FINANCING UNIVERSAL BASIC INCOME THROUGH TAXES: A GENERAL-EQUILIBRIUM APPROACH

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Abstract

This thesis examines whether raising income tax rate can sustainably finance a modest universal basic income (UBI) proposal through a computable general equilibrium module in charge of macro variables combined with a microsimulation modelling the behavioral response of individual's labor supply. Using a German social accounting matrix (SAM) and household panel data, a modest hypothetical UBI can potentially lead to a decrease in labor supply. In that case, a corresponding rise in wage is expected. Firms will pass some of the increasing cost to consumers, causing the consumer price index to go up and aggregation consumption to decline. Ultimately, GDP is negatively impacted. However, it is also equally possible that individuals will increase their labor supply instead. Moreover, the negative effect on GDP (if any) is small. Thus, funding a modest UBI solely though income tax is possible.

Keywords: *Universal Basic Income, General Equilibrium, Microsimulation, Labor Supply*

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List of Abbreviations

General terms	
UBI	Universal basic income
CGE	Computable general equilibrium
ETI	Elasticity of taxable income
EOS	Elasticity of substitution
MS	Microsimulation
IO	Input-output
SAM	Social accounting matrix
CES	Constant elasticity of substitution
CET	Constant elasticity of transformation
GDP	Gross domestic product
DIW Berlin	German Institute for Economic Research
SOEP	German Socio-Economic Panel
CPI	Consumer price index
Social Accounting Matrix	
SEC	Sector
GOV	Government
HOH	Household
IDT	Indirect tax
SSC	Social security contribution
LAB	Labor
CAP	Capital
ROW	Rest of the world

Symbols

Indices	
i, j	Goods, firms, and sectors
h, k	Factors (LAB, CAP)

1. Introduction

UBI proposals have made the rounds in the political sphere from both wings. In the U.S., the former candidate of the Democratic Party, Andrew Yang, placed UBI in the center of his agenda (Lach 2021). On the opposite aisle, the U.S. conservative made the case for a carbon dividends (Feldstein, Halstead, and Mankiw 2017). Field experiments also pop up around the world in Finland, Canada, Kenya, etc. (de Paz-Báñez et al. 2020). For academia, UBI concerns the effect of cash transfers on behaviors at the micro level and the whole economy at the macro.

Before venturing further, a definition of UBI is required. Proposals vary greatly and there is little consensus on the magnitude or policy issues which UBI is supposed to address. This thesis follows Hoynes and Rothstein (2019) by defining a UBI with three features:

1. It provides an adequate amount of cash to live (comfortably), without the need for other types of income.
2. It is granted to a large proportion of the population. As such, it does not entail means tests or any kinds of targeting (e.g., only to the unemployed).
3. It does not phase out or phase out slowly as earnings rise.

Research into UBI has been preoccupied with the effects at the micro level, especially on labor supply. As conventional wisdom in economics prescribes, an increase in non-labor income produces an income effect that potentially reduces labor supply. Coupled with a reduction in taxable income, it threatens the viability of UBI since most proposals are financed through income tax. Fortunately, evidence from adjacent projects to UBI suggests that the effect of cash transfers on labor supply are either insignificant or offset by general equilibrium effects (Jones and Marinescu 2022; Egger et al. 2022).

However, there is a major obstacle if this line of research is to be incorporated into arguments for UBI. The funding for transfers in these experiments does not entail raising direct personal income tax.

Most UBI proposals, however, do. The opposition against UBI, in this case, is that raising income tax rate will reduce labor supply. The literature in public economics has well-established estimates of elasticity of taxable income (ETI) around 0.25 (Saez, Slemrod, and Giertz 2012). The question now turns into whether the general equilibrium effects can offset both the income effect of cash transfers and the substitution effect from a decrease in after-tax income rate.

This thesis is dedicated to addressing the above question through a computable general equilibrium (CGE) model combined with a microsimulation (MS) in an iterative fashion. The CGE model is, in essence, a system of equations describing an economy at equilibrium. By inputting a shock into the model through changing exogenous variables, the model tells us what the new equilibrium looks like. The data required for this method is a social accounting matrix (SAM) which details the flow of goods and expenditure across industries, the government, the representative household, and the rest of the world (ROW). For the thesis, I adapt the standard CGE model from (Hosoe, Gasawa, and Hashimoto 2010) and use the 2018 SAM for Germany (Elshof, Luckmann, and Siddig 2022). The CGE module describes a one-sector, perfectly competitive, small, and open economy at full-employment in which capital is exogenous while labor is endogenous. The representative firm and household face optimization problems under the form of CES functions.

The MS module employs a discrete-choice regime to model the behavioral response in labor supply at the intensive and extensive margin to changes in tax rates, wages, and transfers. The main feature of the microsimulation is 6 discrete options representing different working time arrangements for household. The parameters are estimated using a multinomial logit model with data from the German Socio-Economic Panel (SOEP) (Goebel et al. 2019).

The fundamental idea in linking the model is that the CGE module outputs a vector of change in wages which becomes the inputs for the MS module, while the MS provides a vector of change in labor supply and leisure. The process is repeated until convergence in labor supply is reached.

The result shows that in case of a reduction in labor supply due to higher tax rates and more transfers from the government, wages will increase. Firms pass a part of the increase in wage onto consumers who, working less and facing rising consumer prices, reduce their consumption. Ultimately, GDP contracts. However, it is equally possible that individuals will reduce their labor supply. The impact magnitude, especially on wage, consumption, and CPI, is sensitive to whether capital can easily substitute labor. The effect on GDP is rather small.

While combined CGE-microsimulation models have been used to model impacts of trade and tax reforms, the emerging literature on UBI still hitherto focuses on distributional effects at the micro level. Thus, the thesis aims to bridge the gap to more sophisticated assessment of general equilibrium effects that takes account of both the macro and micro levels.

The thesis is structured as follows: Section 2 reviews the state of research on UBI as well as the uses of MS and CGE models in that context; Section 3 provides a detailed description of the model and the data as well as limitations of this method; Section 4 describes the scenarios simulated and results; Section 5 presents and discusses the findings and policy implications.

2. Background

Research on UBI, in general, is being occupied mostly by field and natural experiments on cash transfers or similar proposals. In this frontier, a consensus on the effects of cash transfers on labor supply is surfacing. Studies have shown that the effects of cash transfers on labor supply are insignificant and rarely negative (de Paz-Báñez et al. 2020). The negative effect, if any, is desirable (e.g. reduction in child labor) or crowded out by the general equilibrium effect on aggregate demand (Jones and Marinescu 2022; Egger et al. 2022).

The major problem is that the funding for these transfer programs is external. Most UBI proposals, on the contrary, rely partly on increase in tax rates to fund themselves. Since it is impossible to implement localized large-scale changes in taxing for experimenting, simulations are arguably one of the next best things when it comes to ex-ante evaluations of UBI's general equilibrium and behavioral effects.

It is common to couple CGE and MS together for analysis of tax reforms' impact on welfare. Arntz et al (2008) used an applied general equilibrium (AGE) linked with a discrete-choice microsimulation allowing for wage bargaining process between unions and firms in the context of Germany. Benczúr, Kátay, and Kiss (2018), building on earlier works that have estimated the ETI in Hungary, model labor supply at both the intensive and extensive margins using two separate modules (one utilizing the estimated ETI, the other a simple discrete-choice regime). Since UBI proposals are essentially tax and transfer reforms, employing a combined CGE-MS model for analysis is a natural extension.

Nonetheless, the use of such models seems confined to certain institutions and is rarely seen in academic literature[1]. To the best of my knowledge, the closest attempts at modeling UBI or UBI-adjacent proposals in the academic literature are Schubert (2018). Schubert utilizes a model similar to that of Arntz et al. (2008) to analyze a negative income tax for Germany.

3. Description of the Model

3.1. Data

The starting data for the CGE model comes from a 2018 social accounting matrix (SAM) for Germany (Elshof, Luckmann, and Siddig 2022). A social accounting matrix is similar to an input-output (IO) table in that it records the flows of goods and expenditure between sectors. The difference is that SAM also includes "agents", like government and households, and other economic accounts, such as taxes and transfers.

This SAM contains 63 activities, which produce 85 commodities. There are two factors of production, labor and capital. There is one representative household and one account for the

[1] This fact can be illustrated by the section about simulation in de Paz-Báñez et al (2020) in which almost all citations there are from research institutions with proprietary models.

government. In terms of taxes, there is a social security tax levied on labor factor income, a direct tax on household income and wealth, an indirect tax on products and another on activities. Finally, there are accounts for stock changes, savings-and-investment, and the rest of the world (ROW).

For my purpose, some aggregation is needed to streamline the model. Activities and commodities are aggregated into 63 sectors. Stock changes and savings-and-investment are merged into one account "Investment". The separate account for the direct tax on household income is substituted by direct transfer from the household column to government row. Two types of indirect tax on products and activities are collapsed into one account "IDT". Table 1 provides an illustration of these accounts and their corresponding entries and dimensions.

The microsimulation module uses the German Socio-Economic Panel (SOEP) compiled by the German Institute for Economic Research (DIW Berlin) since 1984. The SOEP is a representative, multi-cohort survey including data on employment status, income, individual and household characteristics. I pool data from year 2013 to 2018, totaling about 73,000 observations and averaging 12,000 observations a year.

Table 1 Description of entries and dimensions of submatrices (m x n) of the SAM

	SEC	LAB	CAP	HOH	GOV	SSC	IDT	INV	ROW	TOTAL
SEC	Intermediate inputs (63x63)			Private consumption	Government consumption			Investment demand	Exports	Total demand
LAB	Value-added (1x63)									Total factor income
CAP	Value-added (1x63)								Factor income from ROW	Total factor income
HOH		Factor payments to HOH	Factor payments to HOH		Transfers to HOH (social benefits)				Remittances	Total household income
GOV				Direct tax		Social security contribution	Tax on production		Tax and contribution from ROW	Total government income
SSC		Social security contribution								Total social contribution revenue
IDT	Tax on production (1x63)									Total indirect tax income
INV			Capital depreciation	Private saving	Government Savings				Current account balance	Total saivings
ROW	Imports (1x63)		Factor payments to ROW	Transfers to ROW	Transfers to ROW					Total foreign exchange outflow
TOTAL	Gross output	Total factor payment	Total factor payment	Total HOH spending	Total government spending	Total SSC spending	Total indirect tax spending	Total investment spending	Total foreign exchange inflow	

3.2. CGE Module

CGE models numerically describe an economy in general equilibrium through a set of equations. To illustrate this point, consider an example by Hosoe et al. (2010). The set of equations composing the CGE model is expressed in vector form as follows:

$$CGE(x, y, a) = 0$$

In which:

x	Endogenous variable vector
y	Exogenous variable vector
a	Coefficient vector

The goal is to solve the model for the unknown endogenous variable vector x given the coefficient vector a and the (change in) exogenous variable vector y.

Our economy is assumed to be small, open, perfectly competitive, and at full employment. Since sectoral results are not the goal, this economy contains only one sector in order to streamline the calibration process and avoid further assumptions about elasticities of substitution between sectors (more details in Section 3.9) An overview of the CGE model depicting the flow of goods and factors is provided in Figure 1. This module is adapted from the standard CGE model in Hosoe, Gasawa, and Hashimoto (2010) whose main compatibility was with the Japan's SAM. Consider an economy with two sectors and specifically, sector 1 as an example. The flow is explained from the bottom to the top as below:

(1) Capital $F_{CAP,sec1}$ and labor $F_{LAB,sec1}$ are combined into the composite factor Y_{sec1} using the composite factor production function.

(2) This composite factor Y_{sec1} along with intermediate inputs from sector 2 $X_{sec2,sec1}$ and sector 1 $X_{sec1,sec1}$, are used to produce the gross domestic output Z_{sec1}.

(3) The gross domestic output Z_{sec1} is transformed into the exports E_{sec1} and the domestic good D_{sec1}.

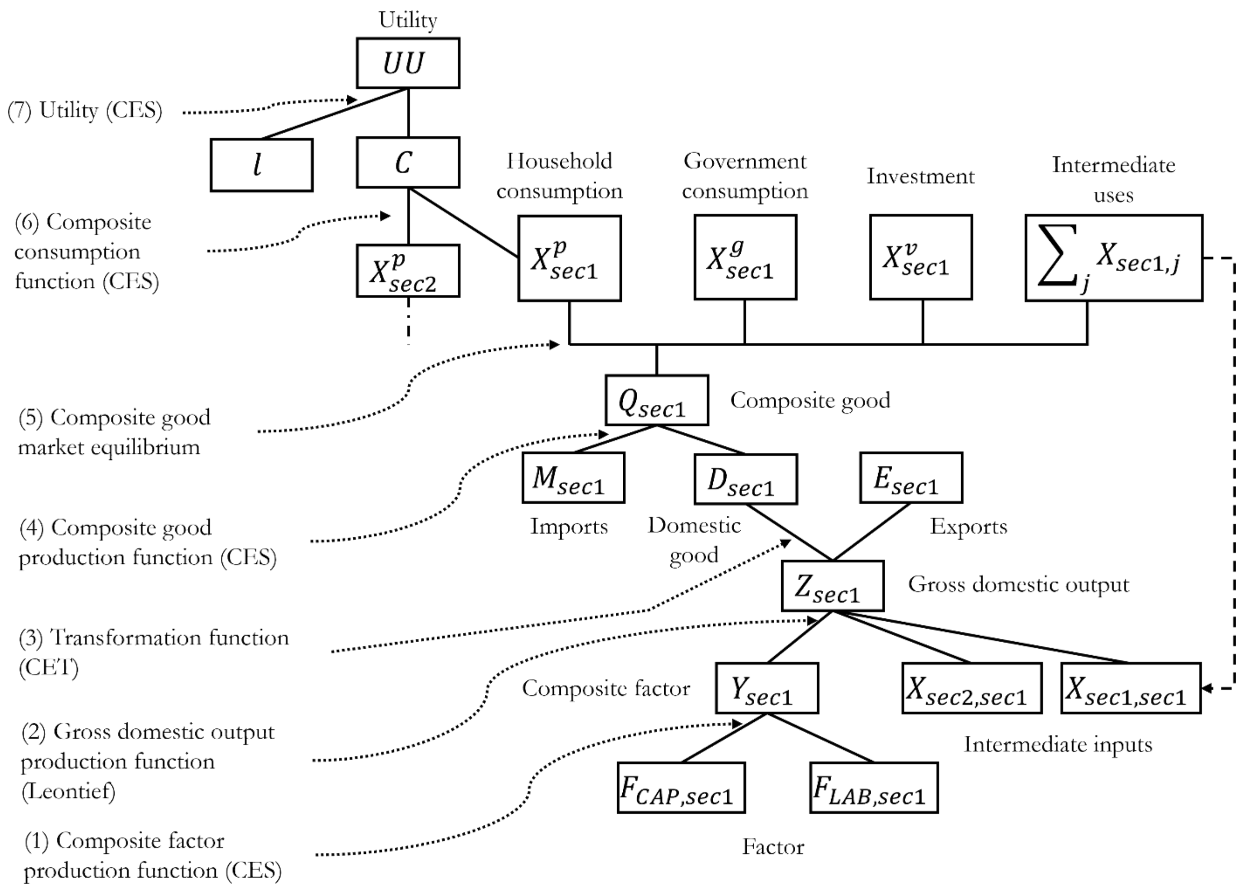

Figure 1: Overview of the CGE model. The viewpoint is from the flow of goods and factors. Assumed functional form in parentheses.

(4) The domestic good D_{sec1} and the imports M_{sec1} is aggregated into the composite good Q_{sec1}.

(5) The composite good Q_{sec1} is distributed among household consumption X^p_{sec1}, government consumption X^g_{sec1}, investment X^v_{sec1}, and intermediate uses by sector 1 and 2 $\sum_j X_{sec1,j}$.

(6) Household consumption of sector 1 and 2, X^p_{sec1} and X^p_{sec2} respectively, forms the composite consumption good C.

(7) Household maximizes utility through the composite good consumption C and leisure l.

My adapted model uses CES functions instead of Cobb-Douglas in the original. Since labor supply is also my focus, I include leisure in utility maximization of household. Various changes were also made to accommodate the peculiarity of the Germany's SAM. Details of equations and terms constituting the models are explained below.

3.3. Domestic Production

3.3.1. Composite Factor

Assuming a CES function to combine capital and labor, the representative j-th sector producing firm faces a profit-maximizing problem as follow:

$$maximize\ \pi_j^y = p_j^y - \sum_h p_h^f F_{h,j} \qquad \forall j \tag{1}$$

Subject to

$$Y_j = b_j \left(\sum_h \beta_{h,j}^f F_{h,j}^{\rho^f} \right)^{1/\rho^f} \qquad \forall j \tag{2}$$

In which:

π_j^y	Profit of the j-th firm producing composite factor Y_j
Y_j	Composite factor
$F_{h,j}$	The h-factor used by the j-th firm
p_j^y	Price of the j-th composite factor
p_h^f	Price of the h-th factor
b_j	Scaling coefficient (or total factor productivity) of the j-th sector
$\beta_{h,j}^f$	Share coefficient of the h-factor in the j-th sector
σ^f	Elasticity of substitution between factors
$\rho^f = \frac{\sigma^f - 1}{\sigma^f}$	Elasticity parameter in the composite factor production function

After setting up a Lagrangian function to solve this problem, we can obtain the demand function for factor:

$$F_{h,j} = \beta_{h,j}^{\sigma^f} \left(\frac{p_j^y}{p_h^f} \right)^{\sigma^f} Y_j b_j^{\sigma^f - 1} \qquad \forall h, j \tag{3}$$

While the calibration process will be elaborated later, I briefly touch on it here. Solving the model requires pinning down the values of certain parameters. Some values are exogenously given from estimations in other branches of economic literature. Some are *calibrated* to a benchmark equilibrium. In the case of the composite factor production function above, for example, the share coefficients can be retrieved by inverting the demand function and inputting data from the SAM. The share coefficient of labor in the j-th sector:

$$\beta_{LAB,j} = \frac{\bar{p}_{LAB}\bar{F}_{LAB,j}^{\sigma^f}}{\bar{p}_{LAB}\bar{F}_{LAB,j}^{\sigma^f} + \bar{p}_{CAP}\bar{F}_{CAP,j}^{\sigma^f}} \qquad \forall j \tag{4}$$

Note: The bar superscript denotes benchmark values originating from the SAM.

Calibration formulae for CES functions are complicated and tedious to derive. As the model grows in scale and complexity, this process is even more prone to error. To address this issue, instead of the coefficient form, I will write some CES functions in the "calibrated share form" following (Böhringer, Rutherford, and Wiegard 2003).

First, re-define $\beta_{h,j}^{f}$ as the value share of the h-th factor in the j-th sector calculated from the benchmark equilibrium:

$$\beta_{h,j}^{f} = \frac{\bar{p}_h^f \bar{F}_{h,j}}{\bar{p}_j^y \bar{Y}_j} \qquad \forall h,j \tag{5}$$

We can write the CES composite factor production function as below:

$$Y_j = \bar{Y}_j \left[\sum_h \beta_{h,j}^{f} \left(\frac{F_{h,j}}{\overline{\overline{F_{h,j}}}} \right)^{\rho^f} \right]^{1/\rho^f} \qquad \forall j \tag{6}$$

This calibrated form eliminates the need to calibrate scale coefficients. The only calibrated parameter is the $\beta_{h,j}$. The factor demand function is:

$$F_{h,j} = \bar{F}_{h,j} \frac{Y_j}{\bar{Y}_j} \left(\frac{p_j^y}{\bar{p}_j^y} \frac{\bar{p}_h^f}{p_h^f} \right)^{\sigma^f} \qquad \forall h, j \tag{7}$$

3.3.2. Gross Domestic Output

In the second stage of production, we establish a similar profit-maximizing problem in which the representative j-th sector firm combines the composite factor with intermediate inputs. However, the production function is of Leontief type:

$$\text{maximize } \pi_j^z = p_j^z Z_j - \left(p_j^y Y_j + \sum_i p_i^q X_{i,j} \right) \quad \forall i, j \tag{8}$$

Subject to

$$Z_j = min \left(\frac{X_{i,j}}{ax_{i,j}}, \frac{Y_j}{ay_j} \right) \qquad \forall i, j \tag{9}$$

In which:

π_j^z	Profit of the j-th firm producing gross domestic output Z_j
Z_j	Gross domestic output of the j-th firm
$X_{i,j}$	Intermediate input of the i-th good used by the j-th firm
p_j^z	Price of the j-th gross domestic output
p_i^q	Price of the i-th composite good
$ax_{i,j}$	Input requirement coefficient of the i-th intermediate input for a unit output of the j-th good
ay_j	Input requirement coefficient of the j-th composite good for a unit output of the j-th good

The Leontief function comes computational obstacles since its differential coefficients are not well-defined like CES functions. To circumvent this, I replace it with a zero-profit condition which should hold given the assumption of perfect competition:

$$\pi_j^z = p_j^z Z_j - \left(p_j^y Y_j + \sum_i p_i^q X_{i,j} \right) = 0 \qquad \forall i, j \tag{10}$$

Substitute $X_{i,j} = ax_{i,j} Z_j$ and $Y_j = ay_j Z_j$ into the above function and eliminate Z_j, we get the unit cost function:

$$p_j^z = \mathrm{a}y_j p_j^y + \sum_i ax_{i,j} p_i^q \qquad \forall \mathrm{i,j} \tag{11}$$

3.4. International Trade

3.4.1. Small-open-economy and balance of payments

The small and open economy implies that prices for import and export quoted in foreign currency, are exogenously given:

$$p_i^e = \varepsilon p_i^{We} \qquad \forall i \tag{12}$$

$$p_i^m = \varepsilon p_i^{Wm} \qquad \forall i \tag{13}$$

The economy also faces balance of payments constraints:

$$\sum_i p_i^{We} E_i + \frac{S^f + \mathrm{Inc}^f}{\varepsilon} = \sum_i p_i^{Wm} M_i + \frac{\mathrm{Tr}f^f}{\varepsilon} \tag{14}$$

$$\mathrm{Inc}^f = \mathrm{KI}^f + \mathrm{Tr}f^{fp} + Trf^{fg} \tag{15}$$

$$Trf^f = K^f + Trf^{pf} + Trf^{gf} \tag{16}$$

Notations are:

p_i^e	Price of export in domestic currency
p_i^{We}	Price of export in foreign currency (exogenous)
p_i^m	Price of import in domestic currency
p_i^{Wm}	Price of import in foreign currency (exogenous)
ε	Foreign exchange rate (domestic currency/foreign currency)
M_i	Imports of the i-th goods
S^f	Current account deficit in terms of domestic currency (or foreign savings; exogenous)
Inc^f	Other payments from ROW (factor income, tax, and contribution from ROW; and remittances) in terms of domestic currency (exogenous)
Trf^f	Other transfers to ROW (from household, government, factor) in terms of domestic currency (exogenous)
KI^f	Capital income from ROW in terms of domestic currency (exogenous)
Trf^{fp}	Transfer from ROW to households in terms of domestic currency (exogenous)
$\mathrm{Tr}f^{fg}$	Transfer from ROW to the government in terms of domestic currency (exogenous)
K^f	Capital factor payment to ROW in terms of domestic currency (exogenous)
Trf^{pf}	Transfer from households to ROW in terms of domestic currency (exogenous)

Trf^{gf} Transfer from the government to ROW in terms of domestic currency (exogenous)

3.4.2. Substitution between imports and domestic goods

In the data, an imported good is not differentiated from the equivalent exported good, i.e., they are *perfectly* substitutable. However, it is evident that it would not make economic sense to import 100 potatoes and export 40 potatoes if they were perfectly substitutable. Therefore, it needs to be assumed that imports and domestic goods are *imperfectly* substitutable. This is known as the Armington assumption.

For our model, this means that agents in the economy consume an "Armington composite good" composed of imports and domestic goods. We can, again, set up a profit-maximizing problem for the firm producing such composite goods:

$$maximize\, \pi_i^q = p_i^q Q_i - \left(p_i^m M_i + p_i^d D_i\right)^2 \tag{17}$$

Subject to

$$Q_i = \gamma_i\left(\delta m_i M_i^{\eta_i} + \delta d_i D_i^{\eta_i}\right)^{\frac{1}{\eta_i}} \tag{18}$$

In which:

π_i^q	Profit of the firm producing the i-th Armington composite good
p_i^q	Price of the i-th Armington composite good
p_i^m	Price of the i-th imported good in terms of domestic currency
p_i^d	Price of the i-th domestic good
Q_i	The i-th Armington composite good
M_i	The i-th imported good
D_i	The i-th domestic good
γ_i	Scaling coefficient in the Armington composite good production function
$\delta m_i, \delta d_i$	Input share coefficients in the Armington composite good production function ($0 \leq \delta m_i \leq 1$, $0 \leq \delta d_i \leq 1$, $\delta m_i + \delta d_i = 1$)
σ_i	Elasticity of substitution between import and domestic good
η_i	Elasticity parameter ($= \frac{\eta_i - 1}{\eta_i}$, $\eta_i \leq_i 1$)

[2] The standard CGE model also includes an import tariff rate. But it is omitted here since Germany's revenue from custom duties is small and the original SAM merges it with other indirect tax.

The demand function for imports and domestic good:

$$M_i = \left(\frac{\gamma_i^{\eta_i}\delta m_i p_i^q}{p_i^m}\right)^{\frac{1}{1-\eta_i}} Q_i \tag{19}$$

$$D_i = \left(\frac{\gamma_i^{\eta_i}\delta d_i p_i^q}{p_i^d}\right)^{\frac{1}{1-\eta_i}} \mathrm{Q_i} \tag{20}$$

3.4.3. Transformation between exports and domestic goods

We can also apply a similar assumption of imperfect transformation for exports and domestic goods. It reflects the reality that domestic outputs, when exported, have to be first transformed to suit foreign needs. For example, electrical appliances produced in China, where 220-volt is the norm, must be modified to take 110 volts when exported to the US. Consider a firm transforming domestic outputs into domestic goods and exports. The profit-maximization problem for such a firm is as follows:

$$maximize\, \pi_i = \left(p_i^e E_i + p_i^d D_i\right) - (1 + \tau_i^z) p_i^z Z_i \tag{21}$$

Subject to a constant elasticity of transformation function (CET):

$$Z_i = \theta_i\left(\xi e_i E_i^{\phi_i} + \xi d_i D_i^{\phi_i}\right)^{\frac{1}{\theta_i}} \tag{22}$$

In which:

π_i	Profit of the firm transforming the i-th good
p_i^e	Price of the i-th export good quoted in domestic currency
p_i^d	Price of the i-th domestic good
p_i^z	Price of the i-th gross domestic output
E_i	Exports of the i-th good
D_i	Supply of the i-th domestic good
Z_i	Gross domestic output of the i-th good
τ_i^z	Production tax on the i-th gross domestic output
θ_i	Scaling coefficient of the i-th transformation
$\xi m_i, \xi d_i$	Share coefficients in transformation function ($0 \leq \xi m_i \leq 1,\ 0 \leq \xi d_i \leq 1,\ \xi m_i + \xi d_i = 1$)
ϕ_i	Elasticity parameter ($= \frac{\phi_i+1}{\phi_i}$, $\phi_i \geq 1$)
ψ_i	Elasticity of transformation in the transformation function

Solving this optimization problem, we obtain the supply function for exports and for domestic goods:

$$E_i = \left[\frac{\theta_i^{\phi_i}\xi e_i(1+\tau_i^z)p_i^z}{p_i^e}\right]^{\frac{1}{1-\phi_i}} Z_i \tag{23}$$

$$D_i = \left[\frac{\theta_i^{\phi_i}\xi d_i(1+\tau_i^z)p_i^z}{p_i^d}\right]^{\frac{1}{1-\phi_i}} Z_i \tag{24}$$

3.5. Government

In this model, the government levies a social security contribution tax on factor labor payment at rate τ^{ssc}, a direct tax on household income at rate τ^d, an indirect tax on gross domestic output at rate τ_j^z. The government spends its revenues on consumption, investment, transfers to households and to the rest of the world. Because our goal is to simulate the impact of UBI, transfers to households are exogenous. Transfers to ROW are also exogenously given. This leaves us with savings-investments and consumption to be endogenously determined. Assuming that the government saves according to an average propensity to save and spends the rest of its budget on consumption, these behaviors can be expressed as follows:

$$T^{ssc} = \tau^{ssc} \sum_i p_{LAB} \mathrm{F}_{\mathrm{LAB,i}} \tag{25}$$

$$\mathrm{T\hat{}d} = \tau\hat{}\mathrm{d}\ (\sum_h p_h^f FF_h \tag{26}$$

$$T_j^z = \tau^z p_j^z Z_j \tag{27}$$

$$\mathrm{S^g} = \mathrm{ss^g}\left(\mathrm{T^{ssc}} + \mathrm{T^d} + \sum_j \mathrm{T^z} + \mathrm{Trf^{fg}} - \mathrm{Trf^{gp}} - \mathrm{Trf^{gf}}\right) \tag{28}$$

$$X_i^g = \frac{\mu_i}{p_i^q}\left(\mathrm{T^{ssc}} + \mathrm{T^d} + \sum_j \mathrm{T^z} + \mathrm{Trf^{fg}} - \mathrm{Trf^{gp}} - \mathrm{Trf^{gf}} - S^g\right) \tag{29}$$

Notation are:

T^{ssc}	Social security contribution
T^{d}	Direct tax
T^{z}	Tax on production of the j-th good
τ^{ssc}	Social security contribution rate
τ^{d}	Direct tax rate
τ_j^{z}	Tax rate on production of the j-th good
F_{LAB}^{p}	Factor demand for labor
FF_h	Factor demand
Z_j	Gross domestic output of the j-th sector
S^{g}	Government savings
X_i^{g}	Government consumption
ss^{g}	Average propensity for savings by the government
Trf^{gp}	Transfers from the government to households (social benefits)
Trf^{gf}	Transfer from the government to ROW
μ_i	Share of the i-th good in government consumption ($0 \leq \mu_i \leq 1, \sum_i \mu_i = 1$)
p_{LAB}	Price of labor factor (equivalently, wage rate)
p_h^{f}	Price of the h-th factor
p_j^{z}	Price of the j-th gross domestic output
p_i^{q}	Price of the i-th composite good

3.6. Household in the CGE Module

3.6.1. Savings

I assume that household savings are determined by an average propensity for savings:

$$S^{p} = ss^{p}\left(\sum_{h} p_h^{f} FF_h^{p} - T^{d} - Trf^{pf} + Trf^{gp} + Trf^{fp}\right) \qquad (30)$$

Notations are:

S^{p}	Private savings
ss^{p}	Average propensity to save for household
FF_h^{p}	Endowment of the h-th factor for the household
T^{d}	Direct tax
Trf^{pf}	Transfer from household to ROW
Trf^{gp}	Transfer from the government to household
Trf^{fp}	Transfer from ROW to household
p_h^{f}	Price of the h-th factor

3.6.2. Composite Consumption

The household in our model derives utility from a nested CES utility function. We start from the bottom where the representative household maximizes a composite consumption good according to a CES function in calibrated form:

$$maximize\, C = \bar{C}\left[\sum_i \beta_i^c \left(\frac{X_i^p}{\overline{X_i^p}}\right)^{\rho^c}\right]^{\frac{1}{\rho^c}} \tag{31}$$

Subject to

$$\sum_i p_i^q X_i^p = \sum_h p_h^f FF_h^p + \mathrm{Tr}f^{gp} + \mathrm{Tr}f^{fp} - T^d - S^p - \mathrm{Tr}f^{pf} = I^{hoh} \tag{32}$$

Notations are:

C	Composite consumption
X_i^p	Private consumption of the i-th good
FF_h^p	Endowment of the h-th factor for the household
Trf^{gp}	Transfer from the government to households
Trf^{fp}	Transfer from ROW to households
T^d	Direct tax
S^p	Private savings
I^{hoh}	Household budget for consumption
p_i^q	Price of the i-th composite good
p_h^f	Price of the h-th factor
β_i^c	Value share of the i-th good in the composite consumption obtained from the benchmark equilibrium$\left(=\frac{\bar{x}_i^p \bar{p}_i^q}{\sum_i \bar{p}_i^q \bar{X}_i^p}\right)$
σ^c	Elasticity of substitution between goods
ρ^c	Elasticity parameter $\left(=\frac{\sigma^c - 1}{\sigma^c}\right)$

The unit expenditure function resulting from solving this problem is also the consumer price index (CPI):

$$cpi = \overline{cpi}\left[\sum_i \beta_i^c \left(\frac{p_i^q}{\overline{p_i^q}}\right)^{1-\sigma^c}\right]^{\frac{1}{1-\sigma^c}} \tag{33}$$

The demand function for good is:

$$X_i^p = \overline{X_\iota^p}\frac{I^{hoh}}{\overline{I^{hoh}}}\left(\frac{\overline{p_\iota^q}}{p_i^q}\right)^{\sigma^c}\left(\frac{cpi}{\overline{cpi}}\right)^{\sigma-1} \tag{34}$$

3.6.3. Utility

At the higher level, household's utility comes from the composite consumption and leisure:

$$maximize\ UU = \overline{UU}\left[\beta^u\left(\frac{C}{\bar{C}}\right)^{\rho^u} + (1-\beta^u)\left(\frac{l}{\bar{l}}\right)^{\rho^u}\right]^{\frac{1}{\rho^u}} \tag{35}$$

The left-hand side of the constraint contains the cost of consumption and the opportunity cost of leisure while the right-hand side represents the total income if the household devotes all its time endowment to labor:

$$\mathrm{cpi\ C} + p_{LAB}(1-\tau^{ssc})(1-\tau^d)\mathrm{l} = p_{LAB}(1-\tau^{ssc})(1-\tau^d)\bar{T} + \mathrm{V} = \mathrm{B^{hoh}} \tag{36}$$

The expenditure and the demand functions of leisure and composite consumption good are:

$$p^u = \bar{p}^u\left[\beta^u\left(\frac{cpi}{\overline{cpi}}\right)^{1-\sigma^u} + (1-\beta^u)\left(\frac{p_{LAB}(1-\tau^{ssc})(1-\tau^d)}{\bar{p}_{LAB}(1-\bar{\tau}^{ssc})(1-\bar{\tau}^d)}\right)^{1-\sigma^u}\right]^{\frac{1}{1-\sigma^u}} \tag{37}$$

$$\mathrm{l} = \bar{l}\frac{B^{hoh}}{\overline{\mathrm{B}}^{\mathrm{hoh}}}\left[\frac{\bar{p}_{LAB}(1-\bar{\tau}^{ssc})(1-\bar{\tau}^d)}{p_{LAB}(1-\bar{\tau}^{ssc})(1-\bar{\tau}^d)}\right]^{\sigma^u}\left(\frac{p^u}{\bar{p}^u}\right)^{\sigma^u-1} \tag{38}$$

$$\mathrm{C} = \bar{C}\frac{\mathrm{B^{hoh}}}{\bar{B}^{\mathrm{hoh}}}\left(\frac{\overline{cpi}}{cpi}\right)^{\mathrm{\sigma^u}}\left(\frac{p^u}{\bar{p}^u}\right)^{\mathrm{\sigma^u}-1} \tag{39}$$

Notations are:

UU	Utility (Utility at benchmark $\overline{UU} = 1$)
C	Composite consumption
l	Leisure
$\bar{T}$	Time endowment of household $\left(= \frac{T^{ssc}}{p_{LAB}} + l + FF_{LAB}\right)$
p^u	Unit expenditure of utility
cpi	Consumer price index
V	Non-labor income (i.e., income from capital, government transfer, and remittances after tax and transfer to other accounts) $\left(\mathrm{V} = (\mathrm{p_{CAP}\ FF_{CAP}})\left(1-\tau^{\mathrm{d}}\right) + \mathrm{Trf^{gp}} + \mathrm{Trf^{fp}} - \mathrm{S^p} - \mathrm{Trf^{pf}}\right)$

p_{LAB}	Price of labor factor, i.e., wage rate
FF_{LAB}	Labor supply
τ^{ssc}	Social security contribution rate
B^{hoh}	Household budget the utility maximization problem
τ^{d}	Direct tax rate
β^{u}	Value share of the composite consumption at benchmark equilibrium $\left(= \frac{\overline{\text{cpi}}\,\overline{\text{C}}}{\overline{\text{cpi}}\,\overline{\text{C}} + \overline{\text{p}}_{\text{LAB}}\,(1-\overline{\tau}^{\text{ssc}})(1-\overline{\tau}^{\text{d}})\overline{l}}\right)$
σ^{u}	Elasticity of substitution between composite consumption and leisure
ρ^{u}	Elasticity parameter $\left(= \frac{\sigma^{u}-1}{\sigma^{u}}\right)$

3.7. Investment and savings

The total savings are assumingly distributed among sectors according to a share parameter:

$$X_i^v = \frac{\lambda_i}{p_i^q}(S^p + S^g + S^f + K^d) \tag{40}$$

Notations are:

X_i^v	Demand for the i-th investment good
S^p	Private savings
S^g	Government savings
S^{f}	Current account deficit in terms of domestic currency (or foreign savings; exogenous)
λ_i	Expenditure share of the i-th good in total investment $(0 \leq \lambda_i \leq 1, \sum_i \lambda_i = 1)$
p_i^q	Price of the i-th composite good

3.8. Market-clearing conditions

I impose market-clearing conditions so that supply equals demand in all markets:

$$Q_i = X_i^p + X_i^g + X_i^v + \sum_j X_{i,j} \qquad \forall i \tag{41}$$

$$\sum_j F_{LAB,j} = FF_{LAB} \tag{42}$$

$$\sum_j F_{CAP,j} + KI^f = \text{F}F_{CAP} + K^d + K^f \tag{43}$$

3.9. Calibration of the CGE module

"Calibration" refers to a common practice in the literature in which unknown parameters are solved by using values of endogenous variables from a known equilibrium (i.e., the SAM) (Böhringer et al. 2003; Hosoe, Gasawa, and Hashimoto 2010, chap. 5). Using the example from section 3.2, this means that in the calibration procedure, we solve the coefficient vector a given the benchmark equilibrium vector $\bar{x}$. However, the number of unknown parameters and exogenous variables almost always exceed the number of equations in the model. Thus, we have to assume values for some of them.

We start with elasticities of substitution. Their values are usually chosen first (shown in Table 2), preferably by consulting the relevant literature in applied microeconomics. As the model contains only one sector, we can avoid assuming elasticity of substitution (EOS) between consumer goods. The biggest problem is the EOS between composite consumption and leisure because it cannot be estimated directly. To circumvent, I assume the baseline elasticity to be 0.5 and run the model with a range of values. This process, known as sensitivity analysis, is also applied to other elasticities.

Table 2 Assumed elasticities in the CGE module

Parameter	Description
$\sigma^f = 0.5$	Elasticity of substitution between labor and capital[3]
$\sigma_i = 2$	Elasticity of substitution between import and domestic good [4]
$\psi_i = 2$	Elasticity of transformation between exports and domestic goods
$\sigma^u = 0.5$	Elasticity of substitution between composite consumption and leisure

Calibration of other parameters are performed as follow:

a) Composite factor function (CES)

$$\beta_{h,j} = \frac{\bar{p}_h^f \bar{F}_{h,j}}{\bar{p}_j^y \bar{Y}_j}$$

CEU eTD Collection

[3] There is large cross-country variation in estimates. However, most falls somewhere between 0.4 and 0.9 (Knoblach and Stöckl 2020). Gechert et al. (2022) suggests that the mean estimated elasticity in the literature after correcting for various issues is 0.3.

[4] Setting the Armington elasticity and elasticity of transformation equal to 2 seems to be the norm in the CGE literature (Hosoe, Gasawa, and Hashimoto 2010; Böhringer, Boeters, and Feil 2005)

b) Gross domestic output function (Leontief-type)

$$ax_{i,j} = \frac{\bar{X}_{i,j}}{\bar{Z}_J}$$

$$\mathrm{ay}_j = \frac{\bar{\mathrm{Y}}_j}{\bar{Z}_J}$$

c) Composite good production function (CES)

$$\delta m_i = \frac{\bar{p}_i^m \bar{M}_i^{(1-\eta_n)}}{\bar{p}_i^m \bar{M}_i^{(1-\eta_n)} + \bar{p}_i^d \bar{D}_i^{(1-\eta_i)}}$$

$$\delta d_i = \frac{\bar{p}_i^d \bar{D}_i^{(1-\eta_i)}}{\bar{p}_i^m \bar{M}_i^{(1-\eta_n)} + \bar{p}_i^d \bar{D}_i^{(1-\eta_i)}}$$

d) Transformation function (CET)

$$\xi e_i = \frac{\bar{p}_i^e \bar{E}_i^{1-\phi_i}}{\bar{p}_i^e \bar{E}_i^{1-\phi_i} + \bar{p}_i^d \bar{D}_i^{1-\phi_i}}$$

$$\xi d_i = \frac{\bar{p}_i^d \bar{D}_i^{1-\phi_i}}{\bar{p}_i^e \bar{E}_i^{1-\phi_i} + \bar{p}_i^d \bar{D}_i^{1-\phi_i}}$$

$$\theta_i = \frac{\bar{Z}_i}{\left(\xi e_i \bar{E}_i^{\phi_i} + \xi d_i \bar{D}_i^{\phi_i}\right)^{1/\phi_i}}$$

e) Composite consumption

$$\beta_i^c = \frac{\bar{x}_i^p \bar{p}_i^q}{\sum_i \bar{p}_i^q \bar{X}_i^p}$$

f) Utility

$$\beta^u = \frac{\overline{cpi}\,\bar{C}}{\overline{cpi}\,\bar{C} + \bar{p}_{LAB}(1-\bar{\tau}^{ssc})(1-\bar{\tau}^d)\bar{l}}$$

Leisure time is usually not directly observed, which means that the total time endowment for leisure and working is also not available. Therefore, we need to approximate the ratio of leisure time to working time in some way. First, I assume that the representative household devotes half the time in a day for sleep, care work, and other activities for reproduction of labor. Moreover, the household only works during 5 weekdays, which is a common practice for full-time employment in Germany. Taken together with the average annual hours worked from the OECD ("Employment - Hours Worked - OECD Data," n.d.), I calibrate the initial leisure time so that the initial working time takes up 44.1% of the total time endowment.

g) Saving rates and tax rates

$$ss^p = \frac{\bar{S}^p}{\sum_h \bar{p}_h^f \overline{FF}_h + KI^f - K^d - K^f - T^{ssc} - T^d - Trf^{pf} + Trf^{gp} + Trf^{fp}}$$

$$ss^g = \frac{\bar{S}^g}{\bar{T}^d + \bar{T}^z + \bar{T}^{ssc} + \overline{Trf}^{fg} - \overline{Trf}^{gp}}$$

$$\tau^z = \frac{\bar{T}_j^z}{\bar{p}_j^z \bar{Z}_j}$$

$$\tau^d = \frac{\bar{T}^d}{\sum_h \bar{p}_h^f \overline{FF}_h + KI^f - K^d - K^f - T^{ssc}}$$

$$\tau^{ssc} = \frac{\bar{T}^{ssc}}{\bar{p}_{LAB} \overline{FF}_{LAB}}$$

3.10. Microsimulation Module

The microsimulation module handles the behavioral response in terms of individuals or households to policy changes. Specifically, the module simulates both the extensive and the intensive margins. The extensive margin refers to the choice of individuals between no work at all or some amounts of work. The intensive margin concerns the intensity of existing work (e.g., work hours).

The intensive margin is related to a previously mentioned strand of literature: estimates of the ETI. For example, this parameter plays the central role in modeling the response at the intensive margin in (Benczúr, Kátay, and Kiss 2018). However, their calibration is built upon their earlier works that requires appropriate administrative tax data, which is not the case for the SOEP. To overcome this problem, I use a discrete-choice model for both the intensive and the extensive margins.

Following (Benczúr, Kátay, and Kiss 2018; Arntz et al. 2008), I setup the utility function for individual i for each k option[5]:

$$U_i(x_k) = \overline{U}_i(x_{i,k}) + \varepsilon_{i,k} \tag{44}$$

In which, $\overline{U}$ is the deterministic part depending on a vector of alternative-specific characteristics $x_{i,k}$, and $\varepsilon_{i,k}$ is assumed to be an independent and identically distributed (i.i.d) type I extreme value random term (in essence, a stochastic term).

As has been shown by McFadden (1974), the formula for the probability of preferring option k over all other options $l \neq k$ from a set of m is:

$$P(U_{i,k} > U_{i,l}) = \frac{exp\left(\overline{U}_i(x_{i,k})\right)}{\sum_m exp\left(\overline{U}_i(x_{i,m})\right)} \qquad \forall l \neq k \tag{45}$$

Finally, the deterministic term is decided by choice-specific and individual characteristics:

$$\overline{U}_{i,k} = \alpha_k \mathrm{log} c_{i,k} + \beta_k \left(log c_{i,k}\right)^2 + \gamma_k Z_i + \eta_i \tag{46}$$

In which, $logc_{i,k}$ is log of disposable income (after social security contributions and tax, plus unemployment benefits, housing benefits, child benefits and allowances, and social assistance). Z_i includes years of schooling, gender, age and age squared, East-German place of residence indicator, number of children in the household, nationality, marital status, and various interaction terms.

The parameters of the utility model are estimated using a multinomial logit model for the total sample from year 2013 to 2018 (a complete set of regressors and estimates are available in the Appendix B). The actual microsimulation is carried out on the year 2018 subset. Individuals are

[5] Note that the definition of indices in this section is different from that in the CGE module and is exclusive to this section only.

categorized into 6 groups based on their initial working time (shown in Table 3) and assigned a time value. Tax, social contributions, and net income are generated from a simplified tax bracket (available in Appendix A). The pre-reform probability of choosing each option is calculated for each person, according to which they are assigned a new choice. After the hypothetical reform is enacted, the probabilities and assigned choices are calculated again. The difference in working-hour weighted averages before and after the reform is the aggregate labor supply change.

Table 3 Categories of working time and corresponding assigned values

Initial working time (hours/week)	Assigned time (hours/week)
$h \leq 0$	0
$0 < h < 22$	15
$22 \leq h < 35$	30
$35 \leq h < 42$	38
$42 \leq h < 56$	47
$56 \leq h$	61

Because the wage of currently idle people is not observed, it is approximated using estimated parameters from a Mincer earnings function which includes most of the individual characteristics as in the utility function plus experience in full-time employment, part-time employment, and unemployment (the estimates are available in Appendix C)

3.11. Linking the Modules

The policy shock is initialized on the CGE module. In this first instance, leisure and labor supply are endogenous in the CGE. The changes in wage coming from the optimal solution is transmitted to the MS module. The MS then outputs the changes in labor supply to a modified version of the CGE module in which labor supply and leisure are exogenous. The process (illustrated in Figure 2) is ran iteratively until the difference in labor supply change between two subsequent iterations is less than 10^{-5}. Finally, the model is run with 500 different random seeds, 411 of which converges.

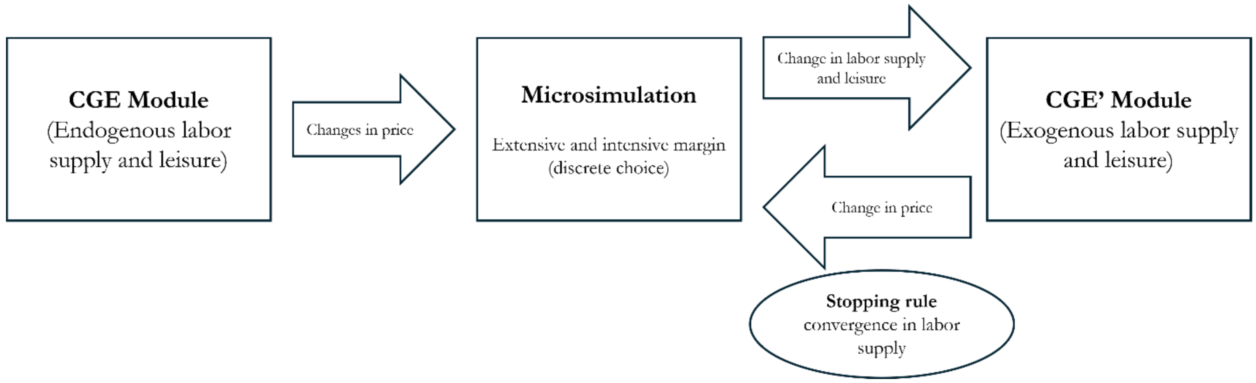

Figure 2 The modules and their links.

3.12. Limitation

Before seeing the results, it is worth stressing the capabilities as well as the limitations of this model since they decide the interpretation of the results. The model is capable of assessment of the short-medium terms aggregate impact of changes in tax and transfers. The model keeps current account deficits exogenous and the government budget balanced. Thus, it contains appropriate macro-closures on the government side. Its relative simplicity also makes interpretation of results straightforward. However, the caveats are:

(1) The model only contains one sector which means that it cannot account for the impact of sectoral heterogeneity.

(2) The model is a comparative statics exercise in nature. Dynamic paths are thus not depicted here. Moreover, economic accounts that involve the time dimension are not sufficiently covered. For instance, investment and savings in this model, strictly speaking, represents a waste of resources since there is no second period in which capital stocks increase due to investment.

(3) Capital endowment is exogenous, which makes it not suitable for long-term evaluation as capital would, given time, flow in (or out) to adjust for the changes in wages (if any).

(4) Unemployment or search-and-matching mechanisms in the labor market are omitted.

(5) The model does not capture long-term effects from other behavioral responses. For example, if the increase in transfers allows some individuals to upskill[6] and achieve high wages, the amount of taxable income also increases and makes the funding easier.

4. Simulation Results

4.1. Scenarios

As alluded to before, UBI proposals vary significantly in their scope and magnitude. Here, I construct a relatively modest hypothetical scenario:

- The amount of UBI for each adult from age 18 to 65 every month is 80% of the poverty line in 2018 (equal to 832 EUR)
- Parents receive an additional 416 EUR for every child in the household.
- The UBI replaces housing benefits, social assistance, family programs, and unemployment benefits.

A back-of-the-envelope calculation based on population by age group informs the additional aggregate labor tax revenue required for the CGE module, approximately 450 billion euros. The aggregate effective tax rate on labor is affected accordingly to ensure the budget balance. This translates to a similar increase in marginal tax rate in every tax bracket for the MS, which is 38.9 percentage points.

4.2. Results

4.2.1. CGE module

Examining the result when running only the CGE module provides insights into how it behaves as well as whether it makes economic sense. The macro elasticities on which sensitivity analysis needs to be performed are also detected during this process. Table 4 shows the impacts of the hypothetical

[6] Assuming that there is a mismatch in labor supply and demand of high-skill labor in the first place.

reform with only the CGE module for different combinations of parameter values. While the magnitude varies, the story is the same. The representative household receiving an increased transfer will reduce their labor supply and substitute it with leisure. As the labor supply goes down, wages increase. The combined rise in tax rate and wage pushes up the revenue from income tax. The firm passes some of the rising cost of labor onto consumers, hence the increase in consumer price index. The household, now both works less and faces higher prices in consumer goods, reduces their consumption. Finally, GDP decreases except in column (1). This difference is because the skyrocketing high tax revenue allows the government to outspend the loss in private consumption.

Regarding the EOS between imports and domestic output and the elasticity of transformation, the result (not included here) is insensitive as there is no change in impact compared to the baseline.

Table 4 Impacts of the hypothetical reform from the CGE module alone

	$\sigma_u = 0.5$			$\sigma_f = 0.5$		
Aggregate Impact (%)	$\sigma_f = 0.1$ (1)	$\sigma_f = 0.5$ (2)	$\sigma_f = 0.9$ (3)	$\sigma_u = 0.1$ (4)	$\sigma_u = 0.5$ (5)	$\sigma_u = 0.9$ (6)
Leisure	4.0	12.3	16.4	3.0	12.3	18.8
Labor supply	-5.1	-15.6	-20.8	-3.7	-15.6	-23.8
Consumption	-19.8	-15.6	-13.7	-3.8	-15.6	-24.1
Wage	67.9	40.3	29.5	7.9	40.3	72.1
Income tax revenue	187.7	124.7	100.4	102.4	124.7	144.3
Consumer price index	39.4	22.8	16.4	4.6	22.8	39.9
GDP	4.0	-5.5	-9.7	-1.3	-5.5	-8.7

Note: Column (2) and (5) are identical since they report the same combination of parameter values.

4.2.2. Combined CGE-MS

As Figure 3 shows, results from the combined CGE-MS show more modest effects in terms of magnitude. The extreme values of all variables are less than 3%. Moreover, there is no significant difference from zero except for the income tax revenue which stabilizes around 96% (not shown here).

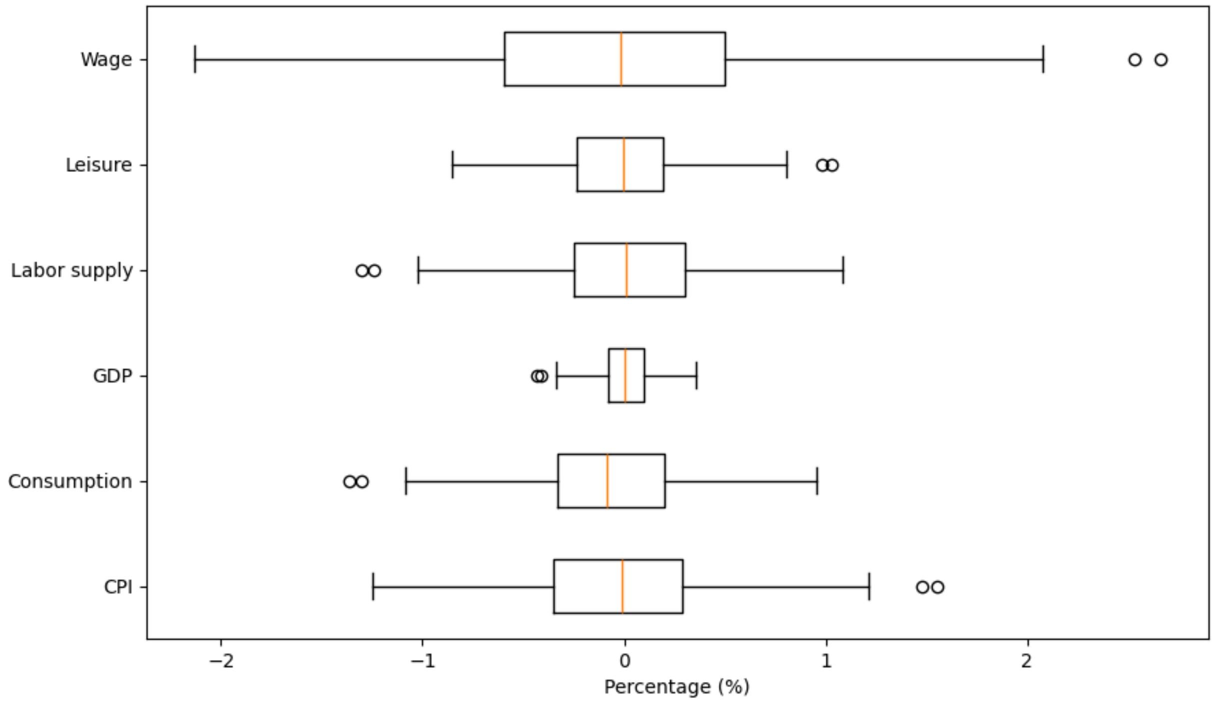

Figure 3 Impacts of the hypothetical reform at baseline parameters
Note: Number of converging seeds: 411

If we plot the results of each iteration with labor supply on the x-axis and the rest on the y-axis (plots not included here), we get a linear relationship with the slope sign consistent with the sign from the results from running only the CGE module, e.g., if labor supply decreases after the reform, wage will increase. This suggests that the mechanism depicted by the CGE module holds. However, now it is not certain whether individuals will reduce their labor supply.

4.2.3. Sensitivity analysis

As suggested by the CGE module, the EOSs between capital and labor, and between leisure and consumption are chosen for the sensitivity analysis. The latter does not affect the result in any ways when adding the microsimulation (and thus, is not shown here).

According to Figure 4, leisure and labor supply are not sensitive to the EOS between capital and labor. This is expected since behavioral response is mostly determined by individual and choice's characteristics in the microsimulation. For the rest of the variables, a higher EOS, meaning that it is easier to substitute labor and capital, shrinks the impact. A lower EOS, meaning that it is harder for the economy to adjust as labor and capital becomes more complementary, inflates the effects. The most dramatic changes continue to come from wage, followed by consumption and CPI. The magnitude of GDP change remains relatively small.

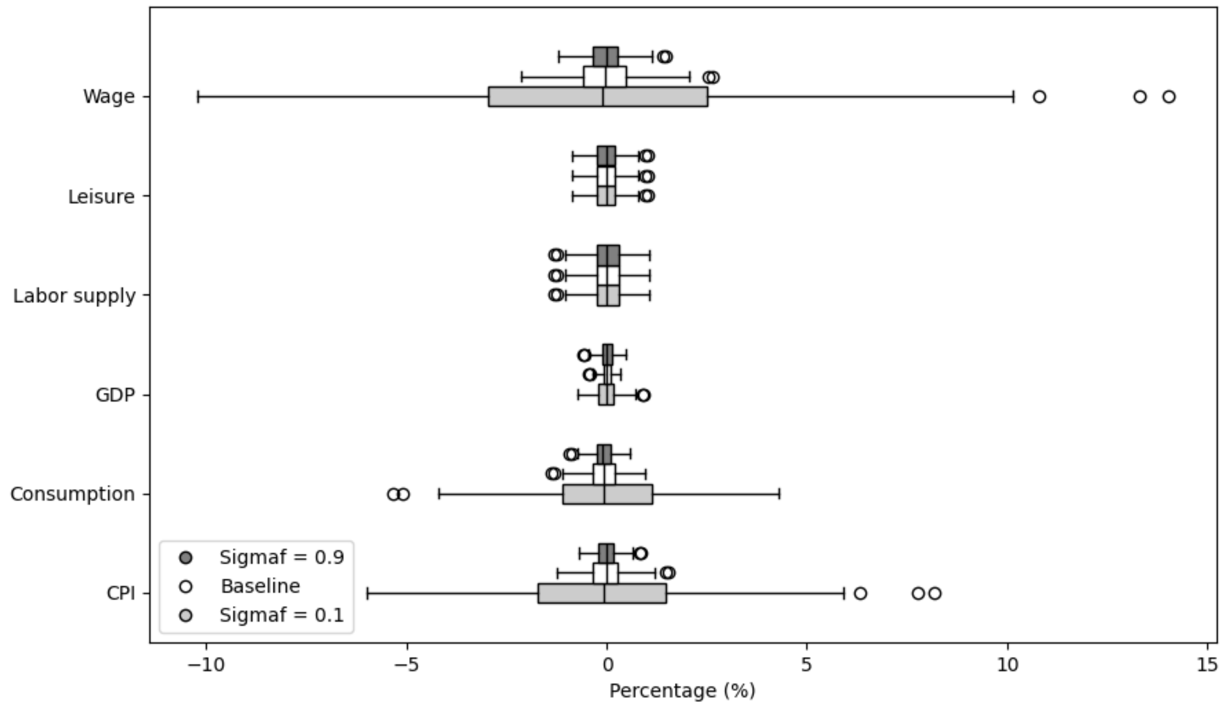

Figure 4 Impacts of the hypothetical reform under three different values of the EOS between capital and labor
Note: Number of converging seeds: 411

5. Conclusion

In this thesis, I construct an iteratively combined CGE-MS to assess the impacts of a hypothetical UBI proposal on labor supply and various macro indicators. The CGE, built upon maximization problems of a representative household and firms, handles the aggregate variables. The MS employs a discrete-choice model to simulate the labor supply response at both the extensive and intensive margins using German micro household data SOEP from 2013 to 2018. I first use the CGE module to sketch the mechanism through which the reform's effects will go through. The combined model then provides appropriate estimates with response at individual level.

The model shows that in case of a reduction in labor supply due to higher tax rates and more transfers from the government, wages will increase. Firms pass some of the increase in labor cost onto consumers who, in the face of rising consumer prices and less work, reduce their consumption. Ultimately, GDP is negatively impacted, suggesting that the effects of large transfers on aggregate are negated by both price hikes and less value-added labor in the economy. However, as the combined model demonstrates, it is not certain that individuals will reduce their labor supply. The impact magnitude, especially on wage, consumption, and CPI, is sensitive to whether capital can easily substitute labor. The effect on GDP, however, is small.

One important thing to note is that the model is limited in several regards. It is static in nature, contains only one sector, omits unemployment and search mechanism in the labor market, and does not construct a comprehensive capital market. Thus, it is ill-suited for long-term projection. Moreover, effects can be exaggerated if capital flows move in (or out) to adjust.

Still, the model as it is in the current state is useful for gauging the effects and mechanisms of tax and transfer policies on labor supply in other countries. With appropriate modification, the model can be utilized for evaluating effects of other policies (e.g., trade) on various outcomes. In this regard, the model will benefit from the addition of a more sophisticated capital market and more sectors, the replacement of the ROW account with regions or countries, and the dropping of some of the initial assumptions, e.g., full employment and perfect competition.

What policy implications can be drawn from this? Consider the question laid out in the beginning. It seems that funding a modest UBI proposal solely by raising income tax is financially sustainable because (1) it does not guarantee that the aggregate labor supply declines (due to household's response at the micro level, i.e., the substitution effect) and (2) even if it does, the negative impact on GDP is insignificant and income tax revenue remains adequate.

It is nonetheless too early to conclude whether UBI proposals of any kind should be implemented. There is not yet a consensus of the effect on (long-term) welfare. In addition, the modest UBI proposed here, while certainly helpful to alleviate absolute property, is nowhere close to the goal of providing everyone a decent living standard to which some proposals aspire. More ambitious proposals will quickly drain the value-added labor. To address this problem, policymakers would need additional tax revenue from other sources, e.g., corporate tax, whose general equilibrium effect is not yet estimated.

Regarding the proposition for UBI, the finding in this thesis, notably concerning the sensitivity to the EOS between capital and labor indeed strengthens a popular argument for UBI as follows. As technology advances rapidly over the last decades, most jobs as we know will disappear and be taken up by robots. The small number of jobs remaining, are either very high-wage jobs for a few elite members of the society, or very low-and-stagnating-wage jobs for the destitute, aggravating inequality. To prevent the impoverishment of the masses, a UBI needs to be introduced (Hoynes and Rothstein 2019). In economic terms, this scenario translates to an increase in the EOS between capital and labor, backed by the increasing evidence for rising EOSs (Knoblach and Stöckl 2020; Ialenti and Pialli 2024). Because the model in this thesis suggests that at higher EOSs the negative effect of UBI (if any) is increasingly smaller and approaching zero, there is probably a free lunch after all.

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Appendix

A. German tax brackets

Table 5 Simplified Germany tax brackets

Year	Income range (EUR)	Marginal tax rate
2013	0 – 8130	0
	8131 – 13469	14%
	13470 – 52881	42%
	52882 – 250731	45%
	250732 and above	45%
2014	0 – 8354	0
	8355 – 13469	14%
	13470 – 52881	42%
	52882 – 250731	45%
	250732 and above	45%
2015	0 – 8472	0
	8473 – 13469	14%
	13470 – 52881	42%
	52882 – 250731	45%
	250732 and above	45%
2016	0 – 8652	0
	8653 – 13469	14%
	13470 – 52881	42%
	52882 – 250731	45%
	250732 and above	45%
2017	0 – 8820	0
	8821 – 13469	14%
	13470 – 52881	42%
	52882 – 250731	45%
	250732 and above	45%
2018	0 – 9000	0
	9001 – 13469	14%
	13470 – 52881	42%
	52882 – 250731	45%
	250732 and above	45%

B. Multinomial logit utility model estimation

Table 6 Multinomial logit utility model estimation for each working time category

Variable	**(1)** $0 < h < 22$	**(2)** $22 \leq h < 35$	**(3)** $35 \leq h < 42$	**(4)** $42 \leq h < 56$	**(5)** $56 \leq h$
Log disposable income	-0.985 (0.449)	-17.818 (0.641)	-25.728 (0.562)	-31.966 (0.845)	-17.15 (8.589)
Log disposable income^2	0.009 (0.056)	1.393 (0.075)	2.942 (0.067)	3.449 (0.107)	1.302 (1.082)
Age	0 (0.001)	0.048 (0.001)	0.097 (0.001)	0.118 (0.002)	0.109 (0.01)
Age^2	-0.098 (0.018)	0.086 (0.026)	0.001 (0.022)	-0.015 (0.038)	-1.021 (0.426)
Marital status	0.001 (0)	-0.001 (0)	0 (0)	0 (0)	0.012 (0.005)
Gender (female=1)	-0.504 (0.105)	-1 (0.178)	-0.284 (0.113)	0.013 (0.198)	0.029 (1.36)
East German residence	0.45 (0.23)	1.188 (0.278)	-0.326 (0.237)	-0.415 (0.293)	0.155 (1.383)
Years of schooling	-1.491 (0.298)	-1.839 (0.302)	-2.867 (0.277)	-2.9 (0.283)	-2.393 (0.394)
Number of kids	0.193 (0.022)	0.297 (0.027)	0.196 (0.023)	0.261 (0.024)	0.237 (0.036)
Nationality (German =1)	-0.457 (0.25)	-0.682 (0.098)	-1.197 (0.084)	-1.14 (0.086)	-0.932 (0.21)
Log disposable income x Age	-0.646 (0.242)	0.176 (0.295)	1.785 (0.255)	1.73 (0.272)	-1.719 (1.722)
Log disposable income x Age^2	0.004 (0.002)	0.003 (0.003)	0 (0.003)	0.005 (0.005)	0.137 (0.056)
Log disposable income x Nationality	< 0.001 (< 0.001)	< 0.001 (< 0.001)	< 0.001 (< 0.001)	< 0.001 (< 0.001)	-0.002 (0.001)
Log disposable income x Gender	-0.004 (0.013)	0.024 (0.012)	0.009 (0.011)	0.024 (0.012)	0.559 (0.235)
Log disposable income x Number of kids	0.018 (0.01)	0.033 (0.012)	-0.008 (0.011)	0.018 (0.026)	-0.102 (0.194)
Log disposable income x Marital status	0.03 (0.032)	-0.022 (0.005)	-0.027 (0.003)	-0.032 (0.004)	-0.042 (0.022)
Years of schooling x East German residence	0.027 (0.01)	0.058 (0.021)	0.029 (0.011)	-0.016 (0.025)	-0.019 (0.178)
Years of schooling x Number of kids	0.089 (0.026)	0.154 (0.025)	0.244 (0.024)	0.264 (0.025)	0.237 (0.033)
Years of schooling x Nationality	0.002 (0.007)	0.027 (0.007)	0.04 (0.007)	0.033 (0.007)	0.02 (0.01)
Years of schooling x Gender	0.056 (0.021)	-0.026 (0.024)	-0.117 (0.022)	-0.113 (0.024)	-0.171 (0.035)
Marital status x Gender	-0.022 (0.02)	-0.048 (0.023)	0.034 (0.02)	0.021 (0.021)	0.017 (0.032)
Marital status x Nationality	1.154 (0.075)	1.002 (0.092)	0.131 (0.073)	-0.126 (0.078)	0.164 (0.149)
Gender x East German residence	0.644 (0.075)	0.838 (0.091)	0.848 (0.079)	0.96 (0.089)	1.009 (0.171)
Gender x Number of kids	-0.853 (0.09)	-0.364 (0.101)	0.285 (0.081)	0.089 (0.088)	0.177 (0.165)
Gender x Nationality	-0.081 (0.03)	-0.275 (0.036)	-0.59 (0.032)	-0.772 (0.037)	-0.568 (0.085)
Number of observations	11342	8980	21808	18331	2089

Note: Standard errors are heteroscedasticity robust and in parentheses.

C. Wage regression

Table 7 Wage OLS Regression with Log gross wage as dependent variable

Variable	Coef.	SE	z	P > |z|
Years of schooling	1.210	0.047	26.02	0.000
Age	-0.277	0.011	-24.41	0.000
Experience with full-time employment	0.947	0.028	33.83	0.000
Experience with full-time employment^2	-0.01	0.000	-28.18	0.000
Experience with part-time employment	0.959	0.024	40.74	0.000
Experience with part-time employment^2	-0.019	0.001	-24.42	0.000
Experience with unemployment	-2.571	0.051	-50.61	0.000
Experience with unemployment^2	0.08	0.003	27.23	0.000
Gender (female =1)	2.282	0.521	4.38	0.000
Nationality (German =1)	4.881	0.151	32.34	0.000
Marital status	3.905	0.509	7.67	0.000
East German residence	-0.063	0.120	-0.53	0.598
Year	-0.131	0.026	-5.08	0.000
Years of schooling x experience with full-time employment	-0.018	0.002	-10.22	0.000
Gender x marital status	-0.782	0.200	-3.91	0.000
Gender x education	-0.219	0.038	-5.78	0.000
Marital status x education	-0.239	0.038	-6.27	0.000

Note: Number of observations: 73843. Standard Errors are heteroscedasticity robust.