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Universal Basic Income Reforms and Household Composition: A Behavioural Microsimulation Analysis

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Preface

About a year ago I would never have thought that I would finish my master's degree with a study on *universal basic income*. Of course,I had heard of the term before, but as an actual research area for my graduation it only came up during the introductory meeting at Topicus. After reading about the subject my curiosity was triggered. In the process of setting up a research proposal, *smart contract* dropped out dragging *blockchain technology* with it. But basic income crossed the finish line.

Meanwhile, in conversations with colleagues, family and friends, I more often took the role of advocate than of the devil's advocate. Not that I am a strong supporter of the idea, but rather because a conversation about basic income, soon ended up with me defending the supposed benefits. Most of the times, because we seem to find it unreasonable to give people money without requiring anything in return. However, suppose that our welfare grows to such a level that not everyone has to work anymore. Why does automation not finally take over a considerable number of elementary jobs, without continuously creating new ones purely to ensure that someone can earn their income? Nevertheless, basic income started as a very interesting thought experiment which is now being tested in practice. I wonder when I read my work in a few years' time, if any form of basic income has become reality.

During the months of working on—what has become—the deliverable that lies in front of you, I have received a lot of help and support from family, friends, and of course my girlfriend. I would like to thank them all for challenging and motivating me, for thinking along or listening to me. The research was not always easy and that is why I am even more proud of the end result. I would also like to thank Topicus for providing the facilities to do my research. Finally, I would like to thank my internal and external supervisors for their insight that the research has brought to this end result.

Martijn, January 17 2019

Summary

In our research we analyse the effects of changes in household composition on universal basic income (UBI) reforms. UBI aims to provide every individual with a periodic payment, unconditionally and universally. It is supposed to decrease inequality and poverty, by assuring every individual receives an equal benefit payment without work requirement or means-test.

Research and experiments concerning UBI are very popular. However, we observed a limitation in microsimulation studies concerning UBI reforms. At present, behavioural responses to a UBI tax-benefit reform are not included in the scientific research area that encompass microsimulation models, e.g. household composition and marriages and divorces. Our research focuses on one specific type of behavioural response, household composition behaviour. We propose it should be included in microsimulation of UBI reforms.

The research question of this study is: *To what extent do changes in household composition, supposedly caused by a universal basic income reform, affect this UBI reform within one year after implementation?*

Our approach encompasses tests whether a change in household composition behaviour affects a UBI tax-benefit system significantly, in what direction it alters the system, and how this alteration compares to the original system. We determine measures that indicate changes in inequality and poverty and use these to compare the observed effects. For our microsimulation exercise we use the Italian tax-benefit system and Italian household data.

First, we model a UBI reform that satisfies the characteristics, as outlined in the definition, to an acceptable extent. This is conducted in a way that the reform complies with the *government budget constraint*. Furthermore, we abolish all benefit and income tax credit and deductible policies, except for the ones that specifically target the retired, disabled and sick. This results in a UBI with a monthly payment of €980, social insurance contribution rate of 39.35 % and a flat income tax rate of 44 %. Children only receive half the amount. Using microsimulation, this UBI reform shows to be favourable for the inequality and poverty measurements, which is a claimed purpose of UBI.

Thereafter, we model three scenarios. One is the *base* scenario, in which a common change in household composition is applied. This results in more households deciding to separate than to cohabit. Then there are two alternative scenarios, one increasing the cohabitation rate and one increasing the separation rate, respectively called the *cohabitation* and *separation* scenario. These scenarios are microsimulated using the UBI reform.

Lastly, we evaluate the scenarios in several ways. We determine whether the inequality and poverty measurements change significantly using a Welch's t-test. Then, we observe in what direction they alter and how this alteration compares to the original system when using the same scenarios.

It appears that changes in household composition do change the performance of the tax-benefit system. *Cohabitation* is favourable for the inequality and poverty measurements, while *separation* is unfavourable. This holds for both the original tax-benefit system and UBI reform. However, in the case of poverty the consequences are more severe than they would be in the original system.

The main conclusion we draw from these results is that changes in household composition, due to a UBI reform, influence a tax-benefit system with a different magnitude than for the original system. The effects to inequality and poverty are different. The results show UBI is performing better at keeping the income distribution constant, while the original system is better at keeping the targeting of low incomes constant.

Therefore, it is recommended to include the behavioural response variable in *dynamic behavioural microsimulation* models in future research. Besides, we also advise to examine the effect of a reform on household composition. Lastly, other behavioural response variables should be investigated as well, e.g. marriages and migration.

Our research has shown that a change in household composition affects the tax-benefit system different for a UBI reform than in the original system. Therefore, our research encourages to investigate the real effects of a UBI reform on household composition behaviour. Moreover, it tells us that we should not only consider household behaviour when designing a UBI reform, but whenever changes to tax systems are proposed.

Contents

List of Acronyms

UBI universal basic income

ISTAT Italian Institute of Statistics

ISER Institute for Social and Economic Research

SILC Statistics on Income and Living Conditions

BIEN Basic Income European Network

NIT negative income tax

GMI guaranteed minimum income

CBI conditional basic income

MTR marginal tax rate

FT flat-tax

SIC social insurance contribution

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Chapter 1

Introduction

1.1 Experiments with Universal Basic Income Are Popular

Numerous experiments are being done by researchers and governments to test for the effects of a universal basic income (UBI). For example, in Finland, The Netherlands, Kenya and Brazil experiments are being or have been conducted (Widerquist, 2018). Moreover, the speed at which scientific literature about the topic is published, is at its all-time high. To illustrate this, the number of publications concerning UBI over the years can be seen in Figure 1.1.

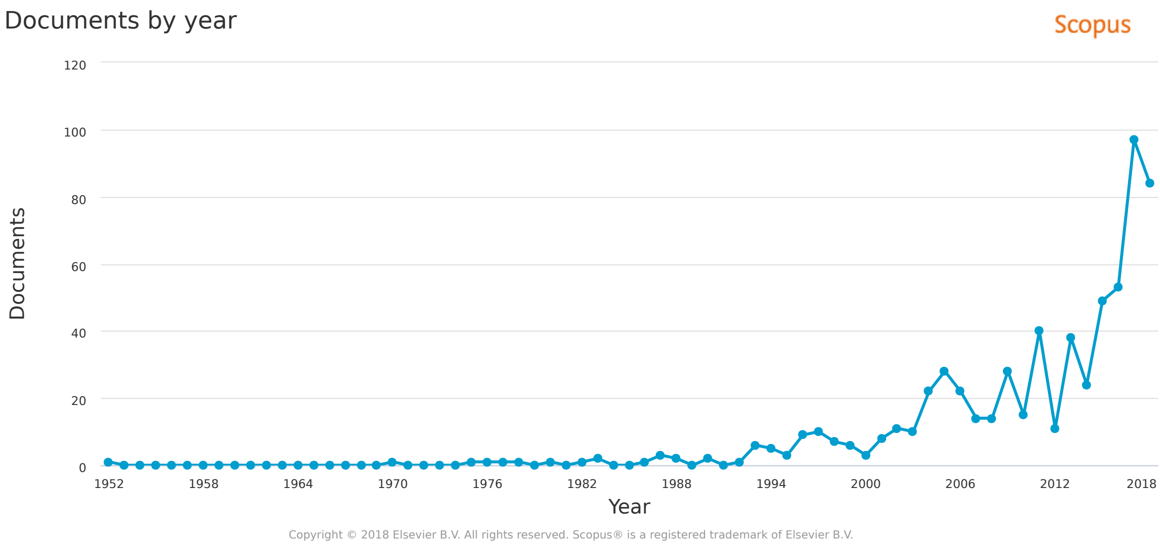


Figure 1.1: Number of UBI publications over the years (Scopus, 2018).

It is remarkable that the idea has supporters on all sides of the political spectrum. Socialists find the inequality decreasing and social security increasing effects appealing, while classical liberals like the idea because there is less governmental means-testing required and the benefit is freely disposable. In the United States a presidential candidate for the year 2020 has even put the topic at the top of his electoral programme (Bizarro, 2018; McLaughlin, 2018). One cause, allowing the discussion to continue, is the ongoing technological development, in terms of the widened technological possibilities and increasing globalisation.

Already in the 18th century Thomas Paine and Thomas Spence advocated basic income (King & Marangos, 2006). Paine was confronted with the problem of poverty, a consequence he claimed was created by civilised life. Poverty does not exist in the natural state of society: a state without private property. In the civilised state, however, land becomes property of the few and efficiency improves, but it also allows for poverty to arise (King & Marangos, 2006). Therefore, Paine came up with the idea to put a tax on land and private property, as he argued they are an effect of society. Paine argued this preliminary form of UBI eliminates poverty.

A few years later, Spence came up with a similar idea. Possibly influenced by Paine, he argued to redistribute rental income of landowners among everybody, as land should be declared common property (King & Marangos, 2006). Nowadays, the concept of a UBI is investigated for various reasons by experts from a variety of scientific fields, such as economists and philosophers, and debated by politicians from different countries (e.g., Bregman, 2016; Browne & Immervoll, 2017; Clavet *et al.*, 2013; Sage & Diamond, 2017; Standing, 2017; Van Parijs & Vanderborght, 2017; Watson & Bianca, 2018; Zwolinski, 2015).

1.1.1 Providing Some Background Information

The concept of UBI claims that every individual should receive an unconditional amount of money. So, this money is given to an individual and not dependent on the household size. All beneficiaries can top up their income matching their own needs with income from other sources, without losing eligibility to the benefit.

The advocates propose various arguments. It would give people more freedom to decline jobs, to participate in training, or to perform unpaid social tasks such as care for the elderly. Additionally, it would remove the complicated means-tests and abolish stigmatisation of poor and unemployed (Van Parijs & Vanderborght, 2017). Many current social welfare systems have been criticised, because of these means-tests, stigmatisation, and wrong incentives to reintegrate in the labour market. Those welfare systems have shown to maintain the gap between rich and poor. The weakest segments of society get stuck in the safety net of social assistance, while the holders of proper jobs prosper (Van Parijs, 1992).

There are also some concerns regarding UBI, e.g. the consequences it may have to the participation rate. Critics wonder whether people become less dependent on work due to an unconditional monthly benefit so that they will participate less in the labour market (Sage & Diamond, 2017). More advantages and disadvantages are discussed in Section 2.1.3.

A growing amount of empirical research is performed to evaluate the effects of UBI. Those effects are identified or tested by conducting experiments, or by evaluating existing UBI-like implementations. The experiments and implementations take place in various countries as can be seen in Figure 1.2. UBI experiments are expensive, so limitations are inherent. For example, they are performed on a sample of the population and conducted for a limited amount of time. So, the actual impact of a UBI can never be fully predicted by conducting experiments. For this reason, researchers have to accept that their experiment samples do not reflect the total population. In Finland, for instance, only unemployed individuals were included, which conflicts with the characteristics of a UBI (Kela, 2016b).

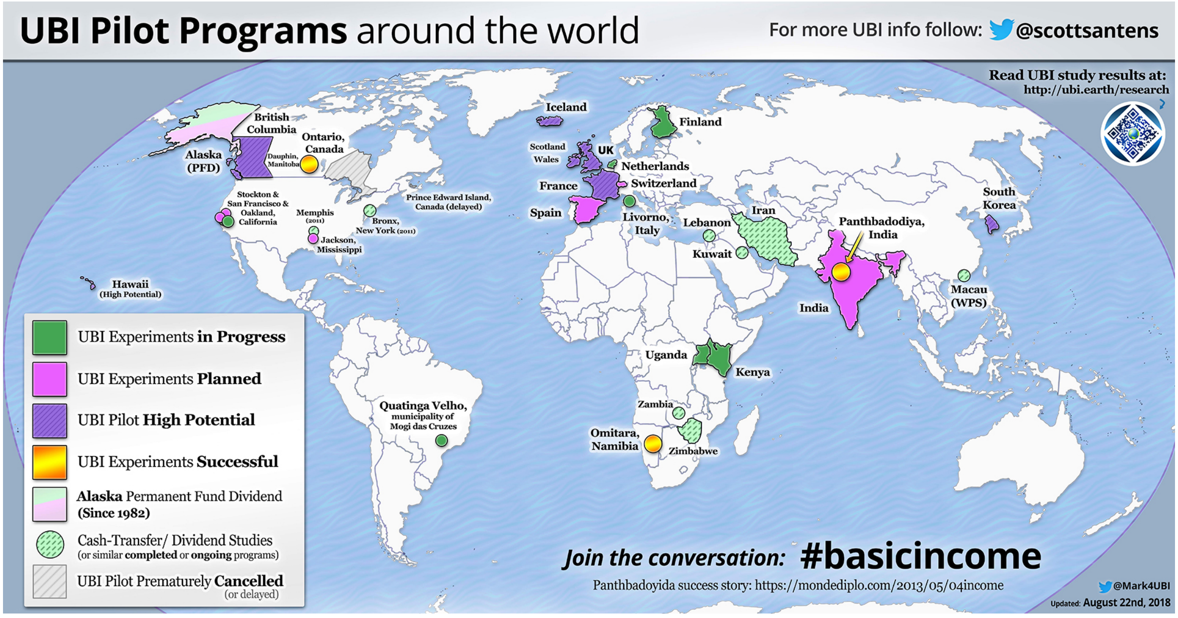


Figure 1.2: Past, current and future UBI pilot programs (scottsantens, 2018).

1.1.2 Observation of the Problem

In addition to the experiments, other types of research test for various effects of a UBI reform. One example of such a research area uses optimal taxation to model the effects of UBI (e.g. Clavet *et al.*, 2013; Van der Veen, 2004). Another type uses microsimulation to simulate these effects (e.g. Browne & Immervoll, 2017; Duncan & Weeks, 1997; Honkanen, 2014; Horstschräer *et al.*, 2010; Jessen *et al.*, 2017; Scutella, 2004). A third type combines the first two (e.g. Colombino, 2015a, 2015b; Colombino *et al.*, 2010; Islam & Colombino, 2018; Labeaga *et al.*, 2008). Most test for labour supply effects and/or distributional effects (e.g. Garfinkel *et al.*, 2002; Horstschräer *et al.*, 2010).

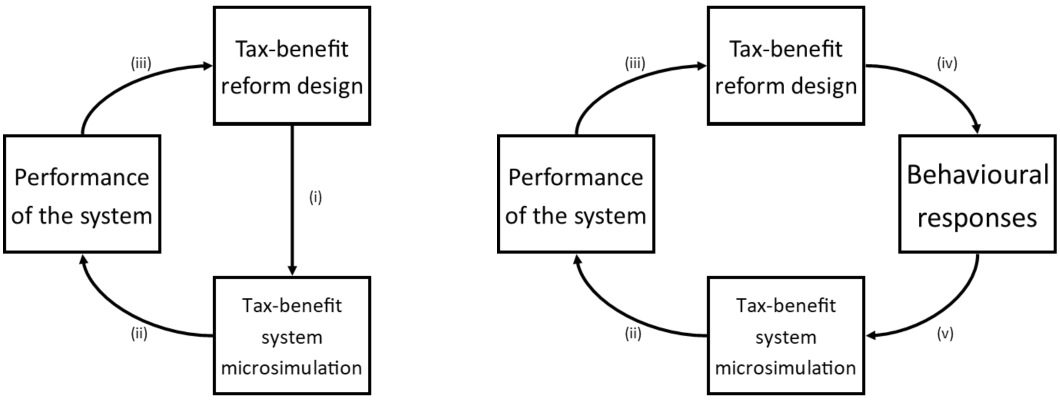
The approach performed by Islam and Colombino (2018), simulates household behaviour based upon a labour supply model, maximises welfare, and simultaneously keeps the introduced tax reforms solvent. This exercise is advanced by combining microeconometric modelling, behavioural microsimulation and numerical optimisation. It includes feedback to tax-transfer rules in terms of job changes, changes in hours of work and household demand. This feedback then influences the tax-benefit system again, making it a complex interaction between tax-transfer rules and the labour supply variable.

We observe a limitation, however. The studies mentioned above consider only the labour supply variable and/or distributional consequences. To the best of our knowledge, the optimal taxation methodology and available behavioural microsimulation tools are not designed to incorporate other variables. Nonetheless, we argue that there are other variables of a tax-benefit reform, that, just as with the labour supply, have a feedback interaction with the same tax-benefit system. Those variables are, for instance, household composition, marriages and divorces, births and deceases, retirement, labour training, education decisions (Creedy, 2001), and migration. To support the existence of this limitation, a study by Ellen and O'Flaherty (2007) indicates a correlation between household size and government policies.

We want to find out whether the current microsimulation models are limited. Current optimal taxation and microsimulation approaches see variables like household composition and, marriages and divorces as static. We investigate whether those should be included in microsimulation models in the situation where UBI reforms are designed. This study contributes to the knowledge of UBI in a microsimulation context.

1.2 Problem Definition

Our research strengthens the UBI discussion and contributes to the research area of microsimulation. It impacts tax-benefit systems to be built in the future. Currently, microsimulation research concerning UBI is performed as shown in Figure 1.3a. The first step optimises the performance of the system by designing a reform, which changes the tax-benefit system (i). This tax-benefit system results in some performance (ii). This performance is measured, for example by evaluating inequality or income measures. If the performance of the system is considered insufficient or it is determined there is room to improve, this may be a reason to redesign the tax benefit-system (iii).



(a) current *(b)* proposed improvement

Figure 1.3: Illustration of the problem definition. Two UBI microsimulation cycles.

We show, whether changes in *household composition* influence a tax-benefit system, in such a way that it should be considered before introducing the UBI reform which can cause these behavioural responses. The changes in incentives for household composition behaviour arise from the method in which tax-benefit systems favour certain living arrangements, while making others disadvantageous (Ellen & O'Flaherty, 2007; Peichl *et al.*, 2012). When a benefit is paid to each individual, which is a characteristic of UBI, this influences the behaviour of people with respect to household composition decisions. Economies of scale arise when people live together, so receiving an individual UBI would increase their personal disposable income if people decide to live together. To support this reasoning, Van Parijs and Vanderborght (2017, pp. 14-16) argue that household-based schemes discourage people to live together. However, Ellen and O'Flaherty (2007) show that certain subsidies are correlated with smaller households. So, switching to a scheme that is more individually based, like a UBI, results in changes in living arrangements, hence in changes in household composition.

To illustrate this interaction between behavioural responses and the performance of the tax-benefit system, we refer to Figure 1.3b. As shown, a tax-benefit system causes behavioural responses, which in our case is household composition behaviour (iv). These behavioural responses influence the microsimulation of the tax-benefit system (v). From here the cycle is the same as in Figure 1.3a.

We choose the UBI context, as this is where we observed the shortcoming of the microsimulation models. Since we argue that a UBI changes the incentives in household composition behaviour, we evaluate whether this household behaviour should be included as a variable in microsimulation models. Referring to Figure 1.3, our research concerns the acknowledgement of Figure 1.3b as improved methodology.

1.2.1 Research Questions

To specify and narrow down the scope of our research, a research question and several sub-questions are established. This leads to the following research question:

> *'To what extent do changes in household composition, supposedly caused by a universal basic income reform, affect this UBI reform within one year after implementation?'*

Answering this question should point out whether changes in household composition should be included in microsimulation models in the future when designing UBI reforms to reflect reality better. More broadly, if it shows it should be included, this also indicates whether more research should be done into other behavioural variables. The aforementioned research question is divided into sub-questions:

1. What are realistic extremes and what is a common scenario for changes in household composition, within a one-year time frame?
2. How to restructure household data to include changes in household composition?
3. What do we adopt as the solvent UBI reform of the Italian tax-benefit system, to be used as status quo in microsimulation?
4. How to determine whether there are effects on the UBI tax-benefit system due to changes in household composition?
5. What are the effects in microsimulation on the UBI tax-benefit system due to the changes in household composition?

The purpose of our research is not to investigate among a real population what their response to a UBI reform would be in terms of household composition behaviour (Figure 1.3b (iv)). Therefore, the first sub-question only examines realistic extreme scenarios that may result from a reform and a normal scenario. The second question determines how these scenarios are modelled. The design of a UBI reform is done at the third sub-question. Our research is directed at Italy, since a decent base of microsimulation research is available on this topic for this country (e.g. Colombino, 2015a; Colombino *et al.*, 2010; Islam & Colombino, 2018). The fourth decides upon the method that is used to evaluate the effects. Lastly, sub-question fifth determines those effects.

1.3 Research Method

We investigate whether microsimulation of UBI reforms should adopt behavioural responses. According to Bourguignon and Spadaro (2006), transition probabilities that are used to generate sequential household data allow the microsimulation model to become more dynamical and responsive to behaviour. In our research those probabilities might reflect the household behaviour. However, we do not adopt these transition probabilities in our microsimulation model. Instead, by applying synthetic adjustment of household compositions our research tests whether household composition behaviour should be included in microsimulation models. The subsequent step then would be to actually determine transition probabilities.

Our research is quantitative statistical. A flowchart of our research workflow is shown in Figure 1.4. This workflow is designed in order to answer our research question but might be applicable to other studies concerning behavioural responses as well.

Our research starts with determining the government budget of the current situation in Step (1). The *government budget* is used as a constraint to define a UBI reform in Step (2). This UBI reform is called the status quo and is the answer to the third sub-question. In a parallel process, the first and second sub-questions are answered. We alter the household data to incorporate changes in household composition according to several scenarios (Step 3). In Step (4), the tax-benefit reform is evaluated using the adjusted data set to answer the remaining sub-questions. Afterwards, we answer the research question and draw a conclusion.

To model synthetic behavioural changes and microsimulate the effects due to these changes after a UBI reform our research requires Italian household data . These data come originally from the Italian Institute of Statistics (ISTAT). The Institute for Social and Economic Research (ISER) prepared the Italian database. The prepared data are based upon the national version of the EU-Statistics on Income and Living Conditions (SILC) rotating panel survey, called IT-SILC. This survey contains a representative selection of the Italian household population.[1] This database contains demographic, employment and income in-

[1]The results presented in this study are based on EUROMOD version H1.0+. EUROMOD is maintained, developed and managed by ISER at the University of Essex, in collaboration with national teams from the EU member states. We are indebted to the many people who have contributed to the development of EUROMOD. The process of extending and updating EUROMOD is financially supported by the European Union Programme

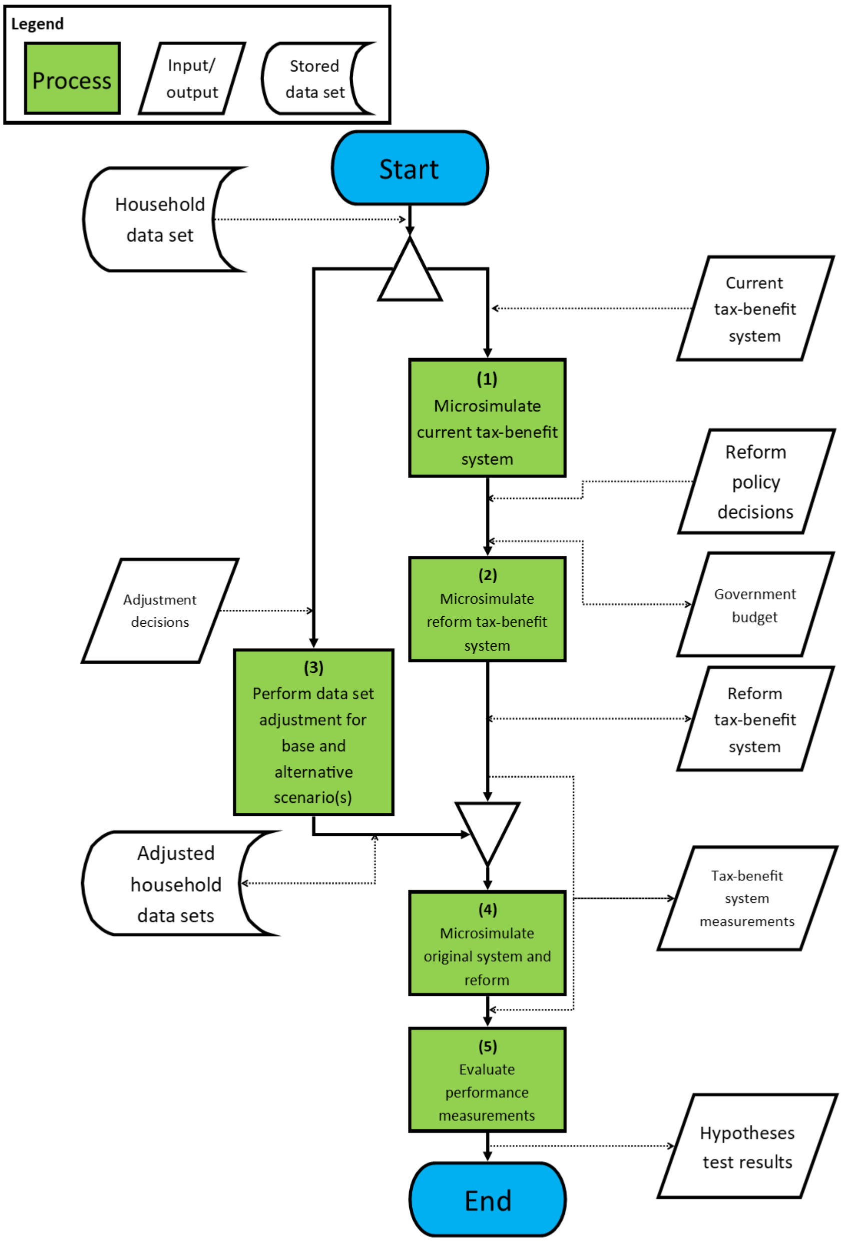


Figure 1.4: Flowchart of our research workflow.

formation of roughly 43 000 individuals in 18 000 households and is processed to be used in EUROMOD.

EUROMOD is maintained, developed and managed by ISER at the University of Essex, in collaboration with national teams from the EU member states. EUROMOD is a static tax-benefit microsimulation model which, in our research, is used to calculate household disposable incomes after the UBI reform. ISER also provided tax-benefit system configuration files for Italy to be used with EUROMOD. Those files contain the model of the Italian tax-benefit system.

for Employment and Social Innovation 'EaSI' (2014-2020). The results and the interpretation are the author's responsibility. The User Data Base(ITSILC XUDB 2015-1 16 December 2016) on which the EUROMOD database (IT_2015_a2) is based is delivered by ISTAT.

1.4 Relevance

Current literature about microsimulation neglects the effect a significant monthly benefit payment may have on household composition, as we explained in Section 1.2. Our research shows whether household composition is significant and, therefore, if not taking this into account is a shortcoming in existing literature. If so, this means microsimulation models should be extended. Eliminating this uncertainty results in a better understanding of the effects and sustainability of a UBI reform. In either case, it is a reason to review other variables than household composition in the same context, such as marriages and divorces, births and deceases, retirement, labour training, and education decisions (Creedy, 2001). And lastly, it is also a motive to evaluate this shortcoming in other types of tax-benefit reform research.

As this is the case for scientific research, we extent this to argue societal relevance as well. As our research contributes to the broad discussion on UBI, it helps policymakers to a better understanding of the effects of a UBI reform. Thus, our results bring policymakers one step closer to being able to decide whether to implement it or not, and how to design the reform.

1.5 Delimitation

Since the effects of the implementation of a UBI influence many disciplines and given the limited amount of time for the completion of a master's thesis, our research delimits certain aspects:

- Only Italy is considered. Eurostat only provided us with data of Italy.[2] Fortunately, some relevant research that is already available on microsimulation also considers Italy (Aaberge *et al.*, 1999; Colombino, 2015a; Colombino *et al.*, 2010; Islam & Colombino, 2018).

- Only changes in household composition are modelled, although there are also other variables that may have been chosen. This has been decided, since our research aims to be the reason to include other variables as well, just as is already done for labour supply. We evaluate household composition behaviour, because we suppose an interaction between behaviour and tax-benefit reforms.

- The changes in household composition behaviour are modelled for one year, not for multiple years. Multiple years requires various transition probabilities for the change in household composition over the years, dependent on characteristics such as demographics, household type, and income information. However, our research tends to find out whether the changes in household composition should be modelled in such a dynamic way in future microsimulation exercises, called dynamic behaviour microsimulation models (Section 3.3.1).

[2] Eurostat is the statistical office of the European Union, located in Luxembourg.

- No labour supply model is used, i.e., no behavioural changes in hours of work and wage rate are simulated. The goal is to evaluate the effects of changes in household composition upon a UBI reform. In order to isolate those effects, the data will only be adjusted to incorporate changes in household composition.
- The tax-benefit reform only alters income taxation, not capital taxation. The available data set does not contain information about assets to determine capital tax. Also cost reductions, originating from more cost-effective bureaucracy that a UBI is supposed to cause, are not simulated in the adopted microsimulation tax-benefit model and is therefore not included.

1.6 Research Structure

In Chapter 2 we provide some background information on UBI and elaborate on the Italian tax-benefit system and EUROMOD. Chapter 3 contains literature that we need to answer the sub-questions. We start with the design of a UBI reform in Chapter 4. Subsequently, we decide what evaluation method to use for the effects. In the last step, we alter the input data set to incorporate changes in household composition. In Chapter 5 we show the results of the evaluation after the microsimulation. Lastly, in Chapter 6, we answer the research question, discuss the results and give some recommendations for improvement and future research.

Chapter 2

Background and Context

In this chapter, we provide background information for a better understanding of the research context. In Chapter 1 we introduced UBI a bit. In Section 2.1 we elaborate on its definition, discus some UBI experiments and pilots, and introduce flat-tax. Subsequently, in Section 2.2 we discuss the Italian tax policies relevant for our research, the input data set and the microsimulation model EUROMOD.

2.1 Universal Basic Income

UBI goes by various names. It is referred to as basic income, unconditional basic income, basic income guarantee, and citizen's income. The ideas about the implementation of UBI vary as well. Who exactly are the beneficiaries, the level of the benefit payments, and the funding method are debated among others. Therefore, the definition as put forward by Basic Income European Network (BIEN) is adopted in our research:

> *'A [universal] basic income is a periodic cash payment unconditionally delivered to all on an individual basis'* (Basic Income European Network, n.d., About Basic Income, para. 1).

This definition consists of a few characteristics that have to be present to make a benefit policy classify as UBI reform according to BIEN. Those characteristics are periodic, cash, unconditional, to all, and individual. In order to fulfil the *periodic* characteristic, a UBI payment cannot be a one-time lump sum of money. It must be paid repeatedly, since it should provide the beneficiaries with purchasing power at regular intervals (Van Parijs, 2004). However, it has also been proposed, a one-time lump sum may be invested, making it a basic income annuity.

The *cash* requirement rules out any form of payment in kind, such as food or food stamps, or timing of the payment, because the purchasing power should be freely utilisable. *Unconditionally* means there are no rules an individual must comply with to be paid a basic income. In other words, there is no obligation to work and there is no review of the individual's financial situation, i.e. no means-test. According to Van Parijs (2004) 'the most striking feature of a basic income is no doubt that it is paid, indeed paid at the same level, to rich and poor alike, irrespective of their income level', making it unconditional (pp. 12-13).

Furthermore, it is paid on an *individual basis* only, not to households. Singles, couples and children receive the same amount per person. Because of this it 'tends to remove isolation traps and foster communal life' Van Parijs (2004, p. 12). Lastly, the characteristic *to all*, refers to the payment being distributed universally, so no one is excluded, and it does not contribute to polarisation of the labour market (Van Parijs, 2004). From now on we refer to this aspect as the *universal* characteristic,

2.1.1 Experiments and Their Characteristics

Overall, experiments differ a lot in the extent they comply with the UBI definition. Figure 1.2 in Chapter 1 shows past, current and future UBI experiments. In Table 2.1 eight experiments are shown. Two have been conducted in the 1970s in America, six are being conducted now, and one is starting soon. They are evaluated based on the five characteristics.

As can be seen, all experiments comply with the periodic and cash requirement. We have split up the unconditional characteristic to show more diversity among the experiments. All experiments eliminate work requirement for at least one treatment group, which let them comply with the definition. Four experiments still apply a means-test, although negative income tax (NIT) can be fairly similar to a UBI in certain circumstances. See Appendix A for more explanation on this.

Furthermore, three experiments depend the payout on household size, and none give the UBI to all. The one getting closest to the universal requirement is GiveDirectly, since the only exclusion criterion is age. Opposed to the other experiments, a whole political community of adults is included in the experiment, because of the affordability of a UBI in Kenya. Including a whole political community in an experiment in developed countries is politically unenforceable, because of high costs and ethical concerns.

2.1.2 Deviations from the Definition

As can be seen in previous section, several characteristics are relaxed during UBI experiments and pilot programs. Experiments are conducted to test for the effects of a UBI and certain aspects of the definition make it otherwise impossible to experiment with. Therefore, most experiments have the goal to test some specific effects on society. For example, the Finnish experiment only incorporated unemployed individuals to test what the effect of a UBI is on employment (Kela, 2016b). But in such experiments, to include employed individuals would have been too expensive. So, the Finnish experiment neglects the universal characteristic.

Moreover, the universal aspect is often scoped to a nation-state, such as to Finland in the Finnish experiment, or to Alaska in the Alaska Permanent Fund (O'Brien & Olson, 1990). As Van Parijs (2004) argues, the basic income is paid by a political community to all members, which is not necessary equivalent to a nation-state. Although a UBI can be

Table 2.1: Characteristics of experiments with UBI.

UBI Experiments[a]	The Seattle/Denver Income-Maintenance Experiments (SIME/DIME)[b]	Basic Annual Income Experiment (Mincome)[c]	Basic Income Pilot[d]	'Perustulokokeilu' (Basic Income Experiment)[e]	'Bijstandsexperimenten' (Social Assistance Experiments)[f]	B-MINCOME[g]	GiveDirectly[h]	Y Combinator
Location	Seattle, Denver	Manitoba, Canada (Winnipeg and Dauphin)	Ontario, Canada (Hamilton, Brantford, Brant County, Lindsay and Thunder Bay)	Finland	The Netherlands (Groningen, Ten Boer, Wageningen, Tilburg, Deventer, Nijmegen, Utrecht, Amsterdam)	Barcelona	Kenya	USA
Period	1970-1976	1975-1978	2017-2018	2017-2018	2017-	2017-	2017-	Unknown
Treatment group size	4.800	1.300	4.000	2.000	Various	1.000	16.000+	1.000
Experiment objective	'Measure the disincentive effects of cash transfers on the market work of those eligible for them' (Assistant Secretary for Planning and Evaluation, 2015, Overview of the Final Report of the SIME/DIME, para. 1).	Examine 'the labour supply responses of households and individuals to a guaranteed annual income' (Hum *et al.*, 1979, p. 4).	'Test how a basic income might help people living on low incomes better meet their basic needs' (Government of Ontario, 2017, What Will Be Measured, para. 1).	'Examine the impact of the basic income.' E.g., 'whether there are differences in employment rates between those receiving and those not receiving a basic income' (Kela, 2016a, Studying the Impact of the Experiment, para. 2).	Determine the best way to motivate or guide people from receiving social assistance to (re-)attaining a place on the labour market.	'Supplement income in the most deprived and poor areas or the City,... with the ultimate goal of developing more efficient welfare services' (Urban Innovative Actions, n.d., Solution Proposed, para. 1).	Examine 'how important the guarantee of future transfers is for outcomes today' (GiveDirectly, n.d., We're Running the Largest Experiment in History, para. 2).	'Gather data on how participants use their time and money, they will focus on the impact of UBI on social and physiological well-being' (Widerquist, 2018, Y Combinator in the United States, para. 2).
Periodic	✓	✓	✓, monthly	✓, monthly	✓, monthly	✓, monthly	✓/✗12 years, 2 years, monthly and lumpsum	✓, monthly
Cash	✓	✓	✓	✓	✓	✓	✓	✓
Unconditional, without means-test	✗, NIT	✗, GMI	✗, NIT	✓	✓	✗, NIT	✓	✓
Unconditional, without work requirement	✓/✗, various experimental groups	✓	✓	✓	✓/✗, various experimental groups	✓/✗, various experimental groups	✓	✓
Individual	✗, to households	✗, to households	✗, to household	✓	✓	✗, to households	✓	✓
Universal for a political community	✗, limited group	✗, age (and limited group in Winnipeg)	✗, age and limited group	✗, unemployed, age and limited group	✗, social assistance beneficiaries and limited group	✗, limited group	✗, age	✗, age and limited group

[a] See McFarland (2017), Widerquist (2018).
[b] See Assistant Secretary for Planning and Evaluation (2015), Widerquist (2017b).
[c] See Hum *et al.* (1979), Widerquist (2017b).
[d] See https://www.ontario.ca/page/ontario-basic-income-pilot
[e] See https://www.kela.fi/web/en/basic-income-experiment-2017-2018
[f] See Gemeente Amsterdam (2018), Rijksoverheid (2017), Verbeek (2018).
[g] See http://www.uia-initiative.eu/en/uia-cities/barcelona
[h] See https://givedirectly.org/basic-income

exceptionally inclusive, truly universal experiments would be impracticable as well. Without the exclusion of newcomers for instance, there would be an incentive to join or move to the political community that provides a UBI. Therefore, 'to all members' can also include non-citizens and newcomers by selecting residents for tax purposes only as member. Besides excluding non-citizens, also children, pensioners, and inmates may be excluded from UBI or receive an adapted version.

In addition to those deviations from the definition, there are more. In Ontario, Canada, it is seen that the payment amount is adjusted for households, thus not paid on an individual basis. The Kenyan experiment includes one treatment group that receives a lump sum payment, so not periodic. Nonetheless, for the sake of feasibility of experimentation, it is reasonable to relax the definition. This is also done in our research. What relaxation exactly is explained in Section 4.1.

2.1.3 Claimed Advantages and Disadvantages

Researchers experiment with UBI, since advantages are proposed that are not completely presumed to really happen. On the other hand, there are also claimed disadvantages that need to be tested. We mention some of them.

According to Standing (2008) a UBI does not distinguish between type of work to receive income support. So, all kinds of work are equally deserving. For instance, informal care currently is unrewarded, although it may take a lot of time. This gives people the opportunity to choose between type of work more easily. Moreover, UBI gives people more freedom, in terms that disadvantaged groups can refuse to be exploited. They do not have to accept low wage jobs with degrading working conditions, which they usually have to. For this reason, such jobs will be paid better.

It is said to eliminate the poverty trap as well, by giving people a reason to earn on top of their benefit, because this additional income is not deducted from the benefit (Standing, 2008; Van Parijs, 2004). This allows beneficiaries to increase their disposable income significantly (Van Parijs, 2004). Also, without mean-test and work-test, a UBI is supposed to be more cost-effective than traditional, conditional benefit policies (Van Parijs, 2004).

On the side of the disadvantages, it is unclear to what degree an unconditional monthly payment would decrease productivity. Society is used to the requirement to work to maintain a living. It disputes people's view of deservingness when work is not required anymore (Sage & Diamond, 2017). Deciding to work less and getting money for free may be classified as being lazy and being a freeloader. This undeservingness is even greater for the alcohol and drug addicted, who may use a UBI to provide in their addiction.

Moreover, Sage and Diamond (2017) argue 'there are also serious question marks over whether a [universal] basic income is best placed to reverse the problems its supporters identify or whether it would merely compensate, or at worst cement, the inequalities it seeks to correct.' The benefits a UBI reform is intended to provide, may go somewhere else than to the recipients, e.g. employers might reduce wages or landlords increase rents (Widerquist, 2017a).

2.1.4 Flat Tax Rate

Under a flat-tax (FT) rate system or proportional tax, the proportion of tax levied is constant whatever the level of income. Since one of the important strengths of a UBI is its simplicity, a lot of models in previous research adopt a FT rate instead of progressive tax (Islam & Colombino, 2018). This suits the characteristics of a UBI reform to simplify the tax system. Other studies just use a FT rate as a practical solution (e.g. Honkanen, 2014), or do not mention the reason at all (e.g. Browne & Immervoll, 2017; Duncan & Weeks, 1997; Jessen *et al.*, 2017). For more detailed information about the relationship between gross and net income for UBI and similar systems, we refer to Appendix A.

2.2 About the Italian Data and EUROMOD

We retrieved two files from ISER that are used for this study. The first is the configuration file containing policy rules for the Italian tax-benefit system for 2017. This file is to be used with EUROMOD, a microsimulation model to determine the effects of a tax reform. The other file we use is the input data set, containing household data. This covers demographic, employment and income information (see Section 4.3.2). These data are obtained through a yearly survey, performed by ISTAT. A country specific team manages the preparation and conversion of the configuration file and input data set. Both files are maintained and updated regularly by this team (Ceriani *et al.*, 2017). Some descriptive information about the origin and content of the input data set can be found in Table 2.2.

Table 2.2: Description of the EUROMOD input data set and some descriptive statistics (Ceriani et al., 2017).

Country	Italy
Provider	ISTAT
Year of survey	2015
EUROMOD database	IT_2015_a2
Income reference period	2014
Sample size	42 987 individuals 17 985 households
Sum of sample weights	60 483 298 individuals 25 775 872 households
Weighted household size mean	2.35 members
Weighted household size variance	1.5517

2.2.1 Italian Tax-Benefit System in EUROMOD

The Italian tax-benefit system in EUROMOD is defined by a set of policy rules that determine the taxes to be paid and the benefits to be received on an individual basis. Those policy rules use the data of the input database to perform the simulation. These data are categorised as monetary or non-monetary.

The non-monetary input data are the demographics and employment information, and they are for instance used to determine eligibility for certain tax and benefit policies and dependencies among families. The monetary input is used to calculate all tax and benefit variables per individual. Those variables aggregated, result in various lists of income, taxation or benefit concepts for every individual, such as disposable income, payable tax, or means-tested benefits. EUROMOD refers to those lists as *income lists*.

Although, everything is stored on an individual basis after the microsimulation, some policies are dependent on the household composition and reassign and transfer cash flows to others within the household where applicable. Moreover, the input data contain cross-sectional weights to reflect the actual Italian population.

Running the 2017 tax-benefit system simulation on the income year 2014 results in the summary in Table 2.3.[1] In this table we use relative poverty and income inequality measures, following EUROMOD's standard. The *government budget* includes earnings from taxes and social insurance contributions minus expenses from benefit and pension payments. The value for *average disposable income* is calculated per household, not per individual, and unequivalised, which will be explained in the following section.

Table 2.3: Performance measurements of the original Italian 2017 tax-benefit system (M = million).

Government budget	€90 838.12 M yearly
Gini coefficient	0.3072
Relative poverty line	€782.96 monthly
Relative risk of poverty	17.97 %
Average disposable income	€2375.80 monthly

Relative Poverty Measures

The *relative poverty line* is defined as 60 % of the median equivalised disposable household income. The *equivalised disposable household income* corrects the regular household disposable income for its composition. The reason for this is that larger households enjoy economies of scale.

We follow EUROMOD's practices in using the OECD-modified scale, which means every first adult counts as 1, all subsequent adults as 0.5 and all children (< 14 years old) as 0.3 (Organisation for Economic Co-operation and Development, 2013). The total disposable household income is then divided by this scale. This results in the equivalised disposable household incomes.

Subsequently, the weighted median of these equivalised disposable household incomes is taken, in a way that a household with five members contributes five times its equivalised disposable household income. Simultaneously the cross-sectional weight of the individual in the data set is accounted for. Then 60 % of this weighted median of equivalised disposable

[1] The income period is uprated to match the 2017 tax-benefit system, using EUROMOD's build-in functionality.

household incomes is called the *relative poverty line*. An individual is defined as being at *risk of poverty* when its equivalised disposable household income is below the poverty line.

Relative Income Inequality Measure: Gini Coefficient

The *Gini coefficient* is a measure for income inequality. It measures the distribution of equivalised disposable household incomes, comparing the cumulative proportions of the population and the cumulative household income they receive.

One approach is based upon what mathematicians call the Lorenz curve (Dalton, 1920). We use a graph, where the x axis represents the cumulative share of individuals from lowest to highest household incomes, and the y axis the cumulative share of total disposable household income (See Figure 2.1). For instance, if the poorest 75 $\%$ of the population receive 56 $\%$ of the total income, then $x = 0.75$ and $y = 0.56$.

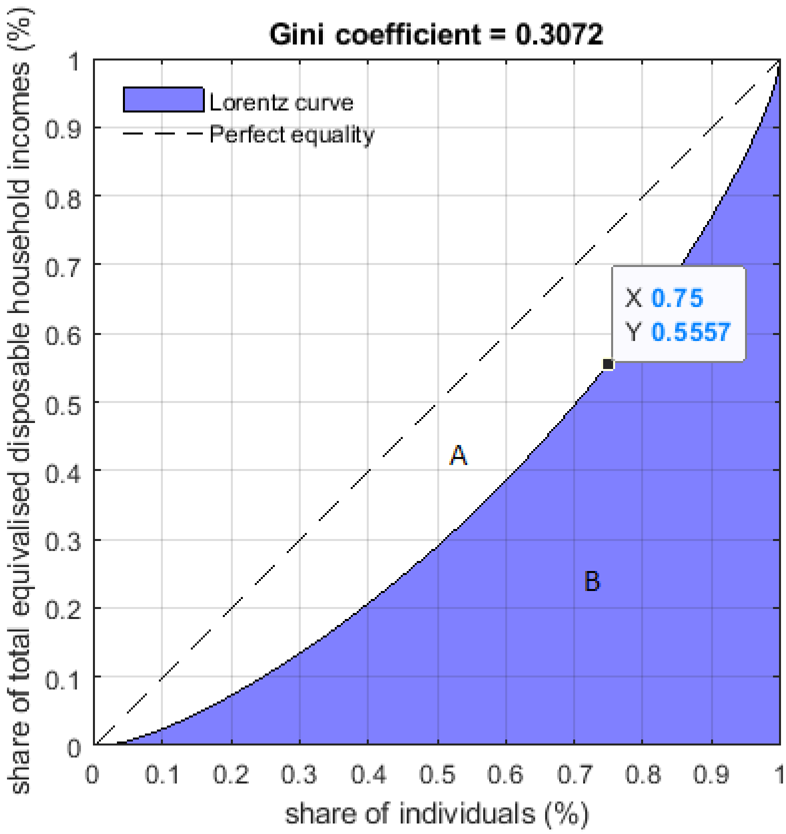


Figure 2.1: Graphical interpretation of the Gini coefficient.

Perfect equality would result in a line of 45° over the whole range from $x = 0$ to $x = 1$. In this approach, the Gini coefficient is the area A between the Lorenz curve and the line of equality divided by the total area $A + B$ under the line of equality.

$$Gini = \frac{A}{A + B}$$

This way, a Gini coefficient of 0 resembles perfect equality and 1 perfect inequality.

Just as with the weighted median in the previous section, in the total disposable household income calculation of the Gini, a household with five members contributes five times its equivalised disposable household income. Simultaneously, its cross-sectional weight of the individual in the data set is accounted for.

Chapter 3

Literature Review

In this chapter we gather relevant existing literature and information that will help us to answer the first sub-question. The second sub-question is answered partly. Those questions are listed in Section 1.2. At first, we offer a rudimentary overview of past and current scientific research concerning UBI microsimulation in Section 3.1. In Section 3.2, we collect information about the direction and magnitude of the household composition to answer the first sub-question. Then, we find in literature methods to apply the obtained transition probabilities. In Section 3.3, we answer the second sub-question partly by determining what household adjustment figures we use in our research. The others are discussed in Chapters 4 and 5, since microsimulation has to be conducted before an answer can be given.

3.1 Scientific Research on UBI

So, we have seen some examples of experiments with UBI in Section 2.1 already. In addition to the experiments, scientific research is also examining the effects of a UBI reform in various ways. Here, we focus on research with UBI that concerns its funding and effects. In Sweden and Finland, popular support for different UBI policies has been tested by Bay and Pedersen (2006). In Norway the effects from immigration on support of UBI has been investigated by Andersson and Kangas (2002).

In the context of increasing financial globalisation, Dymski and Kerstenetzky (2008) argue for a global UBI for the international community, paid for by global institutions through taxes. Huber (2000) introduces the idea to fund UBI by seigniorage, i.e., by creation of new money. A more recent study by Tideman and Tsang (2010) continues on seigniorage and concludes that it is only useful when the economy needs an income stimulus, or to give starting adults such a stimulus . Hence, they conclude that it should not be paid as a periodic guaranteed income.

Larocco (2015) and Flynn (2018) adopt the idea that UBI could be distributed via cryptocurrency. Larocco (2015) argues cryptocurrencies would result in a higher cost-effectiveness and allow automation. Flynn (2018) acknowledges this idea and argues funding by inflation would be better than by transaction fees. Moreover, some UBI blockchain initiatives have arisen as well, one further advanced than the other.[1] Furthermore, Watson and Bianca (2018) argue that a UBI could be funded by revenues realised through production utilising artificial intelligence.

3.1.1 Microsimulation and Optimal Taxation in a UBI Context

Before we discuss more scientific research, we elaborate on optimal taxation and microanalytic simulation. *Optimal taxation* concerns the design of tax-transfer rules, maximising a social welfare or evaluation function (Islam & Colombino, 2018). Such a social welfare function includes judgements about interpersonal comparison and redistribution preferences. In optimal taxation, a government can only observe an individual's income, not their abilities. It is however required for a tax system to be incentive compatible, to direct individuals in the right direction (Creedy, 2001). Optimal taxation makes use of labour supply models to incorporate household behavioural decisions; individuals try to maximise their utility function under a certain tax system.

Optimal taxation models generally assume a rather homogeneous population and rather simple tax systems. For instance, an individual's utility function includes only the choice to be self-employed or wage employed, and the hours of work, resulting in some disposable income, or the tax system modelled concerns flat taxation. Alternatively, there is a discipline called microanalytic simulation that can take substantial heterogeneity into account (Bourguignon & Spadaro, 2006; Creedy, 2001).

Microanalytic simulation, or *microsimulation* in short, usually uses cross-sectional household surveys. Microsimulation models enable the simulation of the effects of a tax-benefit system on a sample of, for example, households (Bourguignon & Spadaro, 2006). This way, some population heterogeneity can be simulated. EUROMOD, as used in our research, is an example of a static microsimulation model. EUROMOD simulates disposable income of households by modelling tax and benefit policy rules and applying them to an input data set with household information (Sutherland & Figari, 2013). Income and capital tax, social contributions, and benefits such as family support, housing allowance, social assistance are included in the microsimulation model. The rules of tax-benefit reform systems can be constructed as desired to evaluate their effects. A more detailed explanation of different microsimulation types can be found in Section 3.3.1.

Previous Optimal Taxation of UBI-like Reforms

Van der Veen (2004) uses optimal taxation to compare a UBI reform to an alternative reform where market wage rates are subsidised. Clavet *et al*. (2013) evaluate the impact of a UBI in Canada.

Using an optimal taxation model, Guerreiro *et al*. (2017) test whether robots can be taxed to compensate for the jobs they replace, while distributing the earnings under the workers

[1] For example, Manna (https://www.mannabase.com/), Circles (https://www.joincircles.net/), UBIcoin (https://medium.com/@annablume/universal-basic-income-ubi-coin-15ec91abcada) and BIG foundation (http://big.foundation/).

as a form of UBI. Guerreiro *et al.* (2017) conclude that it is optimal to tax robots only when partial automation occurs. Thümmell (2018) advances on this conclusion by incorporating a more extensive occupational choice set, concluding that in the medium-run a robot tax and its welfare impact diminishes and moves towards zero when the purchase price of robots fall. So, a robot tax does not seem to be a good solution to fund UBI.

3.1.2 Previous Microsimulation of UBI-Like Reforms

For various countries, optimal taxation has been combined with a microsimulation model for determining UBI policies. Labeaga *et al.* (2008) compare UBI, among others, to reforms of the Spanish income tax system using a microsimulation model. Similarly, Scutella (2004) evaluates the implication of moving to a UBI for Australia. For Germany, Horstschräer *et al.* (2010) conduct an equivalent research. In a multi-paper research project concerning a microeconometric approach to empirical optimal taxation, some UBI policies are evaluated as well, although not always as main purpose of the research (Aaberge *et al.*, 1999; Colombino, 2015a, 2015b; Colombino *et al.*, 2010; Islam & Colombino, 2018).

Then there are also studies, that solely use microsimulation models to evaluate UBI policies. Garfinkel *et al.* (2002) evaluate the effects of different UBI reforms in the US on poverty and income distribution. Callan and Sutherland (1997) use a national microsimulation model to compare such a reform in the UK and Ireland, although merely to advocate for a cross-country microsimulation like EUROMOD. Duncan and Weeks (1997) continue on their UBI reform in the UK by including a behavioural labour supply model for married women. Jessen *et al.* (2017) use a national model for a UBI in Germany, Honkanen (2014) for Finland, and Browne and Immervoll (2017) use EUROMOD for Finland, France, Italy and the UK.

3.2 The Change in Household Composition

In this section the first sub-question is discussed. This first question is:

> *What are realistic extremes and what is a common scenario for changes in household composition, within a one-year time frame?*

Our research method concerns the modelling of a change in household composition. Before we do that, some aspects have to be clarified. First, we define what is understood by household composition and a change to it as we use it in this study. *Household composition* concerns the size of a group of people sharing accommodation and the proportions of adults and children within this group. This is not limited to families.

The scenarios we refer to, includes households combining or splitting up. This may be because of legal arrangements, such as marriage or divorce, but is not restricted to those. Friends living together without a legal living arrangement are also included. This means the sub-question asks what kind of scenarios are extreme but realistic and what is a common scenario, in terms of an increasing amount of household deciding to cohabit or to split.

These realistic but extreme scenarios are not meant to reflect the exact number of changes we can expect due to a UBI reform, but to guarantee spread between a common scenario and two alternative scenarios. In this Chapter we elaborate on the scenarios.

3.2.1 How Do Policies Affect Household Composition?

One of the implications of a tax-benefit system is that it influences people's behaviour in a direction that may be desired or undesired. For example, as is shown by Freeman (2005), where housing assistance is related to household composition, i.e. recipients of housing assistance are less likely to marry. To find out in which direction the change in household composition goes, we first want to know more about the interaction between social benefits and allowances, and household composition behaviour. This is done in a UBI context.

Anti-Isolation Claim

In many tax-benefit systems allowances and benefits are dependent upon household composition. So, the per capita amount received decreases with the size of the household. Normally, living together would entail economies of scale arising from sharing the costs of living, for example accommodation. However, the conditional property of these benefits suppresses that effect.

Introducing a UBI policy, the amount received per capita stays the same regardless of household composition to satisfy the individual basis characteristic. According to Van Parijs (2004), this property preserves economies of scale. It would abolish isolation traps and stimulate living together, as household-based schemes discourage people to live together (Van Parijs & Vanderborght, 2017). This causality will be called the *anti-isolation* claim.

If this *anti-isolation* claim is true, that would mean that, currently, the most rational people avoid living together to receive the highest benefit possible. Needless to say, people do not only make decisions rationally, but also emotionally. Hence, it can be witnessed that people still decide to live together. The decision to live together is not solely based on financial benefits.

Moreover, it can be argued that the economies of scale per capita outweigh the decrease in benefits per capita, making cohabiting financially interesting even without the individual UBI benefits. The least that can be concluded if a UBI would be introduced, is that the economies of scale become more interesting than without, supporting the *anti-isolation* claim that people are stimulated more to live together.

Illegitimate Cohabitation Claim

An administrative advantage of UBI is that, because of the independence on household composition, there is no need to verify the living arrangements of the members of the political community. In other systems it is assumed it is possible to verify those living arrangements. However, this is a costly process, prone to errors and to the incentive to pretend to live apart while living together (Van Parijs, 2004). This is especially interesting, since nowadays living arrangements are becoming less committal than they previously where, such as marriage, making the verification of living arrangements even harder.

Thus, with a UBI there is no more need to verify who lives with whom and the advantage of pretending to live apart would disappear. Although, pretending to live apart would not influence the physical household composition, it does change the way the household is registered at the responsible authority and probably also in the household data used for our research. A household previously pretending to live apart, suddenly is registered as living together. This will be called the *illegitimate cohabitation* claim.

Financial Independence Claim

There are also arguments in favour of decreasing cohabitation rates. When individuals suddenly receive a benefit independent from their household composition, the obtained financial security may also result in divorces and separations (Freeman, 2005). Couples may become financially less dependent on each other. This will be called the *financial independence* claim. The claim also assumes that household-based schemes are currently controlling the living arrangements of people.

Interesting to add here, is that after the introduction of a 'fast divorce law' in Italy in 2015, the number of divorces increased by 57 % (Prati & Simone, 2016). This indicates that household composition is, partly, influenced by legislation and responds to changes in it. Furthermore, Ellen and O'Flaherty (2007) show that households in New York City that receive a subsidy are smaller on average. However, they cannot prove the direction of this causality.

Finding Support in Research and Experiments

It is hard to say anything scientifically sound about the magnitude of the change in household composition, caused by a UBI reform, if any. Giving individuals more financial freedom by means of a periodic guaranteed benefit, may result in both exploitation of the economies of scale acquired by cohabiting, and in untenable marital situations breaking up. Then, there are also other indirect effects that influence the economies of scale household observe after a UBI reform. There are for instance concerns about decreasing wages and increasing prices and rent, in other words inflation. All those effects may influence household composition.

There is, however, no research that mentions a change in household composition resulting from a tax reform. This may either be because no change was observed, or because the change was not noticed since it was not the research focus. However, one experiment supposedly observed an increase of the separation rate, i.e. the Seattle-Denver Income Maintenance Experiment (SIME/DIME).

The SIME/DIME was conducted in the 1970s and tested for the effects of a NIT reform. Its conclusion was, that it contributed to more marital dissolutions (Assistant Secretary for Planning and Evaluation, 2015; Bregman, 2016). Important to mention here, is that a couple did not necessarily need to be married to be classified as couple, so also splitting up was classified as marital dissolution. Besides, the NIT was paid to households, not individuals. So, the incentive to dissolute may also have been originated from the resulting increase of one's disposable income after separation. After the experiment, analysis showed the observed increase in dissolutions disappeared, indicating the experiment caused the increase. A reanalysis of the marital stability in the SIME/DIME experiment, performed by Cain and Wissoker (1990), showed however that the NIT had no effect on the rate of marital dissolution at all. The Manitoba experiment, which was around the same time in Canada, did not replicate this observed increase either.

The SIME/DIME and Manitoba experiment were performed half a century ago. Although they did not conclude that there was any change to the rate of marital dissolution, in the current day and age the negative stigma of divorce is less prominent, and divorce rates have gone up since then. Back then, an increase in marital dissolution was perceived as a problem, resulting in discontinuation of the experiment, which is not necessarily the case now (Bregman, 2016). Thus, it may nevertheless be the case UBI causes *financial independence* claim effects in current society. Also, the tendency to live together without a marriage or other judicial arrangements of that kind, is more common nowadays.

We might use the marital dissolution ratio observed in the SIME/DIME. So, the marital dissolution ratio that later on appeared to be a result of a statistical error. Since this ratio appeared to be that high, it withheld a UBI reform in the US from being introduced (Bregman, 2016), it could be a good input to test an extreme case for the *financial independence* claim. However, it appears that the present marital dissolution ratio is higher than the incorrect ratio observed in the SIME/DIME, i.e. $49.96\,\%$ of the marriages in the year 2014 to $23.7\,\%$ in three years respectively (Assistant Secretary for Planning and Evaluation, 2015; Prati & Simone, 2016). Therefore, it is questionable whether our research can make use of the SIME/DIME experiment.

Deciding On Adjustment Rates

The empirical results from other experiments do not notice or observe a change in household composition. However, as explained in Section 2.1.1, each of those experiments has its own shortcoming towards the UBI characteristics. For instance, only unemployed are included, or it is not paid on an individual basis. Since there are no empirical data available that tells us something about changes in household composition after a UBI reform, an assumption has to be made about the change in household composition.

We have reason to believe the change can go in both directions, since giving people money individually may either result in people securing their freedom by breaking up or exploiting economies of scale by starting to cohabit. Therefore, we look at extreme but realistic country specific changes in household composition in Europe over the last decade in both directions. Those figures are used as a starting point for the data adjustment.

However, it is also of importance what the current trends are of changes in household composition. Observing the households in the Europe Union, it can be seen the average size of households decreased from 2.4 members in 2007 to 2.3 in 2017 (EuroStat, 2018). For Italy specifically, this decrease is even higher; from 2.5 members in 2007 to 2.3 in 2017. The number of households with a single adult, with or without children, in Italy increased with 4.7 percentage point to 35.9 % in 2017. So, more households are smaller, and an increasing proportion are single-adult households. This trend may be the result of a lot of factors. It is, however, not the goal of our research to explain this trend. We are interested how to model an extreme but realistic change to the household composition, that supposedly may be caused by a UBI reform.

3.3 Restructuring the Household Data

Now we have decided what the source of the figures is, that will determine the rates of change to the household composition, we want to know more how to use these figures. In this section the second sub-question is discussed. The second question is:

How to restructure household data to include changes in household composition?

We start with elaborating on microsimulation models.

3.3.1 Dynamic Microsimulation Models

Microsimulation models can roughly be categorised as arithmetical or behavioural (Bourguignon & Spadaro, 2006). *Arithmetical microsimulation models* are characterised as models that apply a change in the policies and determine the households' new disposable incomes accordingly, without considering behavioural changes in their market income and demographic composition. They are also sometimes referred to as static microsimulation models. *Behavioural models* add behavioural responses of individuals and households to the simulation. Using the optimal taxation approach, for example, behaviour is incorporated using labour supply models.

Tax-benefit system redistribute wealth, but also generate certain long-term incentives a government deems important. So, these long-term incentives affect people's *life cycle events*. The microsimulation of a distributional economy-wide policy that changes people's *life cycle events* requires a dynamic perspective (Bourguignon & Spadaro, 2006). Examples of those life cycle events are marriage, retirement, or demographic changes. Thus, life cycle events require *dynamic microsimulation*.

There are different types of dynamic processes (Bozio, 2018). Those are *deterministic transitions*, such as ageing, and *stochastic transitions*, such as unemployment. Microsimulation models incorporating these are called the arithmetical models. *Behavioural responses* on the other hand, such as household composition decisions, are modelled with behavioural models.

To measure multi-annual policy effects, multi-annual input data are required. However, monthly or yearly sequential data that may be available are already dated and/or may not have enough predictive power for an unknown or unique situation. Therefore, dynamic arithmetical microsimulation models generally rely on synthetic data. According to Bourguignon and Spadaro (2006), sequential data are generated by applying transition probabilities to the cross-sectional data that include individuals and households. Such a proportion describes the likeliness that someone depending on his or her characteristics, for example, gets married.

For dynamic stochastic microsimulation, the transition probabilities are assumed to be constant, exogenous and independent of the policy (Bourguignon & Spadaro, 2006). So, in dynamic arithmetical microsimulation models there is no behavioural feedback changing the transition probabilities over the modelled years. Dynamic *behavioural microsimulation models* allow the transition probabilities to become flexible and endogenous. This way, it becomes possible to model behavioural responses that are dependent upon the implemented policy. In either case, since the transition probabilities in microsimulation are chosen by a random drawing procedure, Bourguignon and Spadaro (2006) argue the results of the dynamic microsimulation should be analysed on sensitivity using Monte-Carlo or bootstrapping methods.

A research area where the use of transition probabilities is developing in a similar way is game theory. Making the transition probabilities dependent on current and past actions of actors, Joosten and Samuel (2017) and Joosten and Meijboom (2018) introduce endogenous transition probabilities. Although traditionally there is a link between game theory and certain types of microsimulation, in microsimulation a sole individual's action has almost no impact, only when many behave the same.

The use of transition probabilities is also where microsimulation differs from another form of simulation, called *macrosimulation*. Macrosimulation applies a probability to a whole population and is always stochastic by nature, while microsimulation draws at an individual level (van Imhoff & Post, 1998).

Some more distinctions can be made in microsimulation models. They can be discrete, for example yearly, or continuous with events simulated at exact dates. Then, there are closed microsimulation models, where spouses are selected from the data set, or open models, where they are modelled outside the data set (Bozio, 2018).

3.3.2 Introducing Three Scenarios

We have determined the goal of our research a couple of times already. However, after the previous section, we can also state that we examine whether future practices of modelling UBI should adopt dynamic behavioural microsimulation with a feedback loop. So, as was done with the optimal taxation approach by Islam and Colombino (2018) using a labour supply model, but then also for demographic, pension and retirement decisions to name a few examples. We suppose tax-benefit system reforms influence behaviour, thus influence the transition probabilities. Therefore, the transition probabilities have to be modelled in a way they can respond to changes from year to year, so a UBI can be designed to be optimal.

According to Bourguignon and Spadaro (2006), this type of model is complex, and it is difficult to deal dynamically with 'uncertainty, expectation formation and market imperfections'. Therefore, our research tests whether behavioural decisions should be implemented, to avoid redundant modelling of dynamic behavioural models. This means we synthetically model an increase in some basic behaviour to test for its effect on the model compared to when there was normal behaviour. We argue this increase in behaviour originates from incentives a tax-benefit system generates. The microsimulation model EUROMOD, used in our research, is arithmetical and without behaviour. However, by synthetically modelling a change in behaviour, we can synthetically simulate one year after the reform.

This study models three scenarios. The *base* scenario concerns a microsimulation of a UBI reform without alteration of the rate at which household composition changes. The alternative scenarios are two single-year microsimulations with synthetic adjustments to the household composition proportions, one with an increase towards single-adult households and the other towards non-single-adult households. This way, it is shown whether future evaluation of the feasibility of a UBI reform should incorporate dynamic behavioural microsimulation.

The scenario with an increase towards single-adult households, tests for the *financial independence* claim and from now on is referred to as *separation* scenario. The other one tests for the *anti-isolation* and *illegitimate cohabitation* claims and is called the *cohabitation* scenario.

Direction and Magnitude of the Change

Using household composition statistics provided by EuroStat (2018), we compare households that consist of one single adult to households that consist of several adults. For this data set a household member is considered to be an adult if their age is ≥ 24. The annual increase of single-adult households is determined from the Eurostat statistics. An average of five years is taken to level out outliers due to short-term effects, since for some countries we observe a high increase followed by a large decrease. For Italy the years 2013–2017 showed an average increase of $0.8881\,\%$ in the proportion of single-adult households, resulting in $35.97\,\%$ single-adult households of the total number of households in 2017. So, for the *base* scenario we model an increase of $0.8881\,\%$ in the proportion of single-adult households in the data set.

In the time span 2007–2017, the maximum 5-year average of the annual increase of the proportion of one single-adult households is $8.6014\,\%$ in Turkey in the years 2012–2016. The maximum decrease is $5.0679\,\%$ in Macedonia in the years 2008–2012. Those figures are used for a *separation* scenario and a *cohabitation* scenario respectively.

The resulting scenarios are realistic, since they are observations of real change rates. However, our research does not conclude on the causality between the magnitude of the tax reform and its effect on behaviour. Still, these scenarios of behavioural change underwrite our case, because the behaviour may even happen without the introduction of a UBI or similar tax reforms. Nevertheless, it is still interesting to investigate the real causality between UBI and tax-benefit reforms, but it is not a requirement for the conclusion of our research.

Chapter 4

Methodology and Data Collection

The goal of this study is to determine whether changes in household composition influence a tax-benifit reform, more specific a UBI reform. We start with the design of a UBI reform in Section 4.1. Subsequently in Section 4.2, we decide what evaluation method to use to determine the effects and to be able to answer the research question in the end. In the last step in Section 4.3, we generate altered versions of the input data set to incorporate changes in household composition.

The workflow we apply in our research is presented in a flowchart in Figure 4.1. The step marked (1) in the flowchart is already conducted in Section 2.2. The result can be found in Table 2.3. Steps marked (2) and (3) are performed in this chapter. From now on, we refer to the workflow in Figure 4.1 and its sub-processes in Figures 4.2 and 4.3 to indicate the progression of our research.

4.1 Introducing a Universal Basic Income Reform

In this section the third sub-question is answered. This corresponds to Step (2), for which we provide a sub-workflow in Figure 4.2.

> *What do we adopt as the solvent UBI reform of the Italian tax-benefit system, to be used as status quo in microsimulation?*

To answer this sub-question, we first have to define *solvent*. We assume the current Italian tax-benefit system is designed to be stable and sustainable. Therefore, the resulting government budget, that includes earnings from taxes and social insurance contributions (SICs) minus expenses from benefit and pension payments, should resemble a stable and sustainable system. Thus, we deem the UBI reform also solvent when the government budget remains the same. In this section, a reform is designed for which the government budget does not change. We call this the *government budget constraint*. The government budget of the current Italian tax-benefit system is €90 838.12 million (see Table 2.3).

In order to design a tax-benefit reform, the design of the current Italian tax-benefit system and its policies are determined. From those a selection of policies is made that is relevant to be abolished and replaced by the UBI reform. The detailed list is shown in Appendix

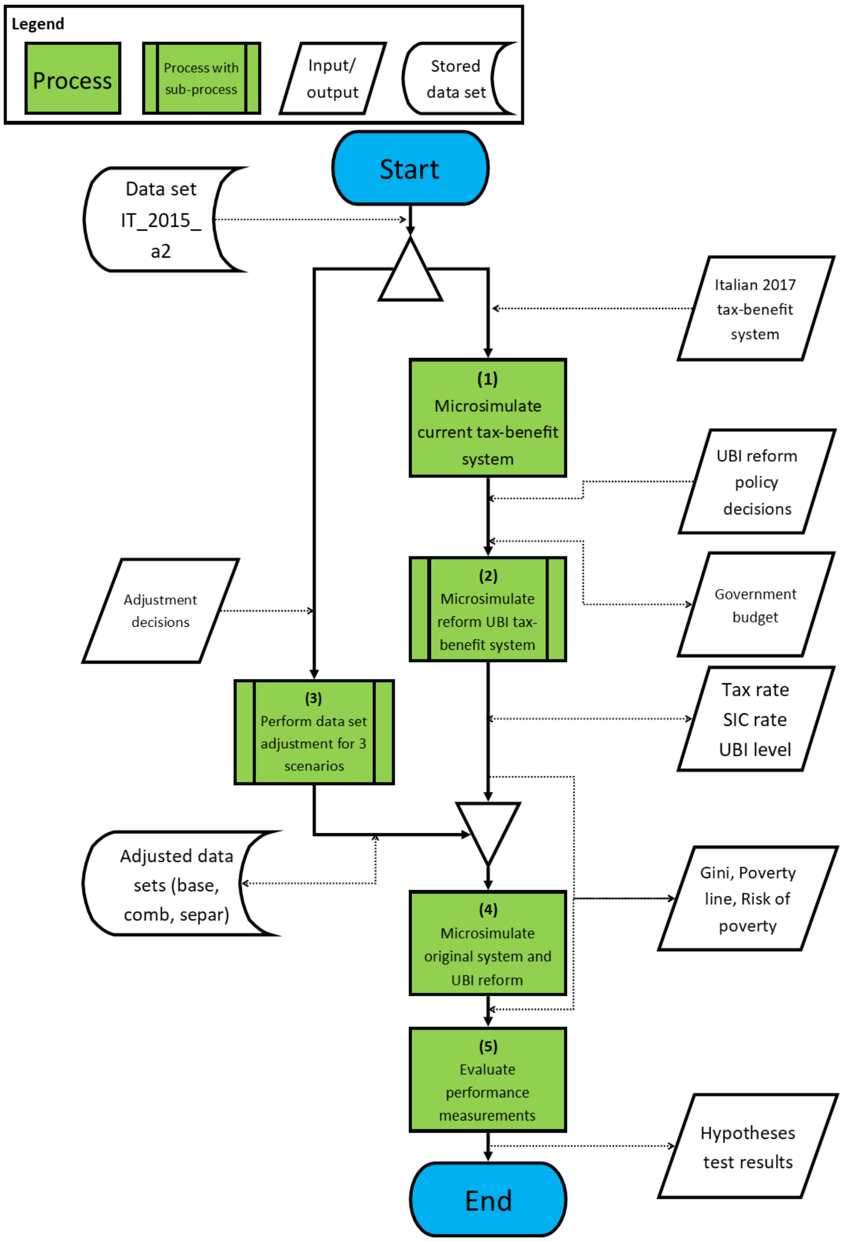


Figure 4.1: Detailed flowchart of our research workflow.

C. The reform we introduce only adjusts income tax policies, not capital tax. Most of the original benefit and income tax credit and deductible policies are abolished, except for the ones designed to target disabled or others in need of medical care. Income tax deductibles or credits for which tax is paid at a later point, such as alimony, and contributions to private pension plans are not abolished either. Also, most other pension policies are kept in place.

4.1.1 Characteristics of the Reform

The UBI reform our research adopts, does also not fully comply with all characteristics of the definition in Section 2.1. It relaxes the universal requirement, since it is modelled to be given to citizens in Italian households only and children receive only half of the amount

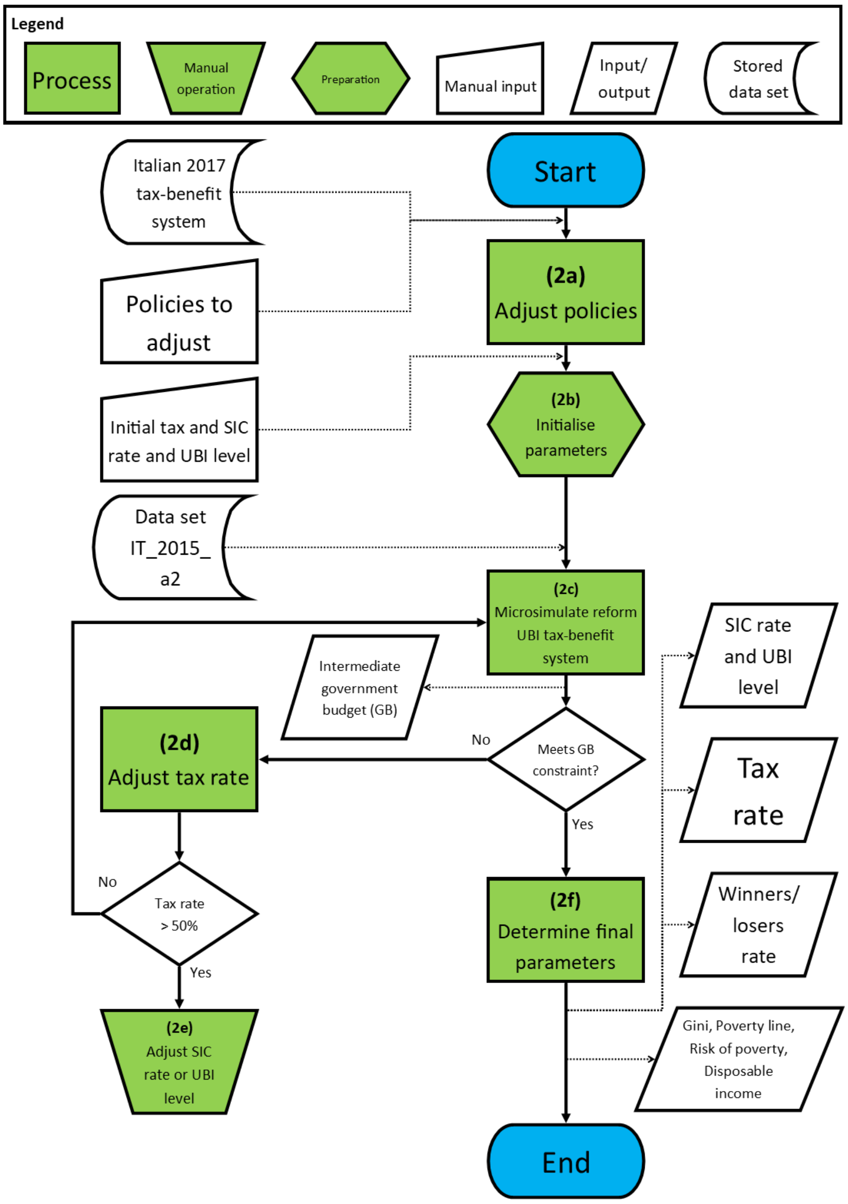


Figure 4.2: Workflow of sub-process '(2) Microsimulate reform UBI tax-benefit system'.

adults receive. We argue that the inclusion of those citizens, concerns a political community, which is inclusive enough for a national tax-benefit reform.

The decision that children receive half the payment, is based on the lower needs that children require since they live in a household. The reform does satisfy the periodic requirement, as it is paid monthly. If we consider the disposable part of the UBI payment as the cash payment, it also fulfils the second condition. It is given without means-test and work requirements, thus unconditional. Everybody gets it personally, so individual.

4.1.2 The Social Insurance Contribution Rate

We introduce FT, so we adjust the national tax scheme to be constant for every amount of income, as explained in Section 2.1.4. Therefore, the SICs are also adjusted to make sure the contributions are paid over the entire income, not just a part of it as is now the case. SICs also have to be paid on the UBI benefit in order to realise FT. The level of the conventional SIC rate vary over industries, age and the type of employment, which we did not change in the policy alteration, since it imposes some characteristics have a higher risk to end-up filing a social insurance claim. So, the SIC rates are only approaching flat tax in our research.

For the conventional employment income, there is a part of SICs that is paid by the employer (29.86 % or 32.08 %) and a part by the employee (9.49 %), or, in case of self-employment, only one part that is smaller than the other two combined (27.99 %–31.09 %). However, in our case the options are different: the beneficiary pays the SIC, the government pays the SIC or they both pay a share. It can be seen, since the government is distributing the UBI and simultaneously collecting the SIC, while the beneficiary gets the benefit for free, the options in the end are all the same once decided what the level of the UBI before tax should be (see Table 4.1).

Table 4.1: Comparison of SIC rate splitting method.

(a) Equal gross UBI.

	Government	**Beneficiary**	**Shared**	
Gross UBI	€980.00	€980.00	€980.00	
Government's SIC share	39.35 %	0.00 %	29.86 %	
Government's SIC amount	€276.73	€0.00	€225.34	−
UBI distributed	€703.27	€980.00	€754.66	
Beneficiaries' SIC share	0.00 %	39.35 %	9.49 %	
Beneficiaries' SIC amount	€0.00	€385.63	€71.62	−
UBI before tax	€703.27	€594.37	€683.04	

(b) Equal UBI before tax.

	Government	**Beneficiary**	**Shared**	
Gross UBI	€836.10	€989.28	€860.86	
Government's SIC share	39.35 %	0.00 %	29.86 %	
Government's SIC amount	€236.10	€0.00	€197.94	−
UBI distributed	€600.00	€989.28	€662.91	
Beneficiaries' SIC share	0.00 %	39.35 %	9.49 %	
Beneficiaries' SIC amount	€0.00	€389.28	€62.91	−
UBI before tax	€600.00	€600.00	€600.00	

In our tax reform we let the beneficiary pay for the whole SIC. One may argue, it would be more reasonable to mimic as if the government is the employer and the beneficiary the employee, thus adopt the method of the column *Shared*, otherwise the SIC is extraordinarily high for the beneficiary. However, as a result we will choose to lower the gross UBI payment to comply with the government budget constraint. In the end we will maintain an equal received UBI before tax, e.g. €600 as shown in Table 4.1b. Thus, this would only change the flow of money or redistribution.

Next, the SIC rate is determined to establish the tax system to be as flat as possible. We choose to use a rate of 39.35 % that is equivalent to the rate of a white-collar employee and its employer combined. This is the lowest rate, which we argue to be reasonable, because there is no risk in receiving a UBI as there is with working in specific risky industries.

4.1.3 Level of the Universal Basic Income Payment

Still, the FT rate and the level of the UBI have to be determined. Those two are dependent upon each other, since the government budget constraint balances them. Because the SICs and the FT rate still have to be subtracted, we reason the level of the gross UBI payment has to be relatively high. However, the research goal is not to determine the optimal properties of a UBI design. We only introduce a cap to the FT rate of 50 %, since above would be unacceptably high. Therefore, we decide, after some trial and error, to model the Italian government paying a monthly UBI of €980 for adults, of which the beneficiary has to pay 39.35 % of SIC and a still to be determined tax rate. For children the UBI amount is half the adults', thus €490. A preliminary microsimulation of this UBI level shows an improvement in the system's performance measurements that were introduced in Section 2.2.1. Those fit the argued advantage of a UBI of decreasing inequality and poverty.

4.1.4 Determining a Government Budget Neutral Flat Tax Rate

Up to now we performed Steps (2a) and (2b) as shown in Figure 4.2. Next, we continue with (2c) up to (2f). The SIC rate and level of the monthly UBI payment have been determined, the national tax rate is now calculated. We need to comply with the *government budget constraint*, thus find the tax rate for which the government budget after the UBI reform stays the same.

As already shown in Table 2.3 the budget constraint is €90 838 million per year. In order to find the appropriate tax rate, we add a policy in EUROMOD that minimises the error of the budget by iterating over the relevant tax policies. Every iteration updates the tax rate based on the intermediate error of the budget. This way it nears the required budget. Performing this exercise, a relaxation and restriction are determined:

- We allowed an error of 0.0001 % of the original government budget. Thus, the *government budget constraint* is relaxed a bit.
- The maximum tax rate is 50 %, since otherwise it becomes so high that doubts will arise about the political feasibility and the social acceptability. If the rate is exceeded, the monthly UBI payment amount is decreased. The initial amount is €980 for adults and half for children as stated in previous section.

The national tax rate corresponding this government budget is 44.3148 %. The disposable UBI resulting from this tax rate is €330.98.

A summary of the microsimulation after the UBI tax reform is shown in Table 4.2. All the measures were explained in Section 2.2.1, expect for *winners* and *absolute risk of poverty*. The measure *winners* concerns the proportion for which the equivalised disposable income increases due to the reform. This is determined on an individual and household basis and is interesting because it tells us how advantageous the reform is in the eyes of households and individuals.

Table 4.2: Performance measurements of the tax-benefit system after the UBI reform (M = million, pp = percentage point).

	Current	**Reform**	**Change**
Government budget	€90 838.12 M	€90 838.51 M	€0.39 M
Gini coefficient	0.3072	0.2453	-0.0619
Relative poverty line	€782.96 monthly	€799.11 monthly	€16.15
Relative risk of poverty	17.97 %	11.22 %	−6.75 pp
Absolute risk of poverty	17.97 %	10.14 %	−7.83 pp
Average disposable income	€2375.80 monthly	€2368.17 monthly	€−7.63
Winners	N/A	54 % individuals 44 % households	N/A

Furthermore, in addition to relative risk of poverty, we determine risk of poverty based upon an *absolute poverty line* of €782.96 and call this *absolute risk of poverty*. This figure is set equal to the *relative poverty line* of the original tax-benefit system, as shown in Table (2.3). As can be seen in Table 4.2, 10.14 % is the proportion of people falling below this absolute poverty line for the reform.

We determine absolute and relative risk of poverty, since they both tell us something different about the microsimulated reform. The absolute poverty tells us better whether the proportion of poor people improved due to the reform without changing the poverty line of €782.96, thus without considering purchasing power. The relative risk of poverty includes effects of economic growth and inflation better, indicating the proportion of people that have fallen behind.

Relaxing the Government Budget Constraint

We also try an alternative approach, to get a higher disposable UBI payment. We argue it is reasonable a government is willing to invest some budget in UBI. Hence, we allow the *government budget constraint* to relax a bit further. The allowed error is 1 %. The SIC rate remains the same and we increase the UBI from €980 to €1.500. This results in a government budget of €90 050.14 million with a high tax rate of 53 %. So, even then the disposable UBI is only €428.

It appears, we are unable to obtain a much higher UBI at the level of a reasonable unemployment compensation. Increasing the UBI to such a level requires an increase in the tax rate above 50 %. Even if the government is willing to invest all its budget into the reform the disposable UBI is not increasing a lot. We find that for a UBI of €980 the tax rate becomes 37 %, which results in a disposable UBI of €374 and decreases the government budget to €349 M. Since we are not trying to find out the optimal level for a UBI, we adopt the €980 and stick to the *government budget constraint*.

4.2 Evaluation of a Change in Household Composition

Now that we have determined the UBI tax-benefit reform, we are going to test for changes in household composition. However, first we determine how to evaluate any difference in the output of the tax-benefit system, resulting from those changes. This is the fourth sub-question:

> *How to determine whether there are effects on the UBI tax-benefit system due to changes in household composition?*

4.2.1 Evaluation of the Effect to the UBI Reform

The effects, referred to by this sub-question, originate from a modelled increase in either the cohabitation or household separation rate. Since one of the purposes of UBI is to overcome poverty and decrease inequality, we argue to use the Gini coefficient, and the risk of poverty as performance measurements to evaluate the effects.

Additionally, we also evaluate the effects on the government budget and average disposable income. The Gini coefficient, relative risk of poverty and average disposable income are calculated as explained in Section 2.2.1 and for the government budget as explained in Section 4.1. The absolute risk of poverty is measured as explained in 4.1.4. We use a fixed poverty line of €782.96 for the absolute risk of poverty.

Now, rereading the sub-question, we first need to determine whether those five measurements change significantly after incorporating a change in household composition.

- We do this by using a Welch's t-test, since we have two samples (the *base* scenario and one of the two adjusted scenarios) and this test does not require equal variances between populations.
- We perform a two-tailed test, since we want to test for a change, not only a decrease or increase. Please note this t-test has to be done ten times in total, five times for each of the two adjusted scenarios.
- It is assumed all the resulting sample scenarios are equally likely to occur and independent. We generate 40 samples for all scenarios and test for normality using Saphiro-Wilk test and Anderson-Darling test, to confirm the sampling distribution is nearly normal.
- We generate multiple *base* scenarios and alternative scenarios and determine each of its measurements. Each of these measurements is an item in the sample population. So, this results in a set of 41 performance measurements for each scenario.

We take the Gini coefficient measure and the *cohabitation* scenario as an example. In this case our null hypothesis states the mean Gini coefficient of the population of *cohabitation* scenarios *equals* the mean Gini coefficient of the population of *base* scenarios. Thus

$$H_0 : \mu' = \mu \tag{4.1}$$

and

$$H_1 : \mu' \neq \mu \tag{4.2}$$

where μ' is the mean Gini coefficient of the population of *cohabitation* scenarios and μ is the mean Gini coefficient of the population of *base* scenarios.

After simulating the required scenarios, we calculate the sample means, standard deviation and Welch's test statistic of the Gini coefficient, determine the p-value from the test statistic, and interpret this p-value in terms of the hypotheses. We use a significance level of 0.01 to interpret this p-value. This enables us to decide whether the household composition changes the measurements significantly.

4.2.2 Evaluation of the Impact of the Implementation of the UBI

At this point we are only able to determine whether the household composition causes significant changes in the performance measurements. Two follow-up questions are what the direction and magnitude of those changes are, and how this compares to the original non-UBI system for the same scenarios. The first is answered by observing the means of the measurements after showing they are significant. The latter, we want to test for the difference between the effects on the original tax system compared to the UBI tax system. Thus, we microsimulate the three scenarios also for the original tax-benefit system. Next, we determine the difference between the *base* scenario and the two alternative scenarios for both systems and compare these results.

Since the sample scenarios are not paired, we should determine the measurements of the *base* scenario with Seed 1 and compare them with the measurements of the alternative scenarios for all seeds, since the seeds are independent of each other. Therefore, we have $41^2 = 1681$ permutations. However, an original *base* scenario with Seed 1 is comparable to a UBI *base* scenario with Seed 1 only, since those are paired. In other words, we can pair the seed of a scenario in the original system with the same seed and scenario of the UBI system, but not with a different scenario. Using this method, we can analyse the impact, which is done in Section 5.2.1.

4.3 Adjusting the Input Data Set

The next step is to model an increase in cohabitation and in separation, respectively, continuing where we left off in Section 3.3 with the second sub-question:

How to restructure household data to include changes in household composition?

This section corresponds with the sub-workflow as shown in Figure 4.3.

We continue with the figures obtained in Section 3.3. These figures are rates of change of one single-adult households we use for the three scenarios. $0.8881\,\%$ for the *base* scenario, $8.6014\,\%$ for the *separation* scenario and $-5.0679\,\%$ for the *cohabitation* scenario

In the data set we use, there are $25\,775\,872$ households, of which $36.16\,\%$ contain precisely one adult and any number of children. Taking the *base* scenario as an example, we need to find a total number of households, for which the number of single-adult households is $36.16\,\% \times 100.8881\,\% = 36.48\,\%$, and for which the affected number of single-adult households is twice the number of the affected other households. The latter is important, since for every two single-adult households that cohabit, only one multiple-adult household is left, resulting in one household less. For simplicity, we assume that only two-adult households are selected to split up. Otherwise a split up would not result in two single-adult households.

In Table 4.3, the number and proportion of single- and multiple-adult households in the original data set are shown, together with the three scenarios. Thus, for the *base* scenario and *separation* scenario, it appears we model $50\,681$ and $498\,788$ two-adult households splitting up, respectively, which results in $101\,241$ and $997\,569$ single-adult households. The *cohabitation* scenario, however, models $285\,145$ more multiple-adult households, resulting in $570\,213$ single-adult households less. The specific households in the data set that are going to be adjusted, are selected in a random uniform manner using a *Mersenne Twister* random number generator.

Table 4.3: Changes in household composition in Italy to be used for the scenarios.

		Original	Base	Cohabitation	Separation
Total households		25 775 872	25 826 495	25 490 804	26 274 653
One single-adult households	**Number**	9 320 555	9 421 796	8 750 342	10 318 124
	Proportion	36.16 %	36.48 %	34.33 %	39.27 %
	Difference w.r.t. original		101 241	−570 213	997 569
Multiple-adult households	**Number**	16 455 317	16 404 699	16 740 462	15 956 529
	Proportion	63.84 %	63.52 %	65.67 %	60.73 %
	Difference w.r.t. original		−50 618	285 145	−498 788

Moreover, the data set contains a cross-sectional weight so the total number of people in the data set reflects the 60.5 million people in Italy accordingly. Therefore, a household can be selected more than once, indicating it is adjusted with a larger cross-sectional weight.

So, we have three scenarios to simulate. Ex-ante, these are called the *base*, *cohabitation* and *separation* scenario. Those are all independent of each other. The *base* scenario and *separation* scenario concern an increase in the proportion of one single-adult households. The *cohabitation* scenario, on the other hand, models a decrease in the proportion of single-adult households.

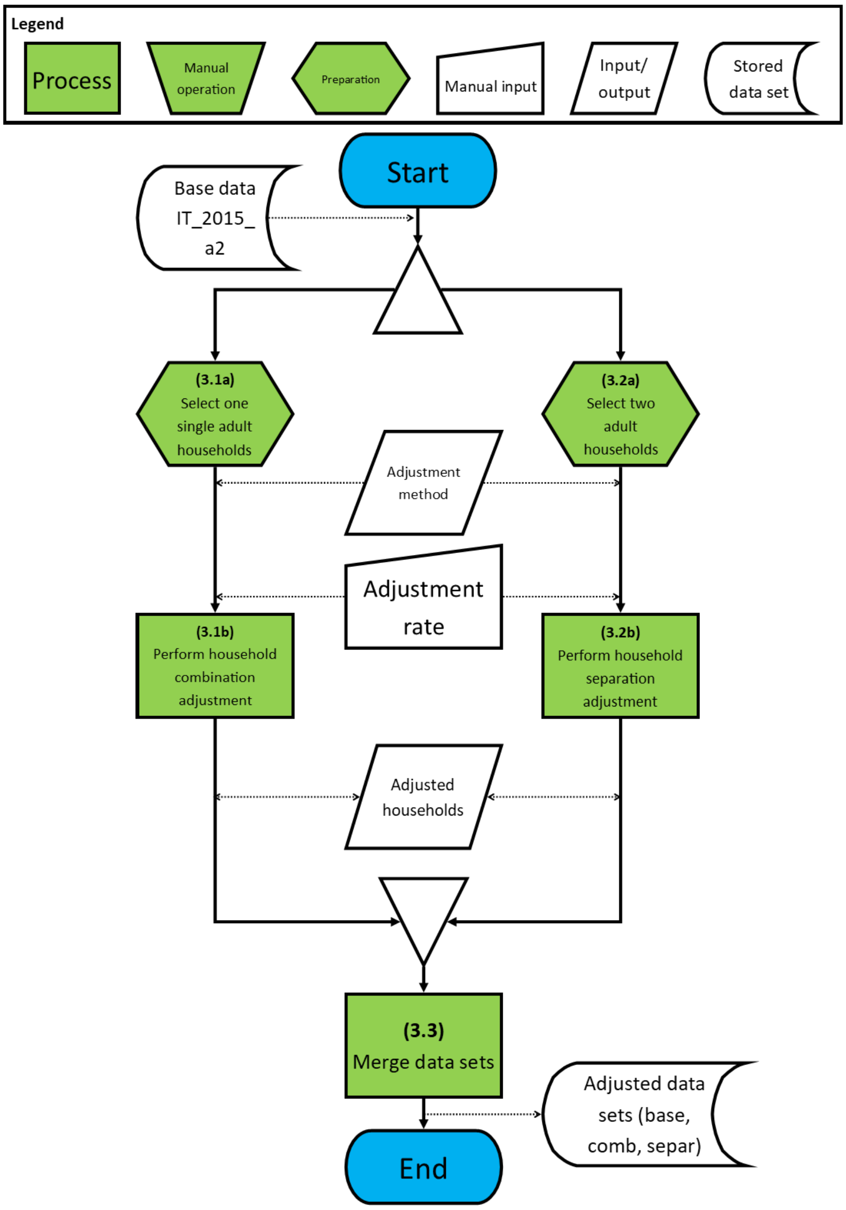


Figure 4.3: Workflow of sub-process '(3) Perform data set adjustment for 3 scenarios'.

4.3.1 Household Selection

For modelling household cohabitation, as is the case with the *cohabitation* scenario, first the number of households containing single adults is determined. For example, 570 213 single-adult households have to be randomly selected (see Table 4.3). Those single-adult households are households that consist of maximum one adult, aged 24 or older, who does not have a partner yet. The number of (dependent) children is not restricted. The random draw considers the cross-sectional weight of the household. This means that households with a bigger weight, each draw, have a higher probability of being selected. The randomly selected households are combined per two, resulting in one household fewer for every household merger. The dependent children and parents from both the original households, if any, become part of the new household.

In the case of modelling splitting household, as is the case in the *base* and *separation* scenario, we select only two-adult households. We do not select multiple-adult households, since splitting those will not result in an increase in single-adult households, which is required for the scenario we are modelling. This results in 50 618 two-adult households for the *base* scenario (see Table 4.3). For each time a household is selected, it is split into two households, so one split results in two single-adult households. Each of the dependent children and parents, if any, is randomly allocated to one of the parents with an equal probability. Multiple assumptions have been made using this methodology:

- Only adults (aged over 24) are considered in the combination procedure, since combining an 18 years old with a 25 years old would otherwise still be seen as a single-adult household.

- In the partner selection procedure, there is no preference towards gender and no preference towards the age of the partner. The singles to be combined are randomly selected. This is reasonable, since we are modelling cohabitation, not marriage.

- We know the net rate of change of single-adult households at the end of a year. However, we do not know how many households did combine and separate within a year ending up in this figure. Therefore, the *cohabitation* scenario only concerns combinations and the *base* and *separation* scenario model only splits households, not a mix of combinations and splits. This also means the model does not allow for a household to be both split and combined within one year and visa versa.

- In the splitting procedure, households with more than two adults are ignored, since splitting those does not result in two single-adult household.

- In the splitting procedure, children are randomly assigned to their mother with 85 % probability or father with 15 % probability. Those probabilities originate from the data set's distribution for single adults with their child.

4.3.2 The Input Data Set

The data set we adjust is structured as shown in Table 4.4. Only the variables that are important in the data adjustment are displayed. Every line resembles an individual in the form of a unique personal identifier (*idperson*), with its cross-sectional weight (*dwt*). The individual belongs to a household, characterised with an identifier called *idhh*. The first numbers of the *idperson* are always the same as its *idhh*. The last two are unique for the individual. The individual optionally has a partner (*idpartner*), mother (*idmother*) and/or father (*idfather*), also referred to with their *idperson*. The age of the individual is given by *dag*. Lastly, the marital status is given by *dms* where 1=single, 2=married and 3=separated.

Table 4.4: First 3 households and 8 variables in an exemplary data set.

idhh	idperson	idpartner	idmother	idfather	dwt	dag	dms
1	101	102	0	0	10	65	2
1	102	101	0	0	10	60	2
1	103	0	102	101	10	30	1
1	104	0	102	101	10	28	1
2	201	202	0	0	10	29	2
2	202	201	0	0	10	25	2
2	203	0	202	201	10	3	1
2	204	0	202	201	10	2	1
3	301	302	0	0	10	72	2
3	302	301	0	0	10	59	2

4.3.3 The Adjustment Procedure

Now, the procedure for adjusting the input data is explained in more detail. The main function can be seen in Algorithm 1. This function calls two other functions, which are shown in Algorithms 2 and 3. The input of Algorithm 1 is a data set that is structured like to the one in Table 4.4, two figures that resemble the proportion of households that need to be adjusted, and the number of loops that have to be done. The algorithm is able to process an input file with combinations and separations subsequently. However, our research only performs one of them for each scenario.

Algorithm 1 Adjust the data set according to one or two ratios.

function ITERATE_SCENARIO($inputset\_base$, $ratio\_comb$, $ratio\_separ$, $loops$)
  for every individual in $inputset\_base$ **do**
    determine $has\_partner, number\_of\_parents, is\_adult$
  end for
  for each household in $inputset\_base$ **do**
    determine $household\_size, number\_of\_adults, number\_of\_partners$
  end for
  $inputset\_other \leftarrow inputset\_base$ where $number\_of\_adults = 0$ or > 2
  for $seed \leftarrow 1, loops$ **do**
    $inputset\_comb \leftarrow$ COMB($inputset\_base, ratio\_comb$, $seed$)
    $inputset\_separ \leftarrow$ SEPAR($inputset\_base, ratio\_separ$, $seed$)
    $inputset\_scenario(seed) \leftarrow [inputset\_comb; inputset\_separ; inputset\_other]$
  end for
  Return $inputset\_scenario$
end function

Preparation of the Data Set

Algorithm 1 starts with preparing some additional information for every individual in the data set. It uses the variables that are also shown in Table 4.4 to determine for every individual whether they have a partner, the number of parents they have in the data set, and whether they are older than 24. Line 6 of Algorithm 1 uses the output to determine the distinct household identifiers and the household size and number of adults and partners. The original data set, where the household does qualify as either being a one single adult or two-adult household, is set aside in *inputset_other*.

Next, the data set is adjusted according to the different scenarios. This is done as many times as is stated by the variable *loops*. The loops differ in the selection procedure. This is realised with a random drawing procedure using a random seed, that changes every loop. Algorithm 2 and 3 describe the adjustment procedures. In the end the two adjusted data sets and *inputset_other* are merged.

Combine Households

The combination function (Algorithm 2) requires the original input data, the proportion to combine and a seed number. First, it is determined how many households are going to be combined. This needs to be an even number, since we require two households per combination. Then we create a table of households that are selected by the random drawing procedure. The number of times the household is drawn, is considered the new cross-sectional weight. The drawing is done with replacement. We only select the relevant single-adult households from the original data.

The original cross-sectional weight is decreased with the new cross-sectional weight (Line 5). We shuffle the households that were drawn, to make sure different households are combined every iteration. Then we start a while-loop as long as there are households to combine. Every loop, the first two household identifiers will be selected and the one with the smaller cross-sectional weight, determines the new cross-sectional weight (Line 9 and 13). The remaining weight is used to combine with the following household.

For example, the two original weights were 100 and 200 and the households are drawn, respectively, 5 and 8 times. First, the original households will get a cross-sectional weight of 95 and 192 (Line 5). Within the loop, the new combined household gets a weight of 5 (Line 9 and 13). The remaining 3 of the latter, is combined in the next iteration with the subsequent household in a similar way. Since every time a household has no weight remaining, it gets removed from *household_ids* (Line 11), at some point there is only one household left. This last household is duplicated, and the cross-sectional weight divided in two, so we can combine it with itself.

We copy the two households from the *inputset_singles* and start to adjust them with the new weight and a new household identifier. The new partners get each other's identifiers in the *idpartner* variable. They also randomly get the marital status 1=single ($9\,\%$) or 2=married ($91\,\%$) as this is the national distribution for people living with a partner (Organisation for Economic Co-operation and Development, 2016). All personal identifiers are then updated

Algorithm 2 Combine households for the *cohabitation* scenario.

function COMB($inputset\_base, ratio\_comb, seed$)
  $number\_of\_combinations \leftarrow number\_of\_households \times ratio\_comb$
  $households \leftarrow$ random sample of households where $number\_of\_adults = 1$ and $number\_of\_partners = 0$
  $inputset\_cohab \leftarrow inputset\_base$ where $number\_of\_adults = 1$
  decrease weights with $times\_drawn$
  shuffle $households$
  while $households$ is not empty **do**
    select $times\_drawn$ of the first two households
    $new\_cross\_weight \leftarrow$ minimum of $times\_drawn$
    $times\_drawn$ subtract new_cross_weight
    remove $households$ where $times\_drawn = 0$
    select the two households from $inputset\_cohab$
    $dms \leftarrow new\_cross\_weight$
    $idhh \leftarrow$ new unique id
    for each of the two adults **do**
      $idpartner \leftarrow$ each others $idperson$
      $dms \leftarrow$ either 2 or 1 randomly
    end for
    update $idperson, idfather, idmother, idpartner$ of new household to match id
    add new household to $inputset\_cohab$
  end while
  Return $inputset\_cohab$
end function

to match with the household identifier in order to comply with the format convention of the original data. This finishes the combination of a household, continuing with the next. The combined households are added to the table *inputset_cohab*. After the loop, this table is returned.

Split Households

The separation function (Algorithm 3) requires the original input data, the two tables *individuals* and *households*, the proportion to separate, a seed number and a maximum household id. First, it is determined how many households are going to be separated. This needs to be an integer. Then we create a table of household identifiers that are selected by the random drawing procedure. The number of times the household is drawn, is considered the new cross-sectional weight. The drawing is done with replacement. We only select the relevant two-adult households with individuals from the original data.

The original cross-sectional weight is decreased with the new cross-sectional weight (Line 5). Then we start a for-loop as long as there are households to split. Every loop,

Algorithm 3 Split households for the *base* and *separation* scenario.

1: **function** SEPAR($inputset\_base, ratio\_separ, seed$)
2: $num\_of\_separations \leftarrow number\_of\_households \times ratio\_separ$
3: $households \leftarrow$ random sample of households where $number\_of\_adults = 2$
4: $inputset\_separ \leftarrow inputset\_base$ where $number\_of\_adults = 2$
5: decrease weights with $times\_drawn$
6: **for** $i \leftarrow 1$,height($households$) **do**
7: select $times\_drawn$ of the first drawn household
8: select the same household from $inputset\_separ$
9: overwrite the weight with $times\_drawn$
10: **for** each child in the household **do**
11: $idfather$ or $idmother \leftarrow 0$ randomly where $number\_of\_parents = 2$
12: **end for**
13: **for** each of the two adults **do**
14: $idpartner \leftarrow 0$
15: $dms \leftarrow 3$ if it was 2
16: $idhh \leftarrow$ new unique id
17: $idhh$ of dependent children $gets$ same new id
18: **end for**
19: update $idperson, idfather, idmother, idpartner$ of new households to match ids
20: add new households to $inputset\_separ$
21: **end for**
22: Return $inputset\_separ$
23: **end function**

we determine how many times the household was drawn. The cross-sectional weight is then updated. Children are randomly assigned to their mother (85 %) or father (15 %) by removing the id of the other (Line 11). Those probabilities are retrieved from the data set's distribution for single adults with their child. For the two adults, *idpartner* is set to 0 and *dms* to 3 (separated) if it was 2 (married), in order to comply with EUROMOD's data format convention. Since each separation results in two new households in the data set, we need two new unique household identifiers.

Next, we look for dependent children of the adults, and update their household identifiers (Line 17). All personal identifiers are then updated to match with the household identifier in order to comply with the format convention of the original data. This finishes the separation of a household, continuing with the next. The combined households are stored in the table *inputset_separ*. After the loop, this table is returned.

Descriptive Statistics of the Resulting Data Set

We use a known seed for the initialisation of the random drawing procedure for replication purposes. After conducting the data adjustment procedure, the average household size has changed. For Seed 1, some descriptive statistics of the adjusted input data sets are shown in Table 4.5 as an example.

Table 4.5: Descriptive statistics of the adjusted input data sets with Seed 1.

	Base	**Cohabitation**	**Separation**
Weighted household size mean	2.342	2.372	2.302
Weighted household size variance	1.5519	1.5528	1.5535

Since one iteration of data alteration only gives us one set of performance measurements per scenario in Step (4), we repeat Step (3) with different seeds. This is done 41 times to generate a sample population for all scenarios. At the end of this step, we have generated 123 input data sets in three scenarios to be used in Step (4), which is performed in Chapter 5.

Chapter 5

Results

Now we have gathered all the data we perform several hypothesis tests in this chapter. In Section 5.1 we test for the effects due to a change in household composition. After that, in Section 5.2 we continue with a comparison of those effects between the UBI and original tax-benefit system. In Chapter 6, we discuss the results that are presented here.

At this point, we are able to determine the measurements after the reform by simulating the altered data, which is Step (4). The final step, as shown in the workflow in Figure 4.1, is conducted thereafter. In this chapter we answer the fifth sub-question.

> *What are the effects in microsimulation on the UBI tax-benefit system due to the changes in household composition?*

5.1 Significance of the Increase in Cohabitation and Separation

First, all the previously generated 123 input data sets are microsimulated using EUROMOD. For this microsimulation step, the UBI reform determined in Step (2) is used, i.e. a FT rate of 44.31 %, a SIC rate of 39.35 %, and a UBI level of €980 Then we determine the government budget, Gini coefficient, risk of poverty and average disposable income for each simulation. The result is three sample sets. The mean consequences of the scenarios are shown in the last three columns of Table 5.1.

Table 5.1: Performance measurements of the two UBI scenarios compared to the UBI base *scenario (*M = *million).*

	Reform	**Base**	**Cohabitation**	**Separation**
Government budget	90 838.51 M	90 846.63 M	90 835.46 M	90 913.38 M
Gini coefficient	0.2453	0.2456	0.2446	0.2480
Relative poverty line	799.11	798.79	802.40	794.64
Relative risk of poverty	11.22 %	11.27 %	11.05 %	11.63 %
Absolute risk of poverty	10.14 %	10.21 %	9.91 %	10.82 %
Average disposable income	2368.17	2363.53	2394.67	2323.33

5.1.1 Testing for Normality

Before we can continue with Welch's t-test, we establish whether normality of the measurements' distribution is a reasonable assumption. We use normal P-P plots and the Saphiro-Wilk test and Anderson-Darling test. Although we are not planning to use poverty line as a measure, we also include it in the normality test.

For all scenarios, it is not reasonable to assume normality for the distribution of the poverty line. In the case of the *base* scenario. This also holds for the average disposable income. The P-P plots can be found in Appendix B. This implies that we also discard the average disposable income in the hypothesis testing procedure.

For further analyses, we argue the government budget is less relevant, since a tax-benefit reform may induce some costs. Since 1997, Italy has known two extensive tax reforms. The estimated costs were €20 000 million (Bernardi, 2005). Compared to that, our scenarios involve only small changes in the government budget. Therefore, it does not seem likely the tax-benefit system becomes less solvable, due to a change in household composition. Thus, although we show means for all performance measures, from here we only evaluate the Gini coefficient and risk of poverty.

5.1.2 Hypothesis Testing

In Section 5.1 we determined the hypothesis by using the Gini coefficient as an example. However, the hypothesis is similar for every performance measurement. Our null hypothesis states the mean performance measurement of the population of alternative scenarios *equals* the mean performance measurement of the population of *base* scenarios. Thus

$$H_0 : \mu' = \mu \tag{5.1}$$

and

$$H_1 : \mu' \neq \mu \tag{5.2}$$

where μ' is the mean performance measurement of the population of alternative scenarios and μ is the mean performance measurement of the population of *base* scenarios.

After simulating the required scenarios, we calculate the sample means, standard deviation and Welch's test statistic of the different measurements, determine the p-value from the test statistic, and interpret this p-value in terms of the hypotheses. We use a significance level of 0.01 to interpret this p-value. The sample means and standard deviation for the three scenarios and the measurements are shown in Table 5.2.

Next, we determine the Welch's test statistic

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}}} \tag{5.3}$$

where $\bar{X}_1$ is the *base* scenario's sample mean, s_1^2 the sample variance, and N_1 the sample

Table 5.2: Sample standard deviation s^2 of the three scenarios.

	Base	Combination	Separation
N	41	41	41
Gini	2.878×10^{-6}	1.490×10^{-5}	1.213×10^{-5}
Relative risk of poverty	6.128×10^{-6}	3.369×10^{-5}	2.917×10^{-5}
Absolute risk of poverty	6.487×10^{-6}	3.462×10^{-5}	2.970×10^{-5}

size. The value of the degrees of freedom is calculated according to

$$v \approx \frac{\left(\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}\right)^2}{\frac{s_1^4}{N_1^2 v_1} + \frac{s_2^4}{N_2^2 v_2}} \tag{5.4}$$

where $v_1 = N_1 - 1$ is the degrees of freedom of the first variance estimate. Next, we obtain the p-value corresponding with the test statistic and degrees of freedom. The test statistics, degrees of freedom and p-values for the three scenarios and the four measurements are shown in Table 5.3. Since the p-value is extremely small for all measurements at the 0.01 level, all the measurements are significant, and we can reject all the null hypotheses. This means that the change in household composition has changed the measurements significant for the UBI reform.

Table 5.3: Test figures and results of the two alternative scenarios tested against the base *scenario.*

		Gini	Relative Risk of Poverty	Absolute Risk of Poverty
Combination versus base	t	421.14	414.20	529.69
	v	42.98	42.64	42.81
	p	<0.001	<0.001	<0.001
	h	1	1	1
Separation versus base	t	−1222.98	−769.49	−1290.82
	v	44.49	43.52	43.81
	p	<0.001	<0.001	<0.001
	h	1	1	1

5.2 Comparison with the Original Tax-Benefit System

Now we know what results are significant, we are curious how this compares to the original tax-benefit system in order to answer the research question. To be able to draw this conclusion about the influences of household composition due to a UBI reform, we want to find out what would happen if the same scenarios happened with the original system. Therefore, we run 123 additional microsimulations using EUROMOD and the adjusted household data. In Step (5), we compare the results.

In Table 5.4 the mean consequences of the scenarios are shown. This table is similar to Table 5.1, but then for the original tax-benefit system. The fixed poverty line we use is retrieved from Table 2.3, which is still €782.96 We use the same approach to test for normality and test for the same hypotheses as before. This way we obtain similar results as with the UBI reform. So, poverty line and average disposable income are not normally distributed, and all the other measures are significant.

Table 5.4: Performance measurements of the two original scenarios compared to the original base *scenario (*M *= million).*

	Current	**Base**	**Cohabitation**	**Separation**
Government budget	90 838.12 M	90 837.83 M	90 855.11 M	90 834.98 M
Gini coefficient	0.3072	0.3076	0.3064	0.3106
Relative poverty line	782.96	782.59	786.02	779.55
Relative risk of poverty	17.97 %	18.01 %	17.91 %	18.37 %
Absolute risk of poverty	17.97 %	18.03 %	17.78 %	18.51 %
Average disposable income	2375.80	2371.17	2402.31	2331.07

Comparing the Gini coefficient and risk of poverty, we see that the UBI is favourable than the original system for each scenario. Since, the differences are considerably large and the p-values of the previous tests considerably small, we conclude this without performing a test. So, these results encourage the implementation of a UBI.

5.2.1 Impact Analysis

We combine each *base* scenario with each alternative scenario, resulting in $41^2 = 1681$ pairs per scenario. So, the *base* scenario with Seed 1 is paired with each (Seeds 1 to 41) *cohabitation* scenario and each (Seeds 1 to 41) *separation* scenario for both systems. The change for each pair is then determined. The first two columns of Table 5.5 show the averages of these changes (Δ) per measure. The third column indicates which system's performance measurement is more sensitive and the last column which system's measurement is favourable.

To illustrate this, we take the absolute risk of poverty and the *cohabitation* scenario as an example (Table 5.5a). This tells us, that the average change to this measurement for the original tax-benefit system is a decrease of 0.2436 pp. For the UBI reform this is a decrease of 0.2914 pp. Hence, we see that the UBI reform affects this measurement more severe. However, the effect is in a favourable direction, since for risk of poverty lower is better.

These results tell us that the measurements react in the same directions for both systems. However, the risk of poverty measure is more sensitive in case of the UBI tax-benefit system. In the *cohabitation* scenario, this is in a favourable direction, but this is not the case in the *separation* scenario. The Gini coefficient is more sensitive in the original system. This is only favourable for UBI in the *separation* scenario.

Table 5.5: Impact analysis of the two alternative scenarios with respect to the base *scenario for both the original and UBI system (*pp *= percentage point).*

(a) Cohabitation versus base

	Δ Original	Δ UBI	Most sensitive	Favourable
Gini coefficient	−0.0011	−0.0010	Original	Original
Relative risk of poverty	−0.1020 pp	−0.2215 pp	UBI	UBI
Absolute risk of poverty	−0.2436 pp	−0.2914 pp	UBI	UBI

(b) Separation versus base

	Δ Original	Δ UBI	Most sensitive	Favourable
Gini coefficient	0.0031	0.0024	Original	UBI
Relative risk of poverty	0.3579 pp	0.3583 pp	UBI	Original
Absolute risk of poverty	0.4883 pp	0.6128 pp	UBI	Original

Chapter 6

Conclusions and Recommendations

This chapter directly answers the research question that was formulated in Section 1.2.1. In Section 6.1 we show how the results that are presented in Chapter 5, support this answer. In addition, we elaborate on relationships among the results. After that, we give recommendations for improvement of our research and for future research in Section 6.2. The research question that is answered is:

> *To what extent do changes in household composition, supposedly caused by a universal basic income reform, affect this UBI reform within one year after implementation?*

6.1 Conclusion

Our research shows that changes in household composition do affect a UBI reform of a tax-benefit system within one year after the implementation. More important, in the case of poverty the consequences are more severe than they would be in the original system. A UBI reform does not affect the direction of the cahnge in the poverty and inequality measurements but it does affect the magnitude of all performance measurements. This tells us the changes in household composition affect the UBI reform and leads to the adoption of the connector (v) in Figure 1.3b.

Moreover, the results show UBI is performing better at keeping the income distribution constant, while the original system is better at keeping the targeting of low incomes constant. This is reasonable, since the original tax-benefit system has many benefits that target low income households specifically. The UBI reform treats all household the same way, except for pensions and some health benefits.

Thus, it seems that the *cohabitation* scenario decreases inequality and the risk of poverty, while the *separation* scenario, on the other hand, has an increasing effect on those two measurements. From this, we can also conclude that poverty and inequality reduce in case the *anti-isolation* and *illegitimate cohabitation* claim happen. For the *financial independence* claim, however, poverty increases, and inequality grows. But this conclusion also seems to hold for the original tax-benefit system.

Despite that our research does not include other types of changes in household composition which may have the same effect on the tax-benefit system, the results also imply a more general conclusion about tax-benefit systems. In this research, our method caused a change in the average household size. In the *cohabitation* scenario we increased the average size, while in the *separation* scenario we decreased it (Table 4.5). So, we can also state, that the results indicate that an increase in household size lowers the inequality and poverty measurements and a decrease in average size raises them. This corresponds with the findings of Ellen and O'Flaherty (2007) and Peichl *et al.* (2012).

Irrespective of the sensitivity, we were able to model a UBI reform that improved the inequality and poverty measurements with respect to the original system. Even when changes in household composition are considered, these measurements remain favourable in the UBI reform (Tables 5.1 and 5.4). Thus, although the sensitivity of UBI towards poverty may be worse compared to the original system, the overall performance remains encouraging.

6.1.1 Discussion

The second sub-question, concerning the method to restructure the cross-sectional data, was performed with as main goal to answer the research question.

- We used several fixed transition probabilities for all relevant households to model the change in household composition.

- We only altered single-adult and two-adult households, regardless of the number of children.

- We applied a net change in household composition. So, we only adjusted the data set in one direction per scenario. Hence, it is more realistic to model households combining and splitting up in a proportion that it results in the same net change. However, we only obtained figures of household composition that are aggregated.

Nevertheless, all these aspects of our methodology do not undercut the results. We have shown that behaviour is able to interfere with the performance of a tax-benefit system. It makes it all the more necessary to include behavioural responses in future dynamic behavioural microsimulation research. That is also the moment to incorporate the foregoing aspects where our methodology deviates too far from reality. Our methodology is enough to show the importance of including household composition behaviour in microsimulation models.

For the third sub-question, about the design of the UBI reform, we had to make several assumptions and concessions. We decided upon a tax and SIC rate, the level of the monthly payment, and for every existing policy to keep or abolish it. Besides, for every characteristic of UBI we had to determine to what extent to satisfy the definition. For example, to pay children half the monthly payment adults receive. Again, this does not undermine the results, but for future research it may be interesting to investigate other UBI reforms as well.

We also refer to Section 1.5 where some other aspects are discussed that were excluded from our research upfront.

6.2 Recommendations

Summarising, we have shown that supposed changes in household composition, due to a UBI reform, influence the tax-benefit system with a different magnitude than the changes influence the original system. Therefore, we recommend investigating the changes in incentives for household composition behaviour (Figure 1.3b, connector (iv)) and, subsequently, include this behaviour in dynamic behavioural microsimulation models.

We expect the conclusion we drew, also holds for other tax-benefit reforms that are incremental enough. At least the reform should induce a considerable change in behaviour. We expect a reform that changes the tax brackets triggers more behaviour than a reform concerning tax credits, because the first concerns a bigger proportion of the population. However, this encourages to investigate the effects of a reform on behaviour. As a precaution, it is advised to consider behaviour in any case.

Thus, we recommend applying dynamic behavioural microsimulation in future research. In this case the changes in household composition are modelled as a multi-agent system. This means that the probabilities that were used to combine and split households, are made dependent on factors like demographics, employment, and income. This makes the sample population less homogeneous, which reflects reality better. Important components can be identified by determining their predictive power, for example by using a principal component analysis. Those components may then be used to predict certain behaviour. Also, dynamic behavioural microsimulation would include multiple years, instead of one year as investigated in our research. If inclusion of these behavioural responses in a dynamic way is for some reason not an option, at least we advise to perform a sensitivity analysis of a designed UBI reform to changes in household composition.

In addition, our conclusion may be evaluated with other countries. Evaluating this, rules out that our results are specific for Italy. It may be that our results are dependent on the composition of the Italian population. However, we believe that performing this evaluation, will not change the main conclusion, only the detailed results.

For future research, it is also interesting to investigate whether our conclusion also hold for other types of behaviour than household composition. Behaviour, such as marriages and divorces, births and deceases, retirement, labour training, education decisions, and migration are recommended to investigate as well. When verifying those other behavioural responses, the main workflow used in our research can be repeated. But first, it is recommended to generalise and evaluate it on completeness and efficiency. After that, it may be used as exemplar methodology. Reusing this methodology ensures that the results of different studies are easier to compare.

6.2.1 A Note on the Social Relevance

Our research concerns UBI, which is a popular subject for debate. Therefore, we thought it would be relevant to put the conclusions in a social perspective.

Researchers and governments experiment with UBI all over the world. Therefore, the acknowledgement that household composition influences UBI reforms, also affects those experiments. After the development of dynamic behavioural microsimulation models, more accurate predictions can be made that help with the design of experiments. Predictions that include household composition behaviour.

Taking this a step further, as we explained in the previous section, other behavioural variables than household composition can also be evaluated. Those variables will contribute to experiments in a similar way household composition does. It will result in a better understanding of all possible variables that can interact with UBI. If, at some point in time, a UBI reform will be introduced, this reform will be more resilient to behavioural responses.

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Appendix A

The Class of Negative Income Tax Policies

When the method of financing a UBI is income tax transfers, it could also be interpreted as a form of NIT. Therefore, some of the research mentioned in the previous section, evaluates UBI concomitant with NIT-like policies. Actually, NIT could be seen as a whole class of policies of which UBI is a member, but also a policy called conditional basic income (CBI). In Figure A.1 the relation between gross and disposable income for each of the three policies is shown according to Islam and Colombino (2018).

With a CBI, an individual for income tax purposes receives a benefit up to a certain threshold, which is also known as a guaranteed minimum income (GMI). When the gross income Y is below the threshold G then this income is supplemented with $G - Y$ Islam and Colombino (2018). Above the threshold, the income is taxed with the marginal tax rate (MTR) t_2. This is one interpretation of a CBI. Another one is all residents receiving a benefit transfer G. For levels of gross income up to G the tax rate t_1 is 1, i.e. a rate of $100\,\%$. If the gross income rises above G the MTR t_2 is applied.

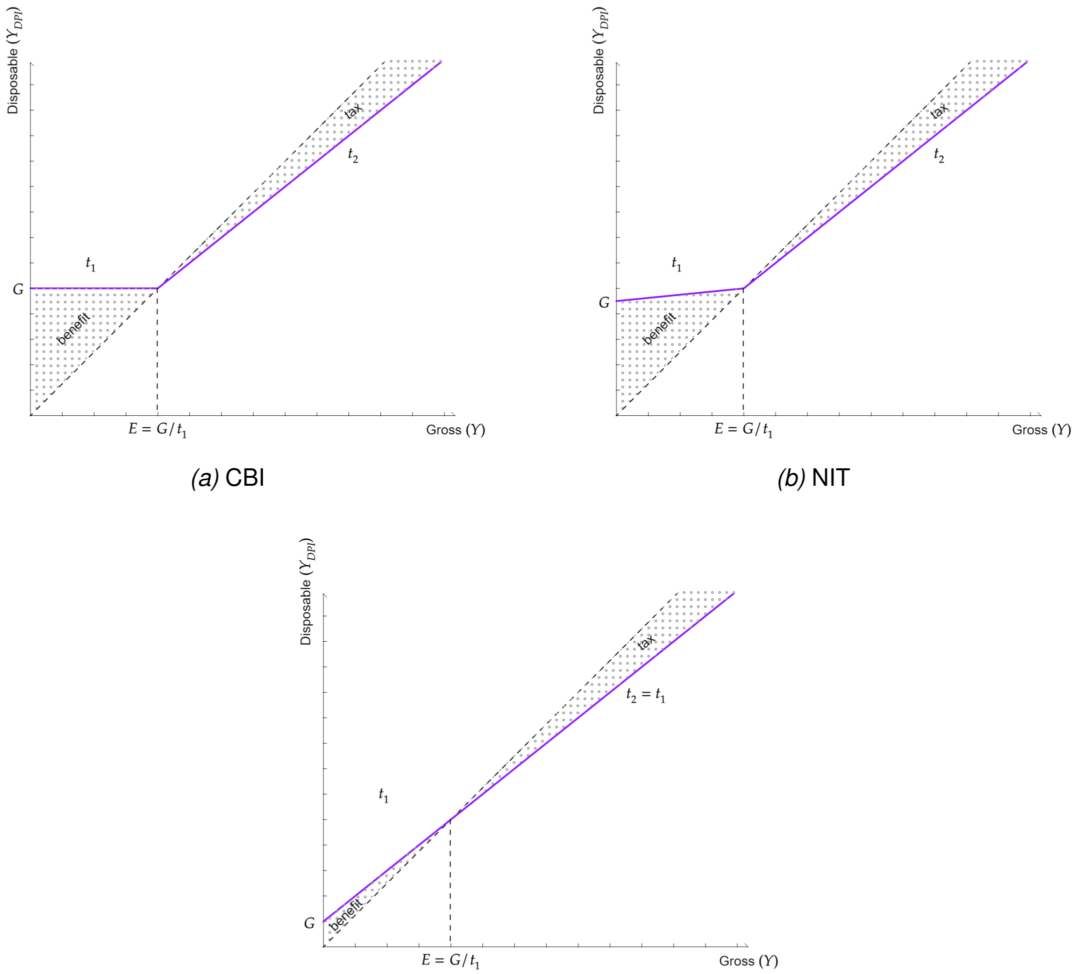
Using the same variables, a NIT can be illustrated too. With this policy an individual also receives a benefit G. Analogous to the second CBI interpretation, however, the income from work is not taxed as high as with CBI. The MTR is lower, that is $t_1 < 1$, according to Islam and Colombino (2018). Because of this, there is added value in labour, even when receiving a benefit transfer. Another interpretation is, for all gross income levels Y below G/t_1 an individual receives a supplement up to

$$G + (1 - t_1)Y \tag{A.1}$$

Above G/t_1 the gross income is taxed that the disposable income is

$$t_2 \times E + (1 - t_2)Y \tag{A.2}$$

where $t_2 < t_1$ and the *exemption level* E is defined as the level of gross income G/t_1. This *exemption level* is the breakeven for which the gross income equals the disposable income. With a CBI $t_1 = 1$, therefore the *exemption level* is equal to the benefit transfer G. The third



(a) CBI *(b)* NIT *(c)* UBI

Figure A.1: Comparison of the negative income tax class (Islam & Colombino, 2018).

method is UBI. In this case

$$t_1 = t_2 \tag{A.3}$$

Since combining (A.2) with (A.3), becomes (A.1), the disposable income is equal to (A.1) for all gross incomes. Thus, receiving a benefit transfer below G/t_1 and paying tax above. Different interpretations are discussed in Section A.2.

In our illustration, the point where t_1 changes to t_2 is equal to the *exemption level* E. It is a point on the line $Y_{DPI} = Y$. It can also be chosen differently. This would alter the Y_{DPI} of the CBI and NIT only, since UBI has only one MTR. However, since our research considers a UBI, it is not required to consider other scenarios.

A.1 Policy Effects

In the case of a CBI, for an income level below G an hour of work does not increase the disposable income. Such a policy does not promote work for low income levels. Somewhat above the threshold G this is still debatable. This effect is one cause of the so-called poverty trap. For a NIT, when a resident's gross income exceeds G/t_1 the MTR decreases, still receiving some benefit transfer G. This way the poverty trap effect is tried to mitigate. In the UBI case, t_1 is equal to t_2, making the poverty trap disappear completely.

Summarising all the policies, it can be seen all three can be characterised by four variables (G, t_1, t_2, E). The expression that can be used for all three policies is:

$$Y_{DPI} = \begin{cases} G + (1 - t_1)Y, & \text{if} \quad Y \leqslant E \\ E \times t_2 + (1 - t_2)Y, & \text{if} \quad Y > E \end{cases} \tag{A.4}$$

In this context, the modelling of a solvent UBI reform consist of deciding upon a universal transfer G and the MTR's $t_1 = t_2$ according to predetermined constraints.

A.2 Not Every UBI Is a NIT-policy

Although this section showed a UBI could be described as a type of NIT, this is just an interpretation or implementation of a UBI. It is said a true UBI does not imply a means-test. However, if we consider the line on the left of E as the benefit (Figure A.1), the level of the benefit changes with the gross income. It could nevertheless also be argued that the benefit is equal to G and the part beyond that up to E is an in-work benefit. In other words, with a NIT a beneficiary's salary gets supplemented up to the maximum benefit, which is the line between G and E. In case of a UBI, one receives an unconditional benefit G, and the salary gets taxed according to the normal tax rate.[1]

To illustrate, consider the case of a UBI-like NIT, that, so to say, includes a means-test. Someone draws a wage of €3500 per month, receives an NIT with *exemption level* €4000 and the tax rate is 25 %. He receives the €3500 of wage without it being taxed, since it is below the *exemption level*. His disposable income according to (A.4) has to be $4000 \times 0.25 + (1 - 0.25) \times 3500 =$ €3625, so the NIT supplement he receives is $3625 - 3500$ or likewise $(4000 - 3500) \times 0.25 =$ €125.

In the other case, for a true UBI, the benefit transfer is €1000, since $1000/0.25 =$ €4000 is the *exemption level*. Simultaneously, the wage is taxed, so his paycheck is $3500 \times (1 - 0.25) =$ €2625. Those two add up to a disposable income that is equal to the one in the UBI-like NIT case. As can be seen, in the second example the transfer is truly unconditional, i.e., without mean-test and without work requirement, whereas in the first it is used as supplement. In our research we implement the latter, since that one adheres to the definition presented in Section 2.1.

[1] Note that a UBI could also be paid for in other ways than by income tax transfers. This make the implementation possibilities of a UBI even wider. Our research does not focus on those implementations, but solely on income tax transfers.

Appendix B

P-P Plots for Normality Tests

This appendix shows the plots for the tests for normality for the UBI reform as used in Chapter 5.

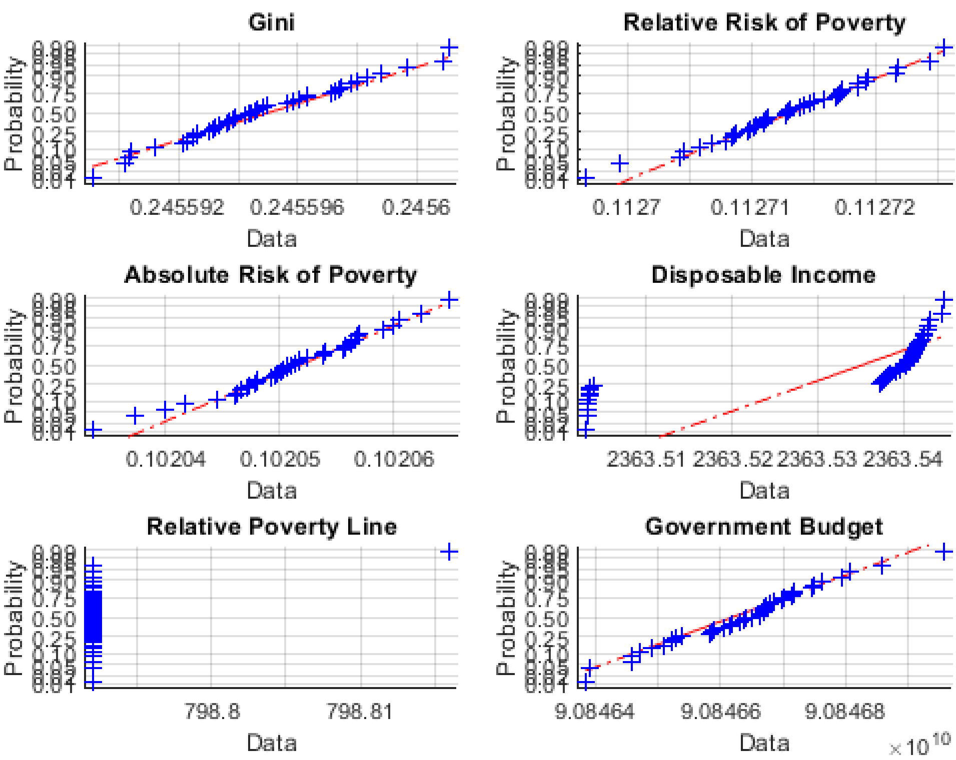


Figure B.1: P-P plots for base scenario.

Figure B.2: P-P plots for cohabitation scenario.

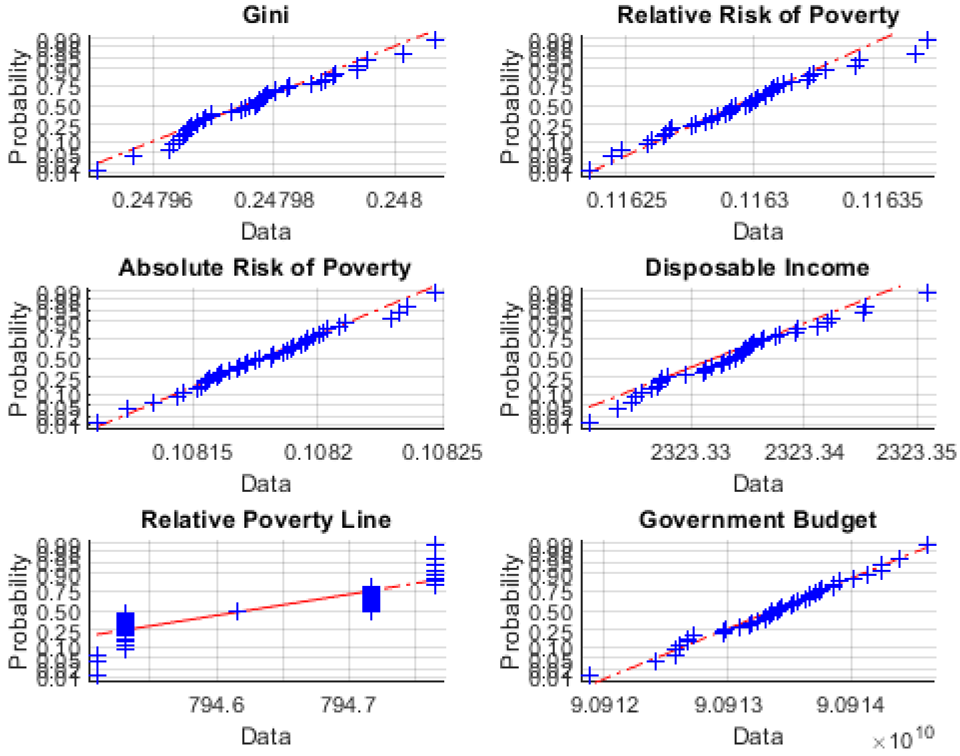


Figure B.3: P-P plots for separation scenario.

Appendix C

Italian Tax-Benefit Policies

In Table C the 2017 Italian tax-benefit policies are listed as present in the EUROMOD model for Italy. The policies are categorised on type and method of simulation. The monetary value resulting from a policy could already have been included in the input data set, so it does not need simulation. Otherwise, it is simulated using EUROMOD, or not available because important information is missing. We determine whether the policy is abolishable and, if so, whether it is abolished, accompanied with a reason.

Table C.1: Italian tax-benefit policies in 2017 (S=simulated in EUROMOD, N/A=not available in EUROMOD, I=included in data).

Policy type	Name	S/I	Abolishable	Abolished	Target Group	Reason	Effect of cohabitation	Effect of separation
Benefit	Unemployment benefit, Procedure for mobility and collective dismissals	S	Yes	Yes	Unemployed	Important reason to introduce UBI		
Benefit	Redundancy payment	S	Yes	Yes	Unemployed	Important reason to introduce UBI		
Benefit	Salary supplement for agriculture workers	S	Yes	Yes	Unemployed	Important reason to introduce UBI		
Benefit	Marriage leave	I	No			Included in employment income	None	None
Benefit	Sickness leave	I	No			Included in employment income	None	None
Benefit	Family Allowance	S	Yes	Yes	Low income families of employees	Means-tested allowance		
Benefit	Maternity Allowances	I	No		Parents of new born	Included in (self-)employment income		
Benefit	Maternity Allowances	I	Yes	Yes	Parents of new born	UBI will provide income		
Benefit	Family leave for severe disability	I	No			Included in employment income	None	None
Benefit	Family Allowance for families with at least three children	I	Yes	Yes	Big families	Children get their own UBI		
Benefit	Family Allowance for families with at least four children	I	Yes	Yes	Big families	Children get their own UBI		
Benefit	Bonus for Babies/new born bonus	S	Yes	Yes	Parents of new born	Children get their own UBI		
Benefit	Allowance for the birth or adoption of minors	S	Yes	Yes	Parents of new born/adopters	Children get their own UBI		
Benefit	Day-care Bonus	N/A	No					
Benefit	Scholarships and Free Textbooks Supplies	I	Yes	Yes	Students of low-income families	Children get their own UBI		
Benefit	Minimum Insertion Income	I	Yes	Yes	Poor citizens	Means-tested allowance		
Benefit	Housing Benefit	I	Yes	Yes	Poor tenants/home owners	Means-tested allowance		
Benefit	Basic Needs Debit Card	I	Yes	Yes	Poor elderly or babies	Means-tested allowance		
Benefit	Young Culture Card	N/A	No					
Business taxation	Corporate Tax	N/A	No					
Business taxation	Value Added Tax	N/A	No					
Business taxation	Regional Tax on Business	N/A	No					
Capital Tax Deductible	Tax deduction for the main residence	I	No			Capital tax is out of the	None	None

Policy type	Name	S/I	Abolishable	Abolished	Target Group	Reason	Effect of cohabitation	Effect of separation
	equal to its cadastral income					research scope		
Capital taxation	Separate Taxation on Capital Income	S	No			Capital tax is out of the research scope	None	None
Capital taxation	Municipality Property Tax	S	No			Capital tax is out of the research scope	None	None
Income Tax Credit	Personal tax credits for income source	S	Yes	Not for 75+	Employed, self-employed, pensioners	Pay tax from the first euro	Via family tax credit	Via family tax credit
Income Tax Credit	Tax credit: main residence mortgage interest payment	S	Possible	Yes	Mortgage payers	Remove incentive on personal expense		
Income Tax Credit	Tax credit: building and refurbishing cost	S	Yes	Yes	General	Remove incentive on consumer behaviour		
Income Tax Credit	Tax credit: education expenses	S	Yes	Yes	Students	Children get their own UBI		
Income Tax Credit	Tax credit: health related expenses	S	Undesirable	No	Sick and disabled	Sick require more social assistance	Via family tax credit	Via family tax credit
Income Tax Credit	Tax credit: other expenses	S	Yes	Yes	General	Remove incentive on personal expense		
Income Tax Credit	Tax credit: insurance premium	S	Yes	Yes	Individuals with life and disability insurance	Remove incentive on personal expense		
Income Tax Credit	Tax credit: rent	S	Yes	Yes	Tenants	Remove incentive on consumer behaviour		
Income Tax Credit	Tax credit: gift to charities	S	Yes	Yes	General	Already switched off		
Income Tax Credit	Tax credit: funeral expenses	S	Yes	Yes	General	Already switched off		
Income Tax Credit	Family tax credits	S	Yes	No	Families	Reallocating tax credits within a family	DI: increase GB: decrease	DI: decrease GB: increase
Income Tax Allowance	Tax deduction of contribution to private pension plans	S	Unnecessary	No	Pension payees	Tax is paid once retired	None	None
Income Tax Allowance	Tax allowances for disabled persons health expenses, grants to religious institutions, expenses for domestic help	S	Undesirable	No	Disabled citizens	Disabled require more social assistance	None	None
Income Tax Allowance	Tax deduction on income paid to ex-spouse	S	Unnecessary	No	Divorced couples	Tax is paid by ex-spouse	None	None

Policy type	Name	S/I	Abolishable	Abolished	Target Group	Reason	Effect of cohabitation	Effect of separation
Income taxation	Personal Income Tax	S	No	No		Income tax is the base of the research	None	None
Income taxation	Personal Income Regional Additional Tax	S	Possible	Yes	Regional residents	Conditional taxation		
Income taxation	Personal income tax on rental income	S	Yes	Yes	Lessors	Already switched off		
Income taxation	Bonus 80 euro	S	Yes	Yes	Low income workers	Means-tested allowance		
Pension	Old-Age, Invalidity and Survivor's Pension	I	Undesirable	No	Retired, disabled or survivor of deceased	Unfavourable to abolish pensions	DI: decrease GB: increase	DI: increase GB: decrease
Pension	Inability pension	I	Undesirable	No	Citizens with a physical or mental disease	Unfavourable to abolish pensions	Via old-age pension	Via old-age pension
Pension	Inability Allowances for Civil Servants	I	Undesirable	No	Civil servants with a physical or mental disease	Unfavourable to abolish pensions	Via old-age pension	Via old-age pension
Pension	Compensation benefit	I	Undesirable	No	Workers disabled by an industrial accident	Unfavourable to abolish pensions	Via old-age pension	Via old-age pension
Pension	War pension	I	Undesirable	No	Disabled citizens or to eligible family members of a deceased citizen because of war events	Unfavourable to abolish pensions	Via old-age pension	Via old-age pension
Pension	Social Pensions and Social Allowances to individuals older than 65	S	Yes	Yes	Poor elderly	Means-tested allowance		
Pension	Civil Infirmity Allowance	I	Undesirable	No	Citizens with invalidity	Unfavourable to abolish pensions	Via old-age pension	Via old-age pension
Pension	Monthly Assistance Allowance	I	Undesirable	No	Citizens with invalidity	Unfavourable to abolish pensions	Via old-age pension	Via old-age pension
Pension	Accompany Benefit	I	Undesirable	No	Citizens with invalidity	Unfavourable to abolish pensions	Via old-age pension	Via old-age pension
Pension	Frequency Benefit	I	Undesirable	No	Minor citizens with a disability	Unfavourable to abolish pensions	Via old-age pension	Via old-age pension
Pension	Sightedness Pension	I	Undesirable	No	Sightless citizens	Unfavourable to abolish pensions	Via old-age pension	Via old-age pension
Pension	Special Benefit	I	Undesirable	No	Sightless citizens	Unfavourable to abolish pensions	Via old-age pension	Via old-age pension
Pension	Deaf-Dumb Pension	I	Undesirable	No	Deaf-dumb citizens	Unfavourable to abolish pensions	Via old-age pension	Via old-age pension
Pension	Communication Benefit	I	Undesirable	No	Citizens with impaired hearing	Unfavourable to abolish pensions	Via old-age pension	Via old-age pension
Pension	Personal, Long-term Assistance Allowance	I	Undesirable	No	Disabled citizens	Unfavourable to abolish pensions	Via old-age pension	Via old-age pension

Policy type	Name	S/I	Abolishable	Abolished	Target Group	Reason	Effect of cohabitation	Effect of separation
Social Insurance Contribution	Invalidity, Old Age and Survivors	S	No			SIC is needed to fund UBI	None	None
Social Insurance Contribution	Unemployment	S	No			SIC is needed to fund UBI	None	None
Social Insurance Contribution	Dependency benefit Fund	S	No			SIC is needed to fund UBI	None	None
Social Insurance Contribution	Redundancy Fund	S	No			SIC is needed to fund UBI	None	None
Social Insurance Contribution	Procedure for mobility and Collective Dismissals	S	No			SIC is needed to fund UBI	None	None
Social Insurance Contribution	Sickness and Maternity Benefit	S	No			SIC is needed to fund UBI	None	None
Social Insurance Contribution	Severance Pay	S	No			SIC is needed to fund UBI	None	None

Appendix D

Matlab Code

In this appendix the Matlab code is documented for replication purposes.

D.1 Step 3 Code: Perform Data Set Adjustment

Listing D.1: get_demographics function.

```
function [individuals] = get_demographics(inputset_base)
%% GET_DEMOGRAPHICS Get Individuals' Demographics
% This function retrieves the id of the person, the household
    and their dependants,
% their age range and their coss-sectional weight.
%%
% Create a new table called individuals that contains the id of
    the person,
% the household and their dependants, their age, and weight.
individuals = inputset_base(:,{'idperson','idhh','idpartner','
    idmother','idfather',...
    'dag','dwt'});
%%
% Determine whether someone has a partner and count the number
    of parents.
individuals.has_partner = individuals.idpartner~=0;
individuals.number_of_parents = int8(individuals.idmother~=0) +
    int8(individuals.idfather~=0);
%%
% Create a variable to classify the age range of the persons
    and remove
% the age variable
dag_range = groupsummary(individuals,{'idperson','dag'},{'none'
    ,[0 18 24 Inf]});
```

```
individuals.dag_range = dag_range.disc_dag;
individuals.is_adult(:) = 0;
individuals{individuals.dag_range == '[24, Inf]','is_adult'} = 1;
individuals(:,'dag') = [];
end
```

Listing D.2: get_households function.

```
function households = get_households(individuals)
%% GET_HOUSEHOLDS Get Households' Demographics
% This function retrieves the id of the household, the cross-sectional weight,
% the size, the number of parents and the status.
%%
% Group the individuals on 'idhh', while counting the members and summing
% the number of partners.
households = grpstats(individuals,{'idhh','dwt'},'sum','Datavars',{'is_adult','has_partner'},...
    'VarNames',{'idhh','dwt','household_size','number_of_adults','number_of_partners'});
%%
% Add an string variable, which is a column, named 'composition'. Determine
% whether a household has multiple, two or one single adult. A household without
% an adult is not counted as single. Add this variable to the household table.
households.composition(:) = "Other";
households{households.number_of_adults == 2,'composition'} = "Two";
households{households.number_of_adults == 1 & households.number_of_partners == 0,'composition'} = "Single";
end
```

Listing D.3: get_dependencies function.

```
function individuals = get_dependencies(individuals,sd)
%% GET_DEPENDENCIES Determine Dependency of Children
%% Determine the dependencies of the selected households
% We will select all individuals and determine their dependency on their
```

```
% parents.
for j = 1:height(individuals)
    to_father = rand(sd) < 155 / (155 + 893);
% Children that have both a father and a mother will be randomly assigned
% to be dependant upon one of them. The original variables are overwritten by
% the new ones.
    if individuals{j,'number_of_parents'} == 2
        if to_father
            individuals{j,'idmother'} = 0;
        else
            individuals{j,'idfather'} = 0;
        end
    end
end
end
```

Listing D.4: new_idperson function.

```
function new_person_id = new_idperson(new_household_id, old_household_id,original_person_id)
%% NEW_IDPERSON Calculate a New ID
% The new person id is the difference between the new and the old household
% id times 100 plus the original person id.
if original_person_id ~= 0
    new_person_id = (new_household_id - old_household_id) .* 100 + original_person_id;
end
end
```

Listing D.5: replace_ids function.

```
function sel_input = replace_ids(id_person, new_id_person, sel_input, k)
%% REPLACE_IDS Replace Person ID's
% Change all the person ids (idperson, idfather, idmother, idpartner) within
% a household. Everywhere the old person id is found, it is replaced with new_id_person
indices = sel_input{:,{'idperson','idfather','idmother','idpartner'}} == id_person;
```

```
if sum(indices(:,2:4),'all') > 0
    sel_input{:,{'idperson','idfather','idmother','idpartner'}}(indices) = new_id_person;
else
    sel_input{k,'idperson'} = new_id_person;
end
end
```

Listing D.6: cohab function.

```
function [inputset_comb, max_hh_id] = comb(inputset_singles,individuals,hh_to_comb,single_adult_households,seed,max_hh_id)
%% COMB Combine Households
%% Adjusting the data by combining random household
% Single households, that have minimal one member older than 18 are eligible
% for cohabitation. No preference for gender nor age.
%% Determine the cohabition Rate
% The amount of single households selected should be an even number, rounding
% down.
num_of_combinations = hh_to_comb - mod(hh_to_comb,2);
%% Random Drawing Procedure
% Randomly select the households to be combined. Only single households are
% selected. The amount of times a household is selected determines the weight.
random_number = RandStream('mt19937ar','Seed',seed);
household_ids = randsample(random_number,single_adult_households.idhh,num_of_combinations,true,single_adult_households.dwt);
household_ids = table(sort(household_ids),'VariableNames',"idhh");
household_ids = groupsummary(household_ids,"idhh");
assert(sum(household_ids.GroupCount) == num_of_combinations,"Incorrect number of households selected.")
%% Combine the Drawn Households
% In this section two subsequent households are selected and combined every
% loop. However, the households have different weights, so the one with the largest
% weight will determine the new household weight. The remaining
```

```
weight of the
% other is kept and used to be combined with the following household in the next
% loop iteration.
%
% All households id's and weights are selected, together with the weights
% of the random drawing procedure. The latter are subtracted from the original
% weights.
weights = outerjoin(inputset_singles,household_ids,'Keys','idhh','LeftVariables',{'idhh','dwt'},...
    'RightVariables','GroupCount');
weights.GroupCount(isnan(weights.GroupCount)) = 0;
inputset_singles.dwt = weights.dwt - weights.GroupCount;
%%
% Create an empty copy of "inputset_singles". Size the inputset_comb table
% to the estimated new height.
first_NaN = 1;
new_Size = round(sum(weights.GroupCount > 0) * 2.05);
inputset_comb = array2table(nan(new_Size,width(inputset_singles)),'VariableNames',inputset_singles.Properties.VariableNames);
%%
% This is where the loop starts. First, the list of households is shuffled,
% since they are ordered. Then, as long as there are households remaining we loop.
% When only one household remains it is combined with itself and therefore duplicated
% and the weight is divided by two.
is_last_household = 0;
household_ids = household_ids(randperm(random_number,height(household_ids)),:);
while height(household_ids) >= 1
    if height(household_ids) == 1
        is_last_household = 1;
        household_ids{1,'GroupCount'} = household_ids{1,'GroupCount'}/2;
        household_ids{2,:} = household_ids{1,:};
    end
```

```
%%
% The old household ids are stored. Now the household with the lowest weight
% determines the combined household weight. If one or both households have no
% weight left, they are removed from the remaining_ids table.
    old_household_ids = [household_ids{1,'idhh'}, household_ids{2,'idhh'}];
    weight_new_household = min([household_ids{1,'GroupCount'}, household_ids{2,'GroupCount'}]);
    household_ids{1:2,'GroupCount'} = household_ids{1:2,'GroupCount'} - weight_new_household;
    household_ids(household_ids.GroupCount <= 0,:) = [];
%%
% Only the adult's age range in the households are retrieved from the individuals
% table and stored in a structure. If it is the last household, one of the ids
% has to be adjusted to be unique.
    id_single_adult = [individuals{individuals.idhh == old_household_ids(1) & individuals.dag_range == '[24, Inf]','idperson'},...
        individuals{individuals.idhh == old_household_ids(2) & individuals.dag_range == '[24, Inf]','idperson'}];
    assert(length(id_single_adult) == 2,'Ineligible household found.');
    if is_last_household == 1
        id_single_adult(1) = id_single_adult(2).* 2;
    end
%%
% Now the two complete households are selected from the inputset_singles
% table and merged in one table, as those will be combined. Again, if this is
% the last household, the ids have to be adjusted to be unique.
    if is_last_household == 1
        sel_input = {inputset_singles(inputset_singles.idhh == old_household_ids(1),:),...
            inputset_singles(inputset_singles.idhh == old_household_ids(2),:)};
        sel_input{2}.idperson(:) = sel_input{2}.idperson(:).*2;
        sel_input{2}.idmother(:) = sel_input{2}.idmother(:).*2;
```

```
        sel_input{2}.idfather(:) = sel_input{2}.idfather(:).*2;
        sel_input = [sel_input{1}; sel_input{2}];
    else
        sel_input = [inputset_singles(inputset_singles.idhh ==
            old_household_ids(1),:);...
            inputset_singles(inputset_singles.idhh ==
                old_household_ids(2),:)];
    end
%%
% A new unique household id is determined. We replace the
    household id and
% cross-sectional weight of both households. Next, the partners
      get each other's
% partner id in the 'idpartner' variable.
    sel_input.dwt(:) = weight_new_household;
    max_hh_id = max_hh_id + 1;
    sel_input.idhh(:) = max_hh_id;
    sel_input{sel_input.idperson == id_single_adult(1),'
        idpartner'} = id_single_adult(2);
    sel_input{sel_input.idperson == id_single_adult(2),'
        idpartner'} = id_single_adult(1);

%%
% By means of a random draw it is decided whether the partners
    marry or
% stay single.
    if rand(random_number) < 52.22 / (52.22 + 5.17)
        marital_status = 2;
    else
        marital_status = 1;
    end
    sel_input{sel_input.idperson == id_single_adult(1),'dms'} =
        marital_status;
    sel_input{sel_input.idperson == id_single_adult(2),'dms'} =
        marital_status;
%%
% We start another loop to change all the person ids (idperson,
      idfather,
% idmother, idpartner) within the household to match with the
    new household id.
% First a new unique person id is determined with new_id_person
    . Then everywhere
```

```
% the old person id is found, it is replaced with new_id_person, which is increased
% by one after each loop iteration.
    id_person = sel_input{1,'idperson'};
    new_id_person = new_idperson(max_hh_id,old_household_ids(1),id_person);
    for k = 1:height(sel_input)
        id_person = sel_input{k,'idperson'};
        sel_input = replace_ids(id_person,new_id_person,sel_input,k);
        new_id_person = new_id_person + 1;
    end
%%
% The generated rows are inserted in the table. The first empty row is determined.
    inputset_comb(first_NaN:first_NaN + height(sel_input) - 1,:) = sel_input;
    first_NaN = first_NaN + height(sel_input);
end
%%
% When remaining_ids is empty the loop stops. Any empty row is removed from
% the resulting table and it is sorted.
inputset_comb = rmmissing(inputset_comb);
inputset_comb = [inputset_singles; inputset_comb];
end
```

Listing D.7: separ function.

```
function [inputset_separ] = separ(inputset_twos,individuals,hh_to_separ,two_adult_households,seed,max_hh_id)
%% SEPAR Separate Households
%% Adjusting the data by separating random household
% Two adult households are eligible for separation. No preference for children
% to live with their mother or father.
%% Determine the Separation Rate
% The amount of two adult households selected is rounded down. The amount of
% times a household is selected determines the weight.
num_of_separations = round(hh_to_separ);
%% Random Drawing Procedure
% Randomly select the households to be separated. Only two
```

```
adult households
% are selected.
random_number = RandStream('mt19937ar','Seed',seed);
household_ids = randsample(random_number,two_adult_households.idhh,num_of_separations,true,two_adult_households.dwt);
household_ids = table(sort(household_ids),'VariableNames',"idhh");
household_ids = groupsummary(household_ids,"idhh");
assert(sum(household_ids.GroupCount) == num_of_separations,"Incorrect number of households selected.")
%% Seperate the Drawn Households
% In this section a household is selected and separated every loop.
%
% Two new unique ids are determined. All households id's and weights are
% selected, together with the weights of the random drawing procedure. The latter
% are subtracted from the original weights.
max_hh_id = [max_hh_id + 1, max_hh_id + 2];
weights = outerjoin(inputset_twos,household_ids,'Keys','idhh','LeftVariables',{'idhh','dwt'},...
    'RightVariables','GroupCount');
weights.GroupCount(isnan(weights.GroupCount)) = 0;
inputset_twos.dwt = weights.dwt - weights.GroupCount;
%%
% Create an empty copy of "inputset_couples". Size the inputset_separ table
% to the known new height.
first_NaN = 1;
new_Size = sum(weights.GroupCount > 0);
inputset_separ = array2table(nan(new_Size,width(inputset_twos)),'VariableNames',inputset_twos.Properties.VariableNames);
%%
% This is where the loop starts. We loop as many times as there are household
% ids selected in the random drawing procedure. The old household id is stored.
% Now the number of times the household was selected is determined, which will
% become the new household weight. Afterwards, the data that has to be adjusted
```

```
% is selected and the weights of the new household is set.
for i = 1:height(household_ids)
    old_household_ids = household_ids{i,'idhh'};
    weight_new_household = household_ids{i,'GroupCount'};
    sel_input = inputset_twos(inputset_twos.idhh == old_household_ids,:);
    sel_input.dwt(:) = weight_new_household;
%%
% The individuals within the household are selected. Additionally children
% are made dependant upon one of their parents.
    sel_individuals = individuals(individuals.idhh == old_household_ids,:);
    if height(sel_input) > 2
        sel_individuals = get_dependencies(sel_individuals, random_number);
        sel_input{:,{'idfather','idmother'}} = sel_individuals{:,{'idfather','idmother'}};
    end
%%
% If there is a "real" couple, their 'idpartner' variable is set to be equal
% to 0. In any case, the two adults are selected. The two 'idperson' are stored
% as 'id_partners'. If the adults were registered as married, they are registered
% as seperated.
    real_couple = sum(sel_individuals.has_partner);
    if real_couple == 2
        sel_input.idpartner(:) = 0;
    end
    id_adult = sel_individuals{sel_individuals.dag_range == '[24, Inf]','idperson'};
    assert(length(id_adult) == 2,'Ineligible household found.');
    for k = 1:2
        if sel_input{sel_input.idperson == id_adult(k), 'dms'} == 2
            sel_input{sel_input.idperson == id_adult(k), 'dms'} = 3;
        end
    end
```

```
%%
% Now we start an iteration to look for the dependants within
    the household,
% which could be parents, children and their partners. As long
    as those are found,
% it will loop and assign the new household id. Two arrays are
    used to keep track
% of whom is checked already. The original partner is skipped
    immedately.
    search = id_adult(1);
%     skipsearch = id_adult;
    found = [];
%     j = 0;
%     while isempty(search) == 0 && j < 50
%%
% Here we search for the children of the searched person, which
     are already
% made dependent upon one of their parents. This way they will
    go with one of
% their parents. Also grandchildren will be found, which will
    follow their parents.
% The personid that is searched for in each iteration is the
    first element of
% the 'search' array.
        if height(sel_input) > 2
            if sel_input{sel_input.idfather == search(1),'
               idperson'} ~= 0
                found = [found; sel_input{sel_input.idfather ==
                    search(1),'idperson'}];
            end
            if sel_input{sel_input.idmother == search(1),'
               idperson'} ~= 0
                found = [found; sel_input{sel_input.idmother ==
                    search(1),'idperson'}];
            end
%%
% Here we look for the partners of the searched person so they
    stick with
% them. This could be the partner of the child of the original
    searched person
% for example.
%             if sel_input{sel_input.idpartner == search(1), '
```

```
idperson'} ~= 0
%                   found = [found; sel_input{sel_input.idpartner == search(1), 'idperson'}];
%               end
%%
% Here we look for parents of the searched person. They should stick with
% them too.
%               if sel_input{sel_input.idperson == search(1), 'idfather'} ~= 0
%                   found = [found; sel_input{sel_input.idperson == search(1), 'idfather'}];
%               end
%               if sel_input{sel_input.idperson == search(1), 'idmother'} ~= 0
%                   found = [found; sel_input{sel_input.idperson == search(1), 'idmother'}];
%               end
        end
%%
% Any found person is added to the 'search' and 'skip' array if it was not
% already in the 'skip' array.
        while isempty(found) == 0
%               if ismember(found(1),skipsearch) ~= 1
%                   search = [search; found(1)];
%                   skipsearch = [skipsearch; found(1)];
%               end
            sel_input{sel_input.idperson == found(1),'idhh'} = max_hh_id(2);
            found(1) = [];
        end
%%
% Now the searched person is placed in the new unique household and removed
% from the 'search' array.
        sel_input{sel_input.idperson == search(1),'idhh'} = max_hh_id(2);
%           search(1) = [];
%           j = j + 1;
%       end
%%
```

```
% When nobody new is found anymore, the remaining people in the
    household
% get another new household id too. We start another loop to
   change all the person
% ids (idperson, idfather, idmother, idpartner) within the
   households to match
% with the new household id. First a new unique person id is
   determined with new_id_person.
% Then everywhere the old person id is found, it is replaced
   with new_id_person.
    sel_input{sel_input.idhh == old_household_ids,'idhh'} =
       max_hh_id(1);
    for k = 1:height(sel_input)
        id_person = sel_input{k,'idperson'};
        id_hh = sel_input{k,'idhh'};
        new_id_person = new_idperson(id_hh,old_household_ids,
           id_person);
        sel_input = replace_ids(id_person,new_id_person,
           sel_input,k);
    end
%%
% The generated rows are inserted in the table. The first empty
    row is determined
% and the replacement ids are increased by one.
    inputset_separ(first_NaN:first_NaN + height(sel_input) -
       1,:) = sel_input;
    first_NaN = first_NaN + height(sel_input);
    max_hh_id = max_hh_id + 2;
end
%%
% When all the household are processed, the resulting table is
   sorted.
inputset_separ = [inputset_twos; inputset_separ];
end
```

Listing D.8: run_step3 function.

```
function [inputset_base,individuals] = run_step3(scenario,
   test_run,loops,inputset_base,individuals)
%% RUN_STEP3 Run Step 3 of the Workflow
%%
%
if exist('scenario','var') == 0
```

```
    scenario = 'base';
end
switch scenario
    case 'base'
        ratio_separ = 50618/25775872; %two adult households to
           separate of total households
        ratio_comb = 0;
    case 'cohabitation'
        ratio_comb = 570213/25775872; %single adult households
           to cohabit of total households
        ratio_separ = 0;
    case 'separation'
        ratio_separ = 498788/25775872; %two adult households to
            separate of total households
        ratio_comb = 0;
    otherwise
        error('scenario can take "base" (default), "
           cohabitation", or "separation".')
end
if exist('loops','var') == 0
    loops = 1;
end
% seed = 1;
%%
%
if exist('test_run','var') == 0
    test_run = 1;
end
switch test_run
    case 0
        first_n_households = 0;
    case 1
        first_n_households = 500;
    otherwise
        error('test_run can take 0 or 1 (default).')
end
if exist('inputset_base','var') == 0
    inputset_base = load_step3(first_n_households);
else
    inputset_base = load_step3(first_n_households,inputset_base
       );
end
```

```
%%
%
if exist('individuals','var') == 0 || height(individuals) ~=
    height(inputset_base)
     individuals = get_demographics(inputset_base);
end
households = get_households(individuals);
%%
%
number_of_households = sum(households.dwt);
hh_to_comb = number_of_households * ratio_comb;
hh_to_separ = number_of_households * ratio_separ;
single_adult_households = households(households.composition ==
    "Single",:);
two_adult_households = households(households.composition == "
    Two",:);
other_households = households(households.composition == "Other
    ",:);
%%
%
individuals_comb = innerjoin(individuals,
    single_adult_households(:,'idhh'));
individuals_separ = innerjoin(individuals,two_adult_households
    (:,'idhh'));
inputset_singles = innerjoin(inputset_base,
    single_adult_households(:,'idhh'));
inputset_twos = innerjoin(inputset_base,two_adult_households(:,
    'idhh'));
inputset_other = innerjoin(inputset_base,other_households(:,'
    idhh'));
max_hh_id = max(inputset_base.idhh);
%%
%
for iloop=1:loops
     seed = iloop;
     [inputset_comb, max_hh_id2] = comb(inputset_singles,
        individuals_comb,hh_to_comb,single_adult_households,seed,
        max_hh_id);
     inputset_separ = separ(inputset_twos,individuals_separ,
        hh_to_separ,two_adult_households,seed,max_hh_id2);

     inputset_scenario = [inputset_comb; inputset_separ;
```

```
        inputset_other];
    inputset_scenario = sortrows(inputset_scenario,{'idhh','idperson'});
    filename = strcat("Step_3_output\IT_2015_a3-",num2str(seed),".txt");
    writetable(inputset_scenario,filename,'Delimiter','\t');

    assert(round(sum(inputset_base.dwt)) == round(sum(inputset_scenario.dwt)), "The weight of the new data set does not match the original weight anymore.")
end
end
```

D.2 Step 4 Code: Evaluate Adjusted Data Sets

Listing D.9: determine_measurements script.

```
%% Calculate the measurements
%% Determine the government budget, Gini, poverty line, risk of
    poverty and disposable income.
% Load the files and prepare a table.

files = dir('Step_4_input/Original_base/it_2017_*.txt');
measurements = table('Size',[length(files),6],'VariableNames',{
   'Filename','Government_budget','Gini','Poverty_line','
   Risk_of_poverty','Disposable_income'},...
    'VariableTypes',{'string','double','double','double','
       double','double',});
for i = 1:length(files)
    file = strcat(files(i).folder,'/',files(i).name);
    comma2point_overwrite(file);
    outputset = readtable(file);
    if ismember('sft_s',outputset.Properties.VariableNames) ==
       0 || ismember('dag',outputset.Properties.VariableNames)
       == 1
        outputset = saveOECD(outputset,file);
    end
%%
% Determine the government budget.

    revenue = sum(outputset{:,{'ils_tax','ils_sicee','ils_sicse
       ',...
        'ils_sicer','ils_sicot'}}.*outputset{:,{'dwt'}},'all')
          *12;
    expenditure = sum(outputset{:,{'ils_ben'}}.*outputset{:,{'
       dwt'}},...
        'all')*12;
    measurements.Filename(i) = files(i).name;
    measurements.Government_budget(i) = revenue - expenditure;
%%
% Determine the equivalised disposable household income.

    if contains(file,'original','IgnoreCase',true) || sum(
       outputset.sft_s == 0) == 0
```

```
        hh=grpstats(outputset,{'idhh','dwt','sft_s'},'sum','Datavars',{'ils_dispy','dwt'});
        hh.equivalised_dispy = hh.sum_ils_dispy./hh.sft_s;
    else
        hh=grpstats(outputset,{'idhh','dwt'},'sum','Datavars',{'sft_s','ils_dispy','dwt'});
        hh.equivalised_dispy = hh.sum_ils_dispy./hh.sum_sft_s;
    end
%%
% Determine the Gini on household basis.

    measurements.Gini(i) = gini(hh.sum_dwt,max(hh.equivalised_dispy,0),false);
%%
% Determine the poverty line on household basis.

    measurements.Poverty_line(i) = 0.6*weightedMedian(hh.equivalised_dispy,hh.sum_dwt);
%%
% Determine the risk of poverty on an individual basis using a fixed poverty
% line.

    %     if contains(file,'original','IgnoreCase',true)
    %         poverty_line = 782.958000000388;
    %     else
    poverty_line = 782.958000000388;
    %     end
    measurements.Risk_of_poverty(i) = sum(hh{hh.equivalised_dispy < poverty_line,'sum_dwt'})/sum(hh.sum_dwt);
%%
% Determine the average disposable income.

    measurements.Disposable_income(i) = sum(hh.sum_ils_dispy.*hh.dwt)/sum(hh.dwt);
end
%%
% Prepare a table for the mean and variance of the measurements.

```

```
statistics = table('Size',[1,6],'VariableNames',{'n','GB','Gini
    ','pl','RoP','DI'},...
    'VariableTypes',{'double','cell','cell','cell','cell','cell
       '});
statistics{1,'n'} = height(measurements);
for m = 2:6
    statistics{1,m}{1} = {mean(measurements{:,m}), var(
       measurements{:,m})^0.5};
end
original_cohab = measurements
statistics
```

Listing D.10: normality_test function.

```
function normality = norm_test(scenario)
%% NORM_TEST Test for normality
%%
% Prepare the table and test each measurement for normality.
normality = table('Size',[2 6],'VariableNames',{'n','GB','Gini'
    ,'pl','RoP','DI'},...
    'VariableTypes',{'double','double','double','double','
       double','double'});
normality{1:2,'n'} = height(scenario);
for m = 2:6
    normality{1,m} = adtest(scenario{:,m},'Alpha',0.01,'MCTol'
       ,0.01);
    normality{2,m} = swtest(scenario{:,m},0.01);
end
%%
% Plot histograms.
figure
subplot(3,2,1)
histogram(scenario.Gini,10)
title('Gini')
subplot(3,2,2)
histogram(scenario.Risk_of_poverty,10)
title('Risk of Poverty')
subplot(3,2,3)
histogram(scenario.Disposable_income,10)
title('Disposable Income')
subplot(3,2,4)
histogram(scenario.Poverty_line,10)
title('Poverty Line')
```

```
subplot(3,2,5)
histogram(scenario.Government_budget,10)
title('Government Budget')
%%
% Plot the Q-Q plot.
figure
subplot(3,2,1)
normplot(scenario.Gini)
title('Gini')
subplot(3,2,2)
normplot(scenario.Risk_of_poverty)
title('Risk of Poverty')
subplot(3,2,3)
normplot(scenario.Disposable_income)
title('Disposable Income')
subplot(3,2,4)
normplot(scenario.Poverty_line)
title('Poverty Line')
subplot(3,2,5)
normplot(scenario.Government_budget)
title('Government Budget')
end
```

Listing D.11: hypothesis_test function.

```
function tests = hypothesis_test(scenario_base,scenario_alt1,scenario_alt2)
%% HYPOTHESIS_TEST Perform the Hyptheses Tests
%% Determine whether the H0 can be rejected.
%%
% Test whether the scenarios are present and prepare the data.
assert(exist('scenario_base','var')==1,'Prepare base scenario first')
assert(exist('scenario_alt1','var')==1 || exist('scenario_alt2','var')==1,'Prepare alternative scenario')
if exist('scenario_alt1','var') && exist('scenario_alt2','var')
    scenarios = {scenario_base, scenario_alt1, scenario_alt2};
elseif exist('scenario_alt1','var')
    scenarios = {scenario_base, scenario_alt1};
else
    scenarios = {scenario_base, scenario_alt2};
end
%%
```

```
% Prepare a table and perform the test statistic for each measurement and
% alternative scenario.
tests = table('Size',[length(scenarios)-1,5],'VariableNames',{'Test','t','v','p','h'},...
  'VariableTypes',{'string','double','double','double','double'});
i = 1;
for s = 2:length(scenarios)
    for m = 2:6
        [h,p,~,stats] = ttest2(scenarios{1}{:,m},scenarios{s}{:,m},'Alpha',0.01,'Vartype','unequal');
        tests(i,:) = {scenario_base.Properties.VariableNames{m},stats.tstat,stats.df,p,h};
        i  = i + 1;
    end
end
end
```