we introduced earlier, we compute the ratio of private wealth to national income for the 6 countries. Results can be seen in figure 3.7. An obvious drawback of our data is its relative limited time-span, starting in 2000, compared to 1870 for Piketty. Some interesting points can however be made looking at the chart. There is a distinctive drop in the ratio in all countries in 2008, during the financial crisis. Another finding relates to the fact that private wealth is sizable in these economies, representing between 3.5 and 6.5 years of national

[5]The complete methodology of the HFCS can be read in European Central Bank (2013a) and a critical review of this data is made by Tiefensee & Grabka (2013).

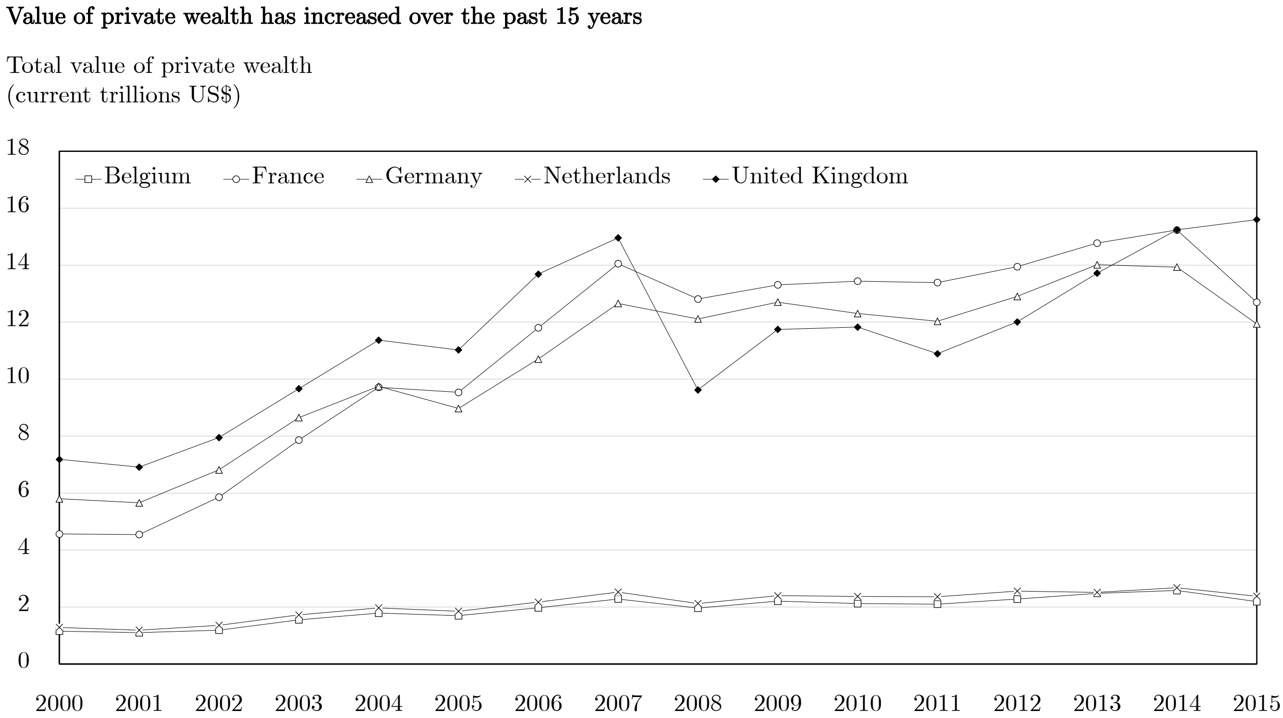


Figure 3.6: Stock of private wealth in selected countries between 2000 and 2015

Source: Shorrocks et al. (2015)

income in 2015.

3.3.2 Private wealth distribution

A rise in the importance of private wealth in our society may mean several things. We now look at how it is distributed within societies.

The wealthiest and their share of total wealth

As it can be seen in figure 3.8, the wealth of the top decile[6] stayed relatively constant in the studied countries between 2000 and 2015, even experimenting a slight decline between 2000 and 2007-8. We however note an upward trend since then, that is further confirmed in figure 3.9 for the top percentile of the population where wealth concentration has increased in all countries except the US. Let us however recall that the wealth of the top percentile - and therefore the top decile - is likely to be underestimated.

Even if the share of the top decile and percentile seems to have experienced a decline during the first half of the past 15 years, the trend reversed and those shares find themselves increasing

[6] In previous section, we refer to fractiles of income. In this section, we refer to fractiles of wealth/net wealth.

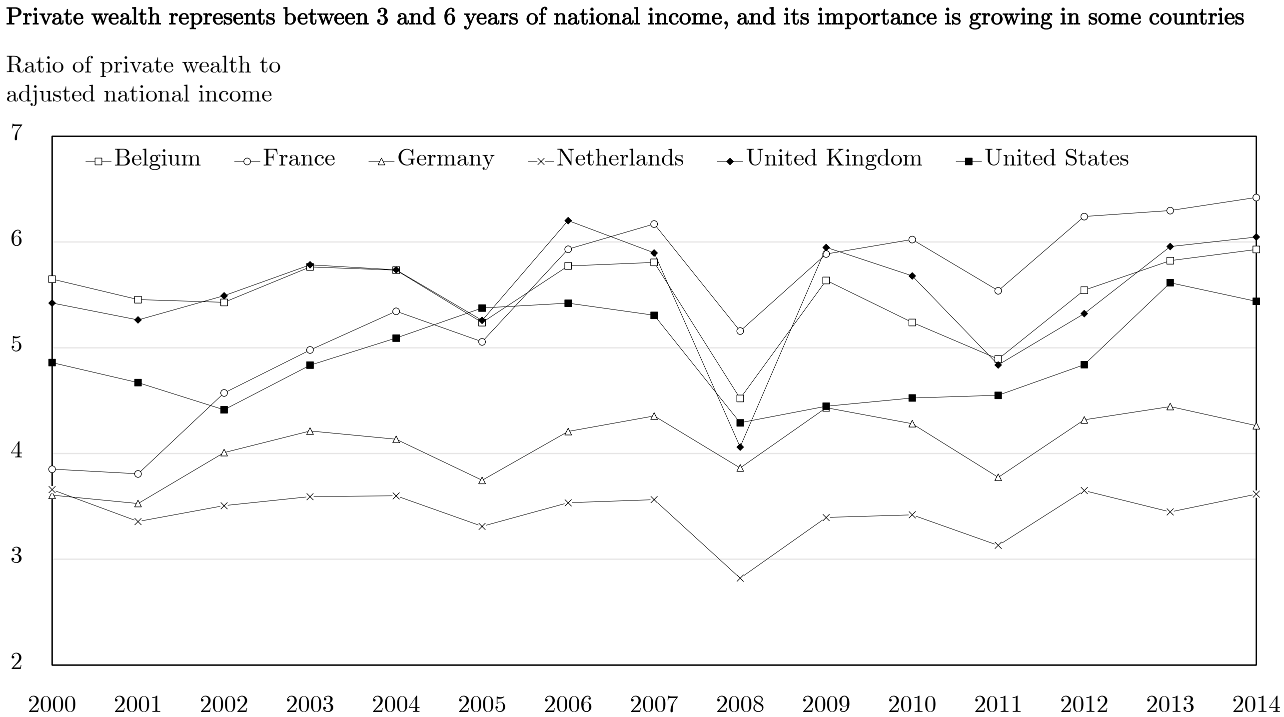


Figure 3.7: Private wealth to net national income ratio in selected countries between 2000 and 2015

Source: Shorrocks et al. (2015), The World Bank (2016a)

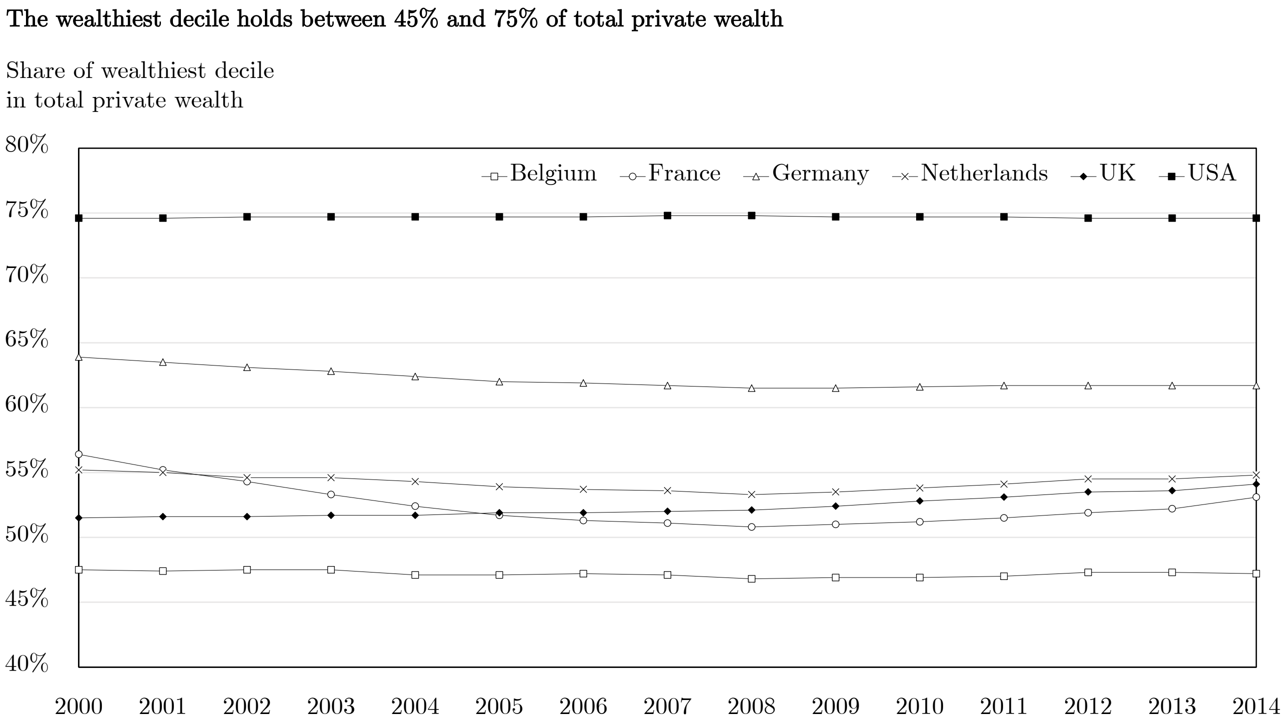


Figure 3.8: Wealth share of the top decile in selected countries between 2000 and 2015

Source: Shorrocks et al. (2015)

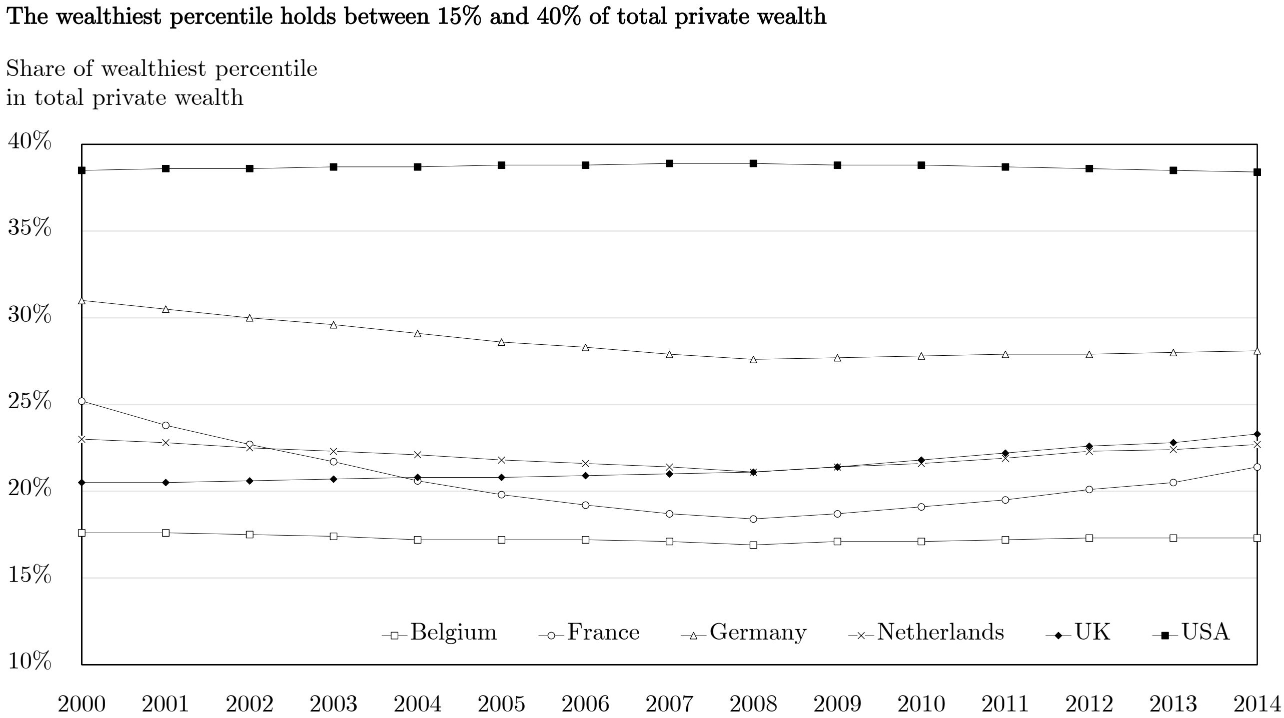


Figure 3.9: Wealth share of the top percentile in Belgium between 2000 and 2015

Source: Shorrocks et al. (2015)

again from 2008 on. This matches Piketty's findings, even if his numbers are much higher in terms of the magnitude of the rise.

Inheritance and private wealth Dedri (2014) analyzes how inheritance evolved in Belgium over the long-term in a comparative study with France and Piketty's work. The main conclusion is that inheritance as a share of private wealth has followed a U-shaped curve from 1960 till 2010, suggesting that inherited wealth is getting a more important share of total wealth. Put into the perspective that we just proved that wealth stock is increasing, and that the top 1-10% are experiencing a rise in their personal wealth, a greater importance of inheritance could imply that no mechanism exist to stop the accumulation of wealth and that the trend is actually going in the opposite direction. Indeed, if wealth is getting more and more concentrated in the hand of the few, and that a generation's wealth is becoming more and more dependent on the previous generation, it seems sensitive that wealth will concentrate with time.

Wealth portfolio The last piece of research we perform looks at how wealth differs between the wealthiest and the poorest people. Piketty (2013) suggests that richest people have more financial wealth while poorest people have more real estate as a percentage of total wealth. Based on European Central Bank (2013b), Kuypers & Marx (2014) analyze the average wealth portfolio for different level of wealth ownership and draw several findings (see appendix A.3 for a graphical depiction).

- The top 10% has a significantly smaller share of total wealth going to owned housing, representing slightly more than 30% of total wealth compared to 40 to 75% for other wealth groups.

- Real (non financial) assets represent more than 50% of total net wealth for all groups. Indeed, 'owned housing', 'other real property' and 'vehicles' altogether amount to slightly above 50% for the top decile and between 65% and 85% of total wealth for other groups.

- The top 10% has significantly less share of total wealth invested in pension funds and life insurance. Representing around 2-3% for the top decile, this category amounts up to 7-8% for the poorest quartile.

- The top 10% has a significantly larger share of wealth coming from entrepreneurial activities, shares of stock-traded companies, obligations, investment funds and other financial assets. Those five categories amount more than 30% of the total portfolio for wealthiest people and less than 5% for the other groups in society.

Overall, Piketty's assumptions seems to hold true for Belgium as financial assets are more heavily represented in the capital of wealthiest people.

3.3.3 Conclusions on private wealth inequalities

Some interesting points have been made in this section.

First of all, it appears that private wealth is growing faster than the economy and now represents a level that is comparable to a century ago, between 4 and 6 times national income. This holds true for all countries analyzed and seems even more important in Continental European countries.

Second, it appears that wealth is getting more concentrated at the top of the tail. Even if we are still far from the levels experienced a century ago, a slight rise has been noticed in the past few years. Now, the top 10% hold between 45 and 75% of total private wealth. Piketty's numbers suggest it went over 90% in France and Britain just before the first World War.

Third, it appears that inheritance is becoming more and more important as well, stemming for more and more concentrated wealth in the future.

Finally, it appears that wealthiest people have a different wealth portfolio than the rest of the society, the top 10% being clearly more focused on financial assets than other fractiles.

3.4 Conclusion

We saw that income and private wealth have both been increasing over the past decades with private wealth enjoying a faster growth and therefore becoming more and more dominant in the economies of developed countries.

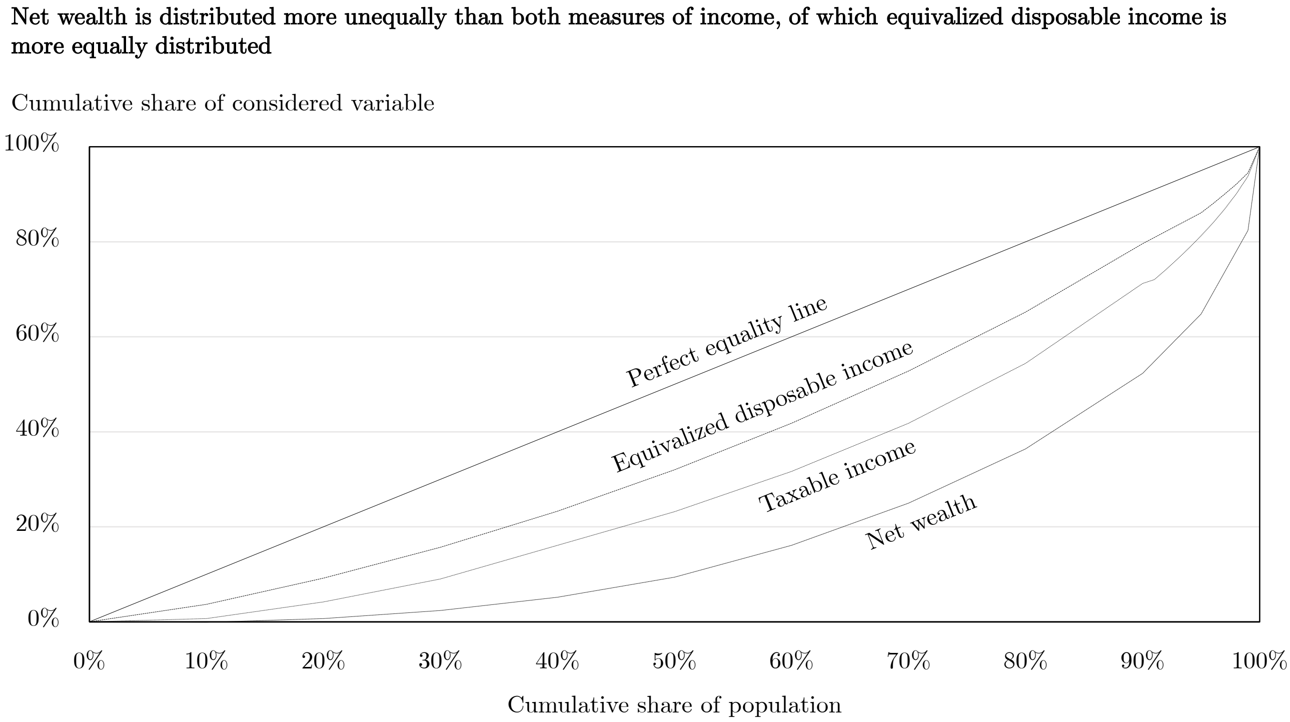


Figure 3.10: Cumulative share of equivalized disposable income, taxable income and net wealth in Belgium in 2015

Source: Eurostat (2016), Shorrocks et al. (2015), Direction générale Statistique (2016)

In both cases, it seems that the distribution is growing more unequal with wealth being already more unequally distributed than income. Indeed, the 10% highest income earners in the six countries observed earnings between 30 and 45% of total income, but the 10% highest holders of wealth hold between 45 and 75% of total private wealth. Figure 3.10 sums up the situation. It depicts how net wealth, disposable income and taxable income are distributed in Belgium. Net wealth data are from 2015 and given by Shorrocks et al. (2015), equivalized disposable income data are from 2014 and given by Eurostat (2016), and taxable income data are from 2013 and given by Direction générale Statistique (2016).

Part II

Wealth tax

Chapter 4

Piketty and theory

4.1 Introduction

OECD (2015) states that "focusing exclusively on growth and assuming that its benefits will automatically trickle down to the different segments of the population may undermine growth in the long run inasmuch as inequality actually increases." But, "policies that help in limiting or, ideally, reversing the long-run rise in inequality would not only make societies less unfair, but also richer." Reforming tax and benefit policies is presented as a way to reduce inequalities, by applying policies both at the top and at the bottom of the income and wealth distribution. Specific policies discussed to tackle the top incomes include "raising marginal tax rates on the rich [...] improving tax compliance, eliminating or scaling back tax deductions that tend to benefit higher earners disproportionately, and [...] reassessing the role of taxes on all forms of property and wealth." Concerning the lowest income earners in the society, redistribution schemes should ensure that "low-income households do not fall further in the income distribution" and "promote and increase access to public services". In the same stream of ideas, Piketty (2013) argues that a global progressive tax on private wealth, coupled with more progressive income taxation and more cooperation between nations is the key to tackling these rising inequalities.

In the first part of this thesis, we analyzed how economic inequalities may impact the economic growth of a nation and look at how those inequalities have evolved in specific developed countries. We concluded that, in line with what OECD (2015) suggests, current trends in economic inequalities are not economically desirable and should be tackled. We now turn our attention to analyzing Piketty's proposed approach. This chapter focuses on explaining his proposed solution and how it compares to what the literature says about wealth taxation. The following chapter analyzes these ideas through a more practical lens by looking at its implementation and historical case studies of countries having implemented some sort of wealth taxation.

4.2 Piketty's framework

In chapter 15 of *Capital in the Twenty First Century*, Piketty (2013) defines his tax, explains its rationale and proposes specific rates for specific levels of wealth. We now examine what his suggestion is, and why he believes this to be the best option.

4.2.1 Definition

Piketty (2013) proposes a global progressive annual tax on net wealth, mentioning that "if democracy is to regain control over the globalized financial capitalism of this century, it must also invent new tools, adapted to today's challenges. The ideal tool would be a progressive global tax on capital, coupled with a very high level of international financial transparency."[1]

The idea is therefore to tax net wealth, defined as the value of marketable assets less debt, for the wealthiest individuals: "taxable wealth would be determined by the market value of all financial assets (including bank deposits, stocks, bonds, partnerships, and other forms of participation in listed and unlisted firms) and non-financial assets (especially real estate), net of debt."

4.2.2 Rationales

As Piketty explains, "such a tax would provide a way to avoid an endless inegalitarian spiral and to control the worrisome dynamics of global capital concentration." The aim is therefore not to increase the State's tax revenue, or replace existing taxes, but truly to add a tool to the tax toolkit of governments.

> "The primary purpose of the capital tax is not to finance the social state but to regulate capitalism. The goal is first to stop the indefinite increase of inequality of wealth, and second to impose effective regulation on the financial and banking system in order to avoid crises. To achieve these two ends, the capital tax must first promote democratic and financial transparency: there should be clarity about who owns what assets around the world."

[1] Note how Piketty uses *capital* to refer to net wealth.

It is often argued that a tax on net wealth is not realistic nor desirable due to the lack of data on people's wealth and the individuals' reactions of avoiding this tax by moving their wealth abroad. Following Piketty's idea, this tax - assuming it is implemented globally - would reduce the incentive of people to relocate their wealth away and would provide gradually more information on private wealth in countries and around the world. He advances two distinct rationales: a contributive and an incentive rationale.

Contributive rationale The contributive rationale is based on the idea that the very wealthy are able to escape income tax, he argues that "effective tax rates (expressed as a percentage of economic income) are extremely low at the top of the wealth hierarchy, which is problematic, since it accentuates the explosive dynamic of wealth inequality". He adds that "only a direct tax on capital can correctly gauge the contributive capacity of the wealthy".

Incentive rationale The incentive rationale assumes that wealth holders are not always using it in the best possible way, arguing that "a tax of 1 or 2 percent on wealth is relatively light for an entrepreneur who manages to earn 10 percent a year on his capital. By contrast, it is quite heavy for a person who is content to park her wealth in investments returning at most 2 or 3 percent a year. According to this logic, the purpose of the tax on capital is thus to force people who use their wealth inefficiently to sell assets in order to pay their taxes, thus ensuring that those assets wind up in the hands of more dynamic investors."

4.2.3 Proposed level of taxation

Even if no analysis is formally done to compute the ideal level for this tax, several rates and brackets (tranches of net wealth) are suggested: "One might imagine a rate of 0 percent for net assets below 1 million euros, 1 percent between 1 and 5 million, and 2 percent above 5 million." Piketty also suggests the possibility to tax higher wealth levels more heavily or even put a light tax on lower level of wealth. The two tax designs are displayed in table 4.1.

Design 1 Tranche of net wealth (€)	Tax rate	Design 2 Tranche of net wealth (€)	Tax rate
0 - 1 000 000	0%	0 - 200 000	0.1%
1 000 000 - 5 000 000	1%	200 000 - 1 000 000	0.5%
Above 5 000 000	2%	1 000 000 - 5 000 000	1%
		Above 5 000 000	2%

Table 4.1: Piketty's suggested taxable bases and tax rates

Source: Piketty (2013)

4.3 Theoretical framework

4.3.1 A note on the role of governments

Standard microeconomics theory tells us that the outcome of a free market[2] that meets competitiveness criteria[3] is most of the time the most desirable outcome for society. First postulated by Adam Smith in *The Wealth of nations* (Smith & Say, 1843), it is argued that free markets, while non-regulated and appearing chaotic, actually reach an outcome that is the most economically efficient, and this only based on the idea that people pursue the maximization of their self-interests. Arrow & Debreu (1954) confirmed this idea more formally by proving that free markets reach an equilibrium that is Pareto efficient in its allocation.[4] If this is the case, why would governments ever need to intervene ? Several reasons can be noted, we retain two of them presented in Gruber (2015): market failures and redistribution.

Market failures Market failures are defined as situations in which the free market economy does not lead to the most socially desirable outcome. This can be explained due to the fact that free markets reach a Pareto efficient outcome only under full competitiveness which is based on several assumptions[5] that often do not fully materialize in practice. One example of a situation where this does not happen is in the case of public goods. As defined by Musgrave (1959), a public good is a good that is both non-excludable and non-rivalrous, meaning that individuals cannot be excluded from its consumption and that its consumption by one individual does not reduce availability to others.[6] Following microeconomics theory, such goods will be

[2] "A market in which people buy and sell voluntarily, without legal compulsion" (Black et al., 2009).

[3] A free market is said to be competitive if it meets several conditions whose main rationale lies in the idea that no actor in the market can either influence prices nor quantities.

[4] A Pareto efficient equilibrium is one where "no other feasible allocation is preferred by one party and is liked at least equally well by the other party", meaning that "further mutually beneficial moves are impossible"(Pareto, 1909).

[5] Among which, no market power for any participant, perfect information, large quantity of buyers, and large quantity of sellers.

[6] Samuelson (1954) formally defines a public good as one that "once produced for some consumers, can be consumed by additional consumers at no additional cost." See Demarais-Tremblay (2014) for a historical

under produced - or not produced at all - hence forcing governments to intervene to encourage production of these goods and then allow all citizens to consume them.[7] Another explanation for market failures is based on the idea of externalities, defined as "the cost or benefit that affects a party that did not choose to incur that cost or benefit" (e.g. passive smoking), with which the maximization of individual utilities does not lead to a socially optimal equilibrium. In this case, governments might intervene to calibrate the situation and improve overall social efficiency.

Redistribution The redistributive rationale is based on the idea that a society might decide that the most efficient outcome obtained in a competitive market might not be socially desirable. It builds up on the fact that a Pareto-optimum says nothing about social equity. This is due to the fact that there exists an infinity of Pareto optimal points and only one is considered fully equitable. In other words, there is an infinity of economically Pareto optimal allocations of resources that a society will deem unacceptable on the ground of equity principles. In this case, the government intervenes to redistribute resources from one group in society, the ones being "too well-off", to another one, the ones being "not well-off enough". This decision usually has an efficiency cost, in the sense that individuals will react to the government intervention and escape from the most efficient outcome.

Governments face two enormous challenges when making decisions: when to intervene, and how. Indeed, if a government decides that a free-market outcome needs interventions, it needs to decide what tool to use in order to change the outcome. Among the various tools, we can mention price mechanisms (taxation, subsidies etc.) and quantity mechanism (public provision, public financing, quotas etc.).

Most governmental decisions face very high cost (e.g. building infrastructure), which the government usually finances either through tax or debt. Taxes therefore are used both from an intervention market failure point of view and as a source of revenue collection for the government's spending. Those two ideas might not be totally correlated in the sense that governments might need to levy taxes that do not improve efficiency or have a redistribution motive.

There is probably no single best taxation scheme and the government intervention depends on a society's expectations and desires. Besides, individuals would rationally hope to see the

perspective on the various definitions of public goods.

[7] Holcombe (1997) challenges the public goods theory and "develops a theory to explain the development of and use of public goods theory as a justification for government production."

level of taxation as low as possible while receiving as much as possible in return from the state. For those reasons, governments face enormous pressure on finding a taxation structure that satisfies all these needs and are constantly rethinking their tax systems.

Wealth taxation is but one type of possible taxation. We now deepen the analysis on its theoretical rationale.

4.3.2 Breaking down wealth taxation

As explained in Cremer & Pestiau (2009), there are two major types of wealth taxes: "those applied sporadically or periodically on a person's wealth (net wealth taxes), and those applied on a transfer of wealth (transfer taxes)."

Most countries currently have or have experienced in the past some sort of taxation on wealth transfers. Concerning net wealth taxation, which corresponds to Piketty's proposal, it has been tried in much fewer countries and in a much narrower sense than what Piketty suggests. Those past trials are analyzed in chapter 5.

4.3.3 Should net wealth be taxed at all?

Reasons for wealth accumulation

Cremer & Pestiau (2009) provide a survey of the theoretical literature on wealth and wealth transfer taxation, and argues that "their implications in terms of efficiency and equity depend on why people hold or transfer wealth". Five motives for wealth accumulation and transfers are identified, two of them are selfish motives, and three are bequests motives.

Selfish motives Selfish motives are the ones for which the individual accumulating wealth does it for personal use.

- **Selfish motive - Consumption smoothing** This is the most traditional motive for savings: one needs alternative source of income after retirement, needs to have a safety account in case an adverse event happens such as a job loss or an accident. It is based on the *Life Cycle Model* introduced by Modigliani & Brumberg (1954) (see explanation in appendix A.4), also called the *precautionary savings* proposal, which explains that people save to face shocks in their income, either short-term events such as unemployment or accidents, or long-term, such as retirement.
- **Selfish motive - Preference for wealth** It seems to be widely accepted that precautionary savings is not sufficient to explain wealth accumulation. Lusardi (1998) points out

that "precautionary savings does not provide a rationale for a large accumulation of wealth and certainly cannot explain the wealth holdings of the very rich." This is confirmed by Arrondel & Lafferère (1998) and Reiter (2004). Carroll (2000) states that "wealth either enters the utility function directly as a luxury good, or wealth yields a stream of services that enter the utility function in ways that would be formally virtually indistinguishable from a model in which wealth enters the utility function directly." In other words, wealth holding provides benefits above and beyond the simple idea of smoothing consumption over a lifetime or transferring wealth to heirs. Utility can be derived from the holding of wealth, either directly or indirectly. Directly because holding wealth does provide utility (see Weber (1958) defining this characteristics as *the essence of modern capitalism*). One can base this either on greed or on the idea that wealth is the metric of one's success in capitalist societies (Carroll, 2000). Indirectly because holding wealth provides other benefits generating utility (see Carroll (2000) pointing out that power and control can be derived from higher levels of wealth).

Bequest motives Bequest motives are the ones for which the individual accumulating wealth does it in order to transfer it.

- **Bequest motive - Altruistic bequest** Introduced by Becker (1974b), the altruistic proposal to private wealth transfer explains that a benevolent individual cares about the well-being of other individuals, and therefore links his utility to theirs. In other words, some people would save wealth in order to transfer it to others that can benefit from it. Parents care about the likely lifetime utility of their children and following generations, therefore saving and accumulating wealth nowadays. This can be linked to the dynastic model introduced by Barro (1974) that assumed that a dynasty optimizes his infinitely lived family's utility under wealth, income, and interest rates. This model implies that "the size of the bequest should be a function of the ratio of the parent's lifetime income and the child's lifetime income; that parents should give larger bequests to poorer children, and that childless wealthy people should leave no bequests" (Carroll, 2000). Becker & Tomes (1979) also conclude that parents maximize a utility function considering their own utility and those of their children. It proves that the utility/welfare of children is raised when they receive more human and non human capital from their parents at an early age and is also affected by their endowments. In other words, parents optimize their own utility by savings to invest in their children's utilities.

- **Bequest motive - Paternalistic bequest** Andreoni (1989) explains that there exist a "model of giving in which altruism is not 'pure'. In particular, people are assumed to get a 'warm glow' from giving.". This 'warm glow' is then defined as the fact that "people derive utility from the act of giving". In other words, people might derive utility from wealth transfer not for what it does to someone else's utility (altruistic bequest), but for the sole act of giving.

- **Bequest motive - Strategic bequest** In this motive, the donor is assumed to use his wealth transferring power in order to impact others' behaviors. As explained in Bernheim et al. (1985), "the testator will necessarily wish to influence his beneficiaries' decisions by conditioning the division of bequests (perhaps through informal means) on actions they take". In other words, the ability to transfer wealth could provide some with strategic power over others by arranging the way wealth is to be transferred. Extending this idea, we can hereby consider that a wealth-transfer can be considered as the mean of exchange for having others' act in a desired way.

Those five motives go further and beyond the two standard basic model: the Life cycle Model (we save to smooth consumption) and the Dynastic Model (we save to transfer wealth) by considering the idea that wealth holding and transferring provide utility in themselves. Which one prevails in reality?

Bequest motive analysis Cremer & Pestieau (2010) explain that "over time the literature appears to have reached a fragile consensus. Altruistic transfers appear to represent a minority of wealth transfers. The remainder would be egoistic, purely accidental[8] or based on either exchange consideration or selfish joy of giving." Indeed, Cox (1987) compares exchange (strategic) and altruistic motives for inter-vivo transfers and concluded that "observed patterns for inter vivos transfers are more consistent with exchange-related motives". Bernheim et al. (1985) present "econometric and other evidence that strongly suggests that bequests are often used as compensation for services rendered by beneficiaries". Further researches coming from Pestieau & Thibault (2007) conclude that "those who in the long run hold the bulk of private capital are not so much motivated by dynastic altruism as by preference for wealth".

Selfish motive analysis The balance between the two selfish motives seems trickier. Indeed, it is often assumed that the consumption of nondurable goods experiences sharply declining marginal utilities of consumption. As Carroll (2000) says, "what matters critically here is really the assumption that there is an alternative way to employ wealth whose marginal utility decreases more slowly than that of consumption [...] It is important to recall that the kind

[8]Note that not all bequests are planned. One does not know when he will die and it is hence likely that some wealth will be inherited while the original owner intended to accumulate that wealth for selfish motives.

of consumption treated in the model is for strictly nondurable goods and services". Following that argument, it seems logical to assume that there is a point where holding one unit of wealth for any other purpose than consumption (be it greed, social status, power or anything else) increases utility more than the marginal utility of one extra unit of consumption (be it by consuming today or by saving to consume tomorrow). Assuming that the consumption of non durable goods decreases sharply, we can state that even low levels of greed or demand for power would lead to such a situation. To explain this more informally, if we consider Bill Gates' situation, whose net wealth is estimated at $75 billion by Forbes World billionaires' 2016 ranking (Forbes, 2016b). Assuming a 1% rate of return on his net wealth, he would have to consume $2 million a day just to avoid accumulating wealth. It seems reasonable to consider that Mr. Gates would not enjoy any relevant marginal utility from consuming that much nondurable goods, and therefore increases his utility by accumulating his wealth, whether be it for using it in charitable purposes, be it for dynastic bequests or his own utility of accumulating wealth for greedy or power reasons.

Summary To sum up, it appears that bequest motives are mostly driven by strategic or joy of giving (paternalistic) rationales rather than by altruistic motives. Wealth accumulation regarding selfish motives seems to be driven both by precautionary savings and consumption smoothing purposes and by preference for wealth motives, assuming that preference for wealth takes over after individuals reach a certain level of 'smoothed' consumption.

Reasons for wealth taxation

Cremer & Pestieau (2010) conclude by stating that a tax on wealth transfer is desirable both from an efficiency and an equity perspective. They however assume a tax on net wealth would be redundant with a tax on capital gains "granted that the tax base is the same and that realized capital gains are correctly taxed".

To analyze this conclusion, we consider the three criteria for evaluating the relevance of a tax system as explained in Boadway et al. (2010) in which authors analyze the UK tax system in terms of wealth and wealth transfer taxation and provide some theoretical background on how to design a tax structure.chapter

- **Welfarist criterion** As explained in Saez & Stantcheva (2013), "the dominant approach in optimal tax theory is to use the standard welfarist framework in which the government sets taxes and transfers to maximize a social welfare function which is an explicit function of individual utilities and solely of individual utilities". The model takes into account government's budget constraints and individual's response to taxes in order to maximize the value of redistribution which, under standard utilitarian criterion and concave utility functions of individuals, means redistribution from high-consuming individuals to low consuming ones. Indeed, adopting the principle of diminishing marginal utilities, a high-consuming individual receives less utility from one extra unit of consumption than a low-consuming individual. Hence, it is socially desirable (under the utilitarian criteria, which aims at maximizing total utility) to transfer that one extra unit of consumption from the former to the later. Instead of using the utilitarian criterion, one could use the *Maximin* criterion, under which social welfare is optimal when the worst possible outcome is maximized. In other words, the utilitarian criterion maximizes overall utility while the Maximin makes sure to improve the situation of the worst-offs.

- **Equality-of-opportunity criterion** Kymlicka (2002) explains that equality of opportunity should "ensure that people's fate is determined by their choices, rather than their circumstances." Applied to the evaluation of a tax system, it means that "individuals ought to be compensated for disadvantages that they face that are beyond control, and ought not to be compensated for differences arising from things for which they are responsible" (Boadway et al., 2010). In other words, different tax scheme should be applied to individuals if their situations is out of their control, but not if it comes from their free will. We do not integrate here Rawls (1999) argument that not only external factors (social classes, family in which we are born, countries in which we are born...) but also internal factors (persistance, intelligence...) are also a matter of luck. Indeed, one could argue that wealth also comprises human capital, which is an internal factor of each individual, and should therefore be taxed. We do not take this approach for two reasons. First, we do not integrate human capital into our definition of net wealth, as we only measure marketable assets. Second, measuring human capital is extremely complicated and would add significant obstacles to the tax design.

- **Paternalist criterion** Boadway et al. (2010) state that "recent literature has stressed out how some individuals make decisions that lead to outcomes that are not in the long-term interests of the individuals themselves". Three general type of problems are pointed out: "(1) some individuals do not have the knowledge or the awareness to make decisions that are best for them, (2) some people make choices that fit their sense of ethics or their values, but are not acting in their own interest, and (3) it appears that people make choices that they later regret, being inconsistent between their will and their actions." In this situation, government might want to intervene in order to make sure people are acting in the way that is best for their own long-term self-interest.

Musgrave (1959) considers three functions of a tax: the allocative function, the distributive function and the incentive/stabilization function. The allocative function refers to the idea that a government needs to levy revenue through taxes to finance the provision of public goods. The distributive function refers to the idea that taxes are used to change the distribution of economic variable to reach an outcome that is more desirable. Finally, the stabilization/incentive function refers to the idea that taxes allow to incentivize people to act in a given way which is in their own self-interest and can also level out behaviors.

Comparing those three functions to the three criterion used in Boadway et al. (2010), two main differences can be noted. First, the allocative function is not considered by Boadway et al. (2010) when evaluating a tax system. Indeed, even if taxes are used to levy government revenue, it says little about whether a specific tax makes more sense than another. Second, the distributive function is further refined in Boadway et al. (2010), distinguishing between redistribution providing direct utility (welfarist criteria) and redistribution allowing long-term individual utilities to level out (equality of opportunity criteria).

Tax efficiency evaluation

One could argue for other criteria when evaluating a tax. Among others, we mention three of them from DeBoer (1997).

- **Ease for the taxpayer** As explained in McDonnell (2013), "the cost of running or operating a tax can be broken down into administration and compliance costs. Administration costs are the costs incurred by the revenue authorities in administrating the tax, whereas compliance costs are the costs incurred by the taxpayer in meeting the requirements of the tax that are over and above the actual tax liability itself." Individuals compliance cost in 2012 in the United States has been evaluated at $20 billion by the IRS (Tax Foundation, 2014), estimating a total amount of 1.35 billion hours spent on filling individual taxes that year. The simpler the tax, the lower the compliance cost, hence the more acceptable the tax for taxpayers.

- **Stability/Predictability** Governments make budget decision in advance of expenses, like most organization, and therefore need to avoid unpredictability in their revenue streams. However, some taxes yields go up and down with time, in an unpredictable fashion, meaning planning becomes complex.

- **Cost efficiency** One reasonable threshold would be that the tax generates higher proceeds than what it cost the government to administrate it. A common measure of efficiency defined in Lepine et al. (1999) is the "intervention rate" and measures

> the management cost of a fiscal tool over its net revenue. This rate, answering the question "How much money has to be spent on this tax to collect 100 monetary units of revenue?" Formally, the management cost of a fiscal tool is computed as "overall cost of the fiscal administration" minus "cost of non-fiscal activities". This amount is divided by the net tax revenue, which equals gross tax revenue, minus tax reimbursement except reimbursement for social reasons.

Those can be used to evaluate the efficiency of a tax, but say little about the need to apply a tax from an economic or social point of view.

Should net wealth be taxed at all?

We now combine the five reasons to accumulate wealth mentioned earlier and the three lenses through which a tax system can be evaluated, as explained by Boadway et al. (2010), and ask ourselves whether wealth should be taxed or not. It is good to first state that a tax on net wealth impacts both the selfish and the bequest motives of wealth accumulation. Indeed, taxing net wealth today impacts how individuals make decision about wealth bequests later on. This means that taxes on net wealth and taxes on wealth transfer are closely related. We however focus on the question of taxing net wealth only.

Welfarist criterion Following the welfarist criterion, wealth should be taxed only in the circumstance of wealth providing benefits above and beyond life-time saving. Indeed, if we assume homogeneity of individual preferences and that wealth is solely accumulated for precautionary savings purposes, then each and everyone is optimizing his wealth so that consumption can be smoothed over time and the accumulation of wealth in itself does not provide utility. On the other hand, if wealth provides utility beyond its precautionary purpose, then the ones with the least amounts of wealth would benefit more of an extra unit of wealth than the wealthiest of us (assuming decreasing marginal utility of wealth stock). This means net wealth should be taxed and transferred to the poorest.

Equality-of-opportunity criterion Following the equality of opportunity criterion, wealth can be seen as a tool for enhancing one's opportunity in society. Indeed, McKnight (2011) estimates that "early asset holding does have positive effects on later wages, employment prospects, excellent general health and in reducing malaise." There seems to be something called an *asset-effect*, introduced by Sherraden (1991) and further developed in Bynner et al. (2001), under which it is assumed that asset-holding impacts future welfare of individuals. In this regard, the equality of opportunity criterion would suggest that taxing wealth of those having much of it to redistribute it to those with the least of it at an early age would level out opportunities and is therefore desirable.

Paternalist criterion Following the paternalist criterion, taxing net wealth could have a negative impact. Indeed, it would encourage people to avoid savings and consume more quickly, meaning under-savings for retirement and not having any precautionary savings. This idea can however be minimized if we only tax wealth that provide benefits above and beyond precautionary savings or source of bequests. If that is done, people would not be incentivized to save less up to a certain amount of net wealth.

Conclusion Boadway et al. (2010) conclude on the idea that, based on the three criteria, a wealth tax may be sound, but only on wealth that is accumulated for non consumption smoothing over a lifetime, which is extremely hard to gauge. Due to this implementation issues, they believe a tax on wealth does not make sense.

4.4 Conclusion

We argued in this chapter that a tax on net wealth is socially desirable if wealth provides benefits above and beyond precautionary savings or bequest purposes. Indeed, if that is the case, both for welfarist reasons and for equality of opportunities reasons would taxing net wealth and redistributing it make sense.

No apparently valid economic nor social reason Piketty's proposed tax suggests that net wealth should progressively be taxed above some monetary threshold. This threshold could be used as a proxy to find what is the amount of money that marks the limit between precautionary savings and preference for wealth. It is however a very poor approximation. It is easy to imagine that individuals with higher uncertainties about their future earnings (self-employed, entrepreneurs...) would accumulate more wealth today to account for the potential shocks in their future earnings than an employee under all social security measures. In other words, the amount of wealth one would use as precautionary savings depends on this individual's economic situation and his own uncertainties about the future, meaning that a monetary threshold is a poor estimate of the delimitation between precautionary savings and wealth deriving utility from itself. In other words, we believe Piketty's suggested approach is not optimal as it would most likely tax net wealth that does not provide utility by and from itself, but is rather seen as a mean of accounting for uncertainties or as a future bequest. This would lead to a situation where wealth is taxed for no apparently valid economic nor social reason.

No sustainable improvements at the bottom tail Besides this, we also believe Piketty's idea is not enough to solve all social and economic issues of our democratic societies. Indeed, as OECD (2015) argues, policies need to address both the top side of the pyramid, as well as the bottom one. Piketty's tax could tackle issues coming from the top wealth owners, but is unlikely to provide strong and sustainable improvements at the bottom of the pyramid. Indeed, research suggests that some individuals make decisions that are not in their economic or social favor, resulting in making them fall to the bottom of the pyramid. Giving them more wealth through redistribution is not the optimal solution that would solve everything about inequalities, and focused social policies should be devoted to empower those people and ensure they do not fall further down in the poverty trap. Even if a tax on individual net wealth is not the ultimate solution, it might still provide positive benefits and we argue it should be enforced on wealth that provide utility by itself. To achieve its overall objective, it should however be used as only one tool in a broader set of policies.

Moving forward Even if Piketty's idea does not fit perfectly what we believe is the perfect wealth tax (that would be a progressive tax on net wealth providing utility by and from itself), we however consider for the time being that it is a close enough alternative and we now turn the analysis to its practical implementation.

Chapter 5

Piketty and practice

5.1 Introduction

This chapter looks at the practical aspects of implementing Piketty's idea. In the previous one, we concluded that his proposal was somehow inadequate due to the fact that only a certain type of wealth ought to be taxed, and that this type of wealth is not appearing at the same financial threshold for everyone in society. Indeed, differences in uncertainties about future earnings make people save different amounts of wealth for different reasons, meaning that Piketty's fixed monetary threshold is inadequate. However, we assume it to be a good enough threshold and carry the analysis further, looking at how such a tax could be implemented.

We start by looking at historical case studies of countries having implemented some level of wealth taxes, conclude on the benefits and challenges faced and ther confrontation with Piketty's idea (section 5.2). We then look at why wealth taxes are often abolished and how Piketty aims to tackle the reasons (section 5.3). We finish by bringing all together and draw implications on the concrete implementation of a wealth tax (section 5.4).

5.2 Case studies

Net wealth taxation is known to be unpopular, though some countries have tried to implement it in the past. As stated by Ernst and Young (2014), "several countries abolished their wealth tax because of the fact that the taxpayers were able to move much of their wealth out of reach of the wealth tax. Because of high compliance costs and the negative effect of taxpayers moving wealth out of the country, these Member States decided to abolish the tax". We focus the analysis on European countries. The following European countries have at some point, or still have, implemented some level of wealth taxation: France, Spain, Norway, Italy, the Netherlands, Luxembourg, Sweden, Switzerland, Austria, Germany, Iceland, Denmark and Finland.

Ernst and Young (2014) differentiates between three categories of wealth taxes:

- inheritance and gift taxes;
- real estate and land taxes;
- annual recurring taxes on the possession of wealth.

We do not analyze wealth transfer taxation and therefore disregard the first category. Considering the second category, the report argues that "real estate is taxed in every member state." The tax is however usually applied on a fictional rental value (the cadastral revenue) that can be disconnected from the market value of the asset. In other words, the tax base is not the marketable value of the concerned asset. Knowing that the tax proposed by Piketty would be applied on the market value of marketable assets, this type of taxes does not fall under our analysis either. The report argues that "only three member states use general net-wealth as a taxable base, Spain and France have a net wealth tax, the Netherlands has a provision in its income tax"[1]. Switzerland also applies a wealth tax, though the definition varies by canton (Deloitte, 2013).

We now closely look at France and Spain on the basis of their annually recurring taxes on net wealth.

5.2.1 The French case

Definition and scope

The *Wealth Solidarity Tax* (Impôt de Solidarité sur la Fortune, ISF), introduced in 1982 as the *Impôt sur les grandes fortunes*, abolished in 1987 and reintroduced in 1989 under its current name, is a progressive tax aimed at individuals' net worth (Trannoy, 2014). Individuals whose fiscal household's net taxable assets are above €1.3 million are subject to this tax. French residents are subject to this tax on their worldwide assets while non-french residents are only subject to it on their French located assets (except financial investments). Table 5.1 displays the different wealth brackets (tranches) and rates in 2016.

[1]Ernst and Young (2014) writes that seven EU countries tax vehicles for environmental reasons rather than on the basis of taxing the possession of wealth. Deloitte (2016) informs that Italian residents are subject to a wealth tax on financial assets located abroad at a rate of 0.2% of the assets' market value as at the end of the year.

From (€)	To (€)	Rate
0	800 000	0%
800 000	1 300 000	0.5%
1 300 000	2 570 000	0.7%
2 570 000	5 000 000	1%
5 000 000	10 000 000	1.25%
10 000 000	above	1.5%

Table 5.1: Net wealth tranches and rates applied in the French Wealth Solidarity Tax in 2016

Source: Ministère des Finances et des Comptes Publiques (2016)

It is important to note that individuals with wealth levels below €1.3 million are exempt. In other words, wealth between €800 000 and €1 300 000 is only taxed for individuals with wealth levels over €1 300 000. Various exemption exist to promote business continuity, public interest and specific cases. There also exists a wealth tax cap (*bouclier fiscal*), set at 75% of the taxpayer's previous year total income. That is, the combined wealth and income (of all kind) tax liabilities of an individual cannot exceed 75% of this individual's income.

Results and challenges

Results In 2013, €4.03bn were levied through the ISF, or slightly less than 0.2% of GDP. This represents a total increase of more than 350% compared to the €0.89bn levied in 1982, which represented only 0.07% of GDP. Better tax enforcement, no indexation of the thresholds and increased housing values are advanced explanations for this change (Comptes Pubiques, 2013). Pichet (2007) concludes that tax revenues from this tax are on the rise, and fraud mostly comes from undervaluation of property assets. The author also points out that "Capital flight since the ISF wealth tax's creation in 1988 amounts to approximately €200 billion. [...] The ISF causes an annual fiscal shortfall of €7 billion, or about twice what it yields. [...] The ISF wealth tax has probably reduced GDP growth by 0.2% per annum, or around €3.5 billion (roughly the same as it yields)." Popular beliefs commonly share the idea that the escape of high net-worth individuals from France - and from this tax - has had a strong negative impact on the overall economy. Even if high net-worth individuals appear to have moved their wealth out of reach of this tax (Pichet, 2007; Trannoy, 2014), the impact on the economy is more subtle as, on the one hand, some wealthy individuals actually came back to France, and on the other hand, wealthy individual moving abroad might still invest in France.

Challenges As any other tax, the ISF has an operating cost. Conseil des Prélèvements Obligatoires (2009) evaluates the intervention rate to be equal to 2.13% in 2007, and estimates it is relatively high compared to other taxes with an overall average rate of 1.2% (see section

4.3.3 for the definition of intervention rate). Blanchard-Dignac (n.d.) however argues that other taxes have a much higher ratio than the ISF, computing a ration of 1.9% for the ISF in 1997 and over 2% for five other fiscal instruments, the highest being the "vignette" tax at 2.7%. This tax was applied on circulating vehicles in France from 1956 until the year 2000, when it was abolished for particulars' vehicles. In 2006, it was also abolished for company vehicles. It is clear that this metric is dependent on the revenue generated by the tax; hence a change in the rate or the threshold can have a substantial impact on its value. Nevertheless, it seems that a tax on net wealth is one of the most inefficient taxes out there. Even if not the most efficient tax, it is important to mention that the intervention ratio still suggests that the tax levied around 47 times what it cost in 2007; which is significant.

5.2.2 The Spanish case

Definition and scope

Definition Spain introduced its wealth tax (*Impuesto sobre el Patrimonio*) in 1977, Cabré & Moré (2007) explain that "the governmental reasons to justify the tax were that (i) it complements the personal income tax (IT), since it levies an additional ability to pay and relies more on the richest taxpayers; (ii) it promotes a more productivity use of capital; (iii) it helps to control IT due to the provided information; and (iv) it has a positive redistributive effect." Wealth is taxed to the owner of the taxable wealth. If the individual is a Spanish resident, he is taxed on his worldwide net wealth, if non-resident, he is taxed for the wealth located in Spain, as for the French ISF (Ernst and Young, 2014). Rates and brackets are mentioned in table 5.2.

From (€)	To (€)	Rates
0	167 129.45	0.2%
167 129.45	334 252.88	0.3%
334 252.88	668 499.75	0.5%
668 499.75	1 336 999.51	0.9%
1 336 999.51	2 673 999.01	1.3%
2 673 999.01	5 347 998.03	1.7%
5 347 998.03	10 695 996.06	2.1%
10 695 996.06	above	2.5%

Table 5.2: Net wealth tranches and rates applied applied in the Spanish wealth tax

Source: Ernst and Young (2014)

Scope Exemptions exist for cultural heritage reasons, as well as for business incentives and 'principle of care' for people with wealth levels below €700 000. In other words, wealth between €0 and €700 000 is taxed only for individuals whose net worth are above €700 000 (Ernst and Young, 2014).

Results and challenges

This tax levied €1.1bn in 2014 (OECD, 2016). It tax was abolished in 2008, then reintroduced in 2011 and extended again in 2013. The motive for abolishing the tax were "changes in the international economic environment and the fact the tax did not fulfill the purposes for which it was introduced" (Ernst and Young, 2014). Cabré & Moré (2007) provide empirical evidence that the Spanish wealth tax "does not achieve taxing real tax ability, and so does not accomplish its main aim of reducing wealth concentration." They conclude that the wealth tax "fails in reducing vertical inequity, as only a small part of wealth is really taxed, while horizontal equity might also be questioned given the differences in the level of tax compliance between the two main assets[2]."

5.2.3 Confrontation with Piketty's proposal

Table 5.3 presents a summary of the two cases analyzed and compares them to Piketty's proposal (design 1 of table 4.1). Two obvious distinctions between what Piketty suggests and what we see in those two countries come from the tax payer and the exemptions. Indeed, Piketty suggests that the tax ought to be global, meaning all individuals would be subject to it. Second, no exemptions are to be applied: all wealth, net of debt, is to be considered in the tax base.

Analyzing the different brackets and rates displayed in figure 5.1, we first note that Spain has a much more granular design than France, starting at much lower wealth levels and with more brackets, and has higher rates for comparable levels of taxable net wealth. Piketty's proposal seems to fall in the middle: the tax-free base is set higher than Spain, at €1 million, and rates fall in between the French and the Spanish ones. Even if he only suggests three brackets in his basic proposal (design 1), Piketty also suggests higher rates for higher levels of wealth as well (design 2).

[2]Namely real estate property and equity shares.

	France	Spain	Piketty
Competent authority	Central government	Local government for residents, central government for foreign residents	N/A
Tax payer	Fiscal household with a net wealth above €1.3 million	Individual owner of taxable wealth greater than €700 000	Individual owner of taxable wealth
Taxable base	Global net wealth of French residents and french wealth (excl. financial assets) of foreign residents	Global net wealth of Spanish residents and Spanish wealth of foreign residents	Global net wealth
Lowest bracket (rate)	€800 000 - €1 300 000 (0.5%)	€0 - €167 129.45 (0.2%)	€1 - €5 million (1%)
Highest bracket (rate)	Above €10 000 000 (1.5%)	Above €10 695 996.06 (2.5%)	Above €5 millions (2%)
Number of brackets	6	8	3
Exemptions	Business assets (under certain conditions), woodlands, forests, certain rural properties, property rights, collectors items, shares of capital in a small businesses	Net wealth below €700 000, the primary residence up to €300 000, Spanish heritage, intellectual property, business assets	None

Table 5.3: Comparison of wealth tax designs in France, Spain and Piketty's proposal

Source: Various (see above)

5.3 Wealth tax abolition

5.3.1 Reasons

In practice, many countries have found themselves abolishing their wealth taxes, or refusing to implement one. Four arguments are usually put forth when explaining why a wealth tax is being abolished (Heckly, 2004).

- **Capital drain** It is argued that a wealth tax can have harmful effect on a country's economic activity, causing productive capital to leave and discouraging foreign investors from coming in. This, in turn, negatively impacts consumption and investments, leading

Spain has the most granular and heaviest wealth tax design. France has lower marginal tax rates for each level of taxable base compared to Spain. Piketty's designs fall in between

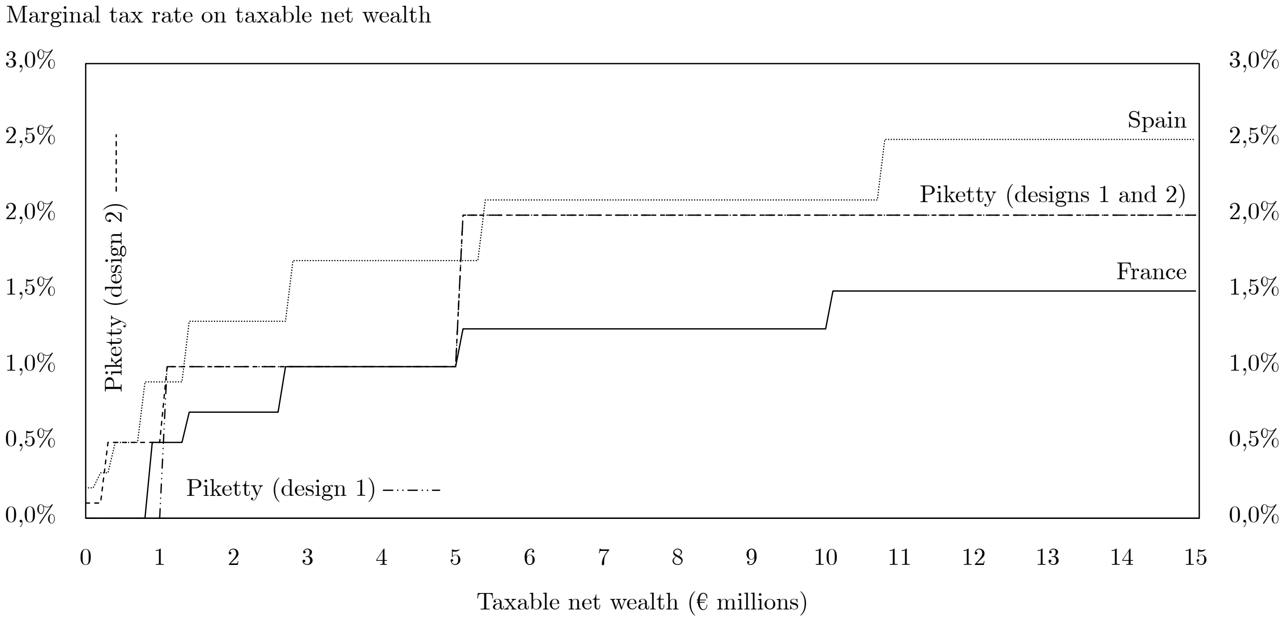


Figure 5.1: Marginal tax rates on taxable wealth in France and Spain in 2016 and in Piketty's designs

Source: Various (see above)

to actually lower overall tax returns.

- **Administrative costs** Wealth taxes are seen as highly inefficient economically. Indeed, they require high administrative costs while bringing relatively little tax revenue (0.2% of GDP in France). Estimates of cost efficiency for the ISF indicate however that costs are relatively low compared to proceeds.

- **Resource allocation** The fact that some kind of assets are exempts make this kind of tax highly unequal for individuals with the same net wealth but different portfolios (horizontal equity). Also, the valuation method used may be different for different assets and may not represent market value. Furthermore, France introduced a wealth tax cap relative to income (i.e. the tax an individual has to pay cannot exceed a certain percentage of this individual's income), meaning that wealthy people reporting low income will pay a lower amount than people with the same tax base and a higher income.[3]

- **Equality** In retrospects, it appears that the wealth tax has not helped reducing inequalities - its main purpose. Indeed, when looking at France's case, both income and wealth inequalities have risen over the last decades, while the net wealth tax was in place. It is unclear whether inequalities would have increased *more* without the tax, but it is clear

[3]This might pose an issue as income is thought to be understated for the wealthiest share of the population.

that the goal is not being met.

Overall, wealth taxes are highly unpopular and are filled with inconsistencies and challenges that push governments to abolish them. Adding to this the fact that they do not seem to reduce inequalities, and actually seem to negatively impact an economy, it appears desirable not to have such a tax at all.

5.3.2 Confrontation with Piketty's proposal

Piketty's tax deals with those arguments in two ways: a worldwide tax (global aspect) on the entire stock (comprehensive aspect) of net wealth.

- **Global aspect** First, the global aspect of the tax and increased collaboration between nations would solve the issue of capital drain - as people would not be able evade the tax by moving their wealth abroad or not reporting it. This would also positively impact administration cost as shared global financial information is likely to reduce the cost of checking on individuals' hidden assets. Indeed, Saez (2015b) confirms that "long term solutions will require (a) systematic registration of assets to ultimate owners", and "(b) systematic information exchange between tax countries with no exceptions for tax heavens", when addressing the issue of off-shore tax evasion.

- **Comprehensive aspect** Second, the comprehensive aspect of the tax would allow governments to actually tax net wealth (and not part of it) with no difference as of the type of wealth (types of assets in the portfolio), which, in turn, should have a positive impact on horizontal equity.

Piketty's ideas remain however highly utopical. Indeed, full cooperation between nations is not expected to happen any time soon. He therefore suggests the tax could initially be implemented at a regional level, such as the European Union. Three issues remain though. First, collaboration with the region would still be required, which, even in Europe, is not perfect. Second, the European Union in particular is not likely to be able to impose taxation on its citizens, and the current eurosceptic trend in several states does not play in its favor, meaning that countries would have to decide independently to levy this tax. Third, if not global, fiscal evasion and capital drain are still likely to happen. In other words, even if the EU would have perfect information about wealth values of its citizen in Europe, and levies a regional tax on this wealth, citizens would still be able to move part of their wealth out of reach of this tax. Negotiating bilateral agreements with tax havens would be tedious and if not global, might not have significant impact on tax evasion (Johannessen & Zucman, 2014).

All in all, Piketty's idea provides relevant solutions to problems facing wealth taxation, mainly international cooperation and the comprehensive aspect of the tax. It however seems unlikely to happen any time soon.

5.4 Implementing a wealth tax

Based on the two previous sections, it seems that a wealth tax in Belgium alone is not desirable. Indeed, all the challenges (capital drain, valuation, fraud) would still be present and Belgium does not have the power to force foreign countries to declare the wealth its residents hold abroad. In this case, the outcome is unlikely to be different from what we have seen elsewhere and inequalities are unlikely to be reduced, meaning this tax does not reach its desired goals. Even so, we might want to consider what would be the issues in designing such a tax for its implementation in Belgium.

Tax administration First of all, operating a wealth tax from an administrative point of view does not seem that tedious. Indeed, McDonnell (2013) estimates that it should be comparatively easier to implement and run a wealth tax nowadays than it was when France or Spain introduced theirs, mainly due to two reasons.

- "Self-assessment[4] is seen as an acceptable way to administer taxation systems;
- Computer systems are comparatively cheap and easy to set up compared to paper based systems of the past."

He adds by quoting OECD (1988) that argues that "the existence of a net wealth tax can assist with the administration of income tax by enabling tax authorities to cross-check data with income earning assets and in so doing identify discrepancies".

Tax avoidance and evasion It might be true that introducing a tax on net wealth can be done easily nowadays and that it might assist personal income taxation, but administrating this taxation can prove more complex. First and foremost, deciding to let the entire responsibility of declaring their level of net wealth to individuals is prone to reduce substantially the tax base. As explained in Baffert (2007) several behaviors can be used to reduce the tax paid by a taxpayer (see also section 8.2 for a detailed definition, illustration and quantification of tax avoidance and evasion).

[4] It refers to the fact that individuals report the value of their assets themselves rather than the fact that the government systematically valuates individuals net wealth.

- **Legal** tax optimization/avoidance: taxpayers can reduce their tax by modifying their portfolios of assets in order to benefit from lighter tax schemes on specific asset types. For example, in Belgium, some types of sovereign obligations are tax exempted.

- **Illegal** motives: undeclared evasion, fraud, misinterpretation or involuntary mistakes are all mentioned as potential explanation for discrepancies between declared tax base and real tax base.

These potential discrepancies have to be monitored and corrected by the administration, meaning more complexity. In the case of a net wealth tax with no exemption, individuals cannot optimize their tax base by changing their portfolio, but all the other issues remain. On the other hand, it would be way too costly for the administration to value each and every individual's net wealth. Reporting for financial assets and debts should be automated with financial institutions while for real assets valuation has to be let to the taxpayer and controlled randomly by the administration. Concerning real estates, the US system, where the government sends taxpayers an estimation of their estate's value based on several valuation techniques or historical transaction in the neighborhood of the taxpayer for similar estate types, could be introduced.

Taxable unit Another issue concerns the definition of the taxable unit. While Piketty talks about taxing individual wealth, it might be hard to appropriate some assets or debts to only one individual. Take the example of a house with several people living in it. One could argue only adults to be liable for this tax, as children typically do not hold substantial share in household wealth. The value of the house might however not fall equally to each adult living in it. One solution could be to allow individuals to report independently what share of the household wealth goes to them, which would create an easy situation for some individuals to optimize their tax base and fall below the tax brackets (take the example of two people living in a house valued at €1.5 million. They can easily say they both own 50% of it and avoid the wealth tax, while it might be true that only one individual actually owns the house). Defining the taxable unit as the household also proves complicated as much wealth is individually owned, and retained when leaving an household, meaning that some members of the households might have to pay a tax on wealth they will never have a say on.

Taxable base Another choice to make concerns the definition of the tax base. Will foreign-residents holding wealth in a country be taxed? Will residents of a country be taxed on their national wealth or their global wealth? By suggesting a global tax on capital, this question becomes trivial as the same tax design will be applied to all wealth of individuals, whatever the country of residency (a question of redistribution between nations may arise that we do not address here), but at a non-global level, the question is all but irrelevant. Most current wealth taxes are applied both on global net wealth of domestic residents and domestic wealth of foreign residents (the case for the French ISF and the Spanish Patrimonio).

5.5 Conclusion

In this chapter, we tried to see whether Piketty's proposed tax could be implemented, and to some extent, how. Even if his proposition has never been seen in practice, some countries have implemented some sort of net wealth taxation and lessons can be learned from history.

It appears that main reasons why net wealth taxes were failing on delivering on their promises of reducing inequalities were driven by capital drain, misvaluation of assets (tax evasion) and strong exemptions (leading to tax avoidance).

Piketty's ideas are based on two foundations that could solve this. First, a global tax where countries have to transmit full fiscal information to one another. In that case, and all assets are taxed worldwide with the same scheme and individuals cannot (and do not have reasons to) evade the tax. Second, a comprehensive tax where the entire stock of wealth is taxed, without exemption. In that case, individuals cannot (and do not have reasons to) avoid the tax by adapting their portfolio of assets.

Those two strong prerequisites are however unlikely to materialize at national level and their absence means no country can escape the pitfalls of wealth taxation on its own. In our world, it seems like a tax on net wealth, while possibly desirable from a theoretical point of view, is not practical in the short (medium) run. We now verify this statement by analyzing what the implementation of a wealth tax at a national level, taking the case of Belgium, would result in.

Part III

Wealth tax and economic inequalities: modeling exercise

Chapter 6

Setting the scene

6.1 Objective, methodology and tool

Objective Regardless of our opinion on the relevance of a wealth tax resulting from the analysis of the two first parts, the objective of the last part of this paper is to estimate what would be the impact over some years if the tax as Piketty imagines it was to be implemented in Belgium today. The forecasting exercise is done by the definition of a formal model, then the estimation of its parameters and finally the results interpretation. The questions this part aims to answer are whether Piketty's tax

- would decrease inequalities (distribution of the stock) and by how much
- would impact the total stock of wealth (size of the stock) and by how much
- would yield substantial tax revenue and how much
- would be evaded by individuals and to what extent

if it was to be implemented today in Belgium.

Methodology It is made of five chapters.

- Chapter 6 gives an overview of the methodology we follow and the practical tool we build. It allows the reader uninterested in technical aspects to know what is in the model and is not (and why) in order to be able to understand and interpret the results.
- Chapter 7 draws an initial model of individual wealth dynamics based on return on assets, cost of debt, income & consumption, leverage behavior and current taxation.

- Chapter 8 builds on the previous one by adding to the wealth dynamics Piketty's tax and redistribution effects along with reactions to the tax introduction: assets hiding, assets undervaluation, and individual expatriation. Doing so makes us able to analyze different state of the world: with/without tax on wealth and with/without tax evasion.

- Chapter 9 gives real values to all the parameters declared in chapters 7 and 8 and tells where those values come from or explains how we estimate them.

- Chapter 10 finally deals with the results interpretation and subsequent conclusions and recommendations.

For practical reasons, chapters 7 and 8 don't involve complicated mathematical concepts (such as differential of infinitesimal calculus). However, they involve a bunch of symbols with heavy sub- and super-scripts, sometimes even more than needed.[1] This should not be seen over-complication. The justification is to make to model (and therefore, way more importantly, the algorithm, see below) as open as possible in order include as many potential cases as possible and allow easy modification by who may have an interest in it.

Tool Willing to leverage our background in business engineering, the model drawn and the results generation are completely automatized through an algorithm coded in R language[2], written in appendix C and available in a dedicated file along with the paper. The formulas we derive in the next two chapters have their equivalent in the code. This algorithm constitutes a considerable personal contribution from us and should not be seen as a useless appendix given the substantial amount of time which has been dedicated to its coding. To answer the question of this part, we could have just developed an Excel model which would have required 10 times less effort but without the advantages mentioned below. Indeed, the extent of automation allows the algorithm to be applied way beyond the scope of what we forecast in this thesis.

- On the one hand, there is a complete split between the data and the computation part which is entirely coded through parameters. This aspect allows to change the values of the input data so as to generate updated results, but without any need to change the computations. The independence of modules in a software is called *modularity.*

- On the other hand, the data part is dynamic, meaning that the size of the input data is not fixed and allows to run the model on bigger/smaller (breadth) or more granular/less granular (depth) information, depending on the availability of data and the needs of the user.

[1] For example, we often assume parameters constant over time but systematically write down the subscript t. Also, we introduce some parameters for which we already know the value will be set to zero when parametrizing.

[2] `https://www.r-project.org/`

Those two points make the R code able to be run on better data on Belgium than the one we use, as new data is published but also to be run on other situations such as other countries. Taking a longer term view, it is as well a starting point for further considerations that can be pretty easily integrated in the model, thanks to its modularity.

6.2 Initial model

The literature related to the theoretical modeling of wealth, tax and tax on wealth include different aspects. Our approach, deliberately practical, takes some and leaves out others. To avoid any misunderstanding, let us directly be clear on what the model can and cannot do. Section 6.2.1 looks at aspects we do not include in the model while section 6.2.2 looks at aspects we do include.

6.2.1 What's out

Inheritance Chapter 4 dedicated a lot of lines to the bequest motive of wealth accumulation. Aaron & Munnell (1992) or Benhabib & Bisin (2007) highlight the relevance of an inheritance tax (tax on wealth transfer) because a substantial part of total wealth is transmitted through inheritance. Therefore, inheritance may be a powerful lever to impact inequalities. Approaches including inheritance in wealth dynamics are part of the overlapping-generation (OGL) family of models, first developed by Modigliani & Brumberg (1954). When we assume only one generation of individuals living forever, we fall in the "infinitely-lived dynasties" family (Cagetti & De Nardi, 2006). Saez (2015b) also makes the distinction between what he calls "life-cycle" and "bequest" models. Considering that the tax on net wealth has other justifications than and is complementary to the inheritance tax as in Piketty (2013), we leave this consideration out and put ourselves in an infinitely-lived dynasties context. Anyway, our forecasting model does not allow us to reasonably provied estimates decades from now.

Utility and welfare function maximization Next to a huge literature including inheritance in the models, a lot of them integrate the processes of maximizing individual utility functions, welfare function, under some constraints or not. See for example Hans Peter & Burkhard (1994), Cagetti & De Nardi (2006) or Piketty & Saez (2013). Those approaches do not fit our objective because they rely on theoretical utility functions, which we do not use in practice.

Stochastic shocks, population growth, consumption behavior and credit rationing We do not include random variables to replicate stochastic shocks (e.g. on return, on productivity etc.) or demographic growth like in Jones (2014). It also assumes no changes in savings rates on which Mian et al. (2013) highlight the impact of wealth. Regarding the impact of wealth tax on savings behavior, Bernheim (2002) and Seim (2004) find that an increase in the tax rate is more likely to lead to tax avoidance/evasion (see section 6.3.2) rather than adjustment of consumption, which strengthens our hypothesis of constant savings rate. Finally, each individual is assumed to have no restrictions in his credit access (remember from Aghion & Bolton (1997) the importance of credit market imperfections developed in chapter 2), meaning that one can borrow and pay back his debt whenever he wants and without fee.

Others In addition to this, our basic model leaves out a number of other considerations. Cagetti & De Nardi (2006) identify some aspects raised in the literature which have an impact on the wealth inequality dynamics: learning abilities (Hugget et al., Becker & Tomes or Heckman et al.) or entrepreneurship (Banerjee & Newman, Paulson & Townsend etc.).

6.2.2 What's in

Wealth components and drivers Instead of looking at wealth as an unbreakable entity, we look at its components (assets and debts) and its drivers (reutrn on assets, cost of debts, income, consumption, taxes etc.). This approach of putting emphasis on the drivers is similar to Saez & Zucman (2016) who also leave out intergenerational considerations (so does Chamley (1986)) and utility maximization.

Assets and debts ventilation Critical to Shorrocks (1982) or Kennickell (2011), different classes of assets exist. Different classes of debts exist as well. They may all present different return realization and tax schemes. For this reason we look more closely than usual at the portfolio composition of assets and debts (as Gollier, Haliassos & Michaelides etc.) and their taxation (as Meh, Quadrini etc.) (Cagetti & De Nardi, 2006).

Population partition Major aspect to Piketty (2013) claiming that wealth drivers (return on capital, cost of debt...) differ by brackets of wealth, we integrate the change in drivers when an individual move from a bracket to another. In his book, he highlights the facts that US universities with higher endowments have higher returns because of their ability to take risks and scale effect in financial advice. That is, the size of their assets influences the magnitude of their return on assets.

6.3 Extensions

On top the initial model are added four modules: first, Piketty's tax and redistribution; second, responses related to the capital elasticity to tax on capital: assets hiding, assets undervaluation and individual expatriation.

6.3.1 Piketty's tax

Piketty's extension is made of two components: a tax on wealth (negative monetary flow for individuals) and a redistribution (positive monetary flow for individuals). Regarding the tax, we take Piketty's scales (tranches/brackets of wealth and associated tax rates) and formalize it. Regarding, the redistribution, which is not at all defined in Piketty (2013), we develop from scratch our own approach.

6.3.2 Tax avoidance and evasion

Multiple individual behaviors may arise from changes in the tax situation, and this must be taken into account by authorities when establishing a tax framework (Slemrod & Yitzhaki, 2000).

Tax avoidance Piketty, together with Saez and Stantcheva, define labor income tax avoidance as the "changes in reported income due to changes in the form of compensation but not in the total level of compensation" (Piketty et al., 2011). This concept arises from the fact that labor income can be distributed (or stocked) under different forms (dividends, participation, donations etc). facing different tax obligations. For example, Saez (2015a) points out intertemporal substitution (e.g. unrealized capital gains, stock-options) and income shifting (e.g. corporate vs. individual tax base), which are completely legal. By the way, according to Piketty (2013), this is one of the major reasons justifying his tax on net wealth since his tax applies on net wealth regardless of its form.[3]

Tax evasion Tax evasion, the process of changing the total level of reported (in this case) wealth, can still occur, by relocating wealth to other jurisdictions (in case of source of capital taxation principle) or by physically moving to other jurisdictions (in case of residence of capital taxation principle) (Saez, 2015b), with a preference to locations without transparent information treaties (Johannessen & Zucman, 2014). In our context, tax evasion takes three forms Pichet (2007): assets hiding, assets undervaluation and individual expatriation.

[3] We come back here to discussions of section 5.3.2.

Assets hiding

Current stock In April 2016, more than 11 million documents related to offshore hidden assets of more than 200,000 individuals clients of the Panamanian law firm Mossack Fonseca have been published (The Financial Times, 2016). This generated a worldwide debate and gave a glimpse of the magnitude of what offshore wealth actually amounts to. Zucman (2015) in *The Hidden Wealth of Nations: the Scourge of Tax Havens* found that the share of U.S. equities held by firms or individuals in tax havens grew from 2% in 1990 to 9% today (see also his article (Zucman, 2014)). He estimates that 8% of worldwide private wealth is held offshore in 2013, that is, $7.6 trillion. Among this, approximately 20% is declared while 80% is not taxed (hidden). The European case is worse with 10% ($2.6 trillion). It should be noted however that some countries are way above with 50% (Russia) or 57% (Gulf region). Back to total offshore wealth, some estimations amount to $32 trillion (Tax Justice Network, 2011). The Boston Consulting Group (2014) published an estimate of $8.9 trillion and also forecasts offshore wealth to grow at an average 5% per year until 2019, geographic proximity being an important driver when deciding where to offshore (The Boston Consulting Group, 2015). Key destinations are Switzerland (25% of total offshore wealth), Hong Kong and Singapore (14%), Ireland and Caribbean & Panama (both 11%), followed by United Kingdom, United States and Luxembourg (The Boston Consulting Group, 2013).[4]

Future flows As summarized by Gérard (2014), Ramsey (1927) first stated that the optimal tax rate is inversely proportional to the elasticity of its base to the tax rate. If wealth is mobile, then the tax on wealth should be low, maybe even null, according to some. The fact is, wealth is mobile, as it is easy to relocate assets abroad, especially financial assets (provided that there is no full information exchange between states). Boiteux (1956) strengthens the argument some decades later, giving birth to the Ramsey-Boiteux rule (Conseil des Prélèvements Obligatoires, 2009).

Piketty et al. (2011) suggest a framework for optimal taxation of top labor income where individuals answer to increase in tax rate in different ways. One of them is tax avoidance/evasion. Another one is work/effort diminution. Allingham & Sandmo (1972) developed a widely quoted model of reported income depending on parameters such as probability of being audited by the government and a fine parameter.[5] Gillman & Kejak (2013) integrate the cost of evading (e.g. cost of alternative entities) per unit of income, as in Fullerton & Karayannis (1993) and Chetty (2009).

[4]For those numbers, the Boston Consulting Group considers financial assets.

[5]For the reader interested in the foundations of economical and mathematical approach of illegal activities, see for example Ehlrich (1973) or Becker (1974a).

Naritomi (2015) studies the case where individuals monitor firms, in addition to authority, and can report evasion, as it is the case in Sao Paulo, Brazil. This uses probabilities of being audited, either from the government or consumers. The conclusion is that individual monitoring has an impact on evasion behavior of corporations. This can be extended to individuals monitoring individuals. Akcigit et al. (2015) study the impact of the origin country of individuals (inventors), and the extent to which they are established there, on their evasion behavior.

The bottom line is that tax evasion behavior is driven by the willingness to evade and the ability to evade (Saez, 2016). Willingness relates to social norms, morality, amount of tax avoided etc. and ability relates to availability of mechanisms, cost of those mechanisms, probability of being caught, either by the authority or by a third party etc. Way too theoretical and not practically implementable, we rather use benchmarks of other wealth tax introductions to quantify the elasticity of reported wealth to tax on wealth.

Assets undervaluation

Assets undervaluation/underdeclaration here relates to disclosing to the tax authority a deliberately lower amount than the real asset value. The real asset value, as defined by Piketty (2013), is what the buyer of the asset can get by selling it on the market. The challenge is that market value of some asset classes may not be straightforward. This arises for example in case of real estates or unlisted financial securities. Pichet (2007) estimates that the undervaluation of assets amounted to up to €700 million of tax revenues in 2004 in France in the context of the ISF already presented in section 5.2.1.

Expatriation

In the same context, Marini (2008) estimates that, over the 1997-2004 period, between one and two individuals left France each day to avoid the ISF. Figure 6.1 shows the absolute (around €2 billion each year in taxable base) and relative (around 0.4% of taxable each year) importance of fiscal expatriation along with the theoretical tax on wealth paid by delocalized people. It shows that the tax paid by expatriated individuals is higher than the one paid by all contributors. As the ISF is a progressive tax, we conclude that the likelihood of expatriation is higher among the very upper tail of the wealth distribution.

Although fiscal expatriation is not the most important drivers of tax evasion, we include it for comprehensiveness purpose.

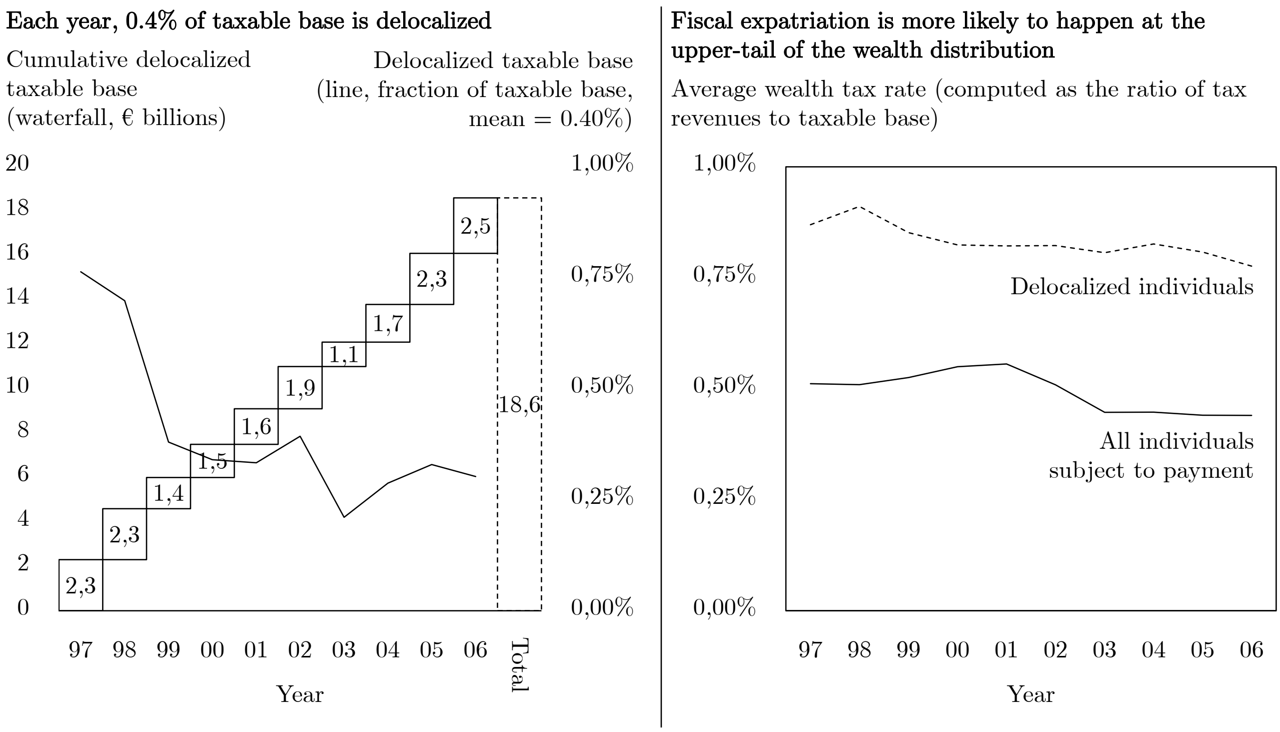


Figure 6.1: French ISF delocalized taxable base and tax rates between 1997 and 2006

Sources: Marini (2004, 2007, 2008), Conseil des Prélèvements Obligatoires (2009), DEFP (2010) and own calculations

6.4 Parametrization

Chapter 9 is about giving actual values to the parameters. To do so, we use different sources and estimation methods. For example, regarding net wealth, Saez & Zucman (2014), when studying inequalities in the United States from 1913, identify three main sources/methods to evaluate the distribution of wealth.

- The first one, the one they use, it the capitalization technique. It consists in deriving wealth by capitalizing income, as income can be quite accurately retrieved from official tax declarations. It has been substantially developed by William N. Kinnard (Sirmans & Worzala, 2003). Correction must be made for wealth which does not return monetary income, primary house for example.

- The second one is surveys, which relies on the honesty of individuals and the formulation of the questions, in addition to other issues such as the size of the sample and the frequency. One predominant survey at a European level on private wealth is the Eurosystem Household Finance and Consumption Survey (European Central Bank, 2013c). Next to those surveys from official institutions, there are private lists such as the Forbes 400 listing the four hundred richest people in the United States (Forbes, 2016a).

- The third one is the estate multiplier method using "annual estate tax statistics and re-weighting individual estates by inverse of death probability" (Saez & Zucman, 2014).

We make use of the work done in previous chapters (for example chapter 3 for income and wealth parametrization) complemented by new sources to input actual values in the algorithm.

6.5 Results analysis

Finally, chapter 10 represents and interprets the outcome of the algorithm so as to answer the four questions related to the quantification of the wealth tax effects mentioned at the beginning of this chapter.

Chapter 7

Initial model

An inventory of selected symbols and their signification is provided in table 8.2.

7.1 Wealth components

The net wealth (or net worth) of an individual is defined as the sum of the values of all assets (gross wealth) detained by the individual, reduced by the sum of the values of all debts the individual is liable to. To see the relevance of deducting debts from assets, take the example (Piketty, 2013) of someone owing ten houses, two boats, and one private jet but only borrowed to acquired them. At some point, he will have to pay for those, that is, to pay back his debt. All in all, he may have a lot of assets but a low net wealth.

7.1.1 Assets

Shorrocks (1982) identifies 17 asset classes. Kennickell (2011) splits financial assets (typical savings accounts, stocks, bonds, life insurances, oil leases, royalties etc.) and non financial assets (vehicles, real estate, antiques etc.). This distinction is quite common. Let us denote by $\mathcal{C}^a$ the set of all assets in the economy. The total value of assets (gross wealth) detained by an individual i at time t is a_t^i with

$$a_t^i = \sum_{c \in \mathcal{C}^a} a_t^{c,i}. \tag{7.1}$$

In some (many) cases, $a_t^{c,i}$ is null. Using Kennickell's distinction, we have $a_t^i = a_t^{f,i} + a_t^{r,i}$ where the superscript f stands for "financial" and r for "non-financial" or "real" assets. By writing $\alpha_t^{c,i}$ the share of asset c in the portfolio of i in t so that $\sum_{c \in \mathcal{C}^a} \alpha_t^{c,i} = 1$, we have the alternative view $a_t^{c,i} = \alpha_t^{c,i} \cdot a_t^i$ emphasizing on the asset class allocation.

We deliberately split the different asset classes, unlike commonly done in the majority of theoretical models not looking for such a level of detail, in order to study the impact of changes in portfolio composition (important to Flavin & Yamashita (2002) or Ameriks & Zeldes (2004)), changes in rates of return on different assets and changes in tax schemes of different assets.

7.1.2 Debts

Let us denote by d_t^i the total amount of outstanding debt of individual i in t. Kennickell (2011) identifies, as example, mortgages, installment debt, credit cards payable and others such as family debt, margin debts etc. As for the asset side, writing $\lambda_t^{c,i}$ the weight of debt class c in i's portfolio of debts, we write $d_t^{c,i} = \lambda_t^{c,i} \cdot d_t^i$ and

$$d_t^i = \sum_{c \in \mathcal{C}^d} d_t^{c,i} \tag{7.2}$$

(with $\sum_{c \in \mathcal{C}^d} \lambda_t^{c,i} = 1$) although debts are not as often ventilated in the databases as assets are. Alternatively, using a debt-to-asset ratio approach as often done in studies (European Central Bank (2016) for example), we define debt as a fraction of gross wealth (noted β_t^i for individual i in t) and write

$$d_t^i = \beta_t^i \cdot a_t^i \tag{7.3}$$

where β_t^i can be seen as the appetite for debt of individual i. In other words, its risk-appetite.

7.1.3 Putting together

Combining asset and liability sides of the identity, we have the net wealth of individual i in t computed as

$$\begin{aligned} w_t^i &= a_t^i - d_t^i && (7.4) \\ &= a_t^i - \beta_t^i \cdot a_t^i && (7.5) \\ &= (1 - \beta_t^i) \cdot a_t^i. && (7.6) \end{aligned}$$

This equation has the non negligible advantage of expressing the net wealth of i through the size of his assets and his choice to issue/pay back debt. Indeed, each individual may decide to increase his debt (i.e. to borrow) in order to increase his assets, or to reduce his debt (i.e. to pay back) by reducing his assets. This is purely up to the agent, and such choices differ from one individual to another. For a given level of net wealth, the parameter β_t^i summarizes the entire choice/behavior of i (see section 7.2.5 for illustration).

7.2 Wealth dynamics

From one period to the next, net wealth is impacted by the return on assets net of taxes, the cost of debts and the income (including social compensations etc.) net of taxes (i.e. disposable income) and consumption.

7.2.1 Return on assets

Each of the asset classes mentioned are meant to generate return, under different forms, usually periodic (interests, dividends, rent etc.) or ad-hoc (capital gain on tradable assets such as stocks, real estates etc.). Again, we here diverge from classical models by deliberately allowing each source of return to face different realization and tax schemes. Denoting by $\mathcal{S}^c$ the set of all sources (interests, dividends, capital gains...) of return on asset c and by $r_t^{c,s,i}$ the return s on asset c for individual i between $t-1$ and t, we have that the average return on assets is

$$\bar{r}_t^{a,i} = \sum_{c \in \mathcal{C}^a} \left(\alpha_t^{c,i} \sum_{s \in \mathcal{S}^c} r_t^{c,s,i} \cdot (1 - \tau_t^{c,s,i}) \right) \tag{7.7}$$

where $\tau_t^{c,s,i}$ is the tax rate on return s on asset c for individual i in t.[1] Considering only the two usual sources or return on assets (r for interests/dividends/coupons/... and q for capital gains), we have[2]

$$\bar{r}_t^{a,i} = \sum_{c \in \mathcal{C}^a} \alpha_t^{c,i} \left[r_t^{c,i} \cdot (1 - \tau_t^{r,i}) + q_t^{c,i} \cdot (1 - \tau_t^{q,i}) \right]. \tag{7.8}$$

7.2.2 Cost of debts

For each period, individual i has to pay interests on his debt. The total amount of interests paid by i in t is

$$\bar{r}_t^{d,i} \cdot d_{t-1}^i \tag{7.9}$$

where

$$\bar{r}_t^{d,i} = \sum_{c \in \mathcal{C}^d} \lambda_t^{c,i} \cdot r_t^{c,i} \tag{7.10}$$

is the weighted average cost of debt between $t-1$ and t, or the so-called WACC (weighted average cost of capital) if we borrow (pun) the famous notion from corporate finance. We keep

[1] Note that this general formulation suits more real cases than is seems. For example, the Belgian cadastral revenue (CR) is a fictive real estate income used to compute the tax on the housing where people live in. Concretely, it's a real tax applied to a fake income; that is, a strictly negative monetary flow for house owners. This tax enters perfectly in the model by solving (sub- and super-scripts omitted) for r and τ the equation $H \cdot r \cdot (1-\tau) = -H \cdot z \cdot \tau^{CR}$ where H is the value of the house and z is such that $z \cdot H$ equals the cadastral revenue. Setting τ at τ^{CR}, we have $r = -(z \cdot \tau^{CR})/(1-\tau^{CR})$.

[2] For simplicity, equation (7.8) is translated in the algorithm in R, equation (7.7) is not.

the same notation $r_t^{c,i}$ for assets and debts as they actually come down to the same concept: a negative asset is a debt and a negative debt is an asset.

7.2.3 Labor, consumption and transfers

People work and earn money. Let us denote by l_t^i the labor income (salary) of individual i in t, the disposable (net of tax) income is $(1-\tau_t^{l,i}) \cdot l_t^i$. They also spend money on day-to-day consumption. Using a savings rate approach, we define consumption as a fraction of disposable labor income for individual i in t and write it $1-\gamma_t^i$. Consumption is then $(1-\gamma_t^i)\cdot(1-\tau_t^{l,i})\cdot l_t^i$ and disposable income net of consumption is $\gamma_t^i \cdot (1-\tau_t^{l,i}) \cdot l_t^i$. Next to this, people receive/give money to/from the state, in terms of social benefits/expenses, a good example being the unemployment allowance. For simplicity and because databases often include this in labor income as the one we use (Direction générale Statistique, 2016), we consider net transfers included in l_t^i. Taking into account the annual growth in income between $t-1$ and t noted g_t^i, we have $l_t^i = (1+g_t^i) \cdot l_{t-1}^i$.

7.2.4 Putting together

The relative change of net wealth between $t-1$ and t for i, is the combination of return on capital, cost of capital, and income & consumption effects, all net of taxes:

$$\delta w_t^i = \frac{a_{t-1}^i \cdot \bar{r}_t^{a,i} - d_{t-1}^i \cdot \bar{r}_t^{d,i} + \gamma_t^i \cdot (1-\tau_t^{l,i}) \cdot (1+g_t^i) \cdot l_{t-1}^i}{w_{t-1}^i} \tag{7.11}$$

$$= \left[\frac{a_{t-1}^i \cdot \bar{r}_t^{a,i}}{(1-\beta_{t-1}^i)\cdot a_{t-1}^i}\right] - \left[\frac{\beta_{t-1}^i \cdot a_{t-1}^i \cdot \bar{r}_t^{d,i}}{(1-\beta_{t-1}^i)\cdot a_{t-1}^i}\right] + \left[\frac{\gamma_t^i \cdot (1-\tau_t^{l,i}) \cdot (1+g_t^i) \cdot l_{t-1}^i}{(1-\beta_{t-1}^i)\cdot a_{t-1}^i}\right] \tag{7.12}$$

$$= \left[\frac{1}{1-\beta_{t-1}^i} \cdot \bar{r}_t^{a,i}\right] - \left[\frac{\beta_{t-1}^i}{1-\beta_{t-1}^i} \cdot \bar{r}_t^{d,i}\right] + \left[\frac{\gamma_t^i \cdot (1-\tau_t^{l,i}) \cdot (1+g_t^i) \cdot l_{t-1}^i}{(1-\beta_{t-1}^i)\cdot a_{t-1}^i}\right] \tag{7.13}$$

which leads to

$$\delta w_t^i = \underbrace{\left[\frac{1}{1-\beta_{t-1}^i} \times \left(\bar{r}_t^{a,i} - \beta_{t-1}^i \cdot \bar{r}_t^{d,i}\right)\right]}_{\text{Return and cost of capital effect}} + \underbrace{\left[\frac{\gamma_t^i \cdot (1-\tau_t^{l,i}) \cdot (1+g_t^i) \cdot l_{t-1}^i}{(1-\beta_{t-1}^i)\cdot a_{t-1}^i}\right]}_{\text{Income and consumption effect}}. \tag{7.14}$$

The absolute change of net wealth $w_t^i - w_{t-1}^i$ is $\Delta w_t^i = \delta w_t^i \cdot w_{t-1}^i$ and the new net wealth is $w_t^i = (1+\delta w_t^i) \cdot w_{t-1}^i$. In case of $w_{t-1}^i = 0$, assets and debts are null by construction of debt-to-asset ratio and the net wealth increase only comes from the income effect: $\Delta w_t^i|_{w_{t-1}^i=0} = \gamma_t^i \cdot (1-\tau_t^{l,i}) \cdot (1+g_t^i) \cdot l_{t-1}^i$. At the end of each period $[t-1 \rightarrow t]$, individual i is assumed to adjust its portfolio between assets and debts taking into account its new net wealth w_t^i according to $a_t^i = w_t^i/(1-\beta_t^i)$ and $d_t^i = \beta_t^i \cdot a_t^i$ in order to match his risk-appetite (see example in section

7.2.5).

7.2.5 Discussion and illustration

Discussion

Although the formula can seem vicious at first, it is actually a quite intuitive summary individual wealth dynamics. Let us first assume that i's net wealth is strictly positive (i.e. $\beta_t^i < 1$ and therefore $1 - \beta_t^i > 0$).[3]

Return and cost of capital effect Regarding the left hand term, the more the average net return on assets ($\bar{r}_t^{a,i}$) and/or the less the average cost of debt ($\bar{r}_t^{d,i}$), the more the growth in net wealth (δw_t^i). Analytically, the ratio $1/(1 - \beta_t^i)$ tends to $+\infty$ (positive vertical asymptotic shape) when β_t^i tends to 1 from the left. That is, the return and cost of capital effect is magnified when β_t^i tends to 1. Does it makes sense? Recall that the more β_t^i, the more leveraged is i or, put another way, the more risk is taken by i. As expected, higher risk taking leads to higher capital effect when the return on assets overcome the cost of debt. The ratio $1/(1 - \beta_t^i)$ can be seen as a measure of the leverage effect. However, when the return on assets doesn't overcome the cost of debt, the leverage effect becomes hammer effect because loss is magnified instead of profit.

Income and consumption effect Regarding the right hand term, the more the savings rate (γ_t^i) and/or the less the labor income tax ($\tau_t^{l,i}$) and/or the more the income growth (g_t^i) and/or the more the labor income (l_{t-1}^i), the more the growth in net wealth (δw_t^i).

Illustration

Consider an individual i starting with a net wealth of $w_0^i = 100,000$ monetary units. At the beginning, he has an income of $l_0^i = 15,000$ growing at $g_t^i = 2\%$ per year, taxed at $\tau_t^{l,i} = 40\%$. Each year, he saves $\gamma_t^i = 20\%$ (consumes 80%) of its disposable income. His leverage behavior amounts to around two third of his assets and is supposed constant: $\beta_t^i = 70\%$. That is, in t_0, his assets are $100,000/(1 - 0.7) = 333,333$ and his debt is $333,333 - 100,000 = 233,333$ monetary units. From year 0 to year 10, i experiences different realizations of return to assets $\bar{r}_t^{a,i}$ (row (3) of table 7.1) while his average cost of debt is maintained to $\bar{r}_t^{d,i} = 5\%$. One possible net wealth dynamics is represented on figure 7.1. Let us look more closely at the two possible cases: decrease in net wealth and increase in net wealth.

[3] The case where $\beta_t^i > 1$ is discussed in appendix B.

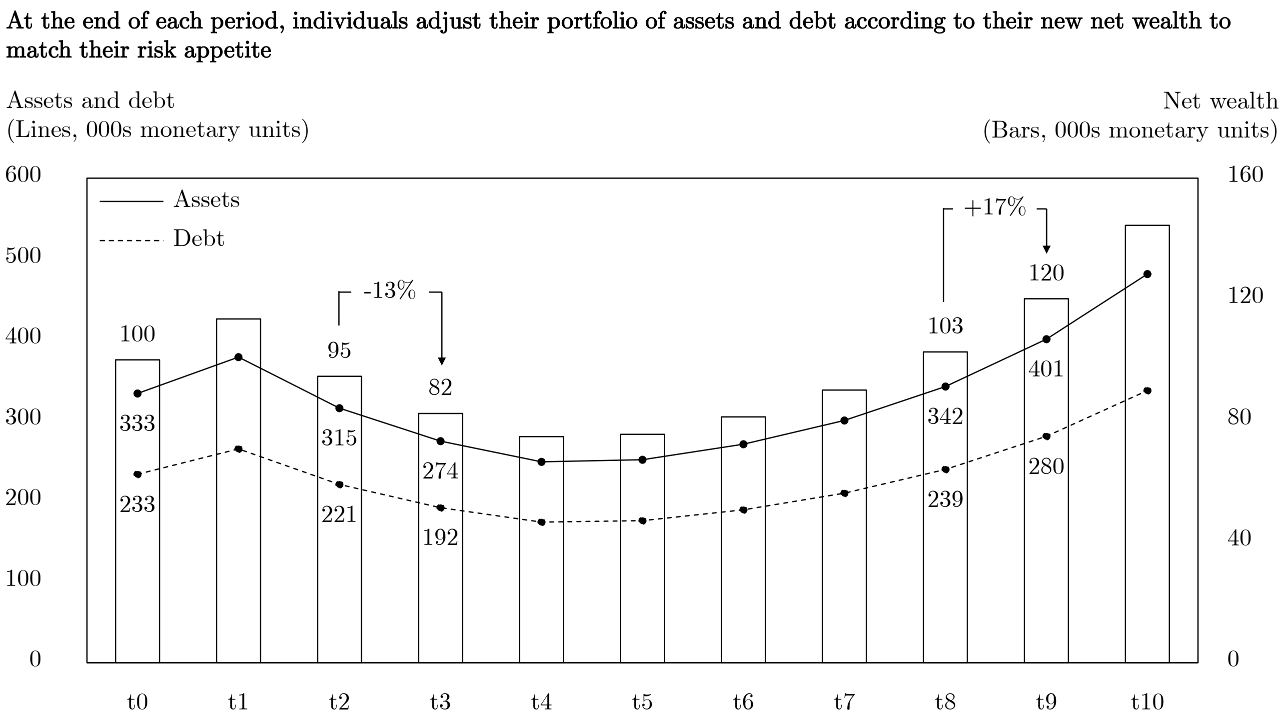


Figure 7.1: Example of individual starting with positive net wealth and experiencing positive and negative returns on net wealth

Note: Numbers may not add up due to rounding

Decrease in net wealth Between t_2 and t_3, i looses 1% on 315 of assets (for example due to negative capital gains) and pays 5% on a debt of 221. All in all, he experiences negative capital effect of -15% of net wealth. His income of 15.9, net of taxes and consumption, only compensates to an extent of 2%. His return on net wealth for this period is $-15\%+2\% = -13\%$, an absolute loss of 13 thousand monetary units. Then, $w_3^i = (1 - 13\%) \times 95 = 82$. Taking his new wealth into account, i adjusts his assets to $82/(1-0.7) = 274$ and his debt to $274-82 = 192$ thousand monetary units. Concretely, it means that i absorbs his loss of 13 by selling some assets for 13 and then, in order to match his preferred level of leverage (70% of his assets), further sells assets for 28 and pays back part of his debt.

Increase in net wealth Between t_8 and t_9, i earns 7% on 342 of assets and pays 5% on a debt of 239. All in all, he experiences positive capital effect of 15% of net wealth. His income of 17.9, net of taxes and consumption, amounts to 2.1% of the net wealth. His return on net wealth for this period is $15\%+2.1\% = 17.1\%$, an absolute profit of 17 thousand monetary units. Then, $w_9^i = (1 + 17.1\%) \times 103 = 120$. Taking his new wealth into account, i adjusts his assets to $103/(1 - 0.7) = 400$ and his debt to $400 - 120 = 280$ thousand monetary units. Concretely, it means that i integrates his profit of 17 by buying some assets for 17 and then, in order to match his preferred level of leverage (70% of his assets), borrows 41 and further buys assets.

		t_0	$\cdots$	t_2	t_3	$\cdots$	t_8	t_9	$\cdots$
(1)	a_t^i	333		315	274		342	400	
(2)	d_t^i	233		221	192		239	280	
(3)	$\bar{r}_t^{a,i}$			-2%	-1%		7%	8%	
(4)	$\bar{r}_t^{d,i}$			5%	5%		5%	5%	
(5)	Capital effect			-18.3%	-15.0%		11.7%	15.0%	
(6)	l_t^i			15.6	15.9		17.6	17.9	
(7)	Income effect			1.7%	2.0%		2.3%	2.1%	
(8)	δw_t^i			-16.6%	-13.0%		14.0%	17.1%	
(9)	Δw_t^i			-19	-13		13	17	
(10)	w_t^i	100		95	82		103	120	

Table 7.1: Example of individual starting with positive net wealth and experiencing positive and negative returns on net wealth

Note: In thousand of monetary unit, except for percentages. Numbers may not add up due to rounding. Rows (3) and (4) are exogenous "random" realization of returns and cost of capital. Analytically, others rows are completely determined by those two ones and the other parameters stated at the beginning of the example.

Last note before going forward

The computation of equation (7.14) and the relevance of the subsequent adjustment in assets and debts illustrated in figure 7.1 and table 7.1 may not seem obvious at first sight. One could challenge such not relevant complexity. The fact is that an individual cannot change his net wealth without generating return on capital or labor income: $w_t^i = a_t^i - d_t^i$ is an *accounting identity* and does not depend on i's choice. However, an individual could decide to borrow in order to invest in assets, increasing both a_t^i and d_t^i but leaving w_t^i unchanged. this is purely up to him. Using economical jargon, $d_t^i = \beta_t^i \cdot a_t^i$ is a *behavioral equation*, not an accounting identity. We decide to summarize the entire behavior of i in only one parameter β_t^i and we call it the leverage ratio, how to make it simpler?

7.3 Wealth aggregation

7.3.1 Fractiles and brackets

As done by Piketty (2013), and pretty much all theories/studies related to wealth distribution (Lorenz (1905), Xu (2004), Palma (2011), Todaro & Smith (2012), OECD (2015) etc.) we partition the population into sub-groups. Technically, any subdivision criteria can be used: net wealth, gross wealth (assets), debts, income, age, household size etc. (European Central Bank, 2013b). Piketty (2013) suggests a tax rate on net wealth which differs from a bracket to another: 0% until €1 million, 1% until €5 million and 2% above. Here, the subdivision is not done on a fractile basis because nothing ensures that each of those three wealth ranges includes exactly a third of the population. In this case, we rather talk about brackets, more general than fractiles.

7.3.2 Individual mobility

Let us denote by n the number of individuals in the economy, then $i \in \{1, 2, \cdots, n\}$. Let us denote by N^v the arbitrary number of brackets defined for a variable v, then $k \in \{1, 2, \cdots, N^v\}$. In case of deciles, $N^v = 10$ and each bracket contains the same number of individuals. In case of Piketty's suggestion just mentioned above, $N^v = 3$ and the number of individuals can differ by brackets. We define the function $b_t^v(i)$ which returns the v-bracket in which individual i falls in t. The supscript v denotes the variables on which the bracket is based, v can be any of the subdivision criteria mentionned above. As time goes forward, individuals experience increase or decrease in their variable v and jump from one bracket to another. Analytically, this means that $b_t^v(i)$ can change from t to $t+1$. We denote by $\mathcal{B}_t^{v,k}$ the set of individuals included in the k^{th} v-bracket in t. Hence, $i \in \mathcal{B}_t^{v,k}$ if $b_t^v(i) = k$. That is, if $\underline{v}_t^k \leq v_t^i < \overline{v}_t^k$ where $\underline{v}_t^k$ and $\overline{v}_t^k$ are respectively the lower and upper bounds of the k^{th} v-bracket in t.

7.3.3 Putting together

Later on, we will measure wealth inequality using, among other, the size distribution approach. This requires to compute the wealth detained by different brackets of the population. Let us write $u_t^{\mathcal{B}_t^{v,k}}$ the sum of u_t^i for i belonging to the k^{th} v-bracket in t. The total wealth detained by the k^{th} w-bracket in t is then

$$w_t^{\mathcal{B}^{w,k}} = \sum_{i \in \mathcal{B}_t^{w,k}} (1 - \beta_t^i) \cdot a_t^i. \tag{7.15}$$

Writing the leverage factor of w-bracket k as $\beta_t^{\mathcal{B}^{w,k}} = \frac{\sum_{i \in \mathcal{B}_t^{w,k}} \beta_t^i \cdot a_t^i}{\sum_{i \in \mathcal{B}_t^{w,k}} a_t^i}$ (weighted average of individual debts-to-assets ratios), we have

$$w_t^{\mathcal{B}^{w,k}} = \left(1 - \beta_t^{\mathcal{B}^{w,k}}\right) \sum_{i \in \mathcal{B}_t^{w,k}} a_t^i. \tag{7.16}$$

In this case, u and v refer to the same variable, wealth. One could ask the wealth detained by a specific bracket of income, then u and v would not be equal, the former standing for net wealth and the latter for income. For example, see table 9.7 for a joint bracket-distribution of net wealth and income.

Advantage This approach, heavy in notations we agree, allows to study the wealth distribution and drivers both on an individual and bracket basis where brackets can be defined at convenience. This is critical to Piketty's world-widely discussed $r < g$ who makes a distinction in the returns between brackets. Recall that, according to Piketty (2013), inequalities are driven, among others, by the fact that wealthier people enjoy higher return on their capital than poorer people. Taking his view, some parameters of the model will follow trends according to some v-bracket, instead of i directly.

Chapter 8

Extensions

In this chapter, we enrich the initial model by introducing new considerations which are Piketty's tax (section 8.1) and tax evasion (section 8.2) in order later to estimate the impact of those considerations on our main wealth size and distribution monitoring metrics.

8.1 Piketty's tax

8.1.1 Concept

Let us denote by $P_t^{-,i}$ (P standing for "Piketty") the amount in monetary units taken from individual i in t. Symmetrically, $P_t^{+,i}$ is the amount redistributed to individual i in t. We therefore have

$$\left\langle \delta w_t^i \right\rangle_P = \delta w_t^i + \frac{P_t^{+,i} - P_t^{-,i}}{w_{t-1}^i} \tag{8.1}$$

$$= \delta w_t^i + \frac{P_t^{+,i} - P_t^{-,i}}{(1 - \beta_{t-1}^i) \cdot a_{t-1}^i} \tag{8.2}$$

Note that we here don't look at all at the mechanisms though which those amounts are perceived/received. It is not likely in practice to see the redistributed quantity to be granted as such and fully in monetary units. We expect it to take the form (at least partially) of non-monetary social benefits: goods and/or services. Written like that, equation 8.1 suggests that the state acts like Robin Hood, taking from the wealthy and directly giving to poor people.

8.1.2 Taxed amount

Formalization Regarding Piketty's tax payers, the French economist defines thresholds of net wealth and associated rates to apply. We write i's taxable base in t as B_t^i and compute

$$B_t^i = \sum_{k=1}^{N_t^P} \max\left[0; \min\left(\overline{w}_t^k - \underline{w}_t^k; w_t^i - \underline{w}_t^k\right)\right] \tag{8.3}$$

such as the absolute amount taxed on i in t is

$$P_t^{-,i} = \sum_{k=1}^{N_t^P} \max\left[0; \min\left(\overline{w}_t^k - \underline{w}_t^k; w_t^i - \underline{w}_t^k\right)\right] \cdot \tau_t^k \tag{8.4}$$

where N_t^P is the number of brackets in Piketty's tax, $\underline{w}_t^k$ and $\overline{w}_t^k$ are respectively the lower and upper bounds of bracket k, in t. Usually, $\underline{w}_t^1 \geq 0$ since it makes no sense to tax a negative wealth. We leave this expression general as Piketty suggests different schemes with different brackets and rates. Figure 8.1 zooms at one bracket, one term of the sum in order to illustrate the formula.

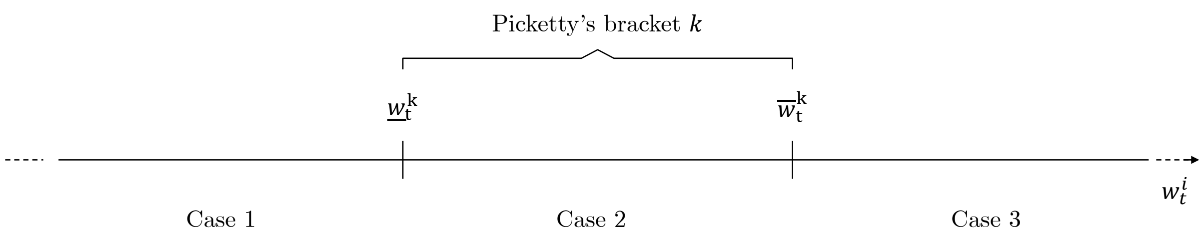


Figure 8.1: Illustration of a Piketty's bracket and its bounds

Let us note $M^1 = \min\left(\overline{w}_t^k - \underline{w}_t^k; w_t^i - \underline{w}_t^k\right)$. Starting with case 1, $w_t^i < \underline{w}_t^b$, the wealth of i does not reach bracket k and therefore should not be taxed at $\tau_t^{P,k}$. We have that $M^1 < 0$ and $\max[0; M^1] = 0$. Moving on to case 2, $\underline{w}_t^k < w_t^i < \overline{w}_t^k$, an amount $w_t^i - \underline{w}_t^k$ should be taxed at rate $\tau_t^{P,k}$. We have that $M^1 = w_t^i - \underline{w}_t^k > 0$ and $\max[0; M^1] = w_t^i - \underline{w}_t^k$. Ending with case 3, $\overline{w}_t^k < w_t^i$, an amount $\overline{w}_t^k - \underline{w}_t^k$ should be taxed at rate $\tau_t^{P,k}$. We have that $M^1 = \overline{w}_t^k - \underline{w}_t^k > 0$ and $\max[0; M^1] = \overline{w}_t^k - \underline{w}_t^k$.

Illustration In one of his tax schemes displayed in table 4.1, Piketty (2013) suggests a rate on net wealth of 0% until €1 million, 1% until €5 million and 2% above. The scale of net wealth is then split in three brackets.

k	$\underline{w}_t^k$	$\overline{w}_t^k$	M^1	M^2	$\tau_t^{P,k}$	$P_t^{-,k,i}$
1	0	1	1	1	0%	0.00
2	1	5	3	3	1%	0.03
3	5	$+\infty$	$-\infty$	0	2%	0.00
$P_t^{-,i}$						0.03

Table 8.1: Example of a tax payer with €4 million of net wealth and one of Piketty's suggested tax design

Considering an individual with €4 million of net wealth, the tax would be €30,000, as shown in Table 8.1 (where $M^2 = \max(0; M^1)$). In this example, the resulting tax rate on net worth is $0.03/4 = 0.75\%$.

8.1.3 Redistributed amount

Formalization Regarding Piketty's tax receivers, Piketty (2013) does not define how the tax should be redistributed. For this reason, we develop from scratch an adjustable redistribution canvas. To keep it simple, we first agree that the redistribution should be at least progressive. That is, $P_t^{+,i} \geq P_t^{+,j}$ if $w_t^i \leq w_t^j$ or, equivalently, if $\phi_t^w(i) \leq \phi_t^w(j)$ where $\phi_t^w(\cdot)$ returns the inverse rank in t on the net wealth distribution (1 for the poorest, 2 for the second poorest, ..., n for the richest). Knowing this and taking inspiration from our good old calculus textbook[1], we decide to compute the fraction of the total amount redistributed, P_t^+, going to individual i as

$$\eta_t^i = \frac{1 - \frac{1}{\left(\frac{n}{\phi_t^w(i)}\right)^{\epsilon_t}}}{\sum_{j=1}^n \left[1 - \frac{1}{\left(\frac{n}{\phi_t^w(j)}\right)^{\epsilon_t}}\right]} \tag{8.5}$$

where ϵ can take any real value but zero. Although this expression may seem a bit dreary, its behavior is very useful.

Discussion Let us focus on the numerator first. By definition $n/\phi_t(i) \geq 1$. Therefore, $[n/\phi_t^w(i)]^{\epsilon_t} \geq 1$. That is, the fraction on the numerator is always below one and above zero. Also, the higher $\phi_t^w(i)$, the higher the fraction, and the lower the entire numerator. That is, the higher i on the net wealth ranking, the less he receives, ensuring the progressiveness of the redistribution. Note that this redistribution strategy looks at the ranking of net wealth, regardless of the magnitude of the gap between individuals. Now, the denominator, simply the sum on of all possible numerators, provides a normalization ensuring that $\sum_{i=1}^n \eta_t^i = 1$.

[1] Stewart (2012) for example.

To finish, let us have a deeper look at the parameter ϵ_t, for which our choice of Greek letter is no coincidence. Do you remember Atkinson's ϵ introduced earlier (section 1.4.4)? It caught the emphasis put on the bottom tail of the population when measuring inequality. As shown by Figure 8.2, our ϵ_t here catches the extent to which redistribution is made towards the same bottom tail. The lower ϵ_t, the higher the redistribution towards it. When $\epsilon_t = 1$, the redistributed amount decreases linearly among individuals. When $\epsilon \to +\infty$, the redistributed amount is equal among individuals.[2]

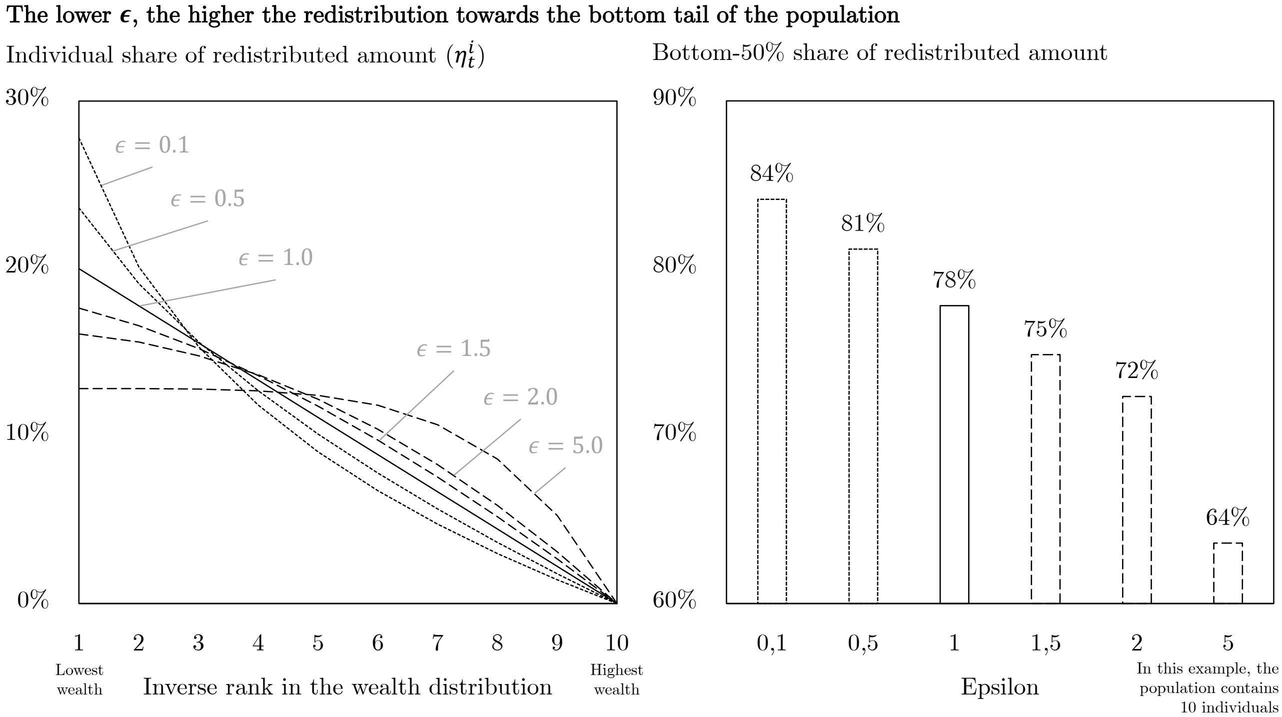


Figure 8.2: Impact of ϵ on redistribution

Extensions In order to give the possibility to redistribute to only a fraction $0 \leq \kappa_t \leq 1$ of the population so that the first $\kappa_t \cdot n$ individuals in the ranking receive a positive amount, we adapt such that[3]

$$\eta_t^i = \frac{\max\left[0; 1 - \frac{1}{\left(\frac{\kappa_t \cdot n}{\phi_t^w(i)}\right)^{\epsilon_t}}\right]}{\sum_{j=1}^n \max\left[0; 1 - \frac{1}{\left(\frac{\kappa_t \cdot n}{j}\right)^{\epsilon_t}}\right]}. \tag{8.6}$$

If one agrees on the fact that redistribution should go to those who don't pay the tax; that is, to i's such that $P_t^{-,i} = 0$, we have that κ_t should be computed as

[2]Except the last one (#10 in figure 8.2), who never enjoys redistribution.
[3]If $\kappa_t = 0$, the denominator is null and η_t^i is set to zero in the algorithm.

$$\kappa_t = \frac{\sum_{i=1}^{n} \rho_t^i}{n} \text{ where } \rho_t^i = \begin{cases} 1 \text{ if } P_t^{-,i} = 0 \\ 0 \text{ if } P_t^{-,i} > 0. \end{cases} \tag{8.7}$$

Finally, denoting by μ_t the fraction of the total amount taxed in t actually redistributed to the population, it comes that

$$P_t^{+,i} = \eta_t^i \cdot \left(\mu_t \cdot P_t^-\right). \tag{8.8}$$

Taking into account the intervention rate IR_t (cost of a tax for the authority as a percentage of its revenue, defined by Lepine et al. (1999)), one can find interesting to see what would happen to inequalities if only $(1 - IR_t)$ was redistributed.

8.2 Tax avoidance and evasion

In this section, three types of fraud are modeled. Each of them is seen as a the result of a fixed and variable (influenced by the tax on wealth) effect. The rationale is that, one the one hand, some fraudulent activities are present without tax on wealth (e.g. hidden assets resulting from other taxes such as financial income tax as developed in chapter 6) and, next to it, depend on the tax on wealth (e.g. the more the tax on wealth, the more assets hiding can be expected). Fixed parts are denoted using a hat ($\hat{\cdot}$) and variable parts are denoted using a tilde ($\tilde{\cdot}$) accent.

8.2.1 Hidden wealth

Formalization If $\hat{\theta}_t^{c,i}$ denotes the fixed fraction of offshored and hidden asset c by i in t (recall that Zucman (2015) estimates that 10% of European wealth is held offshore today, among which 80% is not declared), if $\tilde{\theta}_t^{c,i}$ denotes the variable fraction of offshored and hidden asset c by i in t per unit of theoretical tax rate on wealth, the wealth reported to the tax authority is not w_t^i but

$$\left\langle w_t^i \right\rangle_\theta = \left\langle a_t^i \right\rangle_\theta - d_t^i, \tag{8.9}$$

with

$$\left\langle a_t^i \right\rangle_\theta = \underbrace{\sum_{c \in \mathcal{C}^a} \left(1 - \left[\hat{\theta}_t^{c,i} + \tilde{\theta}_t^{c,i} \cdot \tau_t^{w,i}\right]\right) \cdot \left(\alpha_t^{c,i} \cdot a_t^i\right)}_{\text{Reported assets}} \tag{8.10}$$

where $\tau_t^{w,i}$ is the theoretical effective tax rate on wealth of individual i in t, the one that would have resulted from a situation without fraud:

$$\tau_t^{w,i} = \frac{P_t^{-,i}}{w_t^i}. \tag{8.11}$$

Simply put, $\tilde{\theta}_t^{c,i}$ is the answer to changes in wealth tax. If the theoretical effective rate increases by x percentage points, then the fraction of offshored assets c by i increases by $\tilde{\theta}_t^{c,i} \cdot x$ percentage points. Responses from the taxable base to changes in tax rate are usually measured using elasticity[4] or semi-elasticity[5] approaches. Seim (2004), for example, estimates the elasticity of the taxable wealth to the tax rate on wealth in the context of the former Swedish wealth tax. In this case, $\tilde{\theta}_t^{c,i}$ is applied to an absolute quantity $\tau_t^{w,i}$ and is therefore a form of semi-elasticity. Because of the fixed part $\hat{\theta}_t^{c,i}$, $\tilde{\theta}_t^{c,i}$ is not exactly the relative change (indeed, it quantifies the delta in percentage points rather than in percentage) and we then refer to it as the *adjusted* semi-elasticity.

Discussion Of course, the higher $\theta_t^{c,i}$, the less the perceived and therefore redistributed tax. We deliberately make the hidden fraction depend on i and c because different individuals have different willingness and ability to hide while different class of assets present different offshoring opportunities. Intuitively, it is fair to assume that the mobility of financial assets is higher than the one of real estate assets (although it is proven that real estate assets value reporting is sensitive to tax on real estate (Kopczuk & Slemrod, 2000)).

8.2.2 Undervaluation

Similarly, we respectively write $\hat{\sigma}_t^{c,i}$ and $\tilde{\sigma}_t^{c,i}$ the fixed and variable part of the undervalued fraction of asset c in t by i. For example, a €100,000 house declared to the authority at €80,000 means a σ-effect of 20%. We have

$$\left\langle w_t^i \right\rangle_\sigma = \underbrace{\left[\sum_{c \in \mathcal{C}^a} \left(1 - \left[\hat{\sigma}_t^{c,i} + \tilde{\sigma}_t^{c,i} \cdot \tau_t^{w,i}\right]\right) \cdot \left(\alpha_t^{c,i} \cdot a_t^i\right) \right]}_{\text{Reported assets}} - d_t^i \tag{8.12}$$

and

$$\left\langle w_t^i \right\rangle_{\theta,\sigma} = \underbrace{\left[\sum_{c \in \mathcal{C}^a} \left(1 - \left[\hat{\theta}_t^{c,i} + \tilde{\theta}_t^{c,i} \cdot \tau_t^{w,i}\right] - \left[\hat{\sigma}_t^{c,i} + \tilde{\sigma}_t^{c,i} \cdot \tau_t^{w,i}\right]\right) \cdot \left(\alpha_t^{c,i} \cdot a_t^i\right) \right]}_{\text{Reported assets}} - d_t^i \tag{8.13}$$

The absolute amounts respectively paid and received by i in t become

$$\left\langle P_t^{-,i} \right\rangle_{\theta,\sigma} = \sum_{k=1}^{N_t^P} \max\left[0; \min\left(\overline{w}_t^k - \underline{w}_t^k; \left\langle w_t^i \right\rangle_{\theta,\sigma} - \underline{w}_t^k\right)\right] \cdot \tau_t^k \tag{8.14}$$

[4]The *elasticity* of y to x is the relative change in y following a relative change in x: $(\Delta y/y)/(\Delta x/x)$.
[5]The *semi-elasticity* of y to x is the relative change in y following an absolute change in x: $(\Delta y/y)/(\Delta x)$.

and

$$\left\langle P_t^{+,i} \right\rangle_{\theta,\sigma} = \eta_t^i \cdot \mu_t \cdot \left\langle P_t^- \right\rangle_{\theta,\sigma} \tag{8.15}$$

so that

$$\left\langle \delta w_t^i \right\rangle_{P,\theta,\sigma} = \delta w_t^i + \frac{\left\langle P_t^{+,i} \right\rangle_{\theta,\sigma} - \left\langle P_t^{-,i} \right\rangle_{\theta,\sigma}}{(1-\beta_{t-1}^i)\cdot a_{t-1}^i}. \tag{8.16}$$

To discuss the individual impact and the sensitivity of inequalities to those tax evasion behaviors (as we will), one can just set to zero the parameters and run the algorithm. For example, setting all undervaluation parameters to zero would give $\left\langle P_t^{+,i} \right\rangle_\theta$ or, in other words, the amount redistributed to i if the state perfectly values all assets or constraints individuals to do so and to report accordingly.

8.2.3 Expatriation

As n is constant, the model assumes no change in the population. However, each year, reality sees individuals leaving the country and relocating elsewhere in order to avoid tax. In section 9.4.3, we estimate the annual tax revenue lost due to delocalization as a percentage of actual (perceived) total tax revenue brought by one percent of tax rate on wealth. Let us write this ratio $\tilde{\omega}_t$ at time t. Since $\left\langle P_t^- \right\rangle_{\theta,\sigma}$ is the revenue which should have been perceived without evasion, we have $\left\langle P_t^- \right\rangle_{\theta,\sigma} = \left(1 + \tilde{\omega}_t \cdot \tau_t^{w,\left\langle P^- \right\rangle_{\theta,\sigma},\langle B\rangle_{\theta,\sigma}}\right) \left\langle P_t^- \right\rangle_{\theta,\sigma,\omega}$. Leaving also the possibility for the user to input a fixed part $\hat{\omega}_t$ if needed, we have that the actual total tax revenue is

$$\left\langle P_t^- \right\rangle_{\theta,\sigma,\omega} = \frac{\left\langle P_t^- \right\rangle_{\theta,\sigma}}{1 + \hat{\omega}_t + \tilde{\omega}_t \cdot \tau_t^{w,\left\langle P^- \right\rangle_{\theta,\sigma},\langle B\rangle_{\theta,\sigma}}}. \tag{8.17}$$

At the denominator, $\tau_t^{w,\left\langle P^- \right\rangle_{\theta,\sigma},\langle B\rangle_{\theta,\sigma}}$ represents the average effective (not theoretical) tax rate paid by individuals subject to payment (not the entire population, this is why the subscript $\langle P^- \rangle_{\theta,\sigma}$ is added) on their declared wealth subject to tax (excluding the quantity of wealth not taxed, this is why the subscript $\langle B\rangle_{\theta,\sigma}$ is added):[6]

$$\tau_t^{w,\left\langle P^- \right\rangle_{\theta,\sigma},\langle B\rangle_{\theta,\sigma}} = \frac{\sum_{i=1}^n \left\langle P_t^{-,i} \right\rangle_{\theta,\sigma}}{\sum_{i=1}^n \langle B_t^i \rangle_{\theta,\sigma}}. \tag{8.18}$$

[6]This adds some more useless notations and therefore complication, we agree. However, it is the only way to fit the data on fiscal expatriation published by the French state, which we use to estimate delocalization in chapter 9.

Symbol	Description
	Wealth components (section 7.1)
a_t^i	Total value of i's assets
$\alpha_t^{c,i}$	Fraction of i's assets allocated to class c
d_t^i	Total value of i's debt
$\lambda_t^{c,i}$	Fraction of i's debts allocated to class c
β_t^i	Value of i's debt in fraction of total assets
	Wealth dynamics (section 7.2)
$r_t^{c,s,i}$	Return of source s of asset class c of i
$\tau_t^{c,s,i}$	Tax rate on income source s of asset class c of i
γ_t^i	Savings rate of i
l_t^i	Labor income and/or net transfers of i
g_t^i	Growth rate of labor income of i
$\tau_t^{l,i}$	Tax rate on labor income of i
	Wealth aggregation (section 7.3)
$\mathcal{B}_t^{v,k}$	Set of individuals included in the k^{th} v-bracket
$b_t^v(i)$	Function returning the v-bracket in which individual i falls
$\underline{v}_t^k$ ($\overline{v}_t^k$)	Lower (upper) bound of k^{th} v-bracket
	Piketty's tax (section 8.1)
$P_t^{-,i}$	Pyketty's tax amount in monetary units taken from i
$P_t^{+,i}$	Pyketty's tax amount in monetary units redistributed to i
η_t^i	Fraction of the total redistributed amount allocated to i
$\phi_t^v(i)$	Inverse rank of i in the v-distribution (1 for the lowest, n for the highest)
ϵ_t	Intensity of the redistribution to the bottom tail of the wealth distribution
κ_t	Fraction of the population benefiting from the redistribution
ρ_t^i	Boolean variable equal to 1 if i doesn't pay Piketty's tax, equal to 0 if not
μ_t	Fraction of total taxed amount actually redistributed by the state
	Tax avoidance and evasion (section 8.2)
$\tau_t^{w,i}$	Theoretical effective tax rate on wealth of individual i
$\hat{\theta}_t^{c,i}$ ($\tilde{\theta}_t^{c,i}$)	Fixed (variable) quantity of asset c hidden by i
$\hat{\sigma}_t^{c,i}$ ($\tilde{\sigma}_t^{c,i}$)	Fixed (variable) quantity of asset c undervalued by i
$\hat{\omega}_t$ ($\tilde{\omega}_t$)	Fixed (variable) quantity of actual tax revenue lost due to delocalization

Table 8.2: List of selected symbols and their description

Chapter 9

Parametrization

In this chapter, we parametrize (give actual values), according to Belgium, all the variables we declared in chapters 7 and 8, using the exact same structure as previously.

9.1 Wealth components

9.1.1 Assets

The set of asset classes $\mathcal{C}^a$ is made of 9 asset types based on European Central Bank (2013b). They are split between real and financial assets (Kennickell, 2011) and displayed in table 9.1.

Real assets	Financial assets
Own residence	Deposits/Savings account
Other real estates	Obligations
Vehicles	Shares/Investment funds
Other real assets	Life insurances/Pension funds
	Other financial assets

Table 9.1: Composition of the set of asset classes ($\mathcal{C}^a$)

Source: European Central Bank (2013b)

Using the same dataset, we attribute weights $\alpha_t^{c,i}$ for different brackets of gross wealth (brackets of assets) displayed in table 9.2 where "P" denotes "percentile".

The weights in the table are supposed constant over time. As an example, consider an agent with low assets (P0-P25) in t_0 experiencing positive returns on capital and labor increasing his

Bracket of gross wealth	P0-P25	P26-P50	P51-P75	P76-P90	P91-P100	Belgium
Own residence	40%	76%	74%	57%	31.5%	51.44%
Other real estates	13%	4%	4%	11%	21%	11.62%
Vehicles	12%	4%	3%	2%	1%	2.33%
Other real assets	3.2%	0.3%	1.3%	0.5%	9.5%	4.7%
Total real assets	68.2%	84.3%	82.3%	70.5%	63%	70.09%
Deposits/Savings account	20%	8%	10%	13%	10%	10.89%
Obligations	0%	0.4%	0.8%	4.5%	9.5%	5.46%
Shares/Investment funds	1.8%	0.4%	0.7%	6.5%	11.5%	7.15%
Life insurances/Pension funds	8%	6.5%	5.5%	4%	3%	4.83%
Other financial assets	2%	0.4%	0.7%	1.5%	3%	1.58%
Total financial assets	31.8%	15.7%	17.7%	29.5%	37%	29.91%

Table 9.2: Share of asset types ($\alpha_t^{c,i}$) in gross wealth portfolio per bracket of assets

Source: European Central Bank (2013b), Kuypers & Marx (2014)

net wealth and therefore his assets, making him move from the first to the second bracket (P26-P50) of gross wealth in t_1. For the $[t_1 \rightarrow t_2]$ period, his proportion of deposit in his portfolio of assets will be 8% instead of 20%. This process is the same for each parameter defined on a v-bracket-level rather than on a i-individual-level, throughout this chapter.

9.1.2 Debts

Classes of debts The set of debt instrument ($\mathcal{C}^d$) considers one class of debt, namely mortgage. Based on European Central Bank (2013b), non-mortgage debt represents only around 10% of total outstanding liabilities in Belgium. Meel (2013) confirms this by evaluating total outstanding mortgage lending to be at €183.6bn end of 2012 compared to only €21.2bn for other types of credit, or a 89.6% share for mortgage debt.

Leverage ratio Figure 9.1 and table 9.3 display the relationship between the average debt-to-assets ratio and the net wealth in Belgium, from European Central Bank (2013c) and show that the higher the net wealth, the lower the relative leverage.

Bracket of net wealth	P0-P20	P21-P40	P41-P60	P61-P80	P81-P90	P91-P100
Debt-to-asset ratio	91.5%	44.1%	16.9%	9.5%	8%	2.9%

Table 9.3: Estimated average debt-to-assets ratio (β_t^i) per bracket of net wealth

Source: European Central Bank (2013c)

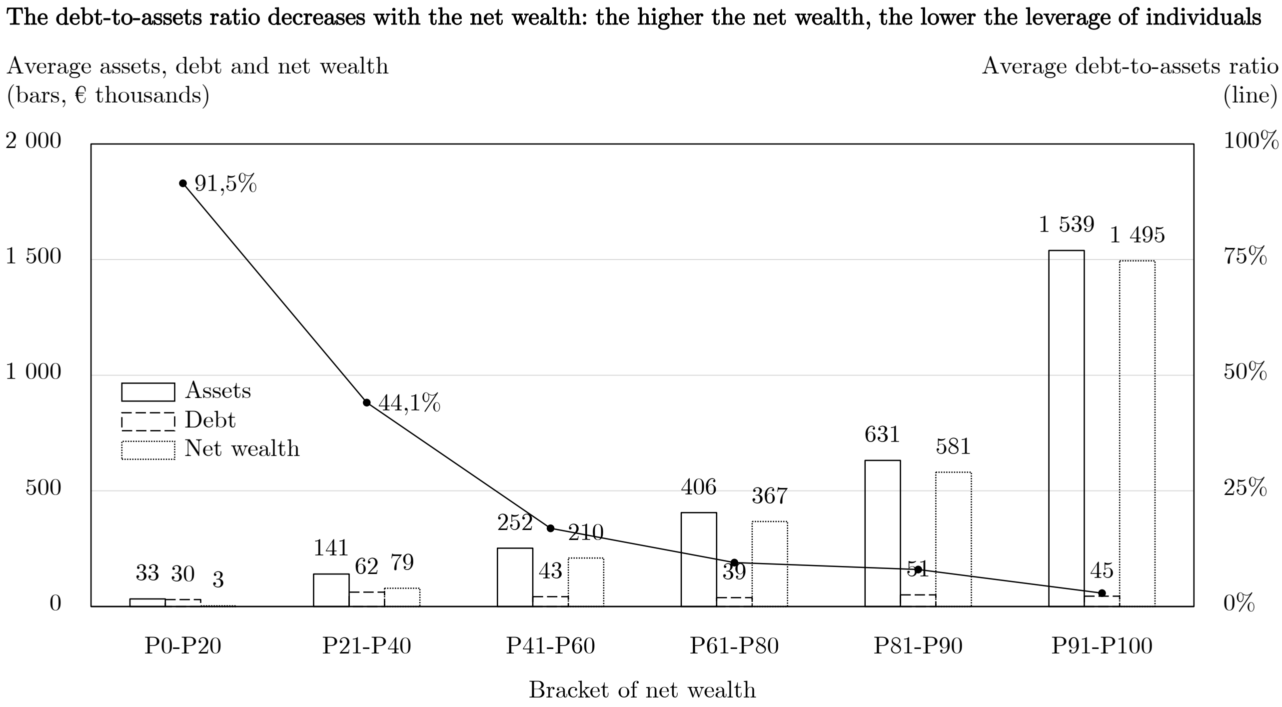


Figure 9.1: Average assets, debt, net wealth and debt-to-assets ratio per bracket of net wealth in Belgium in 2013

Note: Numbers may not add up due to rounding

Source: European Central Bank (2013c), own calculations

9.1.3 Net wealth

Net wealth We use Shorrocks et al. (2015) and Kuypers & Marx (2014) data as a base to create a population of 1608[1] individuals with a distribution of net wealth replicating that of Belgium estimates. Table 9.4 compares for some selected variables[2] of the sample population and the estimates for Belgium while figure 9.2 compares the Lorenz curves.

	Sample population	Belgium
Number of individuals	1608	8 439 308
Total net Wealth	432 018 548	2 189 000 000 000
Average wealth per individual	268 668	259 381
Wealth-share of wealth-bottom 10%	-0.09%	-0.1%
Wealth-share of wealth-top 10%	48.3%	47.7%
Palma ratio	9.5	9.2
Gini ratio	0.634	0.605

Table 9.4: Selected variable comparison between sample population and Belgium estimates

Source: Shorrocks et al. (2015), own calculations

[1]Result of the limitation in tools and computational power.

[2]All data coming from Shorrocks et al. (2015) are in US$ of 2015, we convert it in € based on average rates for the year estimated at 0.937€ = 1US$ (IRS, 2016).

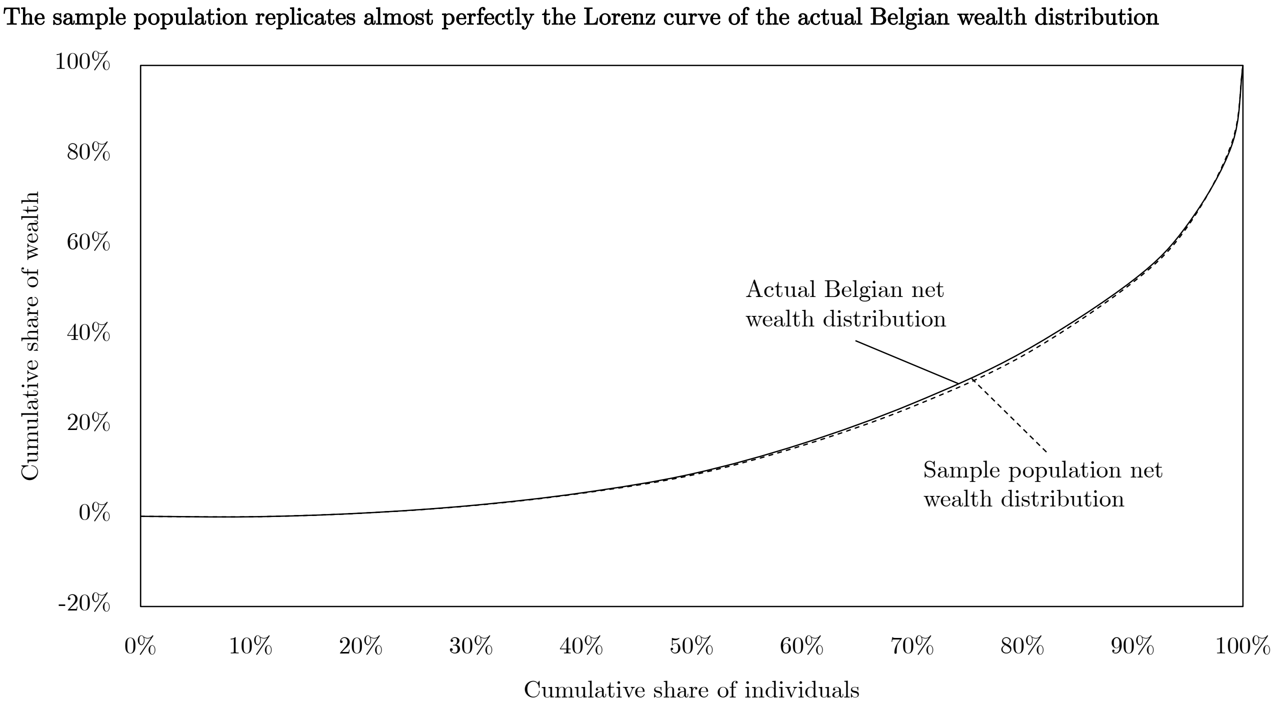


Figure 9.2: Lorenz curve of the sample population and actual Belgian distribution in 2015

Source: Shorrocks et al. (2015), own computations

Fairly, the distribution of net wealth is closely fitted between the data in the model and Belgian estimates, which makes sense as the former has been computed based on the latter. The analysis of the value of key variables from the table also shows close relationship between our the sample population and actual Belgian estimates.

Discrepancies mainly come from the slight undervaluation of wealth going to the middle of the distribution; i.e. we give slightly too much of the overall wealth to the top of the distribution. In a nutshell, our population represent a fitted sample of 0.02% of the size of Belgium, both in number of individuals and total wealth, but with similar wealth distribution. It is however not the goal to have the perfect fit with these Belgian estimates in our model, and this for two reasons. First, no official data exists for Belgium and those are only estimates, over-focusing on them might not provide a more accurate picture when considering the real population. Second, we want to see the impact that the wealth tax will have on this population; this impact should not be dependent on slight variation of inequality measures; otherwise the purpose of this tax would have to be reevaluated continuously.

Breaking down Based on net wealth ans debt-to-assets ratios, the gross wealth and debts of each individual in the sample population follows. Gross wealth and debt are then distributed among the different classes of assets ($\mathcal{C}^a$) and debts ($\mathcal{C}^d$) according to sections 9.1.1 (assets) and 9.1.2 (debt).

9.2 Wealth dynamics

9.2.1 Return on assets

Rates of return

Assets have an impact on net wealth in two ways: their inherent value moves with time (which we refer to as *capital gain*[3] *yield*) and some assets also have the potential to generate dividends, interests, rents etc. (*income yield*). For each of the 9 asset types, we look for historical return and value growth rate data[4].

Own residence We assume we do not receive any income from our own residence, the rate of return hence being equal to zero. It is however clear that real estate varies in value over time. Data for historical and geographical prices of real estate assets in Belgium are available at SPF Economie (2013) and it appears that on top of a general trend for the real estate market, the geographical as well as the type of estate influences the value change over time. The price of estates have on average increased by 5% yearly between 1975 and 2014 (Trevi Invest, 2014; SPF Economie, 2015).

Other real estates On the contrary of the main residence, we assume that 100% of "other real estates" is rented and therefore generates income to the owner. We also assume that the rent applies 100% of the time. In this case, the income yield is estimated by Trevi Invest (2014) which compares the average yearly rental income over real estate prices and is 4.5% per annum. The capital gain yield is set at 5% as we do not see any reason to differentiate main residence and other real estate.

Vehicles Most vehicles lose value over time, not all at the same rate, and some actually gain values (collector cars). The depreciation rate varies from one car to the next depending on a range of variables, such as car characteristics (color, motor,...), car usage (mileage, condition,...) and demand/supply factors. For the model, we assume that depreciation is entirely dependent on the age of the vehicle and that all vehicles are bought at the beginning of the first year. Based on online calculators using historical data, we obtain an average yearly depreciation rate of 15.83% (see appendix D.1). Also, we agree that a vehicle does not generate income from and of itself.

[3] "Plus-value" in French.

[4] It is widely proven that historical yields on assets are not predictive of future yields, we however use this as a proxy.

Other real assets This category comprises several components for which value increase is hard to guess or estimate through external data. We decided to estimate the rates for this category as a weighted average of the rates of the other asset types in the same category (in this case, a weighted average of the rates of the real assets)[5].

Deposits/Savings accounts Most large banks apply the lowest legal rate of 0.11% (Guide-Epargne, 2016), the maximum observable rate being 1.5%. We assume an average rate of 1% on all types of deposits/savings that can be obtained yearly over the 10 years to come. The stock of money in a deposit or a savings account does not change in value (assuming everything is in the same currency, except from a change in the alpha of deposits/savings account of the agent) and we therefore apply a 0% value growth rate.

Obligations For the sake of simplicity, we assume individuals investing in obligation hold it until termination and redeem it at the face value, i.e. obligations do not experience any value change. However, the coupon still generates a yearly rate of return that we estimate at 5.4% based on Dimson et al. (2016) (average return on long-term Belgian government bonds over the 2000-2015 period).

Shares/Investment funds We assume everyone only invests in European stocks (no exchange rate risk) and that the EURO STOXX TMI composite[6] is a correct proxy to estimate the yields of investors' portfolios. In this case, the yearly income yield is 3% (5-year average dividend yield) and the capital gain yield at 6.5% (5-year annualized capital gain yield).

Life insurances/Pension funds The pension system in Belgium is quite complex and comprises several financial tools yielding various rate of returns and subject to different fiscal considerations. To simplify, we assume everyone has the same pension fund, namely a pension savings fund,[7] whose annualized historical return is estimated at 6.19%. This type of pension fund provides taxation incentives that we assume to be non-existent, so as fees and charges to participate in the fund.

Other financial assets This category comprises various assets for which yields are hard to estimate based on external data. We decided to apply the same estimation technique as the

[5] As an example, the income yield will equal [(51.44%/70.09%)*0% + (11.62%/70.09%)*4.5% + (2.33%/70.09%)*0%] = 0.75%

[6] The Euro STOXX Total Market Index (TMI) is an index covering around 95% of the free float market capitalization in Europe, including 12 countries and a variable number of components including small, mid and large capitalization (STOXX, 2016).

[7] A pension savings fund is a Collective Investment Undertaking whose sole purpose is investing in financial products for on behalf of the shareholders (pension savers). In our case, we take the example of ING's Star Fund (ING, 2016).

one used for *Other real assets* by computing a weighted average.

Summary A summary of all rates that we used in our model is displayed in table 9.5.

Asset class	Income yield	Capital gain yield
Own residence	0%	5%
Other real estates	4.5%	5%
Vehicles	0%	-15.86%
Other real assets	0.75%	3.97%
Deposits/Savings accounts	1%	0%
Obligations	5.4%	0%
Shares/Investment funds	3 %	6.5%
Life insurances/Pension funds	0%	6.19%
Other financial assets	2.07%	2.55%

Table 9.5: Estimated yearly income yield ($r_t^{c,i}$) and capital gain yield ($q_t^{c,i}$) per asset class

Source: Various (see above), own computations

Tax rates

For each asset type and for each type of return, there is a potential tax rate that applies. First, let us focus on income yields.

Real assets A yearly tax ("precompte immobilier" in French) has to be paid on a fictive revenue generated for any owner of real estate ("revenu cadastral"). Seeing that no cash income is generated and that this tax generates almost no expense for the taxpayers (due to a very low indexation rate), we consider it non-existent and assume revenue generated from real estates not taxed in Belgium.[8]

Financial assets Since January 2016, the tax rate on financial income is set at 27% (SPF Finances, 2016a). However, reductions apply for various types of investments. For example, interests earned on savings accounts are taxed at a 15% for the amount above €1 880. For simplicity, we set a 27% rate of taxation for all financial returns; except for deposit/savings for which we set a 0% rate of taxation.

[8]Cadastral revenue (CR) is computed has a compounded estimate of the mean revenue the asset could generate over one year. The reference year is still 1975 and 40% is deducted from the 1975 estimated value for expected expenses on the asset ("charges forfaitaires"). In 2014, the index rate was established at 1.7. In other words, the cadastral revenue in 2014 is $1.7 \times 0.6 \times CR_{1975}$. Over the 1975-2014 period, real estate have experienced a value increase of 920% (SPF Economie, 2013), which means that if this CR_{1975} was estimated at 5% of the estate price in 1975 (what we estimate as rate of return today), it would represent only 0.5% return today. At 2%, this tax can be considered non significant for the tax payer.

Second, we move on to capital gain yields.

Real assets Real assets capital gains are taxed if the asset is sold within a given number of years after purchase/reception and rates vary per type of asset and timing of sale (SPF Finances, 2015). We assume people selling their real assets do so late enough to avoid any kind of taxation. In other words, no tax on real assets value gains are considered in the model.

Financial assets Only the sale of shares done within 6 months after purchase is taxed on capital gains in Belgium (SPF Finances, 2015). We assume the investor waits at least 6 months before acting his gains or will use one of the many financial derivatives available to him to insure its gains until he can resell it tax-free. In other words, the tax rate on financial capital gain is set to zero.

A summary of tax rates used used in the model is provided in table 9.6.

Asset class	Tax on income	Tax on capital gain
Own residence	0%	0%
Other real estates	0%	0%
Vehicles	0%	0%
Other real assets	0%	0%
Deposits/Savings accounts	0%	0%
Obligations	27%	0%
Shares/Investment funds	27%	0%
Life insurances/Pension funds	27%	0%
Other financial assets	27%	0%

Table 9.6: Estimated tax rates on income ($\tau_t^{r,i}$) and capital gains ($\tau_t^{q,i}$) per asset class

Source: SPF Finances (2015)

9.2.2 Cost of debts

As said earlier, we assume only one type of debt: mortgages. There exist however several types of mortgage debt, repayment options and rates. Besides this, the profile of the individual borrowing also impacts interest rates. We assume all this to be equal and considered only one case: fixed-rate 20-year mortgage debt. That is, 8 out of 10 mortgage loans in 2013 being for periods of more than 10 years (Meel, 2013). The simulation at one of the leading Belgian bank for a loan of €106 750 (average value of mortgage loan in 2013 (Meel, 2013)) leads to a yearly repayment of 6.58% ($\overline{r}_t^{d,i}$).

9.2.3 Labor, consumption and transfers

Labor and transfers

Income and net wealth joint distribution Based on Durand & Murtin (2015), we estimate the joint distribution of taxable income[9] and net wealth[10] per quintile, as shown in table 9.7. For example 9.44% of the population falls in the first quintile of net wealth and in the first quintile of income.

Net wealth quintile	1	2	3	4	5	Total
Income quintile 1	0.0944	0.0360	0.0290	0.0230	0.0176	0.2
Income quintile 2	0.0564	0.0450	0.0400	0.0300	0.0286	0.2
Income quintile 3	0.0287	0.0450	0.0530	0.0400	0.0336	0.2
Income quintile 4	0.0133	0.0413	0.0450	0.0550	0.0454	0.2
Income quintile 5	0.0072	0.0328	0.0330	0.0520	0.0748	0.2
Total	0.2	0.2	0.2	0.2	0.2	1

Table 9.7: Joint quintile distribution of taxable income and net wealth in Belgium in 2015

Source: OECD Income Distribution Database (2016), OECD Wealth Distribution Database (2016), own calculations

Absolute income levels Next to this, we use official Belgian tax records to evaluate the average value of taxable income per quintile (Direction générale Statistique, 2016). Results can be seen in table 9.8.

Income quintile	Taxable income (€)
Quintile 1	6 182
Quintile 2	15 698
Quintile 3	22 859
Quintile 4	33 430
Quintile 5	112 917

Table 9.8: Estimated average taxable income (l_t^i) per quintile

Source: Direction générale Statistique (2016), own calculations

Putting together Combining those two pieces of information and knowing that 2.5% of the Belgian population has a negative net wealth European Central Bank (2013b) and that no one

[9]The income measure used here is gross of taxes and social contribution, coming from OECD Income Distribution Database (2016), which bases itself for Belgium on official tax records.

[10]The Net wealth measure used for Belgium comes from OECD Wealth Distribution Database (2016), which bases itself for Belgium on the European Central Bank (2013b).

with a negative net wealth falls in the highest quintile of taxable income (Du Caju, 2013), we attribute a mean taxable income to each individual in the sample population.

Growth in income levels In order to forecast over several years, we include income growth rates in the form of compound annual growth rates (CAGR)[11] for each decile of taxable income from 2005 to 2013 (Direction générale Statistique, 2016). Table 9.9 displays the results.

Income decile	Average annual taxable income (€) 2005	2013	CAGR
Decile 1	1 623	2 087	3.20%
Decile 2	7 815	10 276	3.48%
Decile 3	10 929	14 173	3.30%
Decile 4	13 382	17 223	3.20%
Decile 5	16 461	20 830	2.99%
Decile 6	19 919	24 888	2.82%
Decile 7	23 932	29 805	2.78%
Decile 8	29 827	37 055	2.75%
Decile 9	40 029	49 417	2.67%
Decile 10	71 245	88 208	2.71%

Table 9.9: Estimated income growth rate (g_t^i) per decile of income

Source: Direction générale Statistique (2016), own calculations

Labor income tax Based on the income tax rates in 2015 (on income of 2014) from SPF Finances (2015), we estimate the personal income tax rates applied in Belgium and therefore calculate what individuals have to pay on this income and what is left to use on consumption and savings (disposable income). Various exemptions and deductions apply in reality (SPF Finances, 2015) but, for simplicity, we assume that the tax-free threshold is the same for everyone (€7 070) and no deductions apply (see table 9.10).

Consumption

Knowing the taxable income and the tax rates applied in Belgium is sufficient to compute the disposable income. Based on Dynan et al. (2004) who empirically estimates savings rates per bracket of income in the United States[12] obtained interesting results showing that higher income positively relates to higher savings rates.

[11] The geometric average of annual growth rates. For example the CAGR of income decile 1 is computed as $(2,087/1,623)^{1/(2013-2005)} - 1$.

[12] The study has been performed on various data sources. Data coming from the *Survey of Consumer Finances* have been sampled in 1983 and 1989 on a total of 1 749 households (Dynan et al., 2004).

From (€)	To (€)	Tax rate
0	7 070	0%
7 070	8 680	25%
8 680	12 360	30%
12 360	20 600	40%
20 600	37 750	45%
37 750	above	50%

Table 9.10: Estimated personal income tax rates ($\tau_t^{l,i}$)

Source: SPF Finances (2015)

Income bracket	Savings rate
P1-P20 (quintile 1)	0.14%
P21-P40 (quintile 2)	0.09%
P41-P60 (quintile 3)	11.1%
P61-P80 (quintile 4)	17.3%
P81-P100 (quintile 5)	23.6%
P95-P100 (top 5% income)	37.2%
P100 (top 1% income)	51.2%

Table 9.11: Estimated savings rate (γ_t^i) per bracket of income

Source: Dynan et al. (2004)

This idea has been widely reported in research (see Dorothy & Rose (1947), Fisher (1952), Kuznets & Jenks (1953) or Irwin Friend (1959)). It seems however that other variables are to be considered if one wants to comprehensively understand savings patterns (Hugget & Ventura, 1995; Carroll, 1996), among which age (Dynan et al., 2009), wealth (Hubbard et al., 1994) and social security (Gokhale et al., 1996). For simplicity and unavailability of clear information, we use the estimates based on the *Survey of Consumer Finance* done by Dynan et al. (2004) and shown in table 9.11.

9.3 Piketty's tax

9.3.1 Taxed amount

As stated in section 4.2.3, Piketty (2013) suggests several designs for his tax. Two are displayed in table 4.1.

Design 1 is pretty similar to the French ISF, taxing only high net wealth individuals. Design 2 sees the entire population of positive net wealth taxed. Both of them are used to run the algorithm and provide results to compare in chapter 10.

9.3.2 Redistributed amount

Three parameters defining the redistribution scheme are declared in section 8.1.3: ϵ_t (intensity of the redistribution towards the bottom tail of the net wealth distribution), κ_t (fraction of the population enjoying redistribution) and μ_t (fraction of total tax revenue redistributed).

- Regarding ϵ_t, a default linear redistribution ($\epsilon_t = 1$) is firstly applied, followed by more intense strategies ($\epsilon_t > 1$).
- Regarding κ_t, we consider that those who don't pay the tax on wealth enjoy redistribution. κ_t is then computed as in equation (8.7) for each period.
- Regarding μ_t, when there is redistribution, we consider that the entire tax proceeds are redistributed each year. That is, $\mu_t = 1$. Intervention rates IR_t are usually between 1 and 2% (see Pichet (2007) or Marini (2007) for the French ISF), so setting $\mu_t = 1 - IR_t$ would not change much to the results. We also set $\mu_t = 0$ to see what would happen without redistribution, as Piketty (2013) actually does not define how redistribution should be done.

9.4 Tax avoidance and evasion

9.4.1 Hidden wealth

Current stock Based on the fact that 8% of the European private financial assets are hidden in offshore accounts (see chapter 8), we attribute a score of hidden wealth for each decile and type of asset. The estimation is based on the quite intuitive assumption that the higher the assets, the higher the willingness and ability to evade (see appendix D.2 for the detailed computations). Results can be seen in table 9.12. Real assets are assumed be completely not hidden.

Decile of gross wealth	Type of asset: Financial	Real	Decile of gross wealth	Type of asset: Financial	Real
Decile 1	0.57%	0%	Decile 6	2.84%	0%
Decile 2	0.78%	0%	Decile 7	3.91%	0%
Decile 3	1.08%	0%	Decile 8	5.51%	0%
Decile 4	1.49%	0%	Decile 9	7.50%	0%
Decile 5	2.06%	0%	Decile 10	10.88%	0%

Table 9.12: Estimated fixed rate of offshore hidden assets ($\hat{\theta}_t^{c,i}$) per bracket and type of assets

Source: Zucman (2015), own calculations

Future flow Between labor and capital, the latter is obviously known to be more mobile (Gérard, 2014). Most of studies agree that the elasticity of capital to the tax rate on capital is supra-unitary. Seim (2004), for example, estimates the elasticity of taxable wealth to tax rate on wealth to lie between 0.1 and 0.3, depending on the statistical method. That is, a semi-elasticity between approximately 1 and 3. Because we deliberately split the different sources of tax responses (hiding, underdeclaration and delocalization), because this split is pretty much never done in the literature and because data on taxable wealth elasticity is unarguably very limited, a default average *adjusted* semi-elasticity[13] of 2 is distributed among the deciles of gross wealth using the exact same method as above (see table 9.13).

Decile of	Type of asset		Decile of	Type of asset	
gross wealth	Financial	Real	gross wealth	Financial	Real
Decile 1	0.144	0	Decile 6	0.709	0
Decile 2	0.196	0	Decile 7	0.979	0
Decile 3	0.270	0	Decile 8	1.379	0
Decile 4	0.373	0	Decile 9	1.875	0
Decile 5	0.515	0	Decile 10	2.720	0

Table 9.13: Estimated adjusted semi-elasticity of offshore hidden assets ($\tilde{\theta}_t^{c,i}$) per bracket and type of assets

Source: Seim (2004), own calculations

9.4.2 Undervaluation

Piketty (2013) argues for a tax on marketable wealth; that is, at its market value. The true market value of many assets is unknown (e.g. real estates, unlisted securities) . Hence, it is likely that the reporting of this value be quite inaccurate. Pichet (2007) analyses the impact of the French ISF on various variables and states that "what we can reasonably infer from this is that taxpayers [...] whose estates feature a higher proportion of property assets are more likely to file fraudulent returns than upper bracket taxpayers, whose holdings are massively invested in listed securities they are forced to declare at their legal value".

Furthermore, article 1733 of the French General Tax code (Code général des impôts) states that no penalty is attributed when the shortfall does not exceed 10% of the tax base (Code général des impôts, 2016). Aware of the fact that such freedom has to be granted in the context of a wealth tax (because even if people show good faith, it is reasonably impossible to perfectly value all assets (Levitt & Syverson, 2008)) we put ourselves in the same context of 10% margin

[13]See section 8.2.1 for our definition of *adjusted* semi-elasticity.

and assumes individuals make fully use of it without going further ($\tilde{\sigma}_t^{r,i} = 0$ in equation (8.12)). Real wealth is then underdeclared to an extent of 10% ($\hat{\sigma}_t^{r,i}$) of its market value. Financial gross wealth, for which it is easier to assess the market value, is assumed not underdeclared ($\hat{\sigma}_t^{f,i} = 0$ and $\tilde{\sigma}_t^{f,i} = 0$).

9.4.3 Fiscal expatriation

We integrate in the model the effect of fiscal expatriation by estimating the relationship between average tax rate (total tax revenues divided by total taxable base) and delocalized tax revenues (yearly revenues which would have been generated without physical delocalization of concerned individuals).

As shown on figure 9.3 picturing the computation of the delocalized tax revenues to average tax rate ratio (the solid line on the right-hand side of the figure is the division of the two lines on the left-hand side) for the ISF in France between 1997 and 2006, one percent in tax rate on wealth brings on average per year a loss of 1.65 percent of total tax revenues due to fiscal expatriation.[14] In equation 8.17, we set $\hat{\omega}_t = 0$ and $\tilde{\omega}_t = 1.65$.

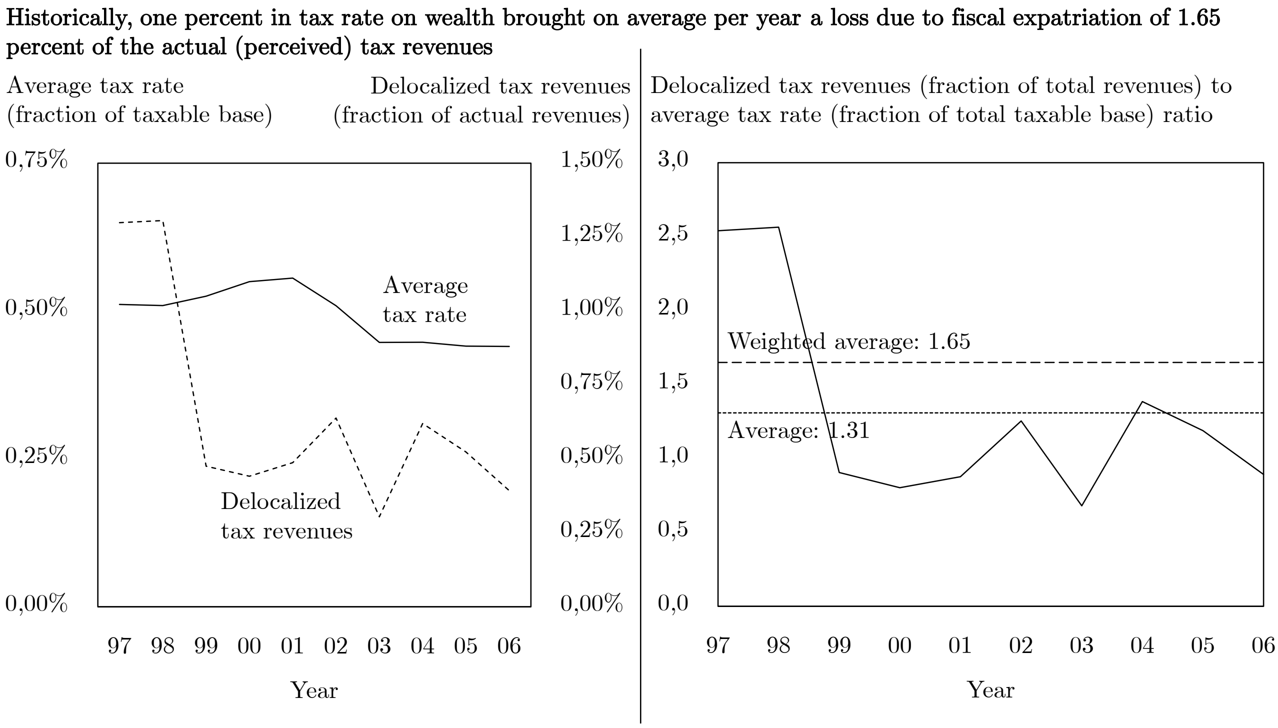


Figure 9.3: French ISF delocalized taxable base and tax rates between 1997 and 2006: key takeaways for the model

Source: Marini (2004, 2007, 2008), Conseil des Prélèvements Obligatoires (2009), DEFP (2010), own calculations

[14]The weighted average is weighted by the delocalized tax revenue-to-total tax revenue ratio.

Chapter 10

Results analysis

In this chapter, we make the model speak. We first estimate the future dynamics of wealth and wealth inequalities over ten years, with and without Piketty's, with and without tax evasion (section 10.1). We then proceed to the scenario analysis of different levers available to optimize the effects of the tax, both directly and indirectly controlled by the state (chapter 10.2).

10.1 Wealth and wealth inequality dynamics

10.1.1 Without Piketty's tax

Currently in Belgium, there is no tax such as Piketty's. In the model, all tax rates on wealth are set to zero and the results are interpreted as the wealth and inequality dynamics in the current state of the world. Figure E.1 represents those results.

Over ten years, the total stock of wealth is expected to grow at 6.15% per year. Important conclusion here: tax costs growth. We come down to the trade-off between efficiency and redistribution already pointed out more than once. The Lorenz curve up to the 50% of the population in translated downwards. The wealth-share of wealth-decile[1] 2 is expected to decrease significantly (∼5% per year[2]) and to become even more negative for decile 1. In the meantime, the lower-middle class (deciles 3, 4 and 5) enjoys both increase in its absolute wealth (∼7%) and share of wealth (∼2%) while deciles 6 to 10 are presumed to enjoy increase in their wealth (∼6%) with an almost unchanged share, meaning that their decile-increase in wealth replicates the total-increase in wealth.

This results in an slight increase in the Palma ratio (because deciles 3 and 4 compensates the loss of deciles 1 and 2) of 0.8% per year from 9.50 to 10.29 and in the GINI coefficient at an

[1]Throughout this chapter, share and fractile respectively refer to wealth-share and wealth-fractile.
[2]Throughout this chapter, growth rates are per annum. Symbol ∼ means "roughly".

average 0.4% per year. That is, a slight increase in total wealth inequalities but a significantly worse condition for the poorest people.

10.1.2 With tax and without evasion

We now assume that the light design of Piketty's tax (see table 4.1, design 1) is introduced in Belgium with full ($\mu_t = 100\%$) linear ($\epsilon_t = 1$) redistribution and that no tax evasion behavior is undertaken (obviously not true in reality). Results are displayed in figure E.2.

Compared to the situation without tax, the growth in total stock of wealth is reduced by 0.07 percentage points to reach 1.8 times the level of year 0 instead of 1.82, that is, 1.11% less than the situation without tax. The Lorenz curve is now translated downwards up to 35% of the population, and upwards further, until 90%. That is, the lower class still experiences decrease in its wealth-share. However, it does so with a lower magnitude, as expected. Indeed, the 10-year CAGR of wealth-share of wealth-decile 2 is almost 5 points[3] higher (less negative). The difference is ∼2 points for deciles 3 to 5 while the highest decile experiences ∼1% per year decrease in its wealth share.

This results in a reduction from 9.50 to 8.35 (-1.28% per year) in the Palma ratio and a very slight increase of 0.08% per year in the GINI coefficient. However, the first design of table 4.1 and/or linear redistribution ($\epsilon_t = 1$) fail to completely avoid the fall of the lower class, especially wealth-decile 1 for which both wealth and share of wealth still go more negative.[4]

10.1.3 With tax and evasion

As expected and shown by figure E.3, the case with tax and tax evasion (as parametrized in section 9.4) leads to results between the case without tax and with tax without evasion. It is already concluded that the current tax design and redistribution scheme do not provide enough effects to prevent the lowest deciles of wealth to loose share. We therefore do not dig deeper in this state of the world. The next section is dedicated to scenario analyses of different levers available to increase the effects of the tax, both directly and indirectly controlled by the state.

[3] Throughout this chapter, point refers to percentage point. A change in percentage expresses a relative delta while a change in points expresses an absolute delta of a relative measure.

[4] Absolute and share of wealth for wealth-decile 1 are not represented on the figure as their CAGR represent the growth of a negative quantity.

10.2 Improvements levers

We consider that all tax evasion behavior are undertaken: assets hiding (θ-effect), assets undervaluation (σ-effect) and individual delocalization (ω-effect) are undertaken.

10.2.1 State directly controlled levers

The government can directly play on multiple variables: redistribution intensity (ϵ-effect), redistribution quantity (μ-effect), redistribution distribution (κ-effect), tax brackets ($\underline{w}^b$ and $\overline{w}^b$-effect) or tax rates (τ^b-effect).

Redistribution intensity

Replacing the redistribution intensity factor $\epsilon_t = 1$ by $\epsilon_t = 0.1$ so that the bottom 50% of the population receives 84% of the redistributed amount instead of 78% (figure 8.2) generates results displayed in figure E.4.

The fall of decile 2 is accelerated (10-year CAGR of wealth share -3.80% instead of -3.08%) by the change in redistribution intensity. This is not unexpected as $\epsilon_t = 0.1$ redistributes less to decile 2 and more to decile 1 than $\epsilon_t = 1$. In the meantime, decile 1 only enjoys a slightly higher redistribution which, again, is not sufficient.

This tells that whatever the "distribution of the redistribution", there are just not enough tax proceeds to prevent the fall of the lower tail. Therefore, the next scenario uses Piketty's heavy tax design.

Tax brackets and rates

Replacing tax design 1 by tax design 2 of table 4.1 generates results displayed in figure 10.1 (with $\epsilon_t = 1$). Now, all individuals with positive net wealth are subject to the tax.

The total stock of wealth increases at 5.93% par yer to reach 1.78 times its initial value after ten years, that is, a cost of 0.16 points per year of wealth growth compared to design 1. The entire Lorenz curve is translated towards higher levels of cumulative share of wealth. Decile 1 enjoys a positive net wealth after ten years. Decile 2 enjoys an annual growth of ∼3.5% in its wealth-share and of ∼10% in its wealth while the wealth-share of decile 10 is reduced at a rate of ∼1% per year.

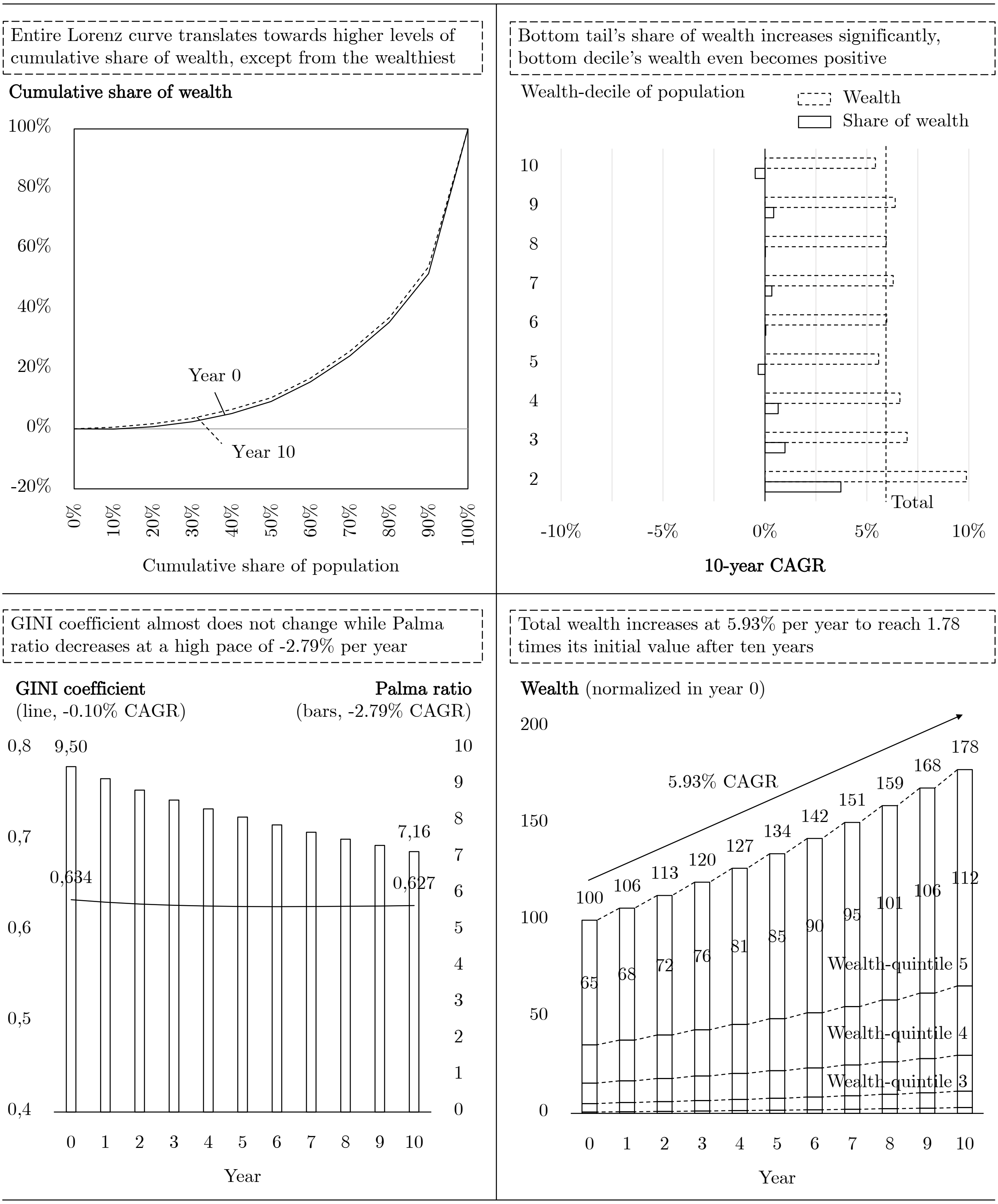


Figure 10.1: Dynamics with heavy tax, linear redistribution and tax evasion

Note: Wealth tranches and rates in table 4.1 (design 2), $\epsilon_t = 1$, κ_t as equation (8.7), $\mu_t = 100\%$, θ-effect, σ-effect, ω-effect

Those differences (respectively ∼7.5 and ∼6 points per year for wealth and wealth-share of decile 2) compared to the light wealth tax are huge. If the objective is to stop the inegalitarian spiral, there is no need to provide the bottom deciles with such treatment. A tax scheme between design 1 (light) and design 2 (heavy) of table 4.1 and/or a partial redistribution ($\mu_t < 1$, which would mean profits for the state provided that intervention costs are covered) seem therefore more appropriate, balancing cost on growth and end of increase in inequalities.

10.2.2 State indirectly controlled levers

In addition, the state may try to reduce individual tax evasion through reductions in assets hiding (θ-effect), assets undervaluation (σ-effect) and/or individual delocalization (ω-effect).

Figure 10.2 represents the normalized 10-year tax revenues perceived by the state assuming different tax designs and evasion behaviors. First, without tax evasion, tax revenues are respectively 24.7% and 19.7% higher for the light and heavy tax designs than with complete tax evasion. Put another way, tax evasion costs[5] the state 19.8% and 16.5%.

Second, we note that assets undervaluation impacts the most tax revenues to an extent of 11.2% the perceived amount without evasion, respectively 2.5 and 10.8 percentage points more than assets hiding and individual expatriation (light tax).[6] This suggests that the most revenue-generating improvement lever for the state is to enhance its assets valuation and controlling processes and/or to constrain individuals to report accordingly (see section 8.2.2). Loss due to individual delocalization amounts to only 0.4% of theoretical tax revenue.

Regarding the so called cooperation between states wanted by Piketty, a complete information exchange all around the world would provide the government with an additional 10.8% compared to what it would be without cooperation (i.e. with assets hiding and individual expatriation).

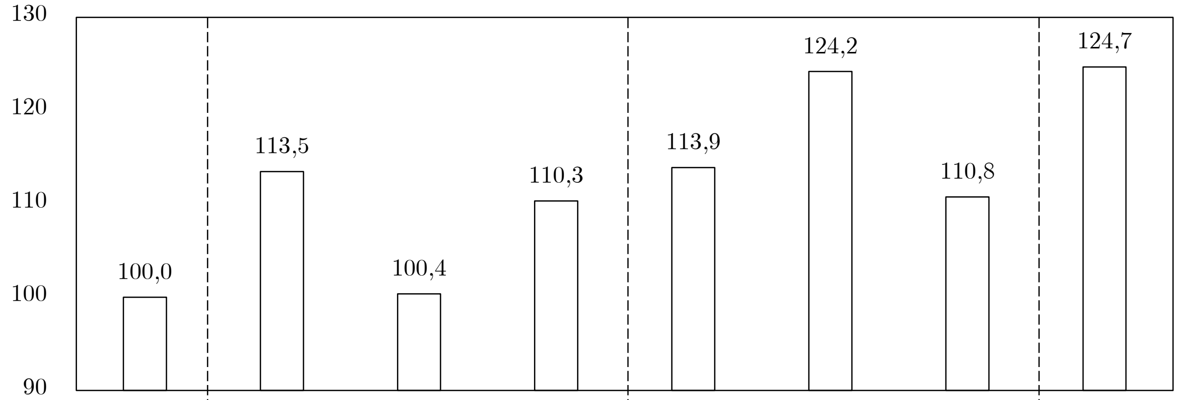
10.3 Limits of the model and its results

There are actually an infinite number of possible configuration (tax designs, redistribution strategies, evasion behaviors etc.). This is the precise reason why we created an open algorithm. We stop here with the results analysis and leave the reader free to run it with other configurations if interested. Taking a longer term perspective, we identify several elements to improve the model.

[5]We define the cost of evasion as the loss in tax revenue as a fraction of total tax revenue without evasion.
[6]Those results are in line with Pichet (2007).

Light tax (design 1) – Without tax evasion, total tax revenues are 25% higher than with complete tax evasion

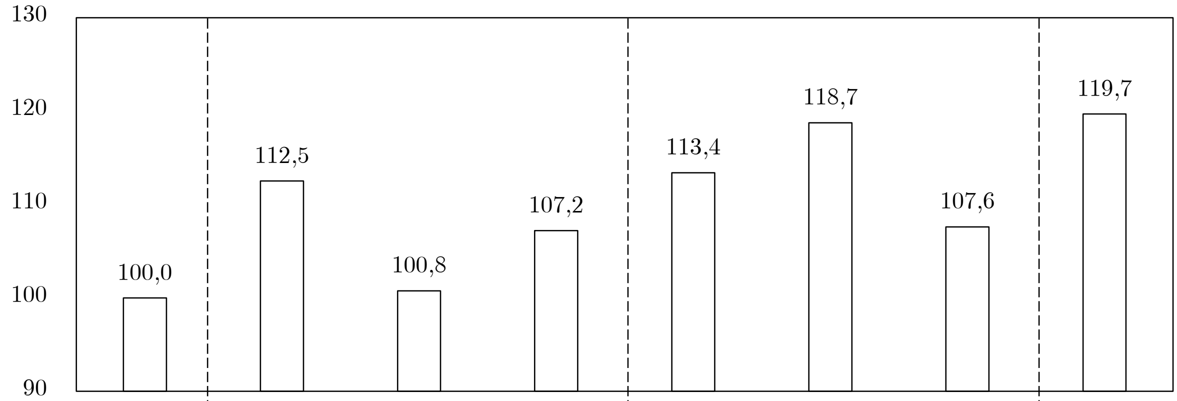
Total 10-year tax revenues
(normalized in base 100 for the full-evasion case)



Assets hiding	Yes	Yes	Yes		Yes			
Individual expatriation	Yes	Yes		Yes		Yes		
Assets undervaluation	Yes		Yes	Yes			Yes	
Cost of evasion	19,8%	9,0%	19,5%	11,5%	8,7%	0,4%	11,2%	

Heavy tax (design 2) – Without tax evasion, total tax revenues are 20% higher than with complete tax evasion

Total 10-year tax revenues
(normalized in base 100 for the full-evasion case)



Assets hiding	Yes	Yes	Yes		Yes			
Individual expatriation	Yes	Yes		Yes		Yes		
Assets undervaluation	Yes		Yes	Yes			Yes	
Cost of evasion	16,5%	6,0%	15,8%	10,4%	5,3%	0,8%	10,1%	

Figure 10.2: Tax revenues under multiple tax evasion behaviors

Note: $\epsilon_t = 1$, κ_t as equation (8.7), $\mu_t = 100\%$, cost of evasion is the loss in tax revenue as a fraction of total tax revenue without evasion (e.g. $(124.7 - 100.0)/124.7 = 19.8\%$)

Input data The data we feed the algorithm with come from various sources and points in time. Also, some assumptions and relatively broad estimations have been done, especially regarding the estimation of evasion behavior parameters conditioning the conclusions and recommendations we just drew. Definitely, there is room for improvement on this side, both on the quality and the quantity (breadth and depth, see section 6.1) of data.

Modeling strategy The model assumes a constant population, which caused some issues when introducing the individual delocalization behavior (see section 8.2.3).[7] Another point is the fact that some variables depend some bracket of gross or net wealth, as Piketty suggests, raising two important comments. First, this idea of variables being function of gross or net wealth has been criticized. Second, doing so aligns the model itself with Piketty's thinking and therefore, makes it inherit of some kind of self-fulfilling prophecy.[8] Then, of course, one may have liked to see some elements mentioned in section "What's out" (6.2.1) such as the introduction of inheritance or the modeling of assets returns and cost of debt using stochastic calculus.

Scope The model focuses on wealth. One may be interested in knowing what would happen to politically important metrics such as gross domestic product, unemployment etc., totally left out here.

[7]One may for instance want to replace n by $(1 + g_t^n - e_t^n) \cdot n_{t-1}$ where g_t^n is the growth rate of the population and e_t^n some kind of "expatriation rate".

[8]However, changing this pattern is not difficult. One may just define another v in the choice of $\mathcal{B}_t^{v,k}$ (see section 7.3.2).

Conclusion

Conclusion

Results summary

In the first part, we look at how to measure income and wealth inequalities and see that a wide literature appeared over the past century, challenging all measures but not providing one singe approach without any known drawbacks. We select the size distribution method to pursue (chapter 1). We then study the mechanisms through which income and wealth inequalities impact economic growth and conclude that the present consensus is that they do have a negative impact, although the quantification of this impact remains unclear (chapter 2). Finally, we analyze available historical data on income and wealth in Belgium and other countries and show that income is more equally distributed than wealth. Moreover, both variables are growing more unequal in their distribution and there is no clear evidence suggesting that this would stop anytime soon (chapter 3).

In the second part, we first look at the theoretical justification of a tax on wealth and argue in favor of a very specific wealth tax: a tax on private individual wealth that provides utility by and from its holding for reasons different than precautionary savings, consumption smoothing or bequests. Since nothing ensures that Piketty's tax absolute thresholds fulfill this, we conclude that his proposed tax does not make theoretical sense on this regard (chapter 4). From a practical point of view, a wealth tax raises several issues, mostly related to its administration and individuals' reactions against it. After analysis, we conclude that Piketty's proposal does provide solutions to those main issues, but in a very utopian and non-practical way. Indeed, we do not expect a complete individuals' wealth information exchange between each and every state, cornerstone of Piketty's idea, to happen any time soon (chapter 5).

In the third part, we build an individual private wealth dynamics model (and algorithm written in R) (chapters 6, 7 and 8) aimed at estimating the impact of Piketty's proposal under various states of the world (hypotheses). We input a sample population along with other parameters replicating the configuration in Belgium (chapter 9). At the end, we run the algorithm over ten years, extract the results, represent and interpret them. We conclude that the current state of the world (without Piketty's tax) leads to higher wealth inequalities. Moreover, the lightest of his tax designs does not provide enough adjustments to prevent the lowest tail of the wealth distribution to loose (share of) wealth. However, his heavy tax design does provide way enough proceeds to inverse the trend, meaning that the objective of *"avoiding an endless inegalitarian spiral and to controlling the worrisome dynamics of global capital concentration"* can be achieved through in-between tax design and/or less intense redistribution than the linear scheme. Overall, we expect the cost on total wealth growth to be relatively small. Finally, we also conclude that the most tax revenue generating improvement lever lies in the reduction of assets undervaluation by individuals, followed by the reduction of assets hiding and fiscal delocalization (chapter 10).

Implications and recommendations

We started this paper by stating the following question:

«Is the introduction of a net wealth tax as defined by Piketty on Belgian residents with the objective of reducing wealth inequalities in Belgium desirable?»

We broke it down in three sub-questions:

(1) Should something be done to reduce wealth inequalities in Belgium?

(2) Is a net wealth tax as defined by Piketty an appropriate (theoretical point of view) and viable (practical point of view) tool to reduce wealth inequalities?

(3) What would be the impact of the net wealth tax as defined by Piketty on wealth inequalities and other selected variables?

Regarding question (1), as it seems that wealth inequalities have a negative impact on economic growth and as it seems that wealth inequalities are on the rise, we answer that some tool(s) should be used to try to reduce them.

Regarding question (2), we conclude that the wealth tax as proposed by Piketty is not theoretically appropriate and not practically viable, at least in the short run.

Regarding question (3), we estimate that a wealth tax can reduce inequalities in Belgium, with relatively low impact on the growth of the total stock of net wealth. We also estimate tax evasion behaviors of individuals to amount up to one quarter of actual tax revenues. While important, no estimations are done on variables such as gross domestic product or unemployment.

Bringing everything together, we would rather not recommend the introduction of a net wealth tax as defined by Piketty on Belgian residents. What should nevertheless be noted is that Piketty pursues a very specific objective of inequality reduction, which has been proved to be attainable under our assumptions. Therefore, even if the theoretical justification of this tax is wobbly, one still may want to consider its introduction as soon as one agrees that the need of reducing wealth inequalities is crucial, keeping in mind that there could be other tools to reach the objective.

Limits and next steps

Our paper aimed at answering a very specific question, and we used specific tools to do so. Some elements are suitable to improvements. We think that further research on the implications of wealth inequalities are needed to confirm that they are an issue that needs to be tackled as the literature on this matter has historically adopted opposite points of view. Further research is needed to understand why wealth inequalities have been rising in some countries and see whether it is indeed fully true that nothing predicts a natural decline. Further research is needed on the actual individual private net wealth size and distribution as current data mostly relies on surveys. Further research is needed on tax evasion behaviors data as current numbers are based on sometimes broad estimates. Finally, further improvements may also be done to the model, but this has been already explained and we refer the reader to the end of the previous chapter for more details on how to improve the third part of this thesis.

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Appendix A

Various additional information

A.1 Net national income

As defined in the *1993 System of National Accounts*(Inter-Secretariat Working Group on National Accounts, 1993), Gross National Income(GNI) is *"equal to GDP*[1] *less primary incomes payable to non-resident units plus primary incomes receivable from non-resident units"* and adds *"GNI at market prices was called gross national product in the 1953 SNA, and it is commonly denominated GNP."*

As detailed in line 2.176. of Inter-Secretariat Working Group on National Accounts (1993) concerning GDP, "the concept of value added should conceptually exclude the counterpart of consumption of fixed capital. The latter, in effect, is not newly created value, but a reduction in the value of previously created fixed assets when they are used up in the production process. Thus, theoretically, value added is a net concept. " Since "by deducting the consumption of fixed capital from GNI, net national income (NNI) at market prices is obtained"(l 2.182., and that "The remarks above about the conceptual relevance of the net concept in case of product apply even more strongly to national income." (l 2.182.), we focus in this paper on the use of NNI as a measure of national income.

As explained by Hamilton & Ley (2010), "by accounting for the consumption of fixed and natural capital depletion, adjusted net national income better measures the income available for consumption or for investment to increase a country's future consumption." The authors then refer to Nordhaus & Tobin (1972) explaining that "income - or consumption - based measures are more relevant for welfare than are production-based indicators", tacking the case for using NNI against other national indicators.

[1] Gross Domestic Product

With this in mind, table A.1 presents the proportional difference between NNI and GNI for several rich countries and different years. Two comments can be made from this table. First, looking at the year 2010, we see the 6 countries present similar numbers, at about 80%. Second, high volatility can be noted from one year to the next, such as the 15% difference between the 1995 and the 2000 value for Germany.

	Belgium	Germany	France	United Kingdom	The Netherlands	United States
1970	/	/	84%	93%	92%	85%
1975	/	80%	86%	82%	82%	77%
1980	/	80%	83%	90%	78%	75%
1985	/	81%	85%	79%	78%	87%
1990	/	89%	90%	87%	86%	83%
1995	/	90%	89%	83%	90%	83%
2000	76%	75%	77%	82%	77%	87%
2005	86%	81%	83%	84%	81%	81%
2010	82%	78%	78%	82%	78%	83%

Table A.1: Net national income (NNI) as a percentage of gross national income (GNI) in selected countries between 1970 and 2010

Source: World Bank national accounts data, and OECD National Accounts data files

A.2 Shadow economy

Elgin & Oztunalı (2012) builds a model-based estimate of the shadow economy for 161 countries that aims at providing the largest historical series, covering the period 1950-2009. Building on the work of Schneider et al. (2010), that used a model criticized by Breusch (2005), Elgin & Oztunalı (2012) aim at providing new estimates. Results can be seen in table A.2.

	Belgium	Germany	France	United Kingdom	The Netherlands	United States
1970	28.21%	18.57%	18.77%	16.08%	15.87%	11.56%
1980	25.26%	17.11%	16.74%	14.84%	14.49%	10.77%
1990	24.17%	16.69%	16.12%	14.17%	14.36%	9.99%
2000	22.25%	15.44%	15.61%	13.04%	13.56%	9.10%
2009	20.82%	15.14%	14.26%	11.94%	12.79%	8.20%

Table A.2: Shadow economy as a percentage of GDP in selected countries between 1970 and 2009

Source: Elgin & Oztunalı (2012)

It is interesting to note that those numbers closely match the ones reported by Schneider et al. (2010). Indeed, table A.3 show that for each country, there was barely any difference in the estimated size of the shadow economy as a percentage of GDP in 2000, both estimation falling short of 1% apart.

While tables A.2 and A.3 both depict Belgium as having the highest estimated shadow economy as a percentage of GDP, it is far from having the highest rate in the world. Indeed, Schneider et al. (2010) ranks Belgium 37th out of 150 countries, the highest being Bolivia, with 63.5% in 2007. Elgin & Oztunalı (2012) also attributed a rate of 63.5% to Bolivia in 2007 and the weighted-averages for Latin America and Sub-Saharan Africa were, respectively, at 36.28% and 36.16% over the 2001-2009 period. The weighted-average over the 2001-2009 period for the OECD countries of the European Union (in which category falls Belgium) was estimated at 16.53%, suggesting Belgium still has a large shadow economy.

	Belgium	Germany	France	United Kingdom	The Netherlands	United States
Elgin & Oztunalı (2012)	22.25%	15.44%	15.61%	13.04%	13.56%	9.10%
Schneider et al. (2010)	22.2%	16.0%	15.2%	12.7%	13.1%	8.7%

Table A.3: Shadow economy as a percentage of GDP in selected countries in 2000

Source: Schneider et al. (2010), Elgin & Oztunalı (2012)

A.3 Wealth portfolio

Kuypers & Marx (2014) analyzes data from European Central Bank (2013b) for Belgium and concludes that "wealth in Belgium is, such as in other rich countries, strongly unequally distributed", stating that "Half of the Belgian households have together less than 10 percent of total wealth. The top 10 percent holds 44 percent of the total" and adds that "Financial wealth [..] is even more unequally distributed".

Looking at figureA.1, presenting the average asset portfolio per different brackets of gross wealth[2], one can see that the wealthiest hold a bigger share of financial wealth than do the poorest. One can further notice that the *own residence*, represents the biggest asset type in any of those average portfolios, and real assets represent more than 50% of total asset value for each of those.

[2] In contrast to net wealth, defined as the marketable value of asset less debts, gross wealth refers to the marketable value of assets.

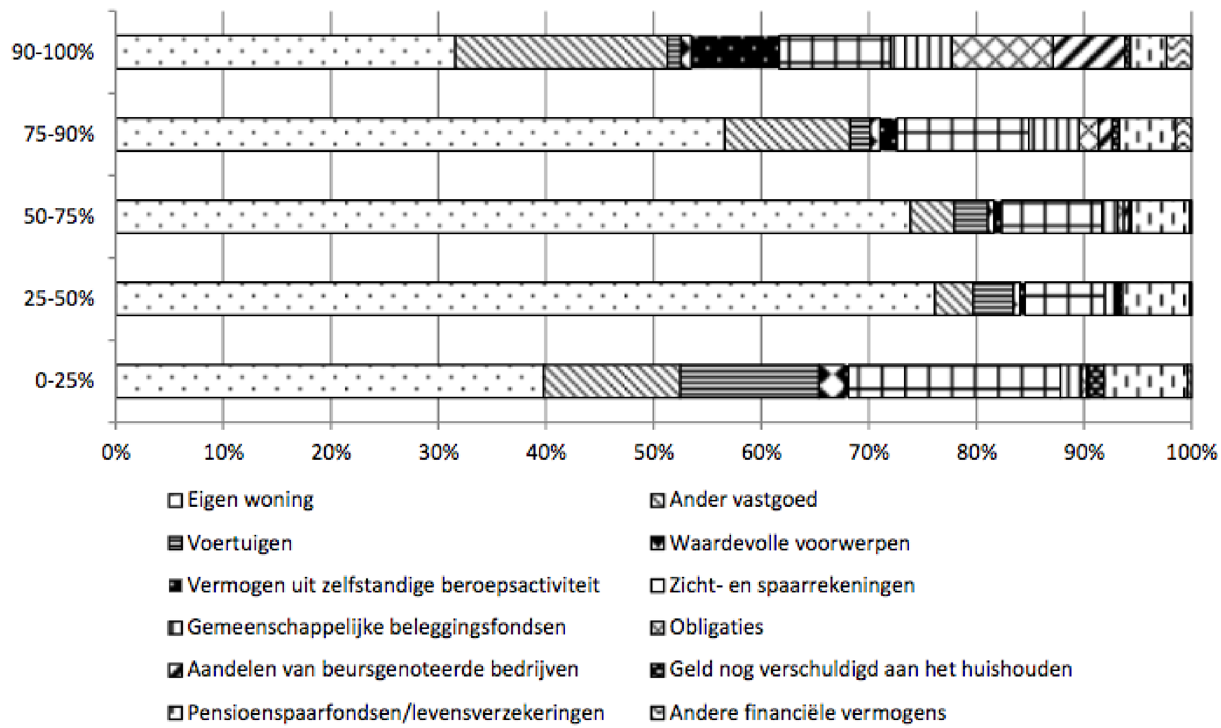

Figure A.1: Average assets portfolio allocation for different bracket of gross wealth in Belgium in 2014

Source: Kuypers & Marx (2014)

A.4 The Life Cycle Model and precautionary savings

Modigliani & Brumberg (1954) introduced in the early 1950s a theory constructing "stable relation between consumption, income, and other relevant variables and to estimate its parameters" and "to provide such an analytical framework through the use of the well-developed tools of marginal utility analysis." Their conclusions lies largely on two propositions: "(a) that the major purpose of saving is to provide a cushion against the major variations in income that typically occur during the life cycle of the household as well as against less systematic short-term fluctuations in income and needs; (b) that the provisions the household would wish to make, and can afford to make, for retirement as well as for emergencies, must be basically proportional, on the average, to its basic earning capacity, while the number of years over which these provisions can be made is largely independent of income levels."

In other words, "the point of departure of the life cycle model is the hypothesis that consumption and saving decisions of households at each point of time reflect a more or less conscious attempt at achieving the preferred distribution of consumption over the life cycle subject to the constraint imposed by the resources accruing to the household over its lifetime." (Modigliani, 1966).

In its simplest form, under several assumptions, the model simply states that each individual saves in the first stage of its life - when his earnings are positive - in order to use the accumulated wealth in the second stage to fuel consumption - when earnings are null. The assumptions in this simplest model are the following:

- No bequest will be given at the death of the individual. In other words, consumption will dry up all savings by the time of death.
- the economy is stationary, population and productivity being constant over time
- Consumption level is constant over time, in both periods
- Earnings are constant over time in the first period and non-existant in the second period
- net wealth does not provide any return

Figure A.2 presents the life cycle for a typical individual under this set of assumptions.

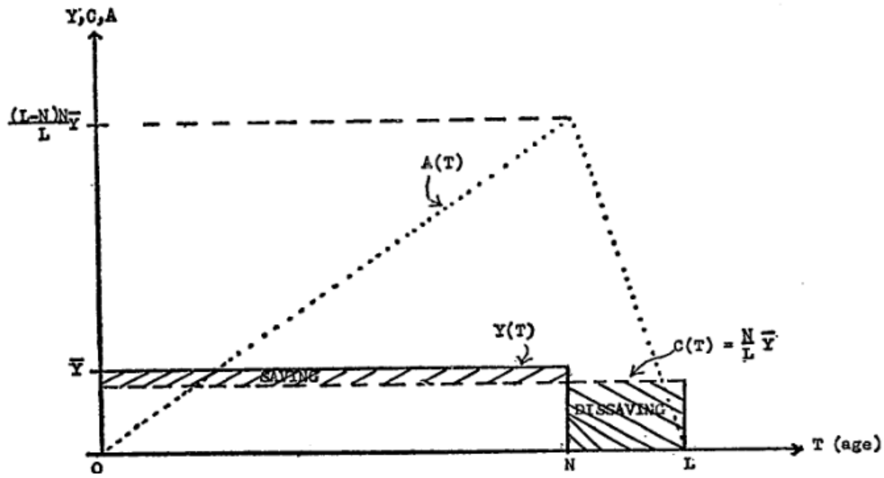

Figure A.2: Income, consumption, savings and wealth as a function of age

Source: Modigliani (1966)

"The mortality rate is assumed to be zero up to age L and one at age L. The solid curve labeled Y(T) shows per capita income from labor as a function of age, which is assumed constant at $\bar{Y}$ up to age N and zero over the rest of the life. On the further assumption of zero rate of return on assets, this locus represents also total per capita income. the dashed line shows the rate of per capita consumption which is assumed to be constant through life; since life consumption must exhaust income, the constant rate must be (N/L)$\bar{Y}$. the distance between Y(T) and C(T), shaded in the figure, is per capita saving (or dissaving). Finally, the dotted locus shows per capita net worth, the cumulant of savings, as a function of age; it starts at zero, rises linearly to a peak at the age of retirement, N, and then falls linearly back to zero at age L."

Adding the assumption that all these values are the same for the entire population, it therefore means that total wealth is constant over time, but constantly moving from the hand of the dissavers into the hands of the savers.

Appendix B

Notes on the model

Debt-to-asset ratio

Back to the example

In section 7.2.5, we illustrate the dynamics of equation (7.14) putting ourselves in the feet of an agent starting with a positive net wealth and a constant leverage of $\beta_t^i = 0.7$. What if net wealth is negative? What if the leverage factor is above one?

Negative net wealth and supra-unitary debt-to-asset ratio

In $t = 0$, in the model and in reality as well, some agents present a negative net wealth (Shorrocks et al., 2015). Since $w_t^i = (1 - \beta_t^i) \cdot a_t^i$, negative net wealth can be achieved through $\beta_t^i > 1$. However, the aggregation level of the data on individual leverage patterns provided by European Central Bank (2013c) and used in section 9.1.2 in table 9.3 does not provide enough information to identify the population with $\beta_t^i > 1$.

Integration in the model

Remember that, accounting terms, a negative asset is nothing else than a debt and a negative debt is nothing else than an asset. To avoid attributing random debt-to-assets ratio to individuals at the bottom tail of the distribution, we keep the $\beta_t^i < 1$ provided by European Central Bank (2013c) which, applied to a negative level of net wealth $w_t^i < 0$, leads to $a_t^i = w_t^i/(1 - \beta_t^i) < 0$, $d_t^i = \beta_t^i \cdot a_t^i < 0$, $a_t^i < d_t^i < 0$ and $w_t^i = a_t^i - d_t^i < 0$, as required. See figure B.1 for illustration. In this case, i owns $|d_t^i|$ of assets and is liable to $|a_t^i|$ of debts.

Analytically, formula (7.14) sees the components of the return and cost of capital effect inverted (two cases: one with $w_t^i > 0$ and another one for $w_t^i < 0$). In addition, we also make

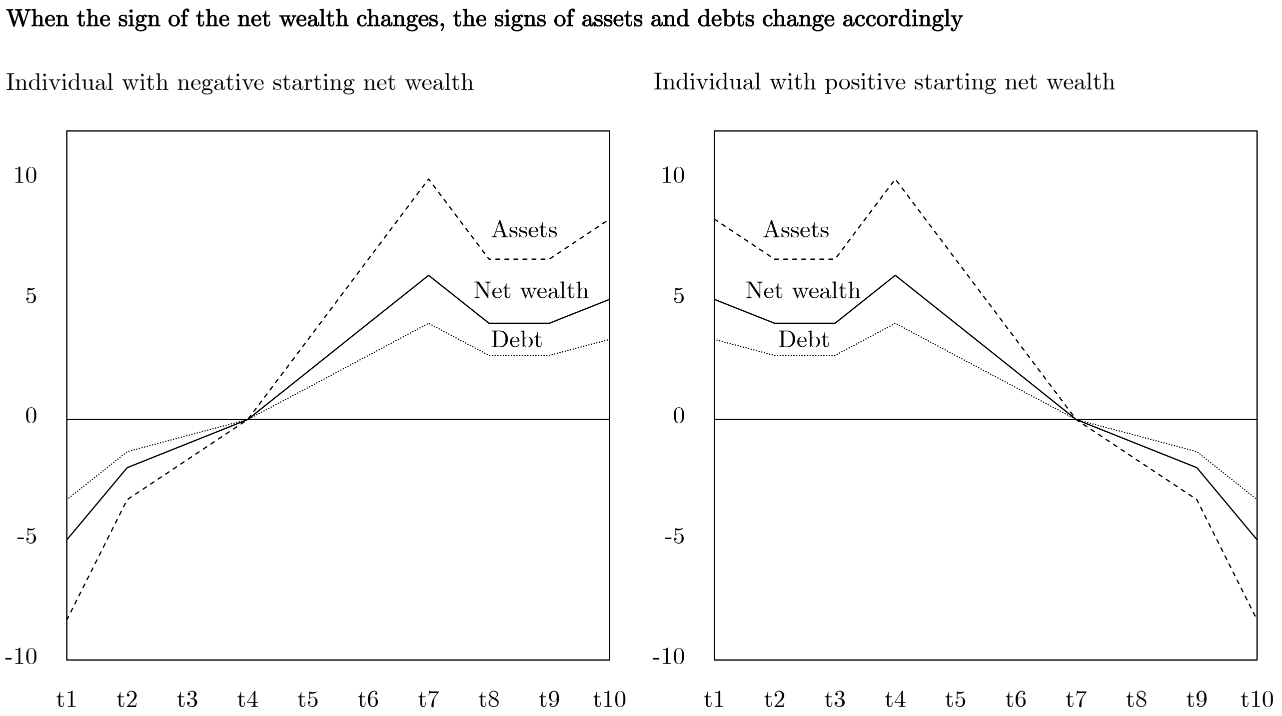

Figure B.1: Examples of change in the sign of net wealth

Note: Constant debt-to-assets ratio of 0.4. Exogenous returns on net wealth generating absolute levels of -5 (t_0), -2, -1, 0, 2, 4, 6, 4, 4 and 5 (t_{10}) for the left-hand graph and the exact inverse for the right-hand graph. Assets and debt are then adjusted each year according to the debt-to-assets ratio

Source: Own calculations

possible for the user to input debt-to-assets ratios above one (two additional cases: $\beta_t^i < 1$ and $\beta_t^i > 1$). As a result, equation (B.1) is written in the R code.

$$\delta w_t^i = \underbrace{\left[\frac{\gamma_t^i \cdot (1-\tau_t^{l,i}) \cdot (1+g_t^i) \cdot l_{t-1}^i}{(1-\beta_{t-1}^i) \cdot a_{t-1}^i}\right]}_{\text{Income and consumption effect}} + \begin{cases} \overbrace{\left[\frac{1}{1-\beta_{t-1}^i} \times \left(\bar{r}_t^{a,i} - \beta_{t-1}^i \cdot \bar{r}_t^{d,i}\right)\right]}^{\text{Return and cost of capital effect}} \text{ if } \begin{cases} \beta_{t-1}^i < 1 \text{ and } w_{t-1}^i > 0 \\ \beta_{t-1}^i > 1 \text{ and } w_{t-1}^i < 0 \end{cases} \\ \underbrace{\left[\frac{1}{1-\beta_{t-1}^i} \times \left(\bar{r}_t^{d,i} - \beta_{t-1}^i \cdot \bar{r}_t^{a,i}\right)\right]}_{\text{Return and cost of capital effect}} \text{ if } \begin{cases} \beta_{t-1}^i < 1 \text{ and } w_{t-1}^i < 0 \\ \beta_{t-1}^i > 1 \text{ and } w_{t-1}^i > 0. \end{cases} \end{cases} \tag{B.1}$$

Note that when $\beta_t^i > 1$, $1 - \beta_t^i < 0$ but the sign of a_t^i compensates so that income and return on assets have a positive effect on net wealth growth while the cost of debt had a negative effect on net wealth growth, as it should be. For example, if $\beta_t^i > 1$ and $w_t^i < 0$, the income effect is negative (provided that consumption does not exceed disposable income) and is applied to a negative stock of wealth, resulting in a "less negative" stock of net wealth for the next period. Bottom line: income increased net wealth, as it should. The mechanism also applies to the return and cost of capital effect.

Appendix C

Source code

```
## ------------------------------------------------------------
#INPUT
#Population.csv with individual ID number (row 1), starting net wealth (row 2), starting income (row 3)
## ------------------------------------------------------------


## ------------------------------------------------------------
#OUPUT
#9 modlels & 5 tables for each model

#9 models
#........
#Model #        Theta-effect    Omega-effect    Sigma-effect
#               1       NO TAX                  NO TAX                  NO TAX
#               2       1                       1                       1
#               3       1                       1                       0
#               4       1                       0                       1
#               5       0                       1                       1
#               6       1                       0                       0
#               7       0                       1                       0
#               8       0                       0                       1
```

```
#                  9         0                                      0
                        0

#5 tables for each model
#......................
#                  1         Net wealth per individual per year (last column in
    GINI coefficient)
#                  2         Income per individual per year
#                  3         Wealth tax per individual per year
#                  4         Transfer weight per individual per year
#                  5         Total tax revenue per year
## ----------------------------------------------------------


## ----------------------------------------------------------
##        0. Initialization
## ----------------------------------------------------------

sink('Output.txt',split=TRUE)
options(scipen=999)
options(stringsAsFactors = FALSE)
library(ineq)
library(xlsx)
ptm <- proc.time()
data<- read.csv2("Population.csv",header=TRUE)
nb.years <- 10
nb.models <- 9
epsilon <- 1
mu <- 1
```

C.1 Input data

```
for (model in 1:nb.models){
  ##
      --------------------------------------------------------------------------------

  ##        1. Population creation based on Shorrocks et al (2015), HFCS
      (2013) and own calculation
  ##
      --------------------------------------------------------------------------------


  ## Input of data from excel file
```

```
NetWealth <- as.vector(data[1,],mode="numeric")
LaborIncome <- as.vector(data[2,],mode="numeric")

## Creation of Betas per bracket
Beta <- NetWealth * 0
Betas <- data.frame(
  Brackets=c(0,0.2,0.4,0.6,0.8,0.9),
  Rate =c(0.915,0.441,0.169,0.095,0.08,0.029),
  stringsAsFactors=FALSE)

for (k in 1:length(NetWealth)){
  for (j in 1: length(Betas$Brackets)){
    if (NetWealth[k]>=quantile(NetWealth,Betas$Brackets[j])){
      Beta[k] <- Betas$Rate[j]
    }
  }
}

GrossWealth <- NetWealth/(1-Beta)

Debt <- GrossWealth - NetWealth

GrossWealthBis <- GrossWealth*0
DebtBis <- Debt * 0
for (k in 1:length(NetWealth)){
  if (GrossWealth[k]>0){
    GrossWealthBis[k]<-GrossWealth[k]
    DebtBis[k] <- Debt[k]
  }
  else {
    GrossWealthBis[k]<- -1*Debt[k]
    DebtBis[k] <- -1* GrossWealth[k]
  }
}

DebtTypes <- data.frame(
  Brackets=c(0),
  RealHousing=c(1),
  stringsAsFactors=FALSE)

DebtBreakdown <- matrix(,nrow=(length(DebtTypes[1,])-1),ncol=length(
    GrossWealth))

```

```
GrossWealthBreakdown <- data.frame(
  Brackets=c(0,0.25,0.5,0.75,0.9),
  RealResidence=c(0.4,0.76,0.74,0.57,0.315),
  RealHousing=c(0.13,0.04,0.04,0.11,0.21),
  RealVehicles=c(0.12,0.04,0.03,0.02,0.01),
  RealOther=c(0.032,0.003,0.013,0.005,0.095),
  FinDeposit=c(0.20,0.08,0.10,0.13,0.10),
  FinObligation=c(0.00,0.004,0.008,0.045,0.095),
  FinShares=c(0.018,0.004,0.007,0.065,0.115),
  FinLife=c(0.08,0.065,0.055,0.04,0.03),
  FinOther=c(0.02,0.004,0.007,0.015,0.03),
  stringsAsFactors=FALSE)

WealthBreakdown <- matrix(,nrow=(length(GrossWealthBreakdown[1,])-1),ncol=
   length(NetWealth))

IncomeIncreaseRates <- data.frame(
  Brackets=c(0,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9),
  GrowthRate=c
     (0.032,0.0348,0.033,0.032,0.0299,0.0282,0.0278,0.0275,0.0267,0.0271),
  stringsAsFactors=FALSE)

LaborIncomeIncrease<-LaborIncome*0
FinWealth <- NetWealth*0
RealWealth <- NetWealth*0
Alpha <- WealthBreakdown *0

Return <- data.frame(
  Brackets =(0),
  RealResidence=c(0),
  RealHousing=c(0.045),
  RealVehicles=c(0),
  RealOther=c(0.0075),
  FinDeposit=c(0.01),
  FinObligation=c(0.054),
  FinShares=c(0.03),
  FinLife=c(0.0),
  FinOther=c(0.0207),
  stringsAsFactors=FALSE)

ValueGrowth <- data.frame(
  Brackets =(0),
  RealResidence=c(0.05),
```

```
    RealHousing=c(0.05),
    RealVehicles=c(-0.1586),
    RealOther=c(0.0397),
    FinDeposit=c(0.0),
    FinObligation=c(0.0),
    FinShares=c(0.065),
    FinLife=c(0.0619),
    FinOther=c(0.0255),
    stringsAsFactors=FALSE)

  ReturnBreakdown <- matrix(,nrow=(length(Return[1,])-1),ncol=length(
      GrossWealth))

  GrowthBreakdown <- matrix(,nrow=(length(ValueGrowth[1,])-1),ncol=length(
      GrossWealth))

  ReturnTax <- data.frame(
    RealResidence=c(0.0),
    RealHousing=c(0.0),
    RealVehicles=c(0.00),
    RealOther=c(0.00),
    FinDeposit=c(0),
    FinObligation=c(0.27),
    FinShares=c(0.27),
    FinLife=c(0.27),
    FinOther=c(0.27),
    stringsAsFactors=FALSE)

  ValueGrowthTax <- data.frame(
    RealResidence=c(0),
    RealHousing=c(0),
    RealVehicles=c(0),
    RealOther=c(0),
    FinDeposit=c(0),
    FinObligation=c(0),
    FinShares=c(0),
    FinLife=c(0),
    FinOther=c(0),
    stringsAsFactors=FALSE)

  SavingRates <- data.frame(
    Brackets=c(0,0.2,0.4,0.6,0.8,0.95,0.99),
    SavingRates = c(0.0014,0.0009,0.111,0.173,0.236,0.372,0.512),
```

```
    stringsAsFactors=FALSE)

  SavingRate <- LaborIncome*0

  ### Autres variables
  PersonalWealthTax <- NetWealth*0
  PersonalIncomeTax <- NetWealth*0
  DispIncome <- NetWealth*0
  AssetReturn <- NetWealth * 0
  DebtReturn<- NetWealth * 0
  ReturnEffect<- NetWealth * 0
  deltaWealth<-NetWealth*0
  DeltaWealth<-NetWealth*0
  TaxRevenue <- 0
  DeclaredWealth <- NetWealth*0

  #DebtReturn data
  DebtReturnData <- data.frame(
    Brackets=c(0),
    Rates =c(0.0658),
    stringsAsFactors=FALSE)

  ### Income Tax Data
  IncomeTax <- data.frame(
    LowThreshold=c(0,7070,8680,12360,20600,37750),
    HighThreshold=c(7070,8680,12360,20600,37750,Inf),
    Rates =c(0,0.25,0.3,0.4,0.45,0.5),
    stringsAsFactors=FALSE)

  ### Wealth Tax Data
  ### Tax Payment
  ExpectedTaxRate <- matrix(,nrow=nb.years,ncol=length(NetWealth))
  ExpectedWealthTax <- NetWealth*0

  FinTheta <- NetWealth*0
  RealTheta <- NetWealth*0
  FinThetas <- data.frame(
    Brackets=c(0,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9),
    Rates =c
       (0.0057,0.0078,0.0108,0.0149,0.0206,0.0284,0.0391,0.0551,0.075,0.1088)
       ,
    stringsAsFactors=FALSE)
  RealThetas <- data.frame(
```

```
    Brackets=c(0),
    Rates =c(0),
    stringsAsFactors=FALSE)
  FinThetasTilde <- data.frame(
    Brackets=c(0,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9),
    Rates =c(0.144,0.196,0.270,0.373,0.515,0.709,0.979,1.379,1.875,2.720),
    stringsAsFactors=FALSE)
  RealThetasTilde <- 0

  FinSigma <- NetWealth*0
  RealSigma <- NetWealth*0
  FinSigmas <- data.frame(
    Brackets=c(0),
    Rates =c(0),
    stringsAsFactors=FALSE)
  RealSigmas <- data.frame(
    Brackets=c(0),
    Rates =c(0.1),
    stringsAsFactors=FALSE)
  FinSigmasTilde <- 0
  RealSigmasTilde <- 0

  WealthTax <- data.frame(
    LowThreshold=c(0,200000,1000000,5000000),
    HighThreshold=c(200000,1000000,5000000,Inf),
    Rates =c(0.001,0.005,0.01,0.02),
    stringsAsFactors=FALSE)

  Omega <- 0
  OmegaTilde <- 1.65
  OmegaImpact <-0

  EffectiveWealthTaxRate <- NetWealth*0

  ### Tax Repayment
  TransferWeight<- 0*NetWealth
  rho <- NetWealth * 0

  ### Output tables
  DataOutput1 <- matrix(,nrow=(nb.years+1),ncol=(length(NetWealth)+1))
  DataOutput2 <- matrix(,nrow=(nb.years+1),ncol=length(NetWealth))
  DataOutput3 <- matrix(,nrow=(nb.years+1),ncol=length(NetWealth))
  DataOutput4 <- matrix(,nrow=(nb.years+1),ncol=length(NetWealth))
```

```
DataOutput5 <- matrix(,nrow=(nb.years+1),ncol=1)

###  Sanity check 1:
#for (i in 1:length(GrossWealthBreakdown[,1])){ print(Reduce("+",
    GrossWealthBreakdown[i,])-GrossWealthBreakdown[i,1])}

## ----------------  1.1. Data creation  ----------------



for (k in 1:length(NetWealth)){
  #2
  for (j in 1:length(DebtTypes$Brackets)){
    for (i in 1:(length(DebtBreakdown[,1]))){
      if((DebtBis[k]>=quantile(DebtBis,c(DebtTypes[j,1])))) {
        DebtBreakdown[i,k] <- DebtBis[k]*DebtTypes[j,(i+1)]
      }
    }
  }

  #3
  for (j in 1:length(GrossWealthBreakdown$Brackets)){
    for (i in 1:(length(WealthBreakdown[,1]))){
      if((GrossWealthBis[k]>=quantile(GrossWealthBis,c(
         GrossWealthBreakdown$Brackets[j])))) {
        WealthBreakdown[i,k] <- GrossWealthBis[k]*GrossWealthBreakdown[j,(
           i+1)]
      }
    }
  }
  #4
  for (j in 1:length(IncomeIncreaseRates$Brackets)){
    if(LaborIncome[k]>quantile(LaborIncome,c(IncomeIncreaseRates$Brackets[
       j]))){
      LaborIncomeIncrease[k] <- IncomeIncreaseRates$GrowthRate[j]
    }
  }
  #5
  for (i in 1:length(Alpha[,1])){
    if (GrossWealthBis[k]!=0){Alpha[i,k] <- WealthBreakdown[i,k]/
       GrossWealthBis[k]}
    else
      Alpha[i,k]<-0
  }
```

```
}

for (k in 1:length(NetWealth)){
  #6
  for (j in 1:length(Return$Brackets)){
    for (i in 1:(length(ReturnBreakdown[,1]))){
      if((WealthBreakdown[i,k]>=quantile(WealthBreakdown[i,],c(Return[j,1])))) {
        ReturnBreakdown[i,k] <- Return[j,(i+1)]
      }
    }
  }
  #7
  for (j in 1:length(ValueGrowth$Brackets)){
    for (i in 1:(length(GrowthBreakdown[,1]))){
      if((WealthBreakdown[i,k]>=quantile(WealthBreakdown[i,],c(ValueGrowth[j,1])))) {
        GrowthBreakdown[i,k] <- ValueGrowth[j,(i+1)]
      }
    }
  }
  #8
  for (j in 1:length(SavingRates$Brackets)){
    if((LaborIncome[k]>=quantile(LaborIncome,c(SavingRates[j,1])))) {
      SavingRate[k] <- SavingRates[j,2]
    }
  }
  #9
  for (j in 1:length(DebtReturnData$Brackets)){
    if((NetWealth[k]>=quantile(NetWealth,c(DebtReturnData[j,1])))) {
      DebtReturn[k] <- DebtReturnData[j,2]
    }
  }
  #10
  for (j in 5:length(WealthBreakdown[,1])){
    FinWealth[k] <- FinWealth[k] + WealthBreakdown[j,k]
  }

  RealWealth[k] <- GrossWealthBis[k]-FinWealth[k]
}
```

```
  DataOutput1[1,] <- append(NetWealth, Gini(NetWealth))
  DataOutput2[1,] <- LaborIncome
  DataOutput3[1,] <- PersonalWealthTax
  DataOutput4[1,] <- TransferWeight
  DataOutput5[1] <- TaxRevenue
```

C.2 Calculations

```
## --------------------------------------------------------------------------------
  ##                                       2. Modelling the impact of wealh taxation
  ## --------------------------------------------------------------------------------

  for (t in 1:nb.years){
    ### ------- 2.1. Wealth Tax payment and repayment computation -------
    if (model > 1){
      for (k in 1:length(NetWealth)){
        ExpectedWealthTax[k]<-0
        for (b in 1:length(WealthTax[,1])){
          ExpectedWealthTax[k] <- ExpectedWealthTax[k] + WealthTax$Rates[b]*max(0,min(WealthTax$HighThreshold[b]-WealthTax$LowThreshold[b],NetWealth[k]-WealthTax$LowThreshold[b]))
        }
        if (NetWealth[k]!=0){
          ExpectedTaxRate[t,k] <- ExpectedWealthTax[k]/NetWealth[k]
        }
        else{
          ExpectedTaxRate[t,k] <- 0
        }
      }
      if (model %in% c(2,3,4,6)){   # calcul de theta (offshoring)
        for (k in 1:length(NetWealth)){
          for (j in 1:length(FinThetas$Brackets)){
            if(GrossWealth[k] >= quantile(GrossWealth,c(FinThetas$Brackets[j]))){
              FinTheta[k] <- FinThetas[j,2] + FinThetasTilde[j,2]*ExpectedTaxRate[t,k]
            }
          }
```

```
      for (j in 1:length(RealThetas$Brackets)){
        if(GrossWealth[k] >= quantile(GrossWealth,c(RealThetas$Brackets[j]))){
          RealTheta[k] <- RealThetas[j,2]+  RealThetasTilde*ExpectedTaxRate[t,k]
        }
      }
    }
  }
    if (model %in% c(2,4,5,8)){   # calcul de sigma (undervaluation)
      for (k in 1:length(NetWealth)){
        for (j in 1:length(FinSigmas$Brackets)){
          if(FinWealth[k]>= quantile(FinWealth,c(FinSigmas$Brackets[j]))){
            FinSigma[k] <- FinSigmas[j,2] + FinSigmasTilde*ExpectedTaxRate[t,k]
          }
        }
        for (j in 1:length(RealSigmas$Brackets)){
          if(RealSigma[k]>= quantile(RealWealth,c(RealSigmas$Brackets[j]))){
            RealSigma[k] <- RealSigmas[j,2]+ RealSigmasTilde*ExpectedTaxRate[t,k]
          }
        }
      }
    }

    if (model %in% c(2,3,5,7)){   # calcul de omega (evasion)
      Omega <- 0
      OmegaImpact <-1
    }

    for (k in 1:length(NetWealth)){
      DeclaredWealth[k] <- (1-FinSigma[k])* (1-FinTheta[k])*FinWealth[k] + (1-RealSigma[k])*(1-RealTheta[k])*RealWealth[k] - DebtBis[k]
    }

    for (k in 1:length(NetWealth)){
      PersonalWealthTax[k]<-0
      for (b in 1:length(WealthTax[,1])){
        PersonalWealthTax[k] <- PersonalWealthTax[k] + WealthTax$Rates[b]*max(0,min(WealthTax$HighThreshold[b]-WealthTax$LowThreshold
```

```
             [b],DeclaredWealth[k]-WealthTax$LowThreshold[b]))
        }

      }
      EffectiveWealthTaxRate <- sum(PersonalWealthTax)/sum(DeclaredWealth)
      TaxRevenue <- sum(PersonalWealthTax)/(1+OmegaImpact*(Omega+
         OmegaTilde*EffectiveWealthTaxRate))
      print(TaxRevenue)
      for (k in 1:length(NetWealth)){
        rho[k] <- 0
        if (PersonalWealthTax[k]>0){
          rho[k] <- 1
        }
      }
      kappa <- 1 - sum(rho)/length(NetWealth)
      if (kappa == 0){
        TransferWeight <- 0*NetWealth
      }
      else{
        for (k in 1:length(NetWealth)){
          TransferWeight[k] <- 0
          TransferWeight[k] <- max((1 - 1/(((kappa*length(NetWealth))/(
             rank(NetWealth)[k]^epsilon)))),0)
        }
    }
}
  ### ------- 2.2. Personal income Tax computation -------
  for (k in 1:length(NetWealth)){
    PersonalIncomeTax[k] <- 0
    for (b in 1:length(IncomeTax[,1])){
      PersonalIncomeTax[k] <- PersonalIncomeTax[k] + IncomeTax$Rates[b]*
         max(0,min(IncomeTax$HighThreshold[b]-IncomeTax$LowThreshold[b],
         LaborIncome[k]-IncomeTax$LowThreshold[b]))
    }
    DispIncome[k] <- LaborIncome[k] - PersonalIncomeTax[k]
  }
  ### ------- 2.3. Net Wealth variation -------
  for (k in 1:length(NetWealth)){
    AssetReturn[k] <- 0
    z <- 0
    for (c in 1:length(WealthBreakdown[,1])){
      if (GrowthBreakdown[c,k]>=0){
        z <- 1
```

```
      }
      AssetReturn[k] <- AssetReturn[k] + Alpha[c,k]*((1-ReturnTax[1,c])*ReturnBreakdown[c,k]+(1-ValueGrowthTax[1,c]*z)*GrowthBreakdown[c,k])
    }
    if((Beta[k]<1) & (NetWealth[k]>0)){
      ReturnEffect[k] <- (1/(1-Beta[k]))*(AssetReturn[k]-Beta[k]*DebtReturn[k])
    }
    else if ((Beta[k]>1) & (NetWealth[k]<0)){
      ReturnEffect[k] <- (1/(1-Beta[k]))*(AssetReturn[k]-Beta[k]*DebtReturn[k])
    }
    else{
      ReturnEffect[k] <- (1/(1-Beta[k]))*(DebtReturn[k]-Beta[k]*AssetReturn[k])
    }

    if (NetWealth[k]!=0){
      if (model == 1) {
        deltaWealth[k] <- ((SavingRate[k]*DispIncome[k])/((1-Beta[k])*GrossWealth[k])) + ReturnEffect[k]
      }
      else if (kappa==0){
        deltaWealth[k] <- ((SavingRate[k]*DispIncome[k])/((1-Beta[k])*GrossWealth[k])) + ReturnEffect[k] - PersonalWealthTax[k]/((1-Beta[k])*GrossWealth[k])
      }
      else {
        deltaWealth[k] <- ((SavingRate[k]*DispIncome[k])/((1-Beta[k])*GrossWealth[k])) + ReturnEffect[k] - PersonalWealthTax[k]/((1-Beta[k])*GrossWealth[k]) + (mu*TaxRevenue*(TransferWeight[k]/sum(TransferWeight)))/((1-Beta[k])*GrossWealth[k])
      }
      NetWealth[k] <- (1+deltaWealth[k])*NetWealth[k]
    }
    else {
      if (model == 1) {
        DeltaWealth[k] <- SavingRate[k]*DispIncome[k]
      }
      else {
        DeltaWealth[k] <- SavingRate[k]*DispIncome[k] - PersonalWealthTax[k] + (mu*sum(TaxRevenue)*(TransferWeight[k]/sum(TransferWeight)
```

```
          ))
      }
      NetWealth[k] <- NetWealth[k] + DeltaWealth[k]
    }
  }

  ### ------- 2.3. Portfolio adjustment -------

  for (k in 1:length(NetWealth)){
    for (j in 1: length(Betas$Brackets)){
      if (NetWealth[k]>=quantile(NetWealth,Betas$Brackets[j])){
        Beta[k] <- Betas$Rate[j]
      }
    }
  }
  GrossWealth <- NetWealth/(1-Beta)
  Debt <- GrossWealth - NetWealth
  GrossWealthBis <- GrossWealth*0
  DebtBis <- Debt * 0
  for (k in 1:length(NetWealth)){
    if (GrossWealth[k]>0){
      GrossWealthBis[k]<-GrossWealth[k]
      DebtBis[k] <- Debt[k]
    }
    else {
      GrossWealthBis[k]<- -1*Debt[k]
      DebtBis[k] <- -1* GrossWealth[k]
    }
  }
  for (k in 1:length(NetWealth)){
    LaborIncome[k] <- LaborIncome[k]*(1+LaborIncomeIncrease[k])

    for (j in 1:length(DebtTypes$Brackets)){
      for (i in 1:(length(DebtBreakdown[,1]))){
        if((DebtBis[k]>=quantile(DebtBis,c(DebtTypes[j,1])))) {
          DebtBreakdown[i,k] <- DebtBis[k]*DebtTypes[j,(i+1)]
        }
      }
    }
    for (j in 1:length(GrossWealthBreakdown$Brackets)){
      for (i in 1:(length(WealthBreakdown[,1]))){
        if((GrossWealthBis[k]>=quantile(GrossWealthBis,c(
            GrossWealthBreakdown$Brackets[j])))) {
```

```
          WealthBreakdown[i,k] <- GrossWealthBis[k]*GrossWealthBreakdown[j,(i+1)]
        }
      }
    }
    for (i in 1:length(Alpha[,1])){
      if (GrossWealthBis[k]!=0){Alpha[i,k] <- WealthBreakdown[i,k]/GrossWealthBis[k]}
      else
        Alpha[i,k]<-0
    }
  }

  for (k in 1:length(NetWealth)){
    for (j in 1:length(IncomeIncreaseRates$Brackets)){
      if(LaborIncome[k]>quantile(LaborIncome,c(IncomeIncreaseRates$Brackets[j]))){
        LaborIncomeIncrease[k] <- IncomeIncreaseRates$GrowthRate[j]
      }
    }
    for (j in 1:length(Return$Brackets)){
      for (i in 1:(length(ReturnBreakdown[,1]))){
        if((WealthBreakdown[i,k]>=quantile(WealthBreakdown[i,],c(Return[j,1])))) {
          ReturnBreakdown[i,k] <- Return[j,(i+1)]
        }
      }
    }
    for (j in 1:length(ValueGrowth$Brackets)){
      for (i in 1:(length(GrowthBreakdown[,1]))){
        if((WealthBreakdown[i,k]>=quantile(WealthBreakdown[i,],c(ValueGrowth[j,1])))) {
          GrowthBreakdown[i,k] <- ValueGrowth[j,(i+1)]
        }
      }
    }
    for (j in 1:length(SavingRates$Brackets)){
      if((LaborIncome[k]>=quantile(LaborIncome,c(SavingRates[j,1])))) {
        SavingRate[k] <- SavingRates[j,2]
      }
    }
    FinWealth[k]<-0
    for (j in 5:length(WealthBreakdown[,1])){
```

```
        FinWealth[k] <- FinWealth[k] + WealthBreakdown[j,k]
      }
      RealWealth[k] <- GrossWealthBis[k]-FinWealth[k]
    }
```

C.3 Reporting

```
### ------- 2.4. Output computation -------

    DataOutput1[t+1,] <- append(NetWealth, Gini(NetWealth))
    DataOutput2[t+1,] <- LaborIncome
    DataOutput3[t+1,] <- PersonalWealthTax
    DataOutput4[t+1,] <- TransferWeight
    DataOutput5[t+1] <- TaxRevenue
  }

  if(model == 1){
    write.xlsx(DataOutput1, "Output11.xlsx")
    write.xlsx(DataOutput2, "Output12.xlsx")
    write.xlsx(DataOutput3, "Output13.xlsx")
    write.xlsx(DataOutput4, "Output14.xlsx")
    write.xlsx(DataOutput5, "Output15.xlsx")
  }
  else if (model == 2){
    write.xlsx(DataOutput1, "Output21.xlsx")
    write.xlsx(DataOutput2, "Output22.xlsx")
    write.xlsx(DataOutput3, "Output23.xlsx")
    write.xlsx(DataOutput4, "Output24.xlsx")
    write.xlsx(DataOutput5, "Output25.xlsx")
  }
  else if (model == 3){
    write.xlsx(DataOutput1, "Output31.xlsx")
    write.xlsx(DataOutput2, "Output32.xlsx")
    write.xlsx(DataOutput3, "Output33.xlsx")
    write.xlsx(DataOutput4, "Output34.xlsx")
    write.xlsx(DataOutput5, "Output35.xlsx")
  }
  else if (model == 4){
    write.xlsx(DataOutput1, "Output41.xlsx")
    write.xlsx(DataOutput2, "Output42.xlsx")
    write.xlsx(DataOutput3, "Output43.xlsx")
    write.xlsx(DataOutput4, "Output44.xlsx")
    write.xlsx(DataOutput5, "Output45.xlsx")
```

```
  }
  else if (model == 5){
    write.xlsx(DataOutput1, "Output51.xlsx")
    write.xlsx(DataOutput2, "Output52.xlsx")
    write.xlsx(DataOutput3, "Output53.xlsx")
    write.xlsx(DataOutput4, "Output54.xlsx")
    write.xlsx(DataOutput5, "Output55.xlsx")
  }
  else if (model == 6){
    write.xlsx(DataOutput1, "Output61.xlsx")
    write.xlsx(DataOutput2, "Output62.xlsx")
    write.xlsx(DataOutput3, "Output63.xlsx")
    write.xlsx(DataOutput4, "Output64.xlsx")
    write.xlsx(DataOutput5, "Output65.xlsx")
  }
  else if (model == 7){
    write.xlsx(DataOutput1, "Output71.xlsx")
    write.xlsx(DataOutput2, "Output72.xlsx")
    write.xlsx(DataOutput3, "Output73.xlsx")
    write.xlsx(DataOutput4, "Output74.xlsx")
    write.xlsx(DataOutput5, "Output75.xlsx")
  }
  else if (model == 8){
    write.xlsx(DataOutput1, "Output81.xlsx")
    write.xlsx(DataOutput2, "Output82.xlsx")
    write.xlsx(DataOutput3, "Output83.xlsx")
    write.xlsx(DataOutput4, "Output84.xlsx")
    write.xlsx(DataOutput5, "Output85.xlsx")
  }
  else if (model == 9){
    write.xlsx(DataOutput1, "Output91.xlsx")
    write.xlsx(DataOutput2, "Output92.xlsx")
    write.xlsx(DataOutput3, "Output93.xlsx")
    write.xlsx(DataOutput4, "Output94.xlsx")
    write.xlsx(DataOutput5, "Output95.xlsx")
  }
}

##
   ------------------------------------------------------------------------------------
##     3. Sanity checks
##
```

```
------------------------------------------------------------------------
# #
# ##  Sanity check: is, for each individual, net wealth equal to GrossWealth - Debt?
# Check <- GrossWealth*0
# for (k in 1:length(GrossWealth)){Check[k]<- round((GrossWealth[k]-Debt[k]) - NetWealth[k])}
# print(sum(Check)==0)
#
# ##  Sanity check: is, for each individual, gross wealth equal to finWealth +RealWealth?
# Check <- GrossWealth*0
# for (k in 1:length(GrossWealth)){Check[k]<- round((FinWealth[k]+RealWealth[k]) - GrossWealthBis[k])}
# print(sum(Check)==0)
#
# ##  Sanity check: is, for each individual, net wealth equal to finWealth+ RealWealth-debts?
# Check <- GrossWealth*0
# for (k in 1:length(GrossWealth)){Check[k]<- round((FinWealth[k]+RealWealth[k]-DebtBis[k]) - NetWealth[k])}
# print(sum(Check)==0)
#
# #  Sanity check: is, for each individual, the sum of its alpha equal to 1??
# Check <- NetWealth*0
#   for (k in 1:length(NetWealth)){
#     for (j in 1:length(Alpha[,1])){
#       Check[k] <- Check[k] + Alpha[j,k]
#     }
#   }
# sum(Check)/length(Check)==1



## ------------------------------------------------------------------------
##      x. Closing the model
## ------------------------------------------------------------------------
```

```
 print (proc.time() - ptm)
#sink()
#warnings()
#write.xls(GrossWealth, "data.xlsx")
```

Appendix D

Data estimates

D.1 Vehicle depreciation rate

Manufacturer	Model	Year	Engine	Transmission
Honda	Accord EX-L	2016	2L/4-cyl	Automatic
Audi	A3 Premium Plus	2016	2L/4-cyl	Manual
Ford	Hatchback Titanium	2016	2L/4-cyl	Automated manual
Jaguar	XF Premium	2015	2L/4-cyl	Automatic
Volkswagen	Golf hatchback TSI S	2016	1.8L/4-cyl	Automatic
Toyota	Prius Hatchback Four Touring	2016	1.8L/4-cyl	Automatic
Volvo	V60 T5 Drive-E Premium	2016	2L/4-cyl	Automatic
Smart	ForTwo convertible passion	2016	1L/3-cyl	Automated manual
Porsche	911 Carrera GTS	2016	3.8L/6-cyl	Manual
Mercedes-Benz	C-Class sport 4matic	2016	2L/4-cyl	Automatic

Table D.1: Types of vehicles considered to estimate the depreciation rate

Source: Edmunds (2016)

Assuming these cars represent a correct approximation of the car pool in Belgium, that US depreciation rates apply in Belgium and that these past data is a good proxy for the future, the average yearly depreciation rate is 15.83%.

Vehicle	Initial market value (US$)	5-year total depreciation (US$)	CAGR (5-year)
Honda Accord	23 532	13 593	-15.83%
Audi A3	36 272	19 340	-14.13%
Ford Focus	20 107	25 189	-15.77%
Jaguar XF	45 483	11 581	-14.91%
Volkswagen Golf	19 763	9 786	-12.78%
Toyota Prius	24 127	15 494	-18.58%
Volvo V60	37 220	19 131	-13.44%
Smart ForTwo	16 849	10 847	-18.65%
Porsche 911	105 395	67 277	-18.41%
Mercedes C-Class	41 995	24 188	-15.77%

Table D.2: Depreciation of market value for selected vehicles

Source: Edmunds (2016)

D.2 Hidden share of assets

D.2.1 Method

Zucman (2015) estimates the share of financial assets in Europe to evade tax by being offshore to 8% (80% undeclared of 10% offshored). The Boston Consulting Group (2013, 2014, 2015) provides similar numbers. This tells us that that the sum of the products between individual financial offshore rates and individual financial assets equals 8% multiplied by the sum of individual financial assets. That is,

$$\sum_{j=1}^{n} \hat{\theta}_t^{f,j} \cdot a_t^{f,j} = \hat{\theta}_t^{f} \sum_{j=1}^{n} a_t^{f,j}$$

with $\hat{\theta}_t^f = 10\%$ where j denotes an individual and f the set of financial assets. The problem now comes down to derive individual offshore rates. It is fair to assume that the higher the assets of an individual, the higher his evasion abilities. We write

$$\hat{\theta}_t^{f,j} = z_t \cdot \hat{\theta}_t^{f,j-1} \text{ and we set } z_t > 1$$

where the j's are increasingly sorted according to assets and z is a progressiveness factor in the offshoring behavior of between individuals. Combining both equations, we have for any j that

$$\sum_{k=1}^{j-1} \left[\left(\frac{\hat{\theta}_t^{f,j}}{(z_t)^k} \right) a_t^{f,j-k} \right] + \hat{\theta}_t^{f,j} \cdot a_t^{f,j} + \sum_{k=1}^{n-j} \left[\left(\hat{\theta}_t^{f,j} \cdot (z_t)^k \right) a_t^{f,j+k} \right] = \hat{\theta}_t^{f} \sum_{k=1}^{n} a_t^{f,k}$$

which leads to

$$\hat{\theta}_t^{f,j} = \frac{\hat{\theta}_t^f \sum_{k=1}^{n} a_t^{f,k}}{a_t^{f,j} + \sum_{k=1}^{j-1} \left[\frac{a_t^{f,j-k}}{(z_t)^k}\right] + \sum_{k=1}^{n-j} \left[(z_t)^k \cdot a_t^{f,j+k}\right]}.$$

The easiest way to compute the rates is to start with $j = 1$ and then move froward according to z_t:

$$\hat{\theta}_t^{f,1} = \frac{\hat{\theta}_t^f \sum_{k=1}^{n} a_t^{f,k}}{a_t^{f,1} + \sum_{k=1}^{n-1} \left[(z_t)^k \cdot a_t^{f,1+k}\right]} \text{ and } \hat{\theta}_t^{f,j} = z_t \cdot \hat{\theta}_t^{f,j-1} \text{ for } j \in \{2, 3, \cdots, n\}.$$

Then, $\hat{\theta}_t^{f,i}$ is given the value of $\hat{\theta}_t^{f,j}$ for the only j satisfying $\phi_t^{a^f}(i) = j$ where $\phi_t^{a^f}(i)$ is the inverse rank of individual i on the scale of financial assets in t. In our opinion, the main bias of this approach is that it assumes continuous progressiveness in offshoring behavior of between individuals. Reality most likely has a pattern where offshoring rates present jumps for certain levels of gross wealth. The lack of data does not allow to integrate this aspect.

D.2.2 Outcome for the fixed part of assets hiding

Taking the distribution of assets in $t = 0$ (result of section 9.1) and adjusting the progressiveness factor to obtain lowest and highest hiding rates which makes sense $z_t = 1.002$ (result of own adjustment generating rates between 0.5% and 11%), figure D.1 follows.

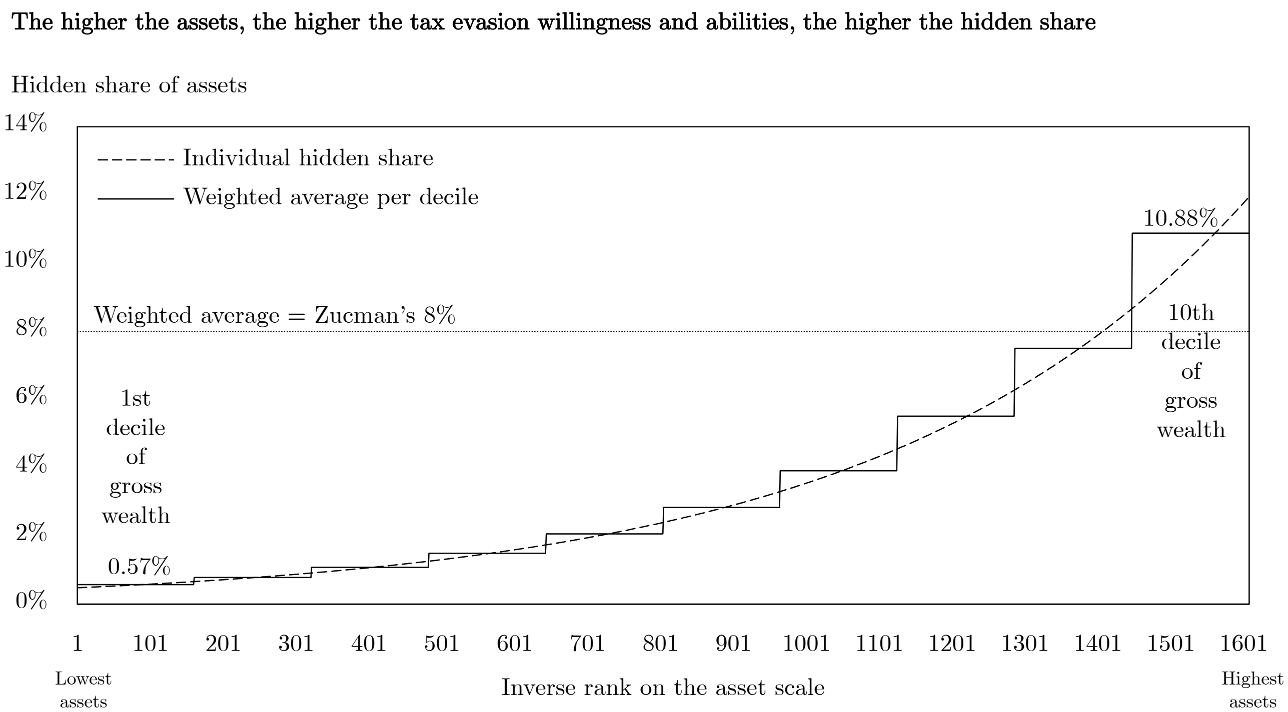

Figure D.1: Estimation of the fixed hidden share of financial assets ($\hat{\theta}_t^{f,i}$) in $t = 0$

Source: Zucman (2015), own calculations

D.2.3 Outcome for the variable part of assets hiding

Applying the exact same process but replacing 8% by the an average adjusted semi-elasticity of 2, figure D.2 follows.

The higher the assets, the higher the tax evasion willingness and abilities, the higher the sensitivity of hiding behavior to change in wealth tax

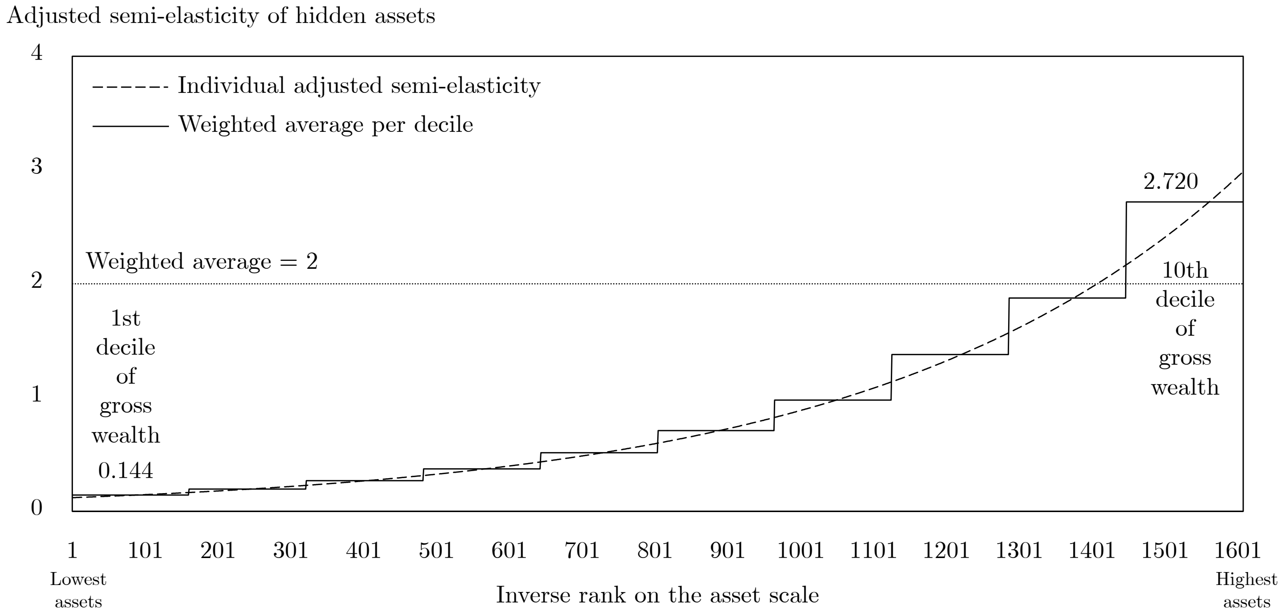

Figure D.2: Estimation of the variable hidden share of financial assets ($\tilde{\theta}_t^{f,i}$) in $t = 0$

Source: Own calculations

Appendix E

Results from the model

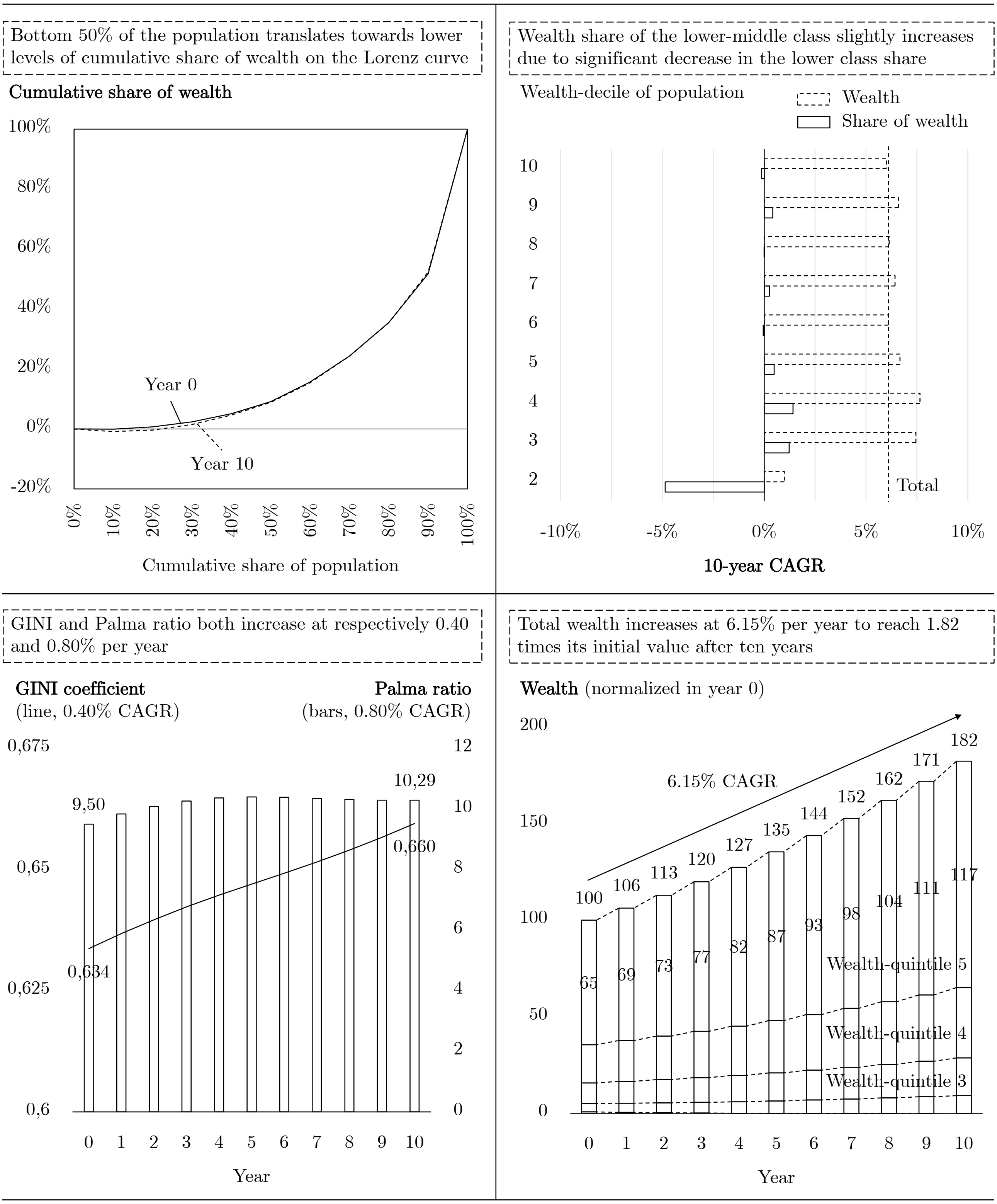

Figure E.1: Dynamics without Piketty's tax

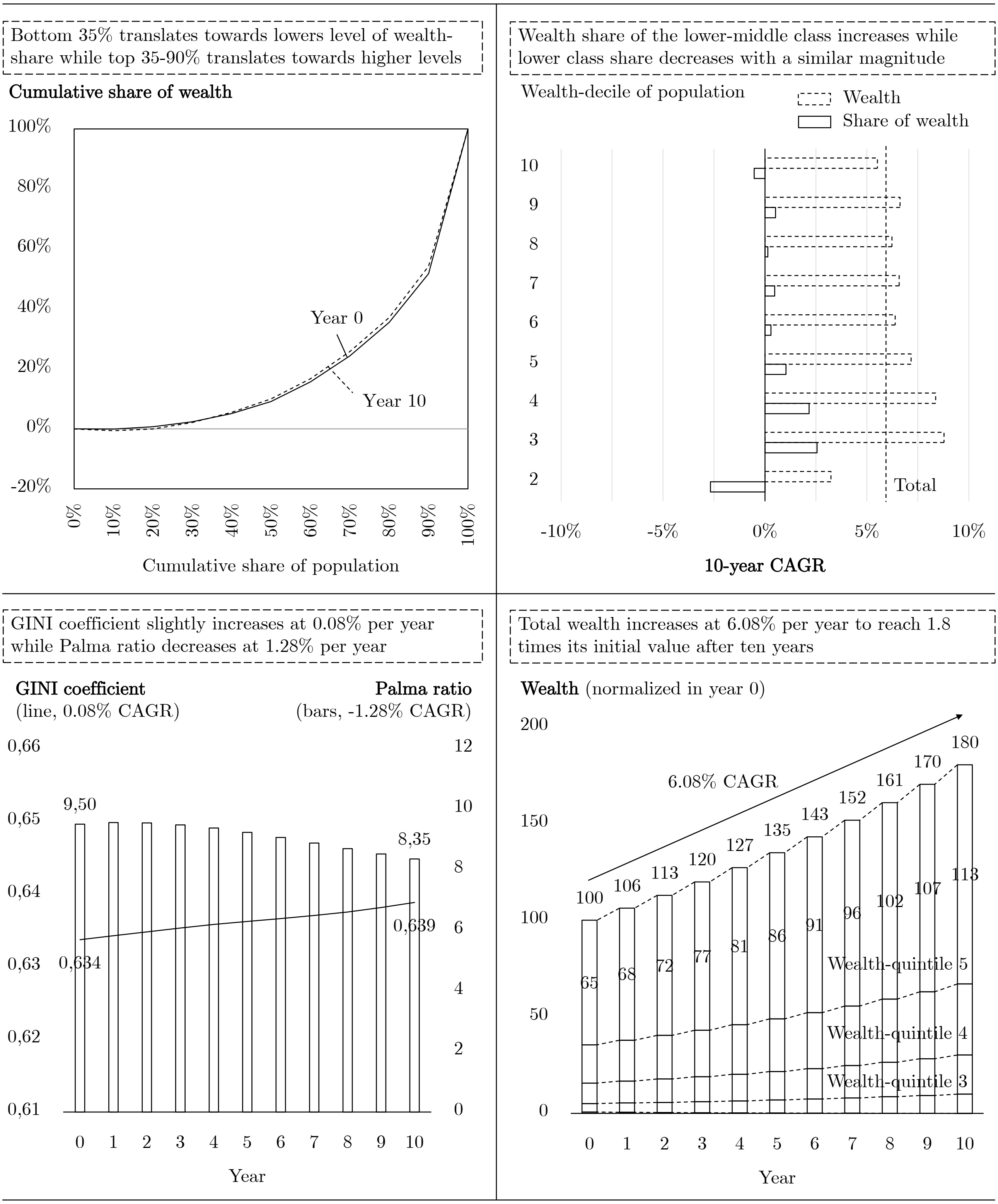

Figure E.2: Dynamics with light tax, linear redistribution and no evasion

Note: Wealth tranches and rates in table 4.1 (design 1), $\epsilon_t = 1$, κ_t as equation (8.7), $\mu_t = 100\%$, no θ-effect, no σ-effect, no ω-effect

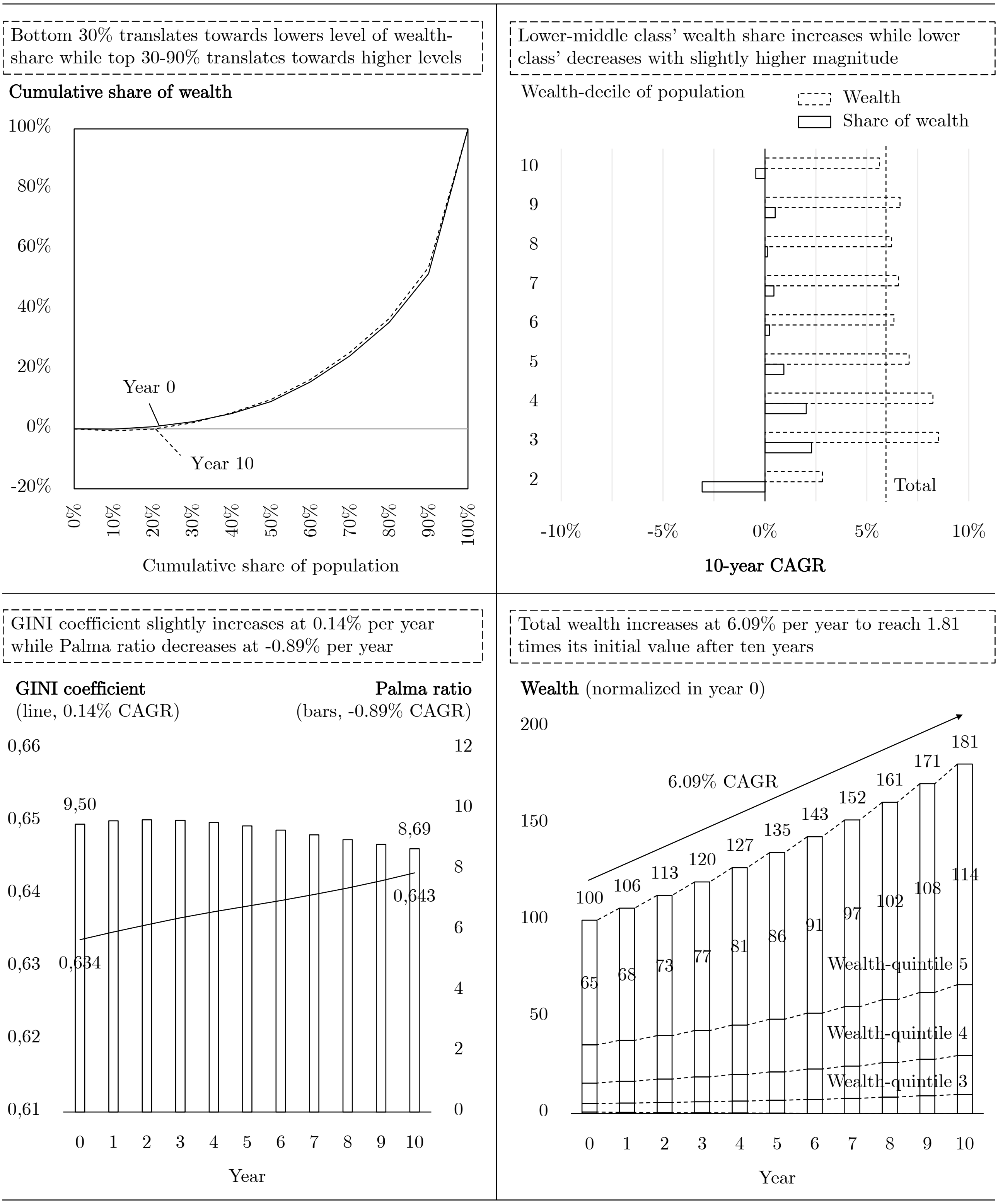

Figure E.3: Dynamics with light tax, linear redistribution and tax evasion

Note: Wealth tranches and rates in table 4.1 (design 1), $\epsilon_t = 1$, κ_t as equation (8.7), $\mu_t = 100\%$, θ-effect, σ-effect, ω-effect

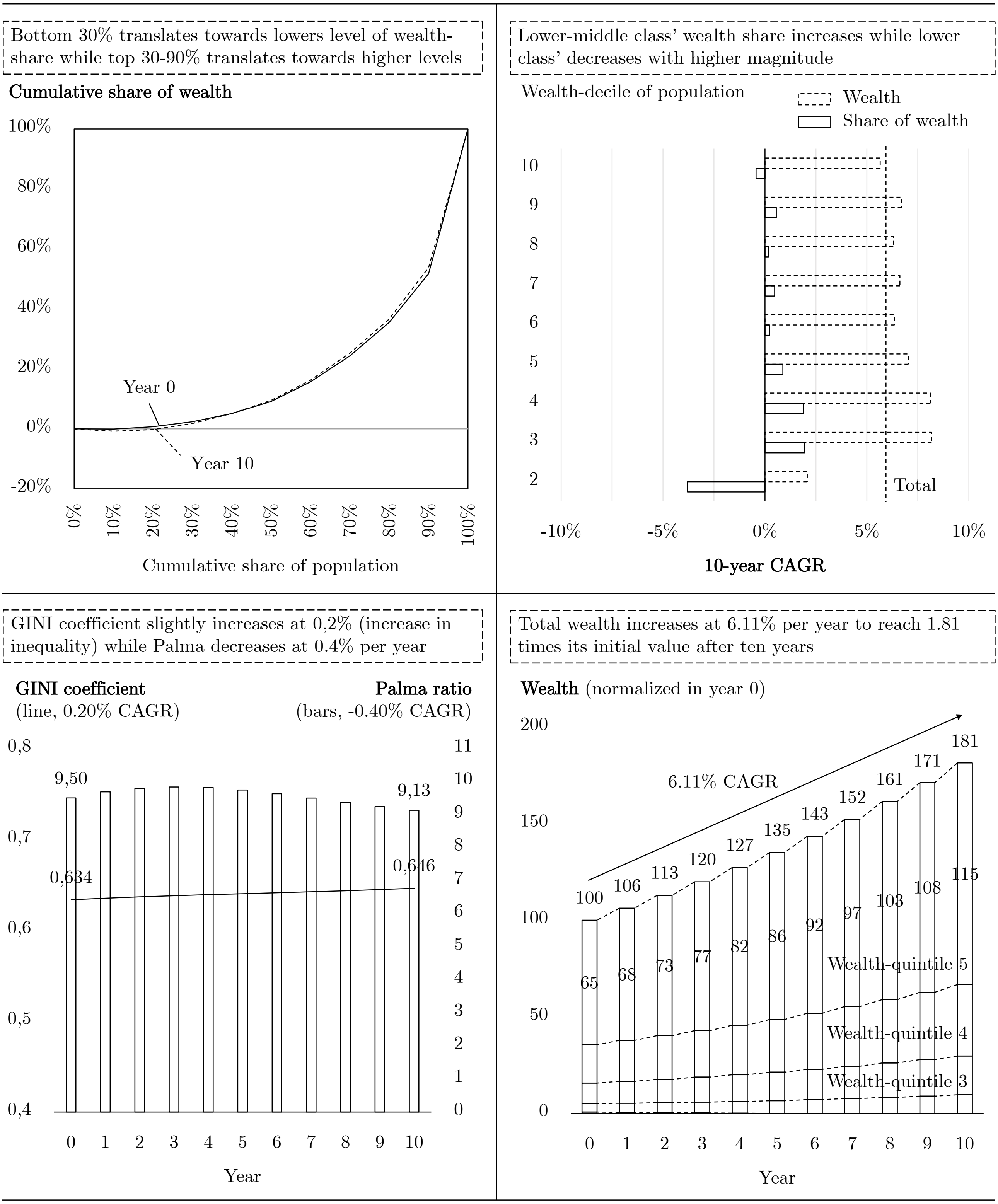

Figure E.4: Dynamics with light tax, relatively intense redistribution and tax evasion

Note: Wealth tranches and rates in table 4.1 (design 1), $\epsilon_t = 0.1$, κ_t as equation (8.7), $\mu_t = 100\%$, θ-effect, σ-effect, ω-effect