Bimic+: microsimulation with labor supply

Antonio Coran, Nicola Curci, Andrea Mattia, Antonella Tomasi

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Outline

Microsimulation at the Bank of Italy

- Objective: build tools for ex-ante policy analysis
- Available tool: BIMic (Curci, Savegnago, and Cioffi (2017))
  - Calculator that allows to estimate conditional expectations for outcomes of interest (for instance: average change in taxes paid conditional on being in the third decile of the income distribution)
- Preliminary work (work in progress): Bimic+, labor supply model integrated with BIMic
  - Include labor supply responses into ex-ante policy analysis
- Future: labor demand and partial equilibrium analysis

Why a labor supply model

1. Government budget: allows to estimate behavioral cost of reforms and therefore total government costs = mechanical costs + behavioral costs. For a given policy change
   - Mechanical costs: change in government net spending due to the policy change keeping taxpayers' behavior fixed

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   - For big reforms, WTP for policy change through EV: additional income the taxpayers require (starting from before the reform) to reach the same utility level that they reach due to the reform

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   - For big reforms, WTP for policy change through EV: additional income the taxpayers require (starting from before the reform) to reach the same utility level that they reach due to the reform
   - For small reforms, WTP approximated by mechanical change in individual budget constraint, so can rely on BIMic only (Envelope Theorem logic). See Bourguignon and Landais (2022) for this point for microsimulation models

ET

Which labor supply model

- Static labor supply model: consumption-leisure trade-off
- Labor supply as discrete choice from a set of work hours, each with utility from disposable income level. RU approach from McFadden (1974) and in microsim literature first Aaberge, Dagsvik, and Strøm (1995), Van Soest (1995)
- BIMic defines precisely the budget set for each individual and expresses policy changes as precise individual changes in such budget set (i.e. in disposable income for each possible hours choice)

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- BIMic defines precisely the budget set for each individual and expresses policy changes as precise individual changes in such budget set (i.e. in disposable income for each possible hours choice)
- We see this as first step
  - Standard incidence theory and empirical labor/PF literature suggest workers do not bear all the incidence of policy changes: need finite elasticity labor demand
  - Potential subsequent steps: labor demand, involuntary unemployment

Outline

Bimic+

- Sample restrictions: families of employees 18-64 years old.
- Heckman two-step selection model (allows to estimate wage also for those who don't work)
- Alternative hours: taxpayers can choose from possible intervals for hours worked. For each possible choice, use wage to compute gross labor income and use BIMic to compute disposable income

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- Alternative hours: taxpayers can choose from possible intervals for hours worked. For each possible choice, use wage to compute gross labor income and use BIMic to compute disposable income
- Estimation and utility function
- Implied labor supply elasticities

Model and max likelihood estimation

- Each hours option k corresponds to a disposable income level that generates utility for individual i

$$\bar{U}(y_{i,k}, h_{i,k}) = U(y_{i,k}, h_{i,k}; X_i)) + \varepsilon_{i,k}$$

- Assume logistic distribution of $\varepsilon_{i,k}$: multinomial logit

- Budget constraint: $y_{i,k} = T(w_i h_{i,k}, I_i; X_i)$ where $T(.)$ models tax/transfers through BIMic

- Max likelihood to estimate coefficients that match observed chosen worked hours

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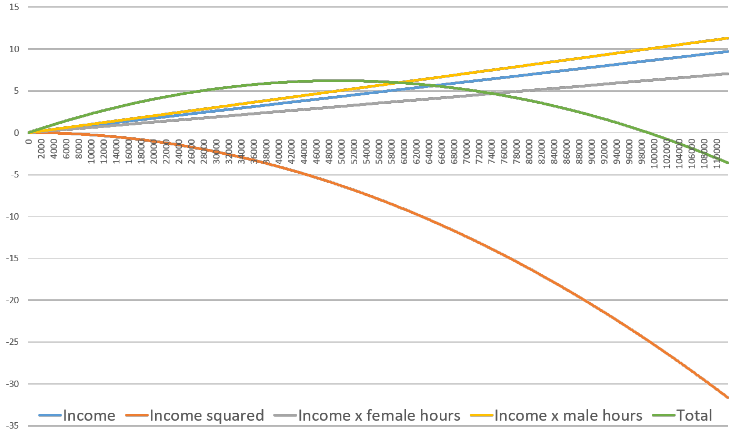
- Max likelihood to estimate coefficients that match observed chosen worked hours
- Functional form utility function:
  - Most common in the literature: quadratic. But not increasing in disposable income | hours worked for all disposable income levels
  - Temporary alternative: square root of disposable income, quadratic in hours
  - Future: explore less parametric specifications. Robustness checks.

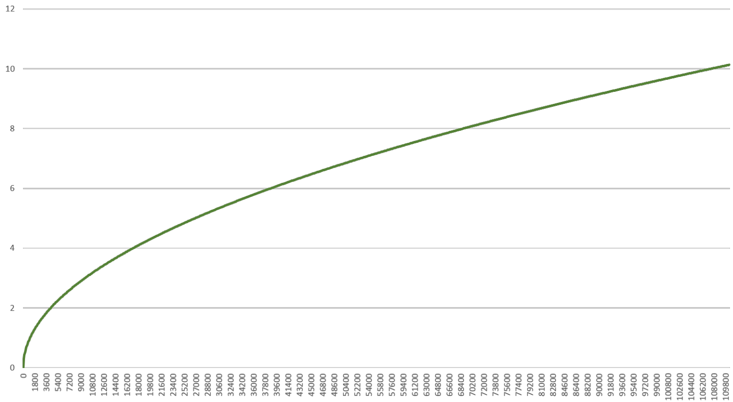
Choice of utility function

$$U(y_i, h_{i,f}, h_{i,m}) = \beta_0 y_i + \beta_1 y_i^2 + \beta_2 h_{i,f} + \beta_3 h_{i,f}^2 + \beta_4 h_{i,m} + \beta_5 h_{i,m}^2 + \beta_6 h_{i,f} y_i + \beta_7 h_{i,m} y_i + X_i \gamma$$



Choice of utility function

$$U(y_i, h_{i,f}, h_{i,m}) = \beta_0\sqrt{y}_i + \beta_1 h_{i,f} + \beta_2 h_{i,f}^2 + \beta_3 h_{i,m} + \beta_4 h_{i,m}^2 + X_i\gamma$$



⏩ Estimation table ⏩

Implied labor supply elasticities

		Women			Men		
		All	Children	No Children	All	Children	No Children
Couples	Total hours	0.23	0.25	0.19	0.06	0.06	0.06
	Intensive margin	0.05	0.05	0.04	0.02	0.02	0.02
	Extensive margin	0.18	0.19	0.15	0.04	0.04	0.04
Singles	Total hours	0.11	0.10	0.11	0.19	0.15	0.19
	Intensive margin	0.03	0.03	0.03	0.06	0.03	0.06
	Extensive margin	0.07	0.06	0.08	0.13	0.12	0.13

- Hours % change from 1% increase in gross hourly wage Details calculation
- Economic literature:
  - Mode for Marshallian elasticity: around 0.2
  - Recent work Kleven, Kreiner, Larsen, and Søgaard (2024) says it could be larger if account for dynamic responses such as promotions/jobs switches: 0.5

More

Outline

The reform in a nutshell

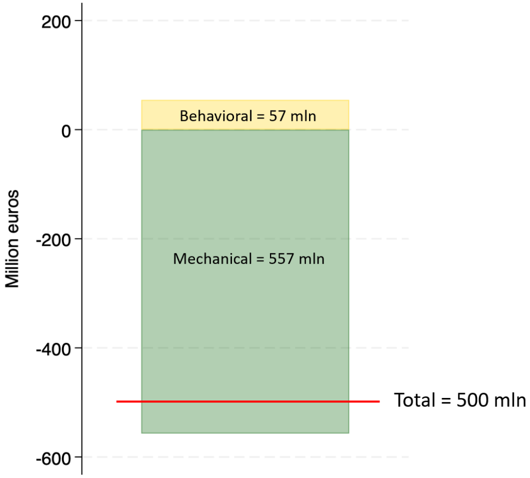
- Cut in social security contributions for mothers with at least two children. Exemption for full portion paid by workers
- We simulate the introduction of this policy change starting from the tax/transfer system present in 2022 (survey year)
- Recipients:
  - 96% of recipients are in couples
  - Earn a little less than all working women, on average (21,260 vs 22,458 euro)
  - Belong to families with mid-high income in the Italian family income distribution

Labor supply responses and government costs

Table: *Average hours response to the reform for different demographic groups (recipients only)*

		Women			Men		
		All	Children	No Children	All	Children	No Children
Couples	Total hours	2.50%	2.50%	-	−0.05%	−0.05%	-
	Intensive margin	0.37%	0.37%	-	−0.02%	−0.02%	-
	Extensive margin	2.14%	2.14%	-	−0.03%	−0.03%	-
Singles	Total hours	1.44%	1.44%	-	-	-	-
	Intensive margin	0.05%	0.05%	-	-	-	-
	Extensive margin	1.40%	1.40%	-	-	-	-

Labor supply responses and government costs



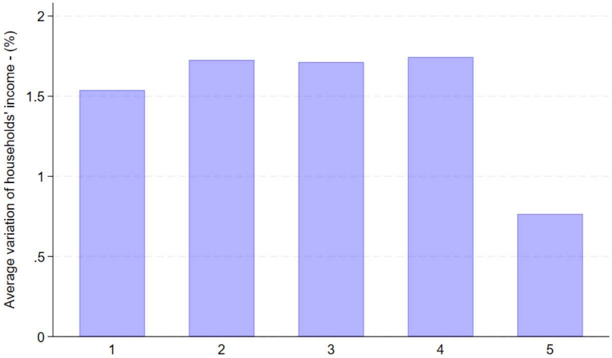
Redistributive analysis

- If reform big: estimate WTP through EV (*work in progress*)

Redistributive analysis

- If reform big: estimate WTP through EV (*work in progress*)
- For now assume reform small enough: WTP $\approx$ mechanical change in agents' budget constraint ⏩ Euros ⏩ Over mothers' income ⏩ Not only recipients

Figure: Mechanical change budget constraint of recipients/household disposable income



Indicator for efficient public policy?

- We can potentially summarize the policy through an indicator such as:

$$\text{Ex-Ante MVPF}_{cut} = \frac{\text{WTP}}{\text{Net gov cost}} = \frac{557\text{ mln}}{557\text{ mln} - 57\text{ mln}} \approx 1.11$$

- Value for each euro spent by the government. Select most efficient policy for same beneficiaries. Need SWF (and MU) if policies don't have same beneficiaries (but quantify redistributive trade-offs)
- Mostly used to map ex-post causal estimates into welfare analysis: Hendren and Sprung-Keyser (2020). It can be useful also in this model-based ex-ante analysis:
  - to compare different policies we can simulate
  - to compare our estimates to existing estimates from ex-post causal studies

Concluding remarks

- BIMic transparent and assumption free method to do redistributive analysis with small reforms
- BIMic+: labor supply model for impact on government budget + redistributive analysis with big reforms
- Next: labor demand, involuntary unemployment

Envelope Theorem

- ET:
  - Assumptions: no behavioral bias (the welfare-relevant utility is being maximized) + the reform is small enough
  - A small policy variation does not cause a first order utility change for optimizing agents around the former optimum
  - Advantages (in our setting):
    - Can just use BIMic: more transparent and assumption free
  - It does not apply to the effects on the government budget, as the agent is not internalizing it!
- PF in the last 15 years has relied a lot on this theorem to make welfare statements about policies using parameters estimated via design-based methods at the core of the so-called "credibility revolution" (Angrist and Pischke (2010)): Chetty (2009), Hendren and Sprung-Keyser (2020), Kleven (2021)

Back

Selected sample

Table: *Selected sample*

	sample		population	
	households	individuals	households	individuals
total, of which at least one partner :	9,641	23,057	25,388,702	58,646,264
not of working age	4,892	9,506	9,992,653	17,910,667
pensioner	5,148	10,180	11,374,824	21,303,120
self-employed	2,048	5,741	3,304,554	9008099
agricultural worker	241	735	909,456	2,588,295
over 64 employee	229	510	425,496	791,697
final selection	2,671	7,580	10,597,037	27,835,384

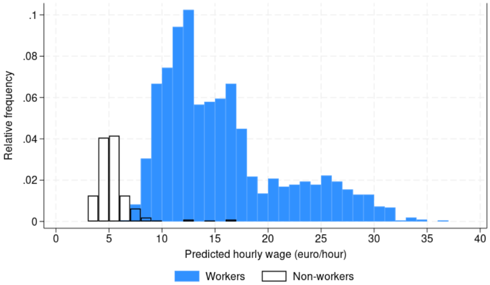
⏩ Back

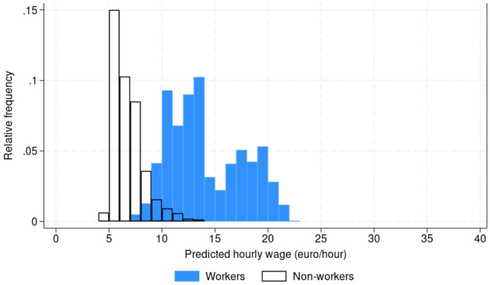
Heckman selection

- Wages observed in the sample are not good estimates of salaries of people who are not employed: there is selection into work
- Approach: Heckman two-step selection model
- Tax-benefit system from static BIMic key component of selection equation
- Average predicted hourly wage: 14,70€ for workers, 6,64€ for non-workers
  ⏩ Predicted hourly wage distributions by gender
- In the future: could add Maximum Simulated Likelihood step (Elder et al. (2025))

⏩ Back

Distribution of predicted hourly wage by gender





Average predicted hourly wage for men: 15,50€ for workers, 5,41€ for non-workers.
Average predicted hourly wage for women: 13,65€ for workers, 6,89€ for non-workers.

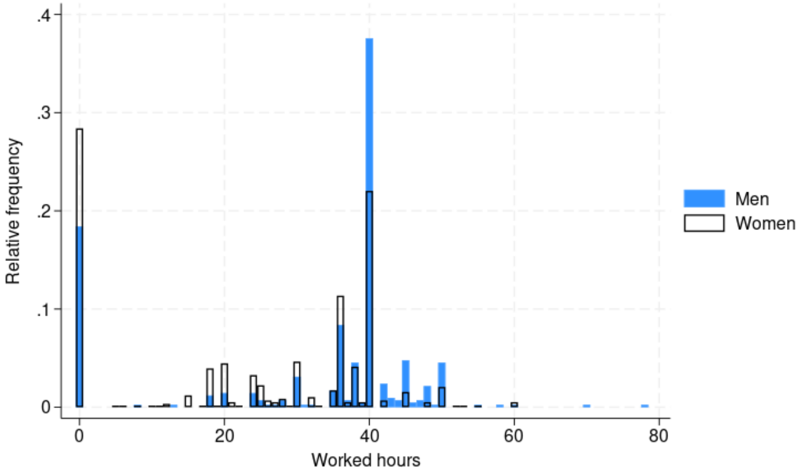
Back

Alternative hours

- What alternatives did people have to the hours they actually chose?
- Divide observed worked hours distribution into intervals:
  ⏩ Worked hours distribution — singles ⏩ Worked hours distribution — couples
- Options:
  - Couples, females: 0-9, 10-19, 20-24, 25-29, 30-35, 36-39, >39
  - Couples, males: 0-9, 10-25, 26-33, 34-37, 38-40, 41-48, >48
  - Single, females: 0-9, 10-19, 20-29, 30-36, 37-40, >40
  - Single, males: 0-9, 10-25, 26-33, 34-38, 40-42, >42
- Within each interval, assign hours across individuals to reproduce observed distribution

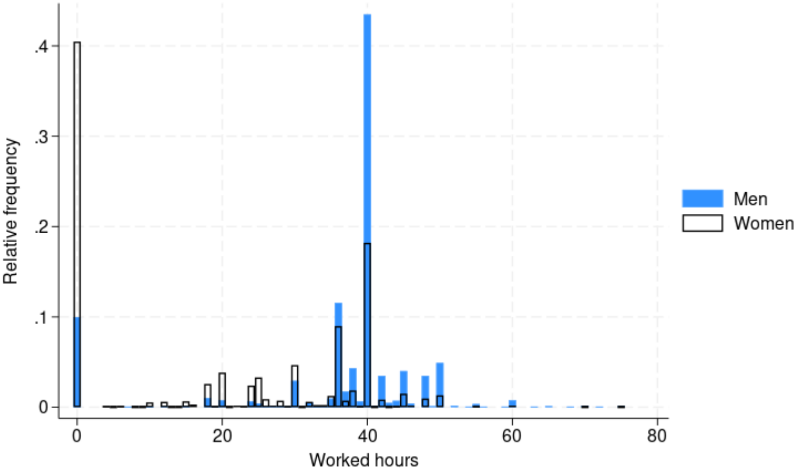
⏩ Back

Distribution of worked hours (singles)



⏩ Back

Distribution of worked hours (couples)



▸▸ Back

Coefficients estimates (couples)

⏩ Back

Variable	Coefficient	Std. Error
Square root of disposable income	0.0305***	(0.0114)
Hours male	0.00237	(0.119)
Hours female	-0.170**	(0.0725)
Hours male squared	-0.00175	(0.00112)
Hours female squared	0.000225	(0.000484)
Male working	-4.028	(2.606)
Male part-time	0.241	(0.588)
Male full-time	1.365***	(0.437)
Male over-time	-0.300	(0.563)
Hours male $\times$ age	0.00785*	(0.00415)
Hours male $\times$ age squared	-0.0000892**	(0.0000437)
Hours male $\times$ n. children	0.00335	(0.00422)
Hours male $\times$ n. children under 6	-0.00960	(0.00993)
Hours male x foreign	0.0181	(0.0233)
Female working	-1.162**	(0.591)
Female part-time	-0.291	(0.325)
Female full-time	0.292	(0.445)
Female over-time	0.459	(0.645)
Hours female $\times$ age	0.00844***	(0.00285)
Hours female $\times$ age squared	-0.000103***	(0.0000318)
Hours female $\times$ n. children	-0.0138***	(0.00343)
Hours female $\times$ n. children under 6	-0.000235	(0.00833)
Hours female x foreign	-0.0299**	(0.0133)

Coefficients estimates (single females)

⏩ Back

Variable	Coefficient	Std. Error
Square root of disposable income	0.0156	(0.0183)
Hours single female	-0.112	(0.0945)
Hours single female squared	5.27e-05	(0.000802)
In work	-0.885	(1.182)
Part time	-0.399	(0.380)
Full time	-0.0473	(0.604)
Over time	-2.175***	(0.797)
Hours x age	0.00607*	(0.00323)
Hours x age squared	-6.38e-05*	(3.53e-05)
Hours x n. children	-0.0176***	(0.00590)
Hours x n. children under 6	-0.000867	(0.0150)
Hours x foreign	-0.0110	(0.0282)

Coefficients estimates (single males)

Back

Variable	Coefficient	Std. Error
Square root of disposable income	0.0491*	(0.0293)
Hours single male	-0.0821	(0.174)
Hours single male squared	-0.00108	(0.00114)
In work	-2.318	(2.985)
Prime time	-0.0678	(0.897)
Full time	0.300	(0.809)
Over time	-0.586	(0.977)
Hours x age	0.00944**	(0.00407)
Hours x age squared	-0.000122***	(4.57e-05)
Hours x n. children	0.00192	(0.0119)
Hours x n. children under 6	0.158	(0.129)
Hours x foreign	0.0155	(0.0221)

Model fit, hours

Back

Females in couples	Mean	Obs
Expected hours model	20.1	1,670
Hours choice data	19.9	1,670
Males in couples	**Mean**	**Obs**
Expected hours model	37.3	1,670
Hours choice data	35.7	1,670
Single females	**Mean**	**Obs**
Expected hours model	26.7	582
Hours choice data	24.3	582
Single males	**Mean**	**Obs**
Expected hours model	32.9	416
Hours choice data	31.9	416

Labor supply predicted by the model

- For each individual we compute the probability distribution over his/her K possible hours choices: $\hat{p}_i = (\hat{p}(h_i = h_1), ..., \hat{p}(h_i = h_K))$
  - How? We simply compute the predicted values from the estimated logit
- Then for each individual we can compute: expected total hours worked, expected probability of working, expected hours worked conditional on working

$$\mathbb{E}[h_i] = \sum_k \hat{p}(h_i = h_k) h_{i,k}$$

$$\mathbb{E}[h_i > 0] = \sum_k \hat{p}(h_i = h_k) 1\{h_{i,k} > 0\}$$

$$\mathbb{E}[h_i | h_i > 0] = \sum_k \frac{\hat{p}(h_i = h_k)}{\sum_j \hat{p}(h_i = h_j) 1\{h_{i,j} > 0\}} h_{i,k} 1\{h_{i,k} > 0\}$$

Back

Labor supply under new scenario: calculation

- To compute elasticities, we increase gross hourly wage by 1%
- Using the coefficients of the estimated model, the new values of disposable income for each hours choices, we can compute the new probabilities of working different hours in the new scenario
- We can then compute again total hours worked, extensive and intensive margin for each individual/couple:

$$\mathbb{E}[\tilde{h}_i]$$

$$\mathbb{E}[\tilde{h}_i > 0]$$

$$\mathbb{E}[\tilde{h}_i | \tilde{h}_i > 0]$$

Back

Elasticity calculation

$$e_{h,w} = e_{tot} = \frac{\mathbb{E}\left[\Delta \mathbb{E}[h_i]\right]}{\mathbb{E}\{\mathbb{E}[h_i]\}} \frac{w}{\Delta w} =$$

$$= \frac{1}{\mathbb{E}\{\mathbb{E}[h_i]\}} \frac{w}{\Delta w} \mathbb{E}\left[\mathbb{E}[\tilde{h}_i > 0]\mathbb{E}[\tilde{h}_i | \tilde{h}_i > 0] - \mathbb{E}[h_i > 0]\mathbb{E}[h_i | h_i > 0]\right] =$$

$$\frac{1}{\mathbb{E}\{\mathbb{E}[h_i]\}} \frac{w}{\Delta w} \mathbb{E}\left[\left(\mathbb{E}[\tilde{h}_i > 0]\mathbb{E}[\tilde{h}_i | \tilde{h}_i > 0] - \mathbb{E}[\tilde{h}_i > 0]\mathbb{E}[h_i | h_i > 0]\right)\right]$$

$$+ \frac{1}{\mathbb{E}\{\mathbb{E}[h_i]\}} \frac{w}{\Delta w} \mathbb{E}\left[\left(\mathbb{E}[\tilde{h}_i > 0]\mathbb{E}[h_i | h_i > 0] - \mathbb{E}[h_i > 0]\mathbb{E}[h_i | h_i > 0]\right)\right] =$$

$$= e_{int} + e_{ext}$$

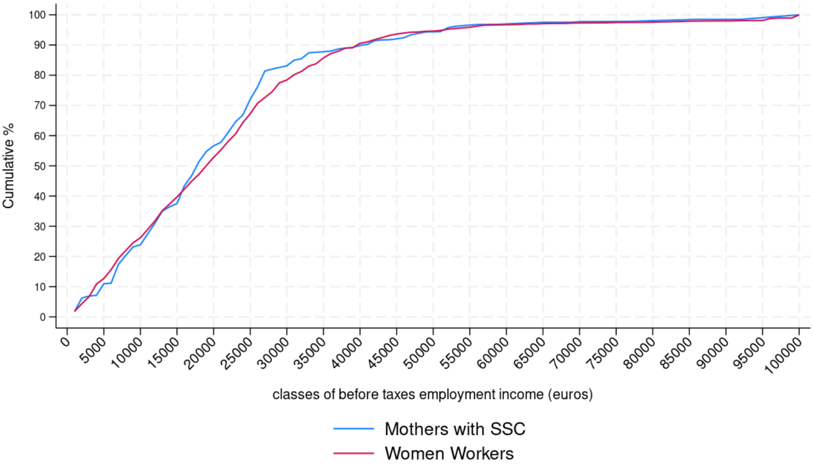
Back

Elasticities: literature

- Literature consensus on micro-elasticity of labor supply: 0.2, higher for women, especially if married (Blundell and MaCurdy (1999) and Keane and Rogerson (2015))
- If leisure is a normal good, Marshallian elasticity lower than Hicksian (among others, review by Chetty (2012))
- Elasticity lower with job market frictions, higher for job-switchers (Labanca and Pozzoli (2022), Kleven, Kreiner, Larsen, and Søgaard (2024))
- Microsimulation papers in Italy find elasticity between 0.1 and 1 for women

Back

Cdf of working women's income



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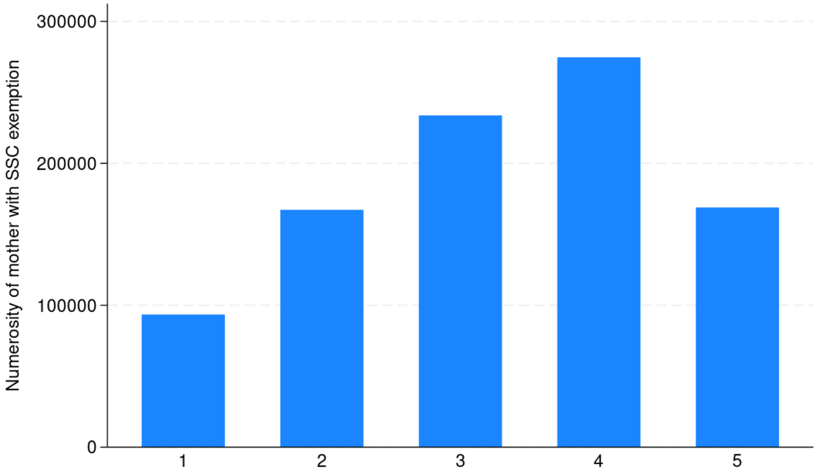
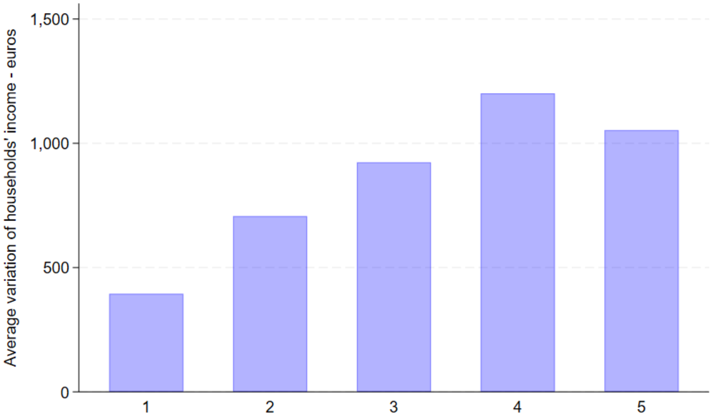
Number beneficiaries for family income quintile



Back

Redistributive analysis

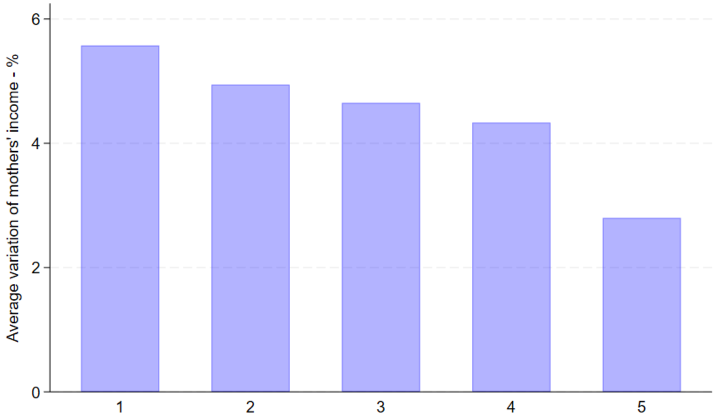
Figure: Mechanical change in budget constraint of recipients



⏩ Back

Redistributive analysis

Figure: Mechanical change budget constraint of recipients/mothers' income



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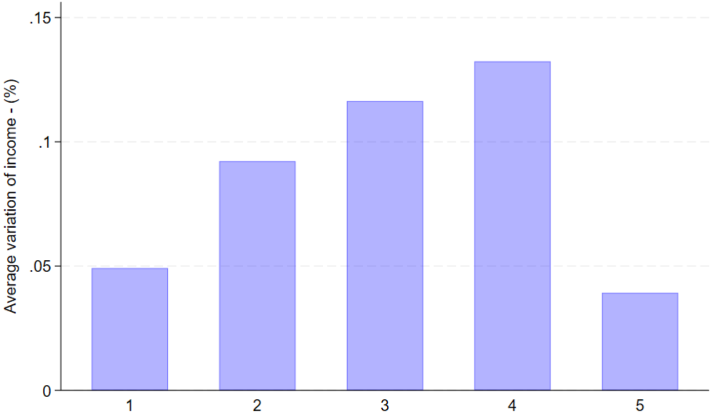
Redistributive analysis

Figure: Mechanical change in agents' budget constraint, all taxpayers



Back

Labor supply responses and government costs

Table: *Average hours response by quintiles of the family income distribution (female recipients)*

	Q1	Q2	Q3	Q4	Q5	Total
Total hours	3.25%	3.04%	2.88%	2.10%	1.92%	2.50%
Intensive margin	0.45%	0.32%	0.37%	0.41%	0.30%	0.37%
Extensive margin	2.80%	2.72%	2.51%	1.68%	1.63%	2.14%

Back

MVPFs

- EITC reforms are tax cuts for mothers (but low-income mothers and more single):
  - 1993 EITC expansion studied in Kuka and Shenhav (2024) for recent mothers: 1.3
  - Other studies on the EITC find larger numbers, up to MVPFs equal to 3 in Bastian (2024)
- Payroll tax cuts find MVPFs between 1 and 1.7, (but in those cases the cuts involve the payroll tax paid by firms) - see Paradisi (2021), Lobel (2021)

Back

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