Marginal Personal Income Tax Changes: Tax Revenues, Redistribution and Labour Supply Responses

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Motivation

- **State's fiscal policy**: a trade-off among
  - state budget (tax revenues, government spending);
  - income redistribution (equity, poverty);
  - efficiency (competitiveness, labour supply).
- An **exhaustive analysis of a reform** in the tax-benefit system requires a set of tools to explore its effects on each of these aspects simultaneously.
- In this study:
  - **Belgian arithmetic microsimulation model (Beamm)** for the tax-benefit system → effects on inequality and state budget;
  - **Random Utility Random Opportunity (RURO) model** → effects on labour supply.

Fiscal system in Belgium[1]

- Income tax rate: **50%** (Ranked in the world: **7**; Global average: **30.3%**).
- Tax burden: **42%** (Ranked in the world: **3**; Global average: **20.8%**).
- Tax wedge: **53%** (Ranked in the world: **1**; OECD average: **34.6%**).

[1] Latest available data from 2022/2023.

Institutional Context

- Major **tax reform in 2016**: removal of the 30% tax bracket and broadening of the tax thresholds for low income earners.
- Belgium continues to have the **highest tax wedge** in the world.

Table 1: Personal income tax rates in Belgium (2023)

TI (€) from	TI (€) to	Rate (%)	Max tax on bracket (€)	Cumulative tax (€)
0	15,200	25	3,800	3,800
15,200	26,830	40	4,652	8,452
26,830	46,440	45	8,824.5	17,276.5
46,440	∞	50		

Source. PWC Belgium. *Notes*. Tax brackets for income year 2023 are applicable to net taxable income after the deduction of social security charges and professional expenses.

Research Question

What are the effects of **marginal tax changes** (tax rates and income brackets) in the Personal Income Tax (PIT) on tax revenues, redistribution and labour supply?

1. Assessment of the pre-reform scenario:
   - Run of the tax-benefit microsimulation model to determine tax revenues, inequality, and individuals' disposable income.
   - Use of the individuals' disposable income to estimate the labour supply.
2. Definition of **five reform scenarios** (based on Creedy et al. (2018) → optimal directional changes).
3. For every scenario, replication of Point 1.
4. Comparison of results from Points 1 and 3.

Marginal PIT Reforms

- **Reform 1**: 1% increase of all marginal tax rates.
- **Reform 2**: 1% decrease of all marginal tax rates.
- **Reform 3**: €1000 increase of all income brackets.
- **Reform 4**: €1000 decrease of all income brackets.
- **Reform 5**: A combination of marginal tax rates and income brackets increase/decrease.

Optimal direction of taxation

- **No optimal taxation** → the **government objective function** does not need to be explicitly defined.
- **But optimal direction of tax changes** → We **assume** the government's utility to be $\mathcal{U} = f(\overset{+}{T - B}, \overset{-}{Ineq}, \overset{+}{l^s})$:
  - ↑ with the differences between collected taxes and provided benefits $(T - B)$;
  - ↓ with inequality $(Ineq)$;
  - ↑ with labour supply (l^s).
- **Optimal direction**: a reform's outcome that **improves** one or more input of the government's utility function **without exacerbating** the others.

Three strands of research

- **Taxation as a redistributive tool**: Piketty et al. (2011), Saez and Diamond (2012), Stephenson (2018), Saez and Zucman (2020), Dianov et al. (2022).
- **ΔLabour supply in response to tax reforms using structural models**: Decoster et al. (2010), Müllbacher and Nagl (2017), Bosch et al. (2017), Creedy et al. (2018), de Mahieu (2021).
- **RURO models**: Aaberge et al. (1995), Aaberge et al. (1999), Dagsvik and Strøm (1995), Dagsvik and Strøm (2006), Capéau et al. (2016), Aaberge and Colombino (2018), Capéau et al. (2018), de Mahieu (2021).

Contribution

- **Bridging the gap** between the literature on the effects of taxation on redistribution and inequality and the one on the impact of taxation on labour supply.
- Use of a novel tool (**Beamm**) for policy analysis and simulation.
    - Unique model with complete information on Belgian population, which replicates the fiscal system to a very detailed extent.
    - Existing research only based on Euromod.

Data set

- Novel **synthetic database** fully representative of the Belgian population → no existing representative Belgian data cover this information.
- **Sources**: Administrative data from Personal Income tax declarations, Survey on Income and Living Conditions (EU-SILC), Household Finance and Consumption Survey (HFCS), Household Budget Survey (HBS), Labour Force Survey (LFS), Beldam, Monitor, and Time Use Survey (HETUS).
- **Methods**: Statistical Matching + Generative Adversarial Networks (GAN).

Steps

1. Run of **Beamm** to obtain tax revenues, inequality indicators, and individuals disposable income at the current state of the art.
2. **RURO**'s estimation and calculation of the **labour supply**.
3. **Reforms**' simulation.

The Belgian arithmetic microsimulation model

- **Static microsimulation model** of the tax-benefit system in Belgium.
- The rules of the tax-benefit system are translated into `R` code such that each tax and benefit[2] is calculated **for every individual and household (micro-data)**.
- **Outputs**: household disposable income, state budget, tax burden, tax wedge, and inequality, poverty and redistribution indexes.
- **Current rules** of the fiscal system $\rightarrow$ state of the art; Δ**parameters** $\rightarrow$ reform.

[2] Child benefits, income support, investment income tax, maternity leave, real property tax, personal income tax, vat and excise duties, and wealth tax.

Random Utility Random Opportunity Models

- **Structural** labor supply models.
- **Agents** face a choice among a set of **options**:
  - Agents = workers → *utility*;
  - Options = bundles of hours to work and the respective wage at which they are remunerated (*i.e.*, the labour supply) → *opportunities*.
- A random component is imposed on each side (utility and opportunities) of the **behavioural causal process** that leads to the agent's choice.
- Individuals' labour supply is calculated using the **estimated parameters** of the model.

Reforms' evaluation

- What are the **effects** on:
  - State budget;
  - Income distribution;
  - Labour supply.
- **Aim**: deriving the optimal direction of taxation based on these effects.

Next steps

- **Results** are yet to come.
- Currently working on:
  - **RURO's code** (integration with Beamm + adjustments);
  - Fine-tuning **Beamm's dataset**.

Thanks for your attention!

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6 Appendix

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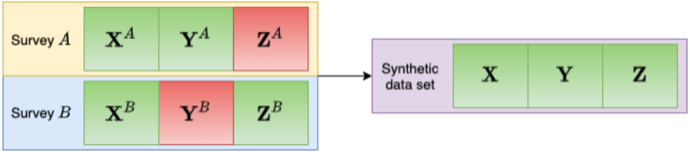
Data generation

RURO parameters' estimation

Statistical Matching BACK

- **Administrative data** are complemented with the information from the other data sources.
- Information is connected in a way that the final data set is accurate at the level of the entire distribution, *i.e.*, at the **level of the entire population**.

Figure A.1: Schematic representation statistical matching



Source. D'Orazio et al. (2002). *Notes.* Neural networks are trained on the available information (Y^A and Z^B) to the common variables X to fill in the gaps (marked in red).

Generative Adversarial Networks BACK

- Despite statistical matching, observations can still contain chunks of **real information**.
- For confidentiality reasons, generation of a purely fictitious data set that has the **same joint distributions**[3] as the original synthetic one.
- Generative AI algorithms based on neural networks competition.

[3] These are obtained by minimizing the Wasserstein distance, which is one of the most commonly used distances for calculating the distance between two distributions.

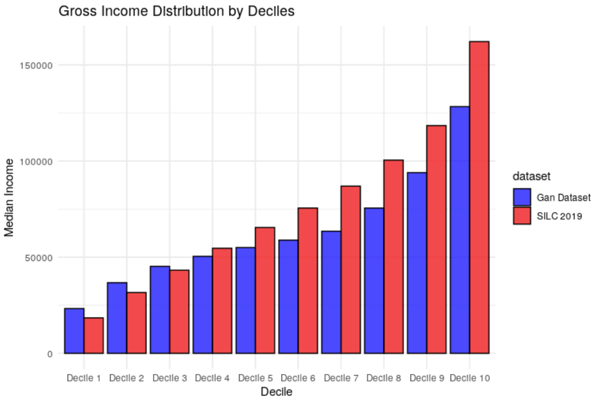
Example (1)

Employment status	*GAN dataset*	*SILC dataset*
Employed FT	35.6%	30.3%
Employed PT	10.6%	11.1%
Self-employed FT	4.6%	4.9%
Self-employed PT	0.2%	0.5%
Unemployed	3.0%	3.6%
Student	6.9%	8.7%
Retired	28.9%	27.1%
Disable	3.7%	4.4%
Housewife/man	5.5%	4.5%
Other Inactive	1.0%	2.4%
NA	0.1%	2.5%

Table A.1: *Source.* GAN and SILC data, own calculations.

Example (2) BACK

Figure A.2: Median gross income, by income decile



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Model's building blocks: Utility (1)

$$U_{ij}(d_j, l_j, \epsilon_{ij}) = V_i(d_j, l_j) + \epsilon_{ij} \quad (1)$$

Where:

- i refers to the agent, and j to the job.
- $V_i(d_j, l_j)$ is the **deterministic part** $\sim$ Box-Cox $\rightarrow$ $V(d, l) = \alpha_d(\frac{d^{\alpha_1}-1}{\alpha_1}) + \alpha_l(\frac{l^{\alpha_2}-1}{\alpha_2})$:
  - d_j is the disposable income (**comes from Beamm**);
  - l_j are the weekly hours of leisure;
  - $\alpha_l = \alpha_{l0} + \alpha_l' X$, where X is the vector of covariates;
- ϵ_{ij} is **the random part** $\sim$ Gumbel(0, 1) $\rightarrow f(\epsilon) = e^{-\epsilon}e^{-e^{-\epsilon}}$.

Model's building blocks: Utility (2)

The agent i **prefers** job j over job k if $U_{ij}(d_j, l_j, \epsilon_{ij}) > U_{ik}(d_k, l_k, \epsilon_{ik}), \forall j \neq k$.

$$\begin{aligned} P_{ij} = Prob(V_{ij} + \epsilon_{ij} > V_{ik} + \epsilon_{ik}) \\ &= Prob(V_{ik} + \epsilon_{ik} < V_{ij} + \epsilon_{ij}) \\ &= \int_{\epsilon} I(\epsilon_{ik} - \epsilon_{ij} < V_{ij} - V_{ik}) f(\epsilon_i)\, d\epsilon_i \\ &= \frac{e^{V_{ij}}}{\sum_k e^{V_{ik}}} \end{aligned} \tag{2}$$

Where $I(\cdot)$ is the **indicator function**: 1 if $(\cdot)$ is true, 0 otherwise.[4]

[4] This is a multidimensional integral over the density of the unobserved portion of utility $f(\epsilon_i)$ (see Train (2002) for the full proof).

Model's building blocks: Opportunities (1)

We assume that **hourly wages** are:

- **independent** of hours worked;
- $\sim$ log-normal distributed as $g_1(w)$.

$$g_1(w) = \frac{1}{w\sigma\sqrt{2\pi}} exp\left(-\frac{1}{2}\left(\frac{ln(w) - \gamma' Y}{\sigma}\right)^2\right) \tag{3}$$

Where σ and the vector γ are the parameters of the distribution, and Y is a vector of covariates.

Model's building blocks: Opportunities (2)

Average weekly working hours of job opportunities ∼ uniform-with-peaks distribution (peaks in correspondence to part-/full-time regimes).

$$g_2(h) = \begin{cases} exp(\alpha^g_{h0}) & : h \in H \backslash \{[18.5, 20.5], [29.5, 30.5], [37.5, 40.5]\} \\ exp(\alpha^g_{h0} + \alpha_{h1}) & : h \in [29.5, 30.5] \\ exp(\alpha^g_{h0} + \alpha_{h2}) & : h \in [18.5, 20.5] \\ exp(\alpha^g_{h0} + \alpha_{h3}) & : h \in [37.5, 40.5] \end{cases} \quad (4)$$

$$g_0 = exp(\alpha_o + \alpha'_o Z), \textit{ for ``out of market'' job opportunities} \quad (5)$$

Where H are the possible values (0 to 70), and Z is a set of covariates.

Estimation of the model (1)

Given $\Psi_i(h,w) = exp(V_i(d_i(T-h,w), T-h)) = exp(V_i(d_i(l,w), l))$, and D_i a set of offers, the **estimated likelihood** that agent i chooses a job offer j is:

$$P_i(w,h|D_i) = \frac{\Psi_i(h,w) g_{0j} g_{1j}(w) g_{2j}(h) / \mathbb{S}(w,h)}{\sum_{r,t \in D_i} \Psi_i(r,t) g_{0j} g_{1j}(r) g_{2j}(t) / \mathbb{S}(r,t)} \quad (6)$$

For "out-of-market" job opportunities:

$$P_i(0,0|D_i) = \frac{\Psi_i(0,0)/\mathbb{S}(0,0)}{\Psi_i(0,0)/\mathbb{S}(0,0) + \sum_{r,t \in D_i} \Psi_i(r,t) g_{0j} g_{1j}(r) g_{2j}(t) / \mathbb{S}(r,t)} \quad (7)$$

Where $\mathbb{S}$ is a **prior density function** conditional on the observed choice being included.[5]

[5] We use uniform distributions for the hours (from 0 to 70) and hourly wages (from 0 to 60). The prior probability to draw an out-of-market offer is set at 0.10.

Estimation of the model (2)

$$L = \prod_{i=1}^{N} P_i(w, h|D_i) \tag{8}$$

- L: likelihood that individuals receive the drawn opportunities.
- **Parameters that maximize the log-likelihood** by using the Broyden-Fletcher-Goldfarb-Shanno (BFGS) optimization algorithm.
- **Estimated parameters**: vectors α_l (Equation 1), γ (Equation 3), α_h (Equation 4), and α_o (Equation 5).

BACK