# Combining Register and Survey Data to Understand Carbon-Intensive Time Use

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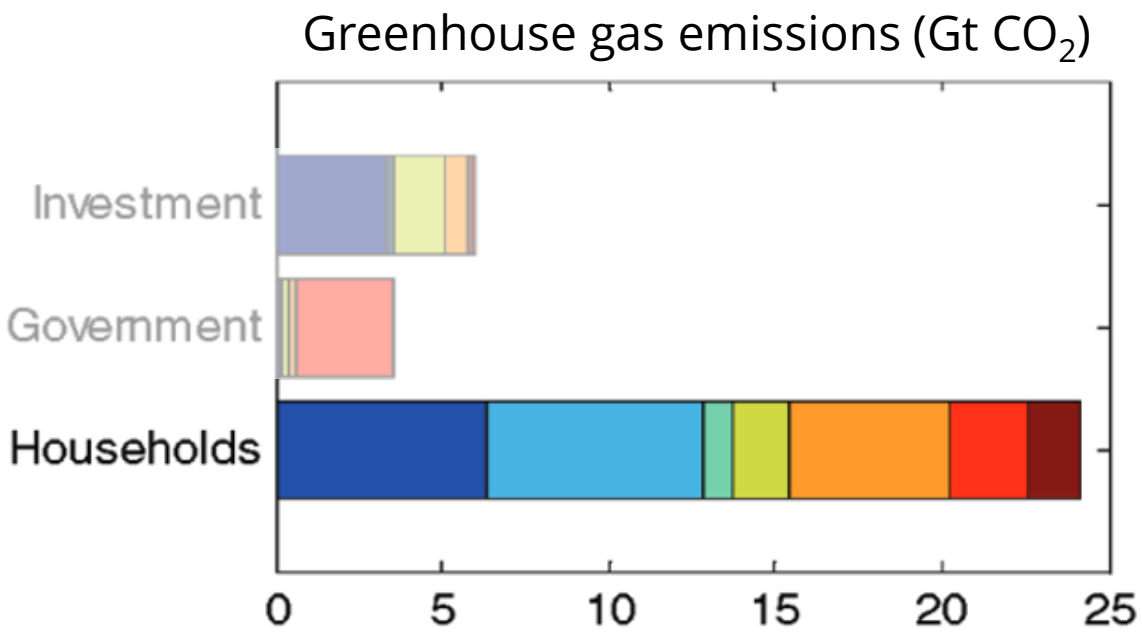
SoDA
ODISSEI Social Data Science Team

SCOOP
SUSTAINABLE COOPERATION

125 jaar
Centraal Bureau
voor de Statistiek

# The Context

# Consumption-Based Emissions





Hertwich, E. G., & Peters, G. P. (2009). Carbon Footprint of Nations: A Global, Trade-Linked Analysis. *Environmental Science & Technology, 43*(16), 6414–6420. https://doi.org/10.1021/es803496a

# Research Questions

- What are the carbon emissions of Dutch households?
- How do household members contribute to their household carbon emissions?

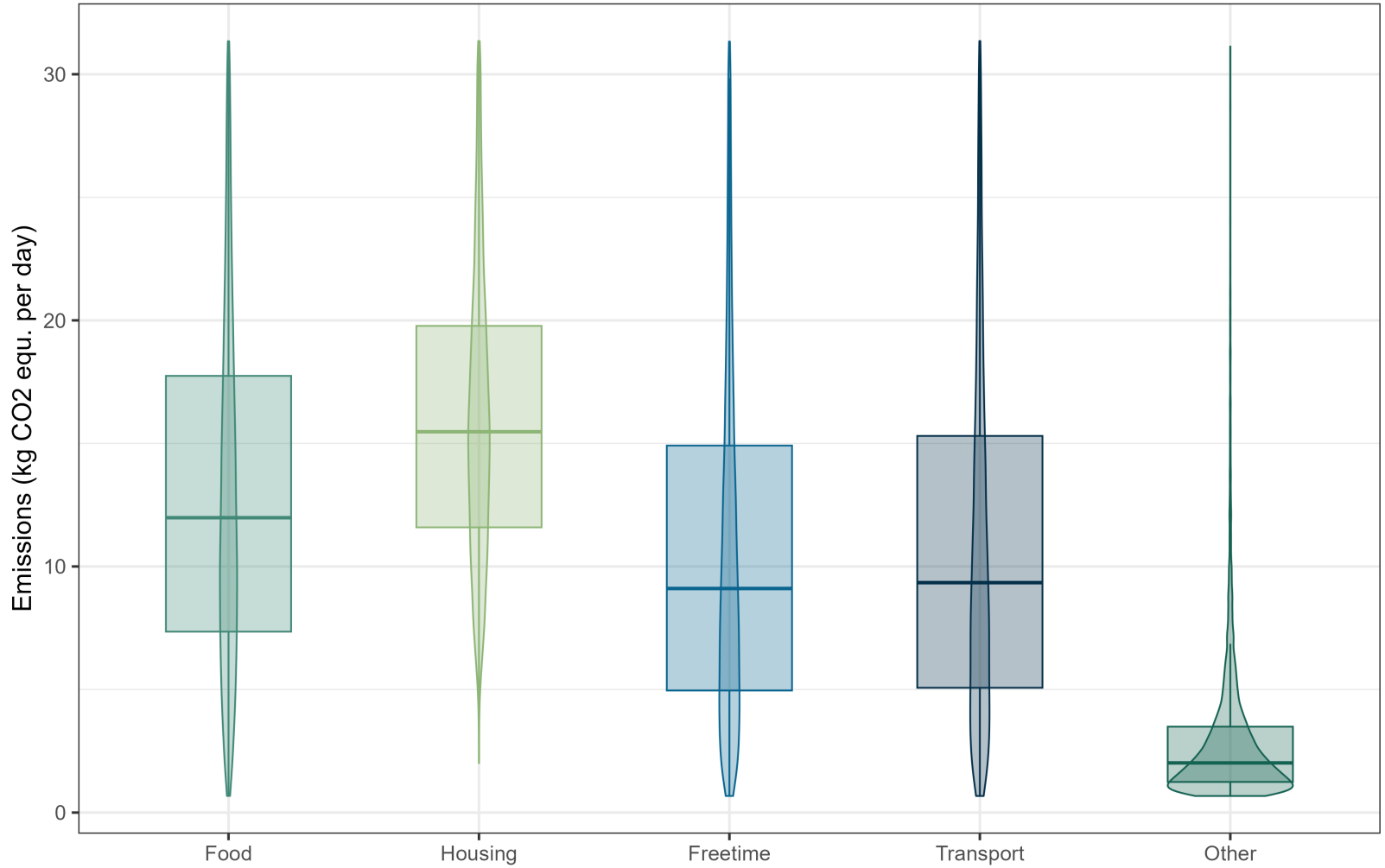
# Household Carbon Emissions

- Household expenditure survey
  - 15.000 households in 2015
  - 1 month expenditures
  - 155 products
- Environmentally-extended input-output analysis

Kok, R., Benders, R. M. J., & Moll, H. C. (2006). Measuring the environmental load of household consumption using some methods based on input–output energy analysis: A comparison of methods and a discussion of results. *Energy Policy*, *34*(17), 2744–2761. https://doi.org/10.1016/j.enpol.2005.04.006

Leontief, W. (1970). Environmental Repercussions and the Economic Structure: An Input-Output Approach. *The Review of Economics and Statistics*, *52*(3), 262–271. https://doi.org/10.2307/1926294

# Household Carbon Emissions

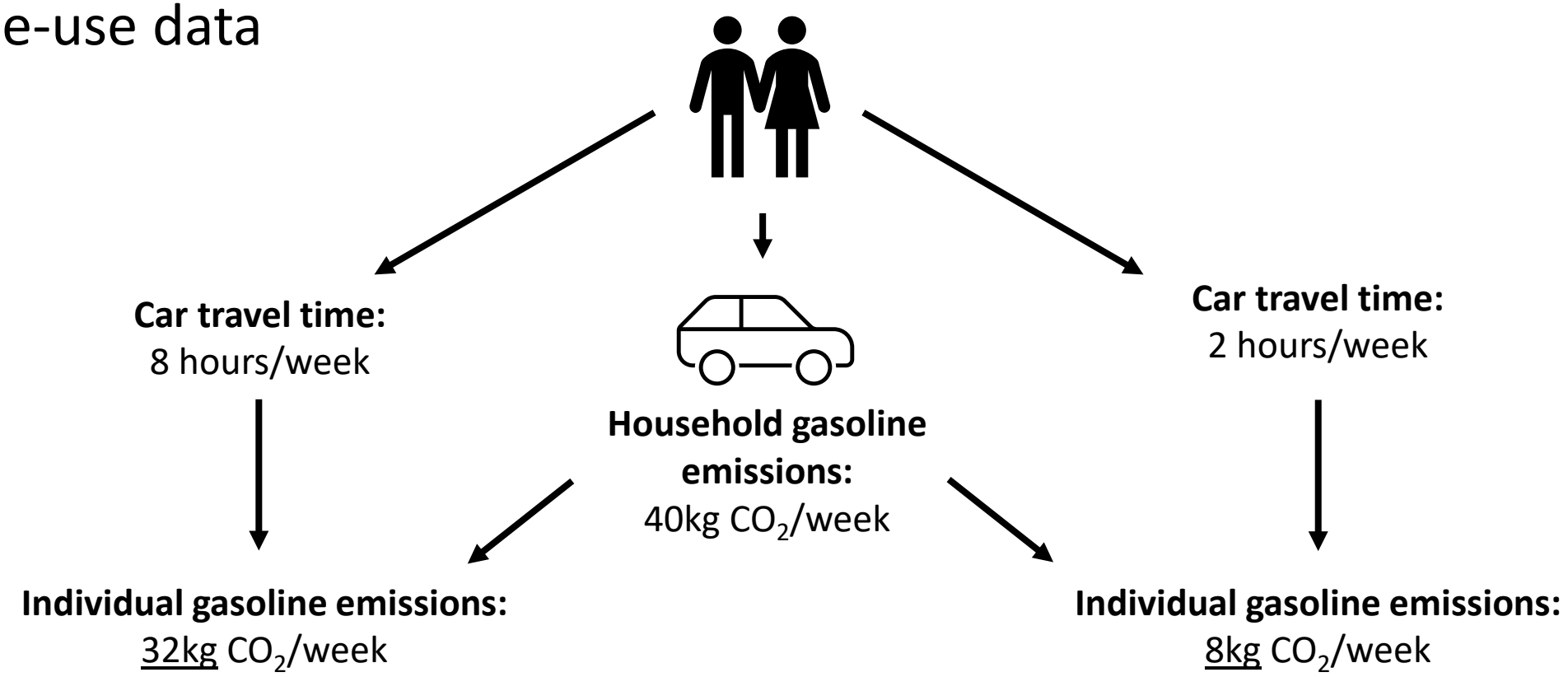


# Research Questions

- What are the carbon emissions of Dutch households?
- How do household members contribute to their household carbon emissions?
  - What are the carbon emissions of individuals living in the Netherlands?

# Individual Carbon Emissions

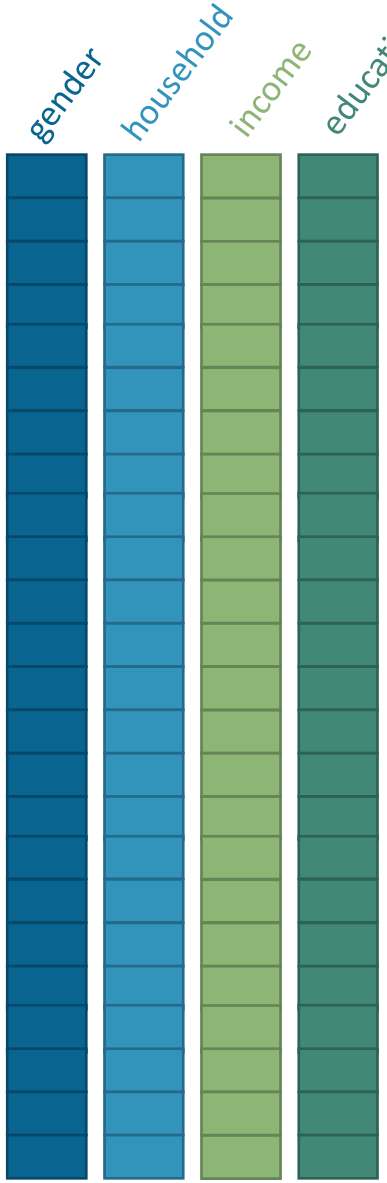
- Attribute household carbon emissions to individuals
- Time-use data

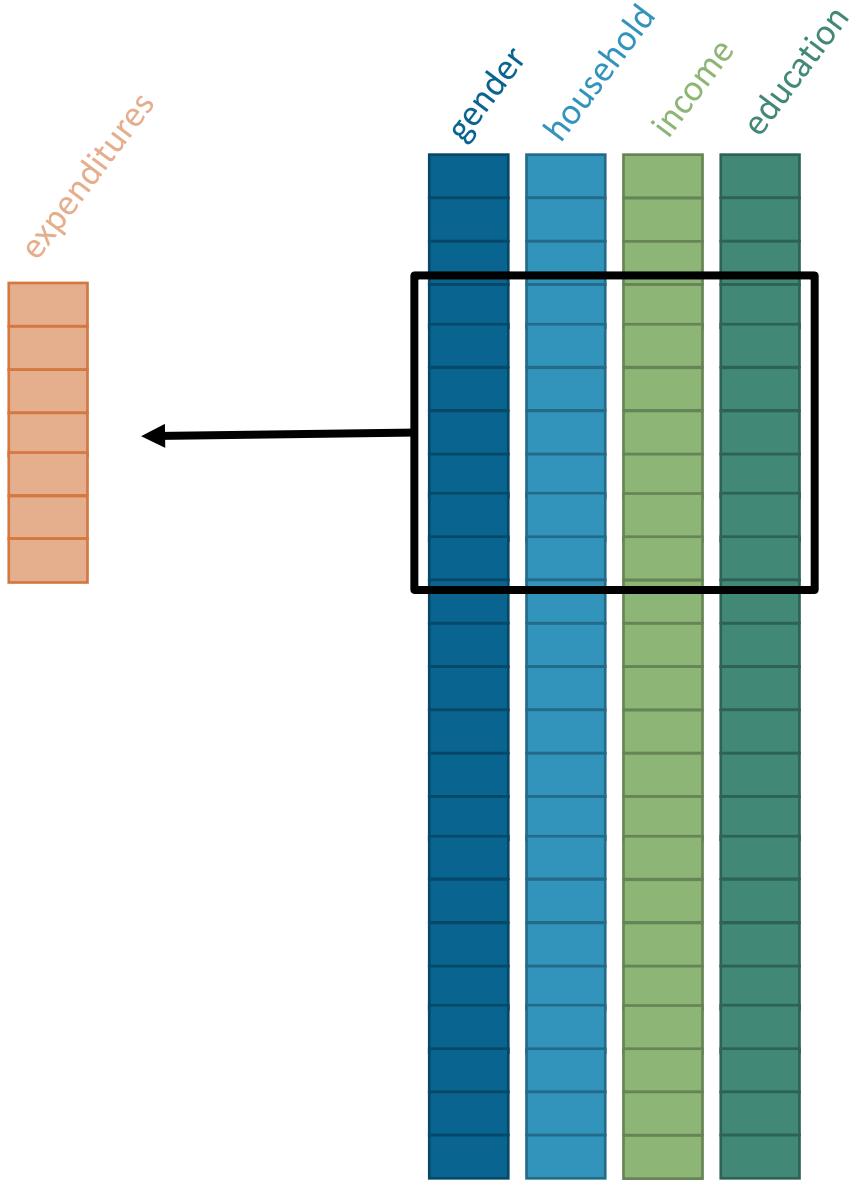


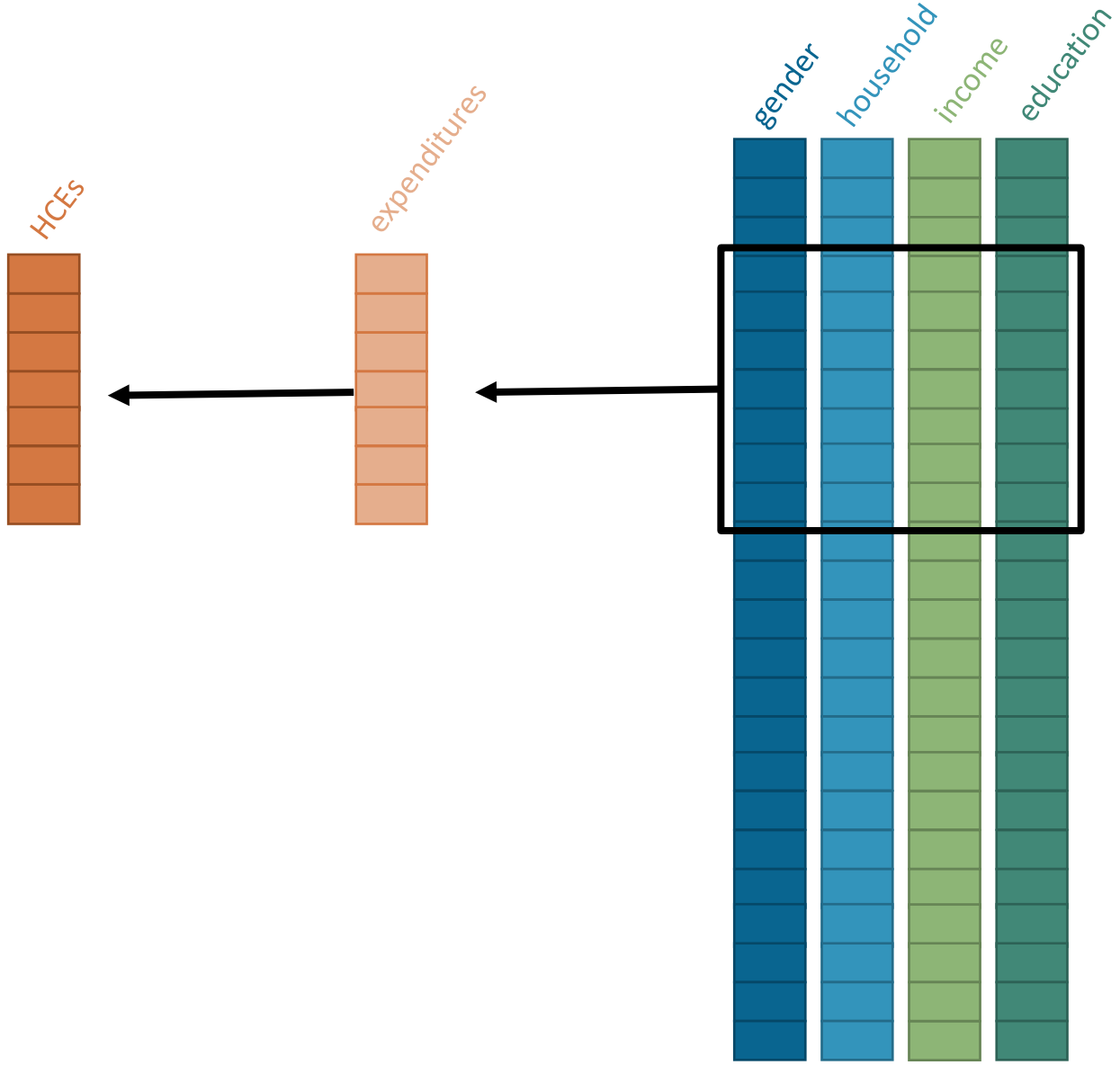
# Individual Carbon Emissions

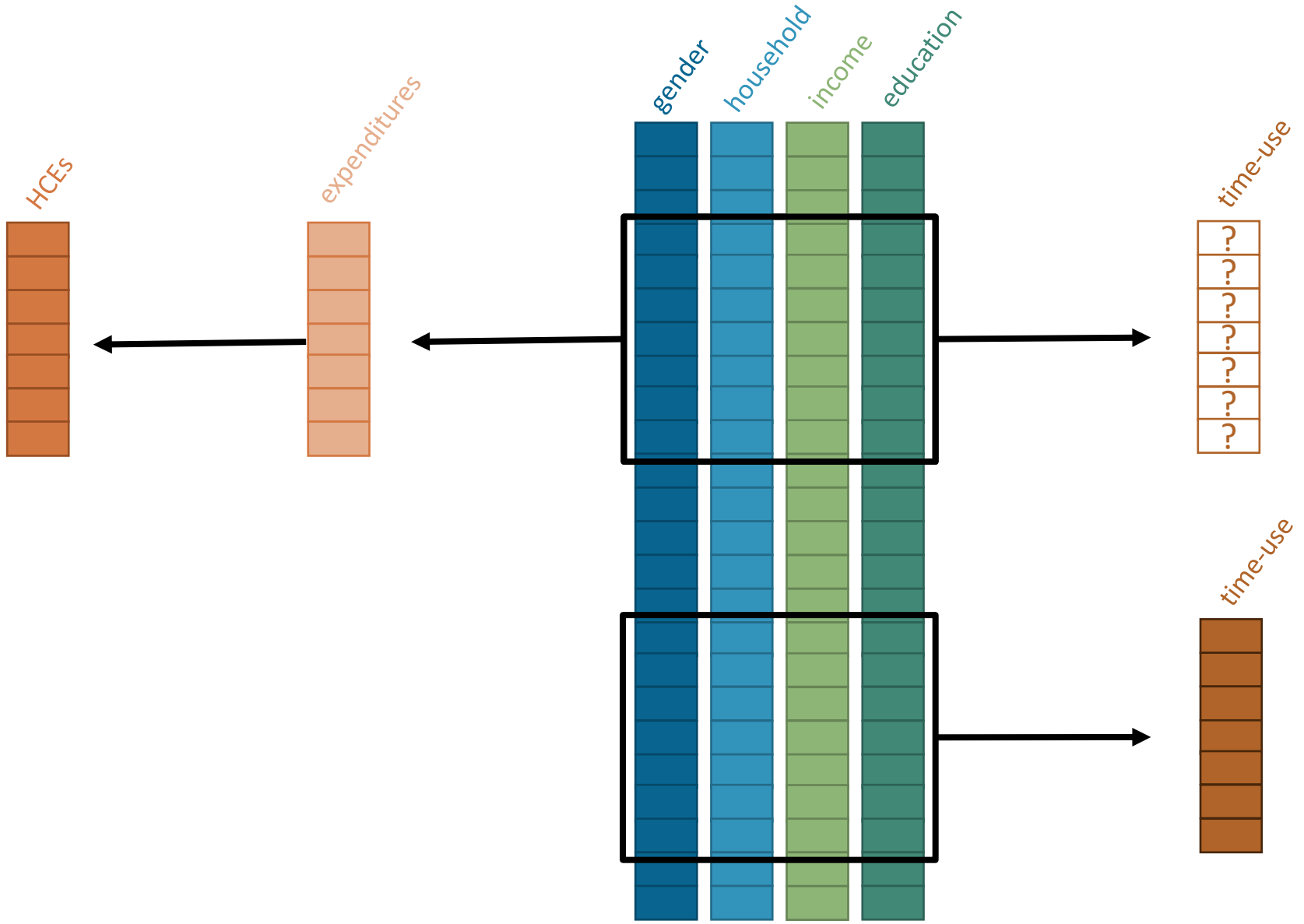
- Attribute household carbon emissions to individuals
- Time-use data
  - ~ 2300 individuals in 2016
  - 1 week of activities
  - 10 minute intervals

# The Problem

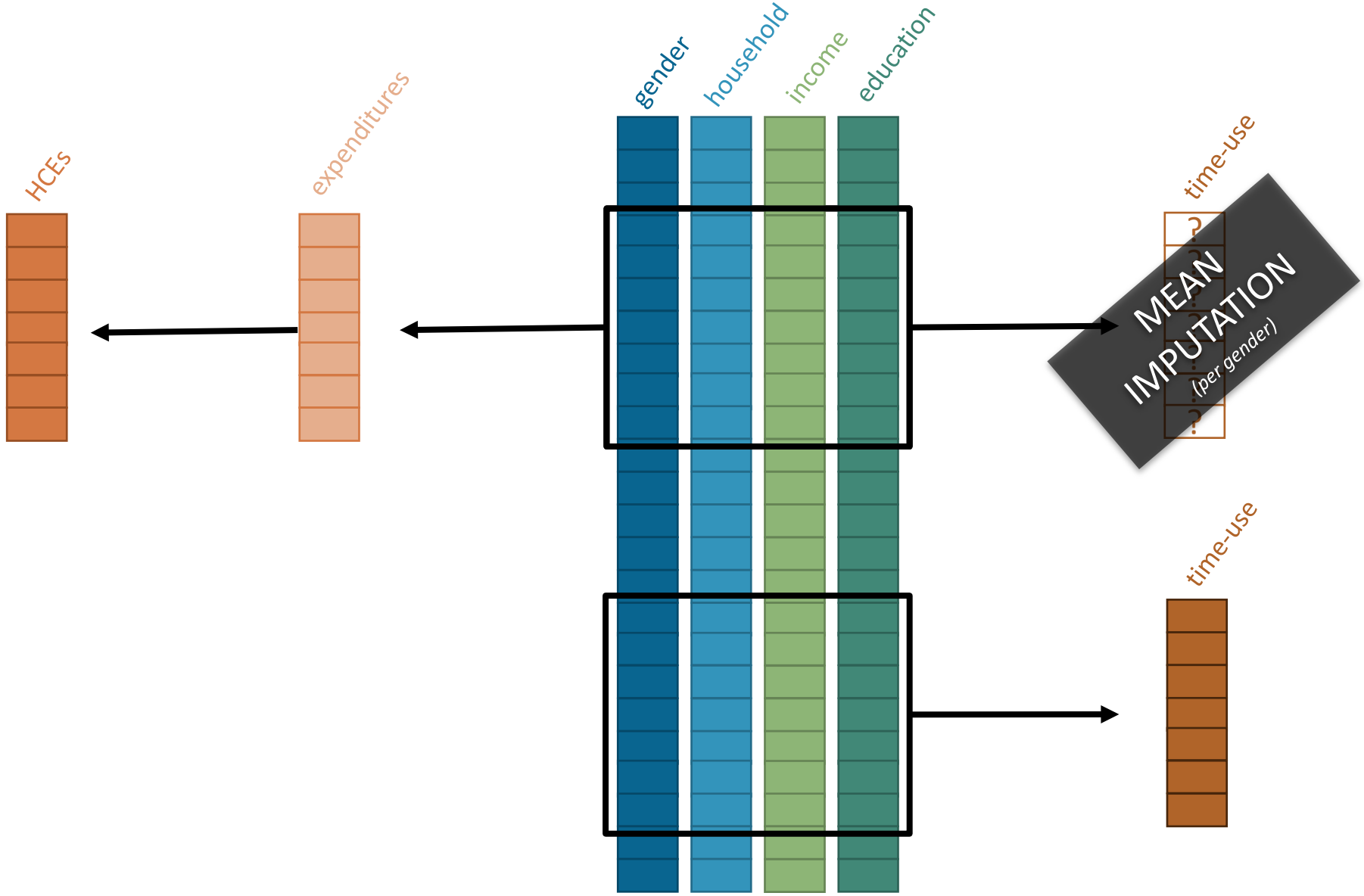

gender
household
income
education

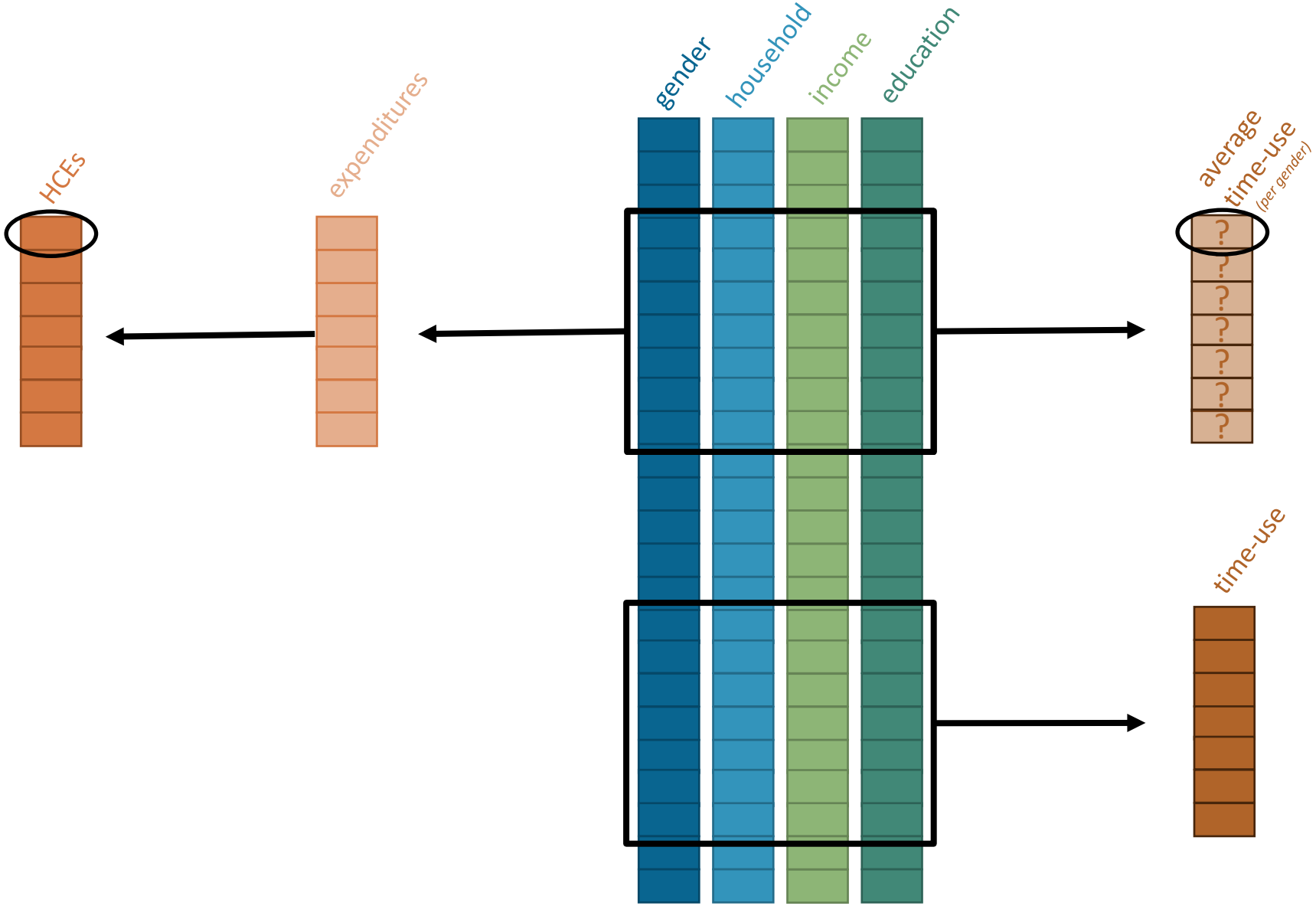

expenditures
gender
household
income
education


HCEs
expenditures
gender
household
income
education

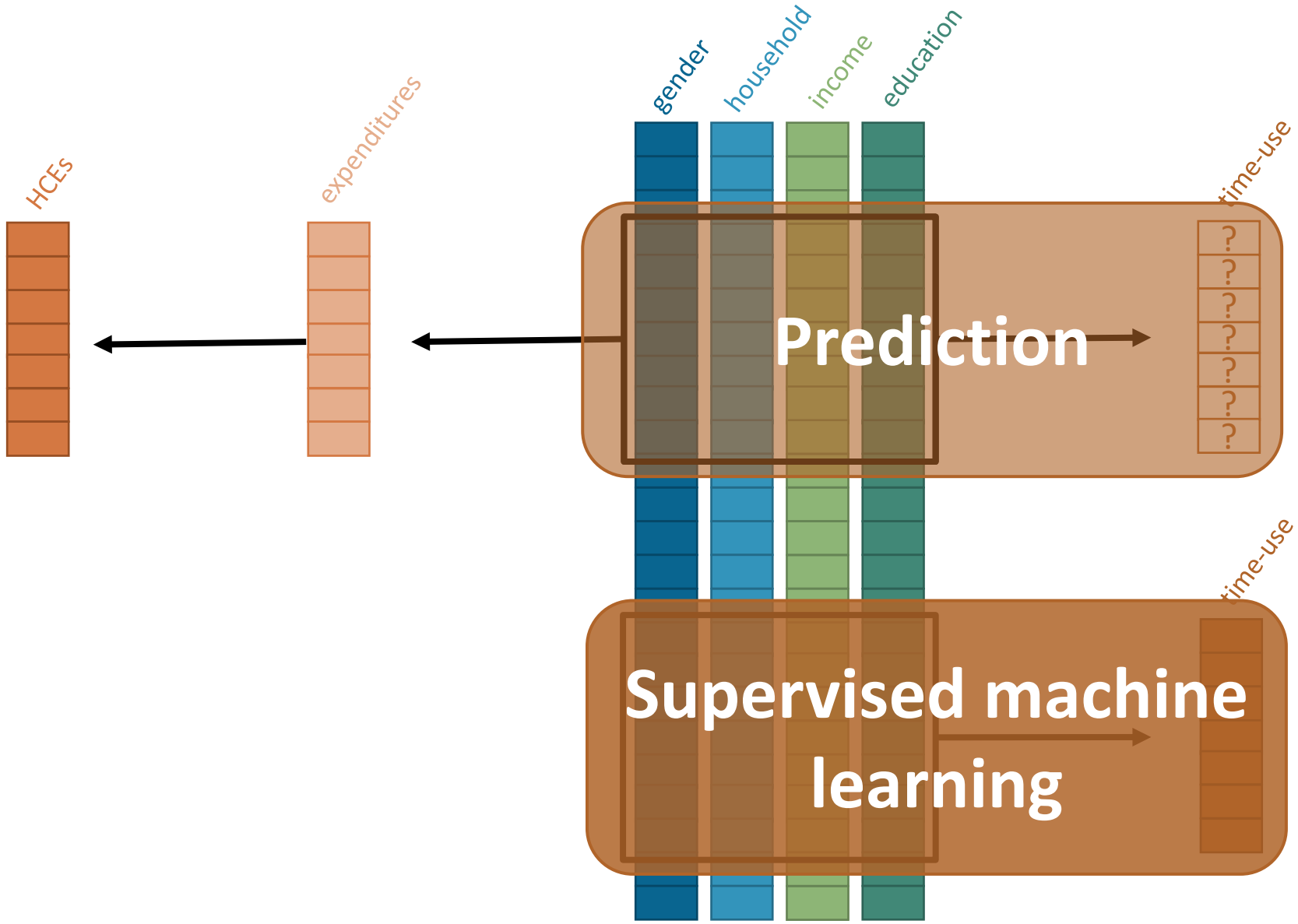

HCEs
expenditures
gender
household
income
education
time-use
?
?
?
?
?
?
?
time-use

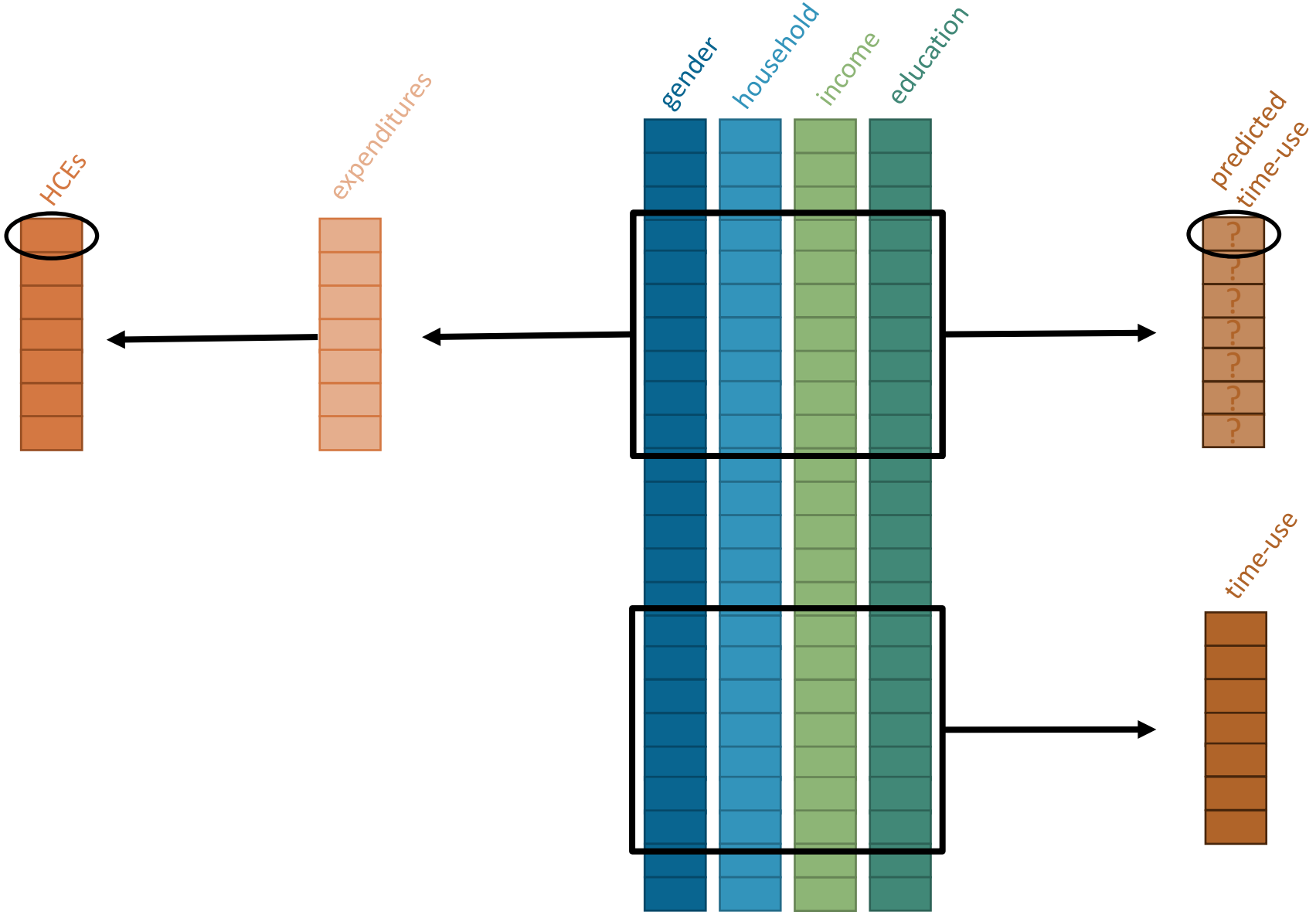
# What others have done…


HCEs
expenditures
gender
household
income
education
time-use
?
?
?
?
MEAN
IMPUTATION
(per gender)
time-use

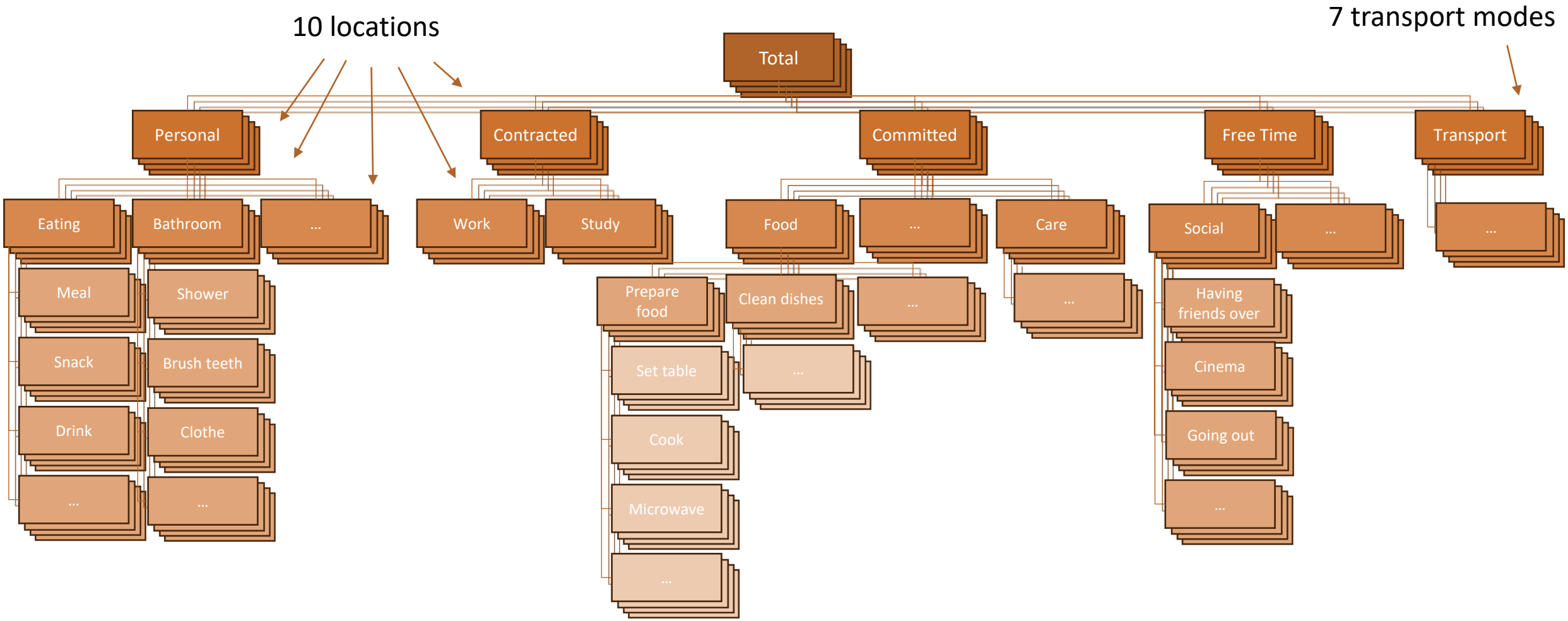

HCEs
expenditures
gender
household
income
education
average
time-use
(per gender)
?
?
?
?
?
?
?
time-use

We think we can do better!


HCEs
expenditures
gender
household
income
education
time-use
Prediction
time-use
Supervised machine learning

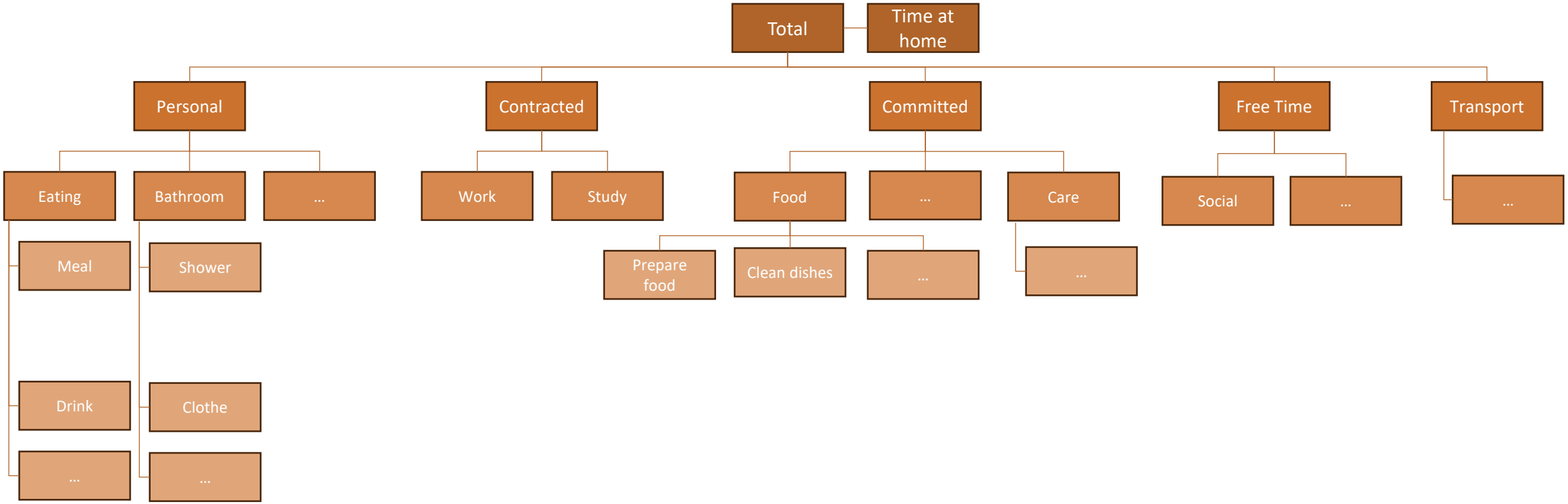

HCEs
expenditures
gender
household
income
education
predicted time-use
time-use

# Predicting Time-Use



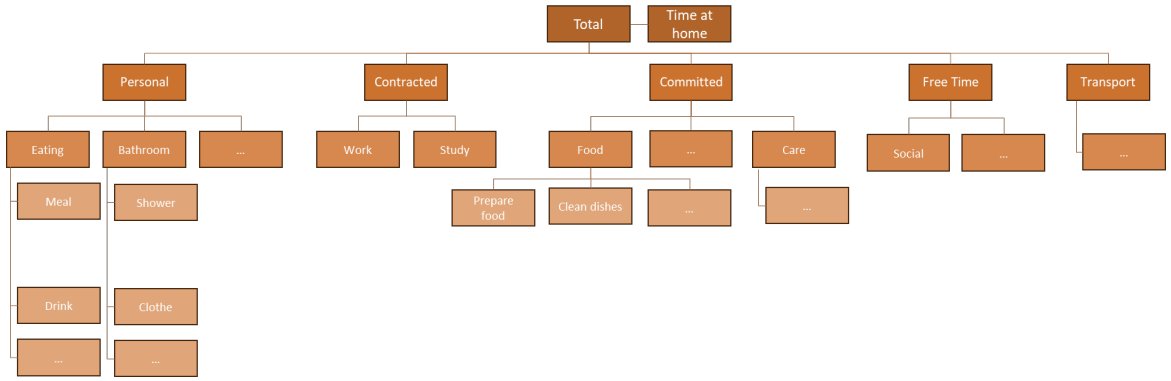

= 3323 unique activities

# Predicting Time-Use



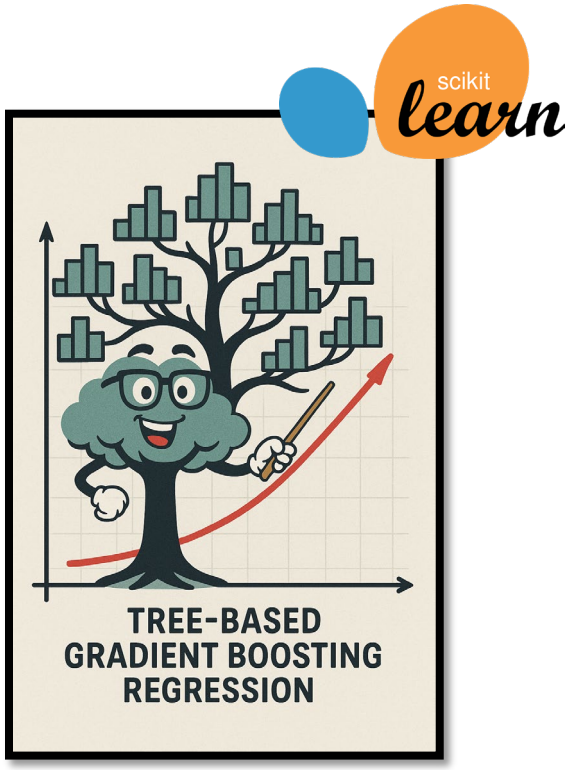

= 114 unique activities

# Predicting Time-Use




- 114 activities to predict
  - Not normally distributed
- Features
  - 7 CBS datasets
  - 20 features (10 categorical)
  - Missing values

- Histogram-based gradient boosting regressor
  - Based on a number of sequential decision trees



# So, did we do better?

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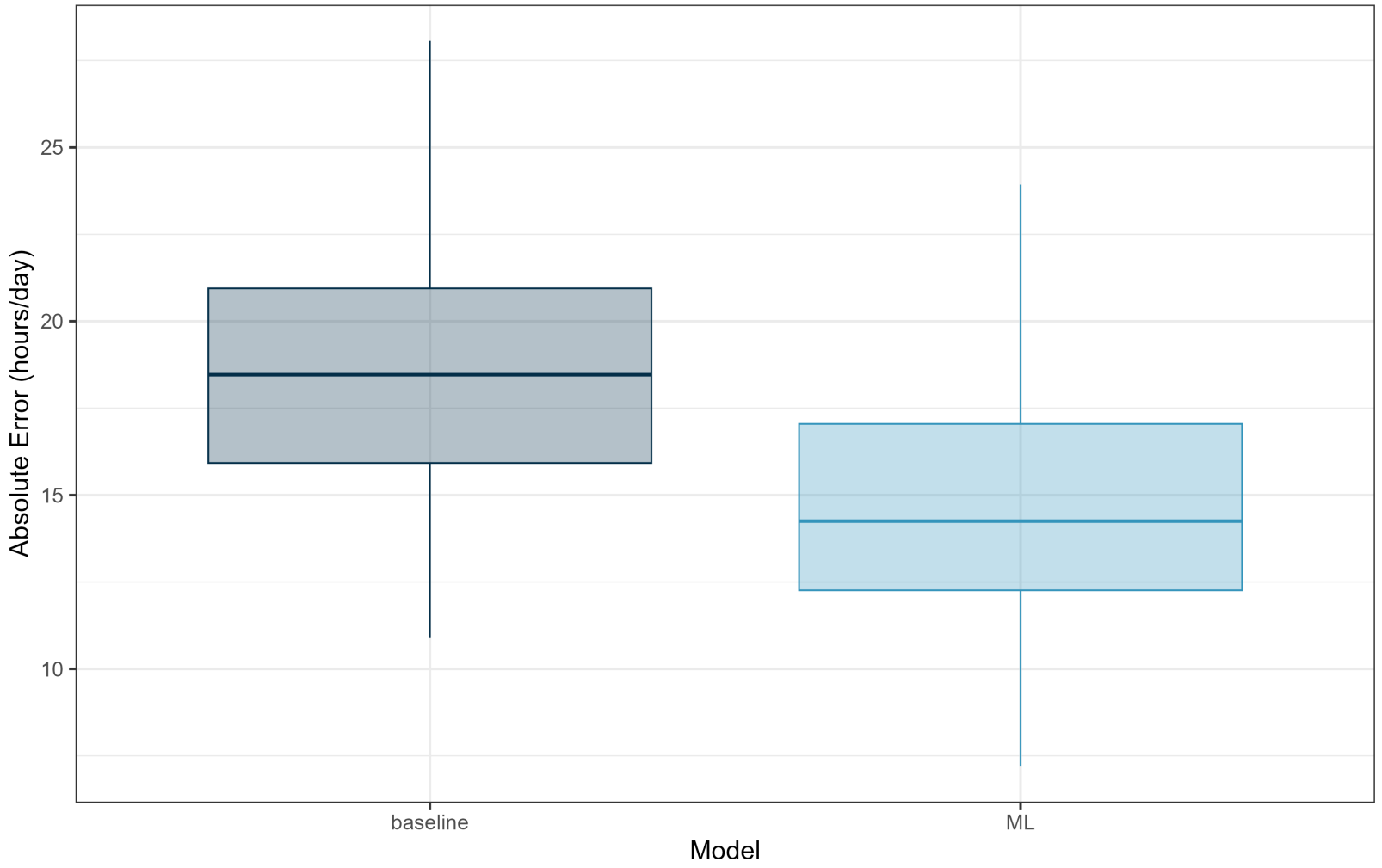
Prediction errors

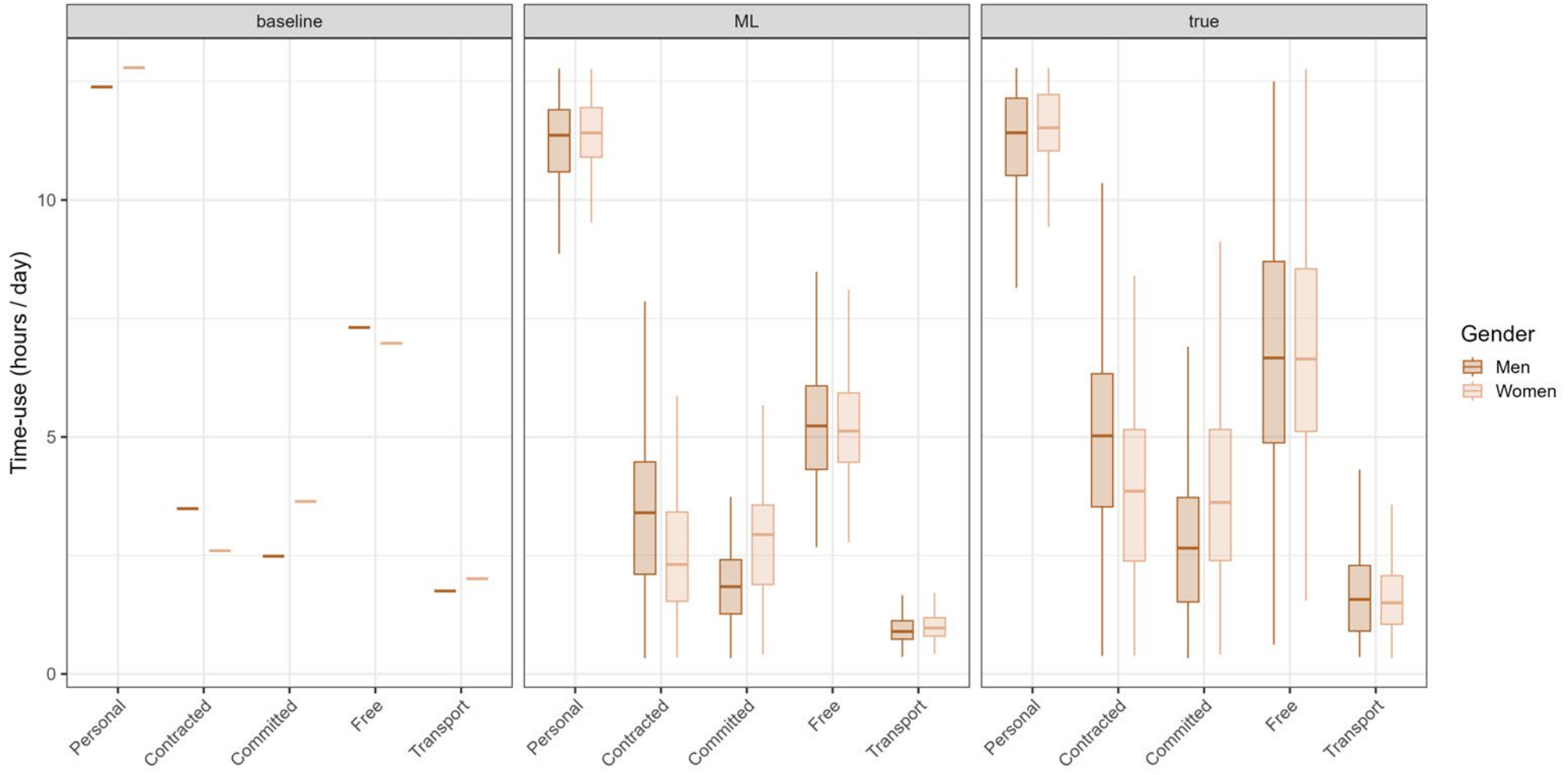
# Predicted Time-Use (errors)



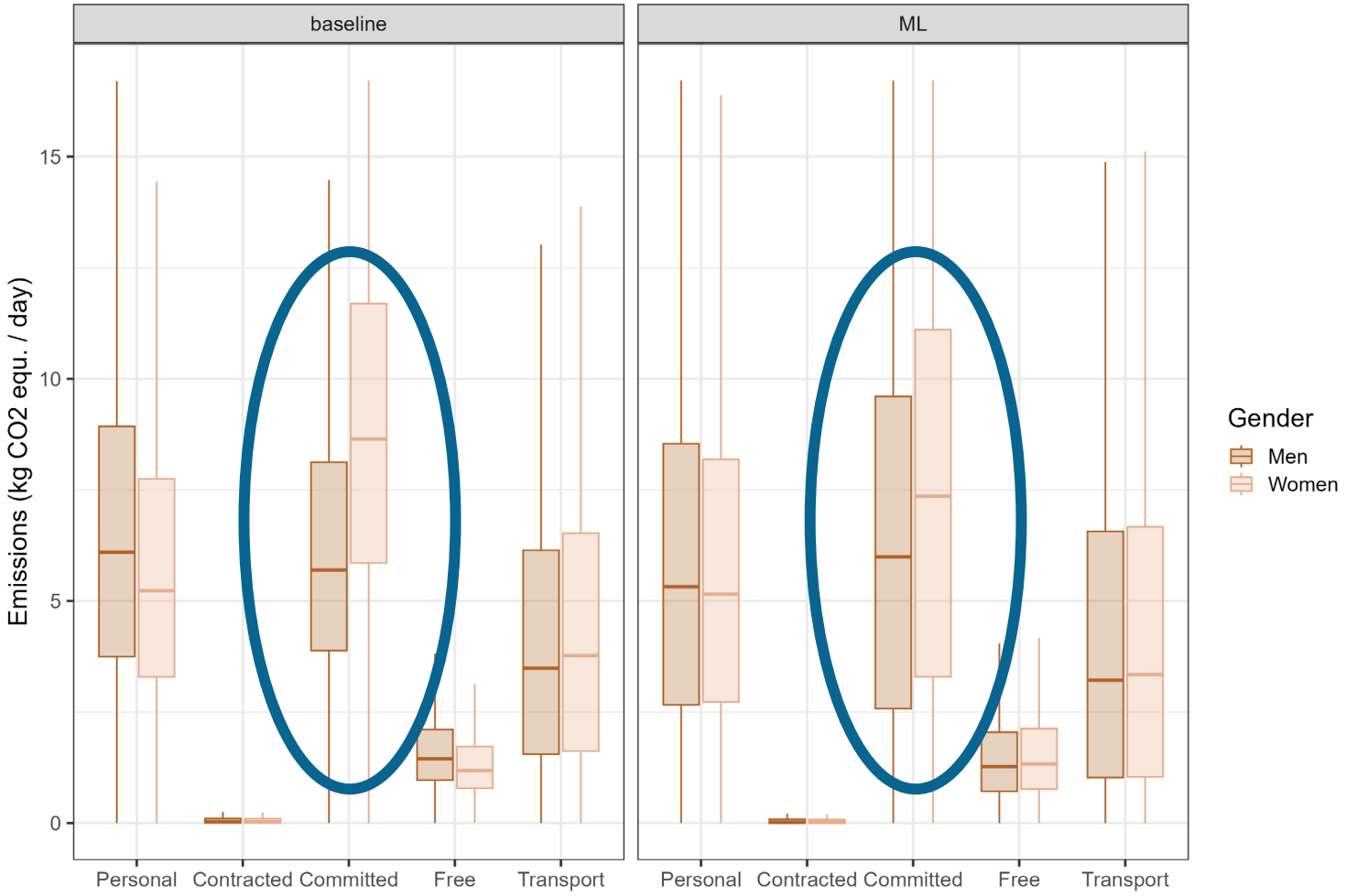
# So, did we do better?

Time-use predictions

# Predicted Time-Use



# Individual Carbon Emissions

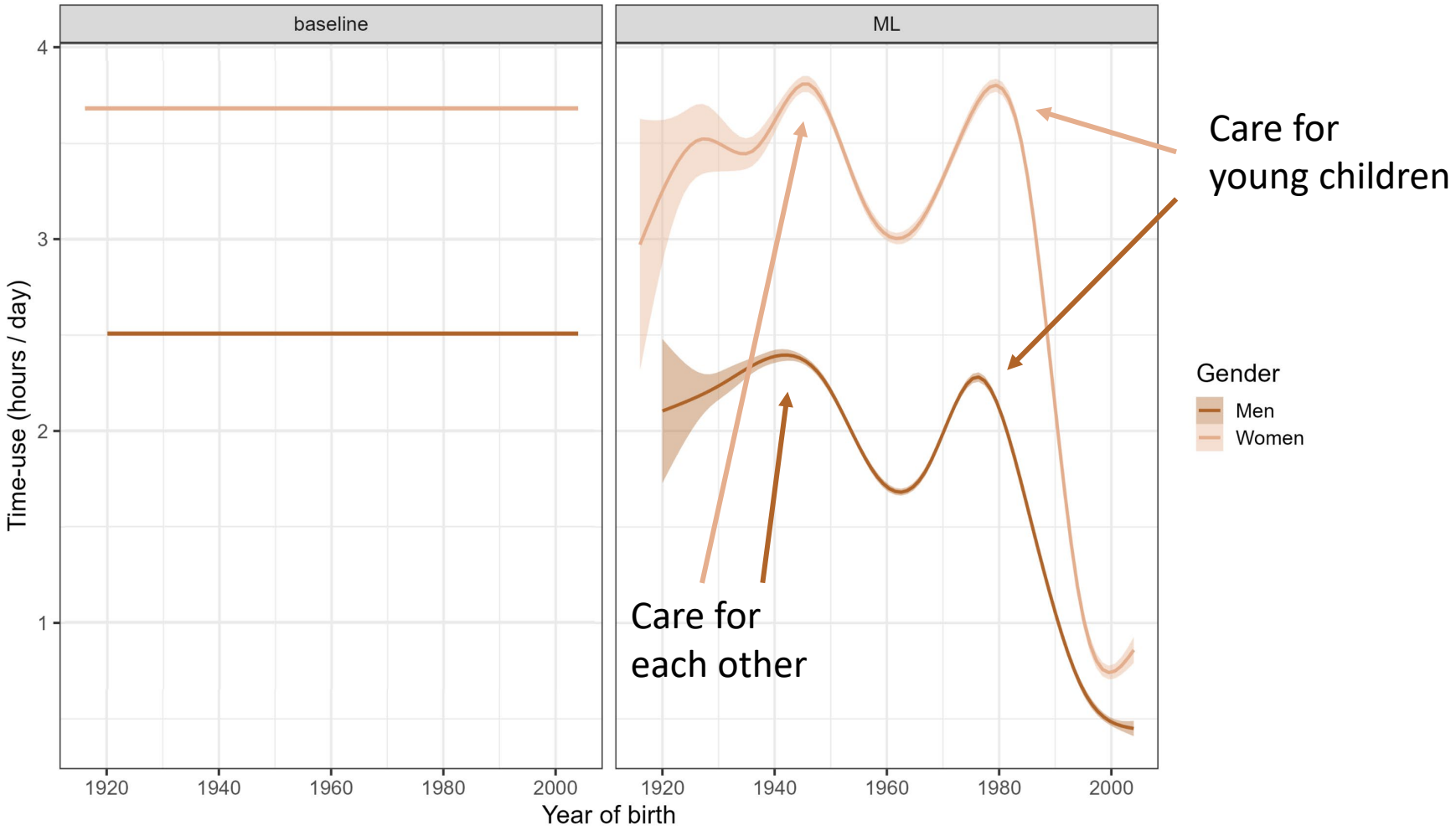


# Implications

Committed time-use & emissions

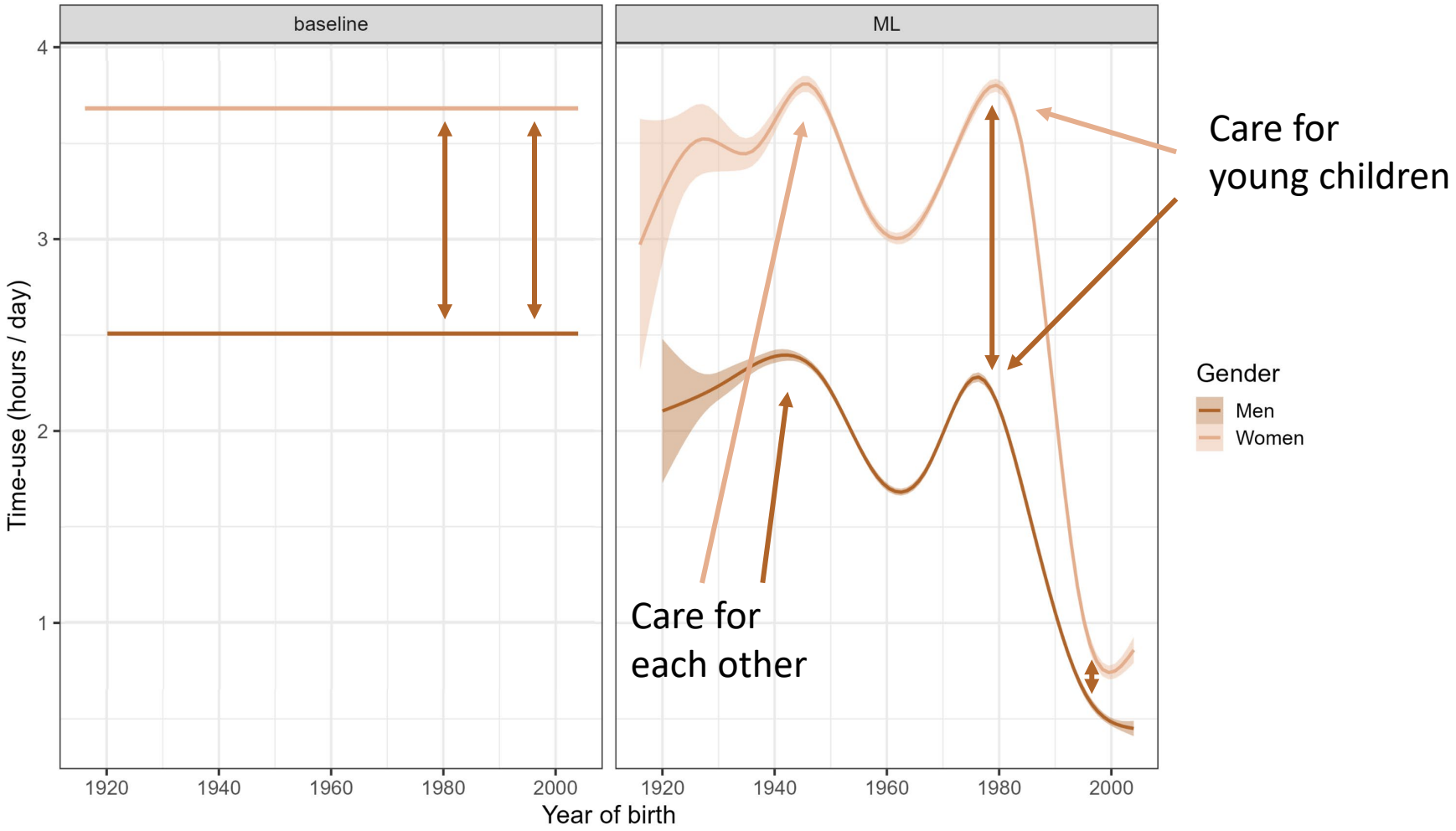
# Committed Time-Use

## Gender * Year of Birth



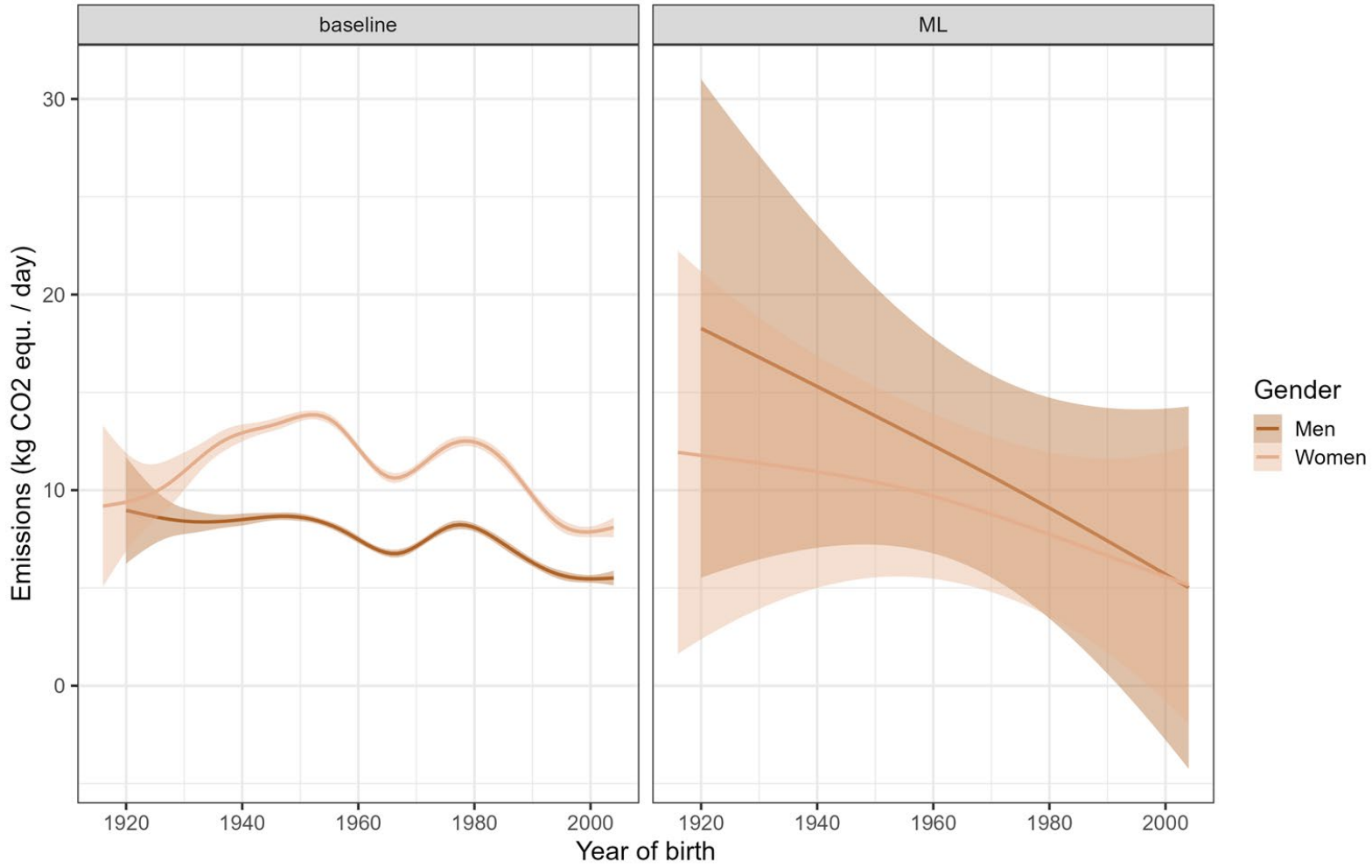
# Committed Time-Use

## Gender * Year of Birth



# Committed Time-Use - Emissions

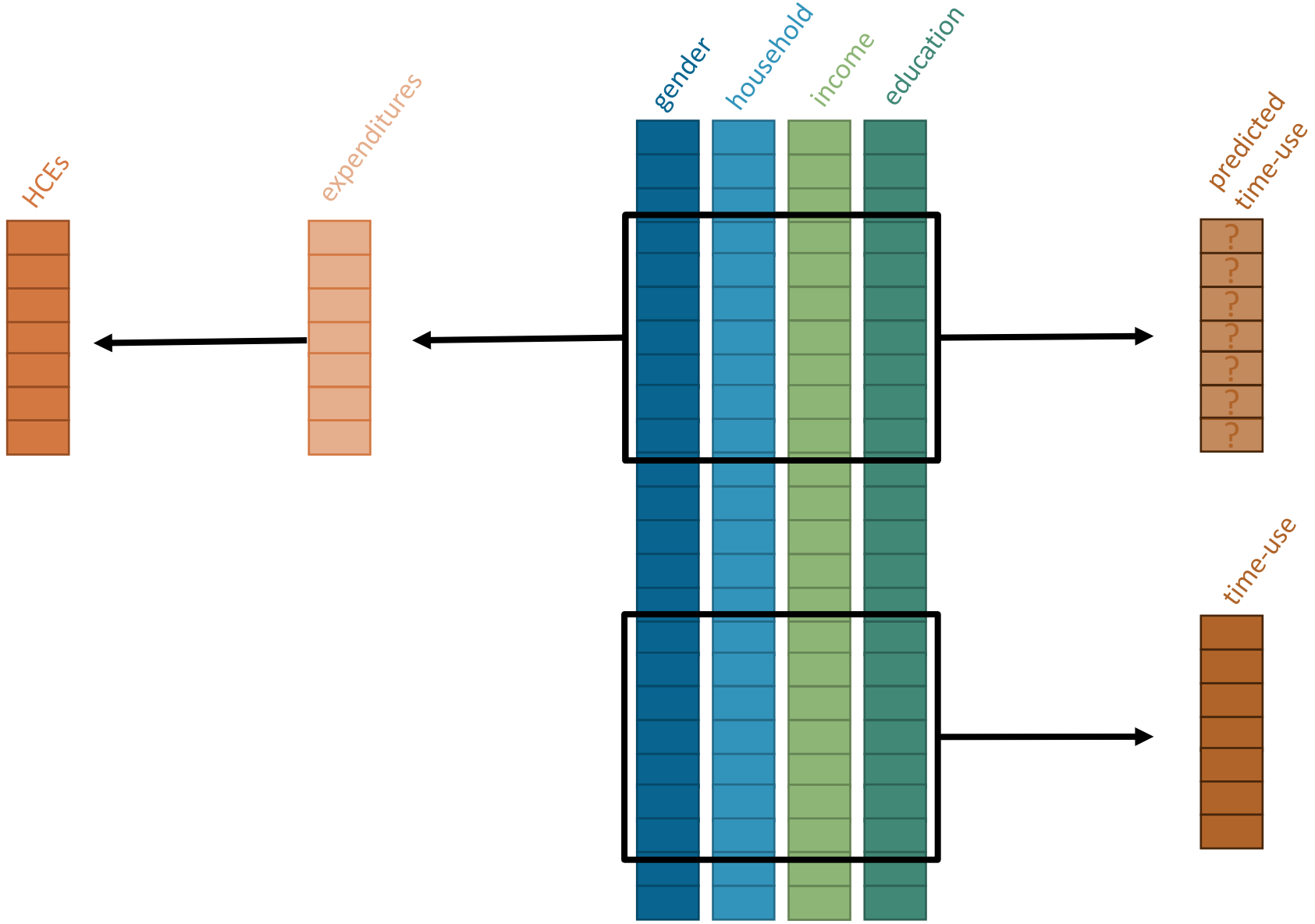
## Gender * Year of Birth

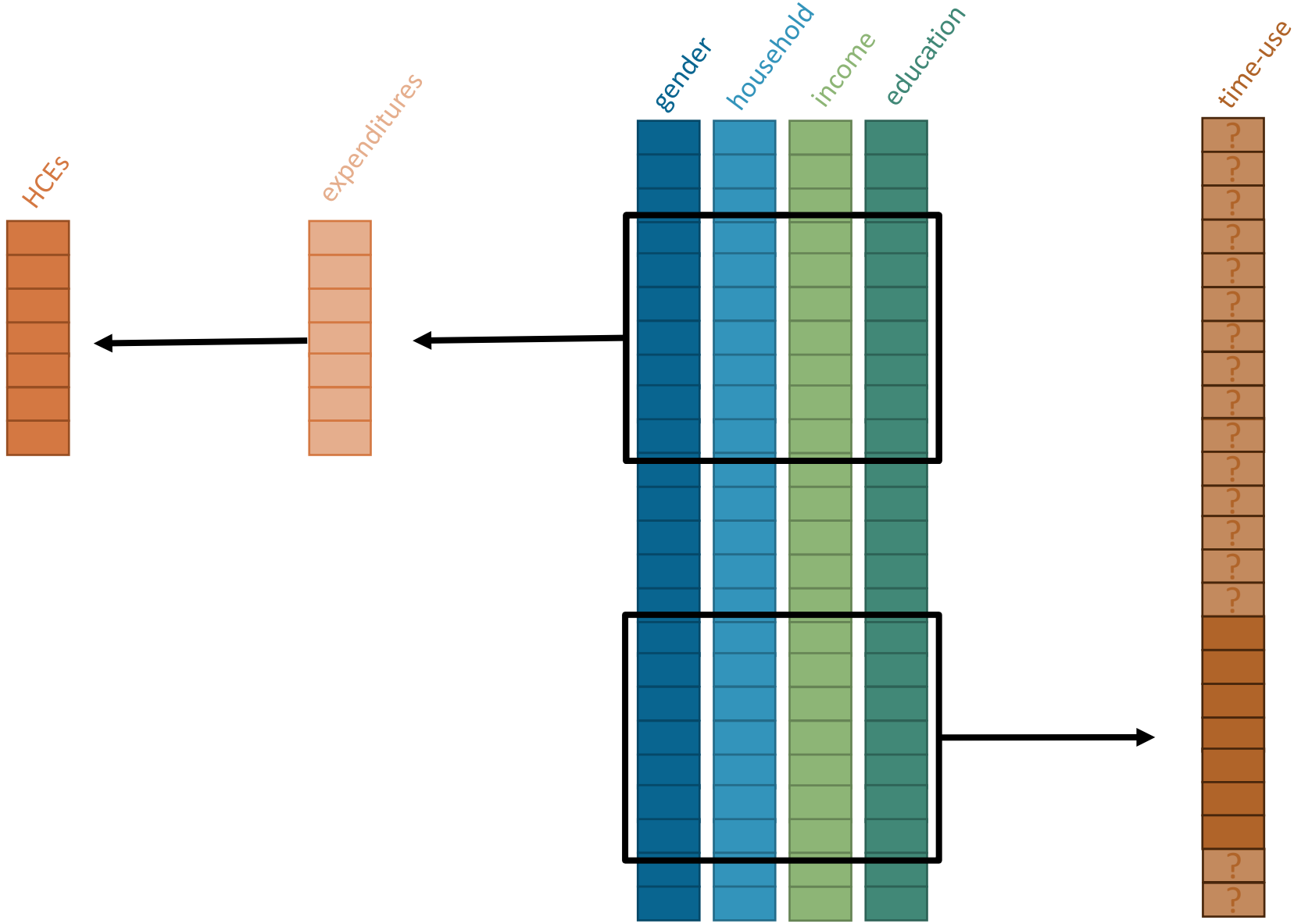


# Next Steps

# Next Steps

Calculate population-level individual carbon emissions


HCEs
expenditures
gender
household
income
education
predicted time-use
time-use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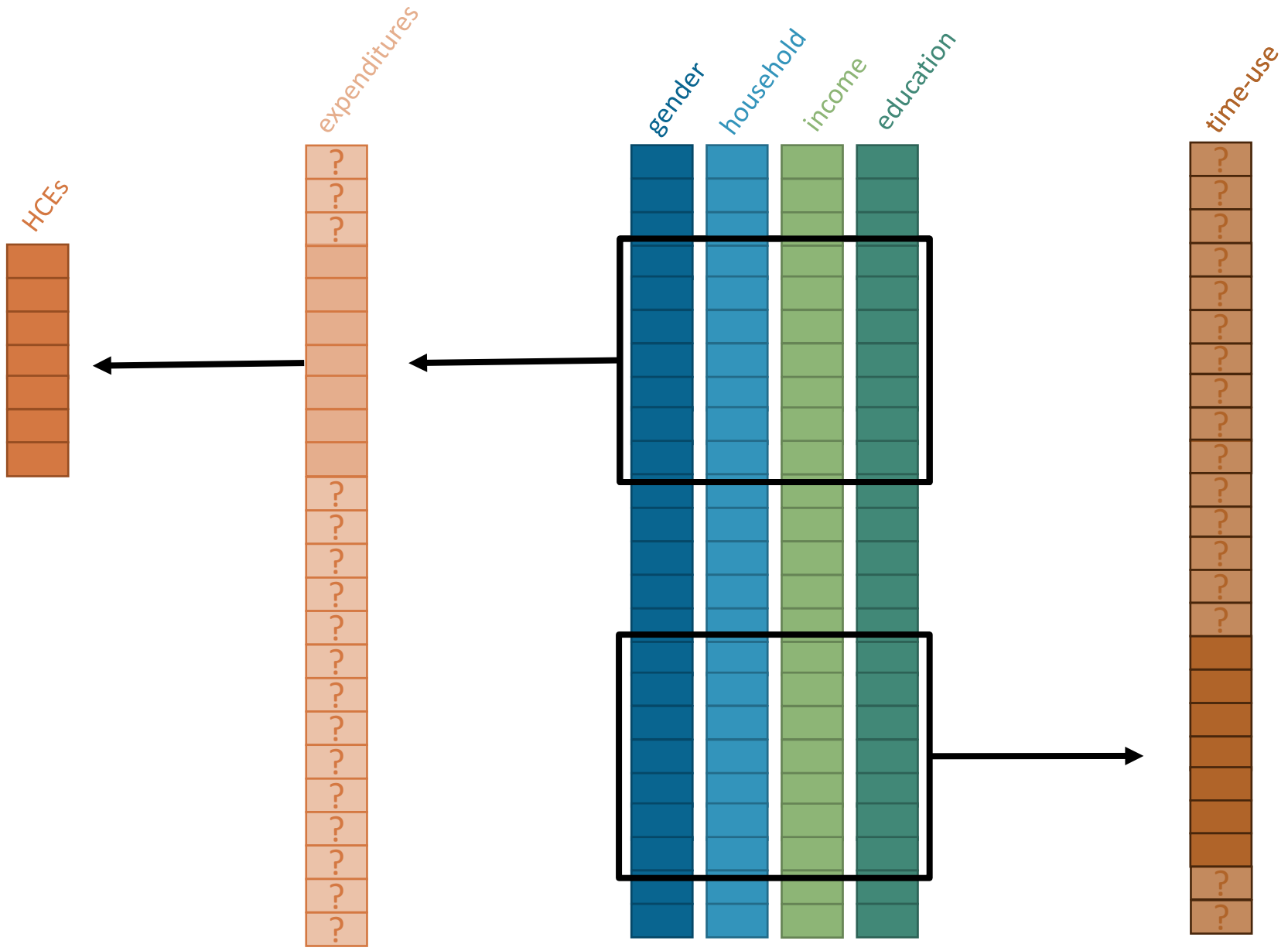
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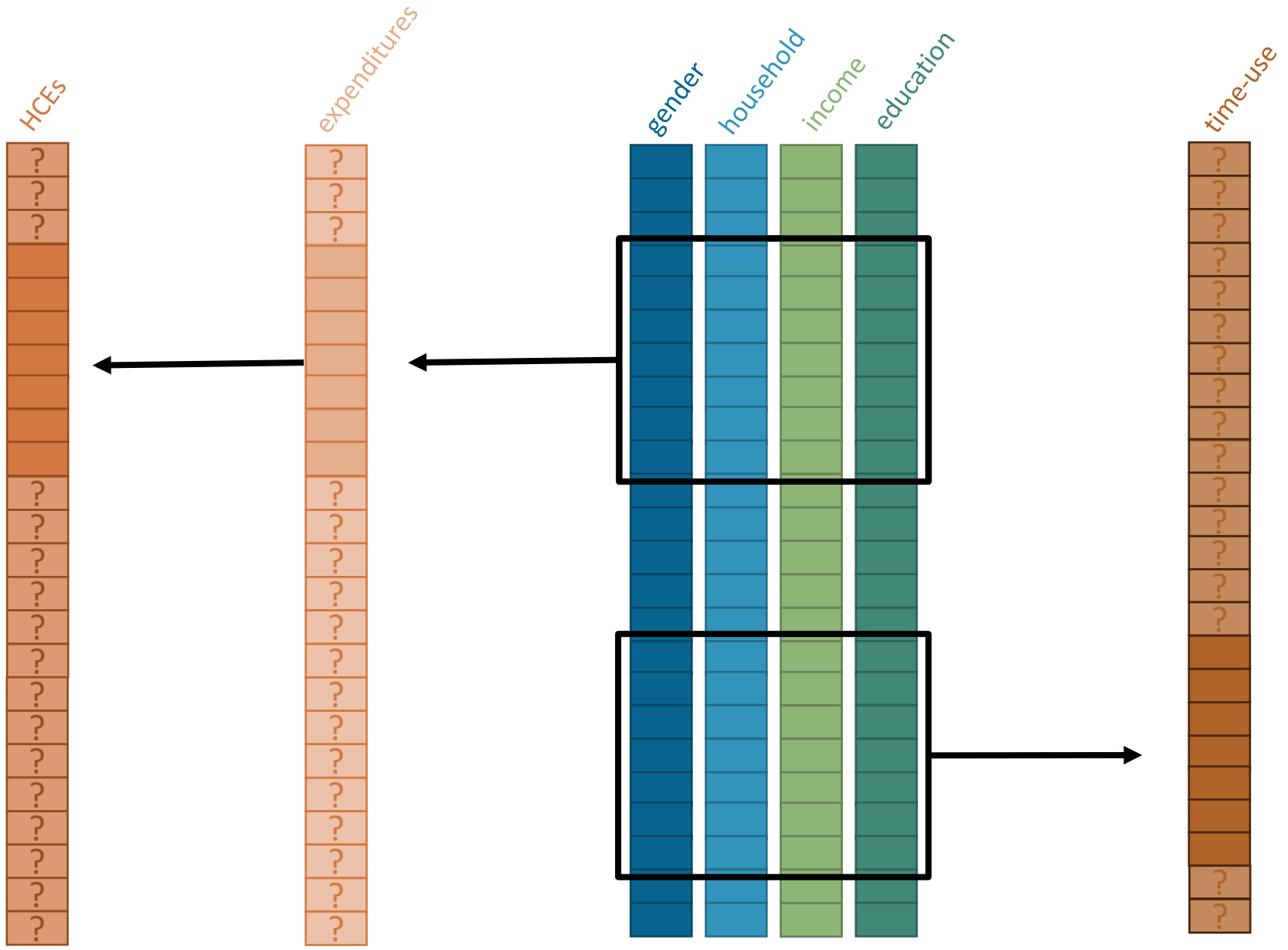
HCEs
expenditures
gender
household
income
education
time-use

# Next Steps

Estimate & account for uncertainty in predictions

# Conclusions

- Imputing the average time-use of men & women **ignores** many **underlying household dynamics**
- Simple ML techniques can **improve the time-use predictions** by a lot
- This allows us to study time-use & individual carbon emissions on a much **larger (population) level**
- This technique can be applied to many **other contexts** & is relatively **easy to implement**

Thank you for listening

# Combining Register and Survey Data to Understand Carbon-Intensive Time Use

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https://github.com/sodascience/time_emissions

# Funding information


- This study is part of the research program Sustainable Cooperation – Roadmaps to Resilient Societies (SCOOP). The authors are grateful to the Netherlands Organization for Scientific Research (NWO) and the Dutch Ministry of Education, Culture and Science (OCW) for generously funding this research in the context of its 2017 Gravitation Program (grant number 024.003.025)
- Results based on calculations by Utrecht University using non-public microdata from Statistics Netherlands


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