Accounting for the Evolution of Sedentarism in Food Security Assessment

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Introduction

- Prominent estimates of food insecurity such as:
  - The Food and Agriculture Organization's (FAO) The State of Food Security and Nutrition in the World (SOFI).
  - USDA ERS' International Food Security Assessment (IFSA).
  - And others (GHI) likely biased upwards (overestimating!).
- Lack of updating of physical activity levels (PALs) used in minimum dietary energy requirements (MDERs), since 1985.
  - MDER serves as a kcal cutoff in the methodology of estimating food insecurity.
- Other criticisms of the MDERs related to inflated BMRs (basal metabolic rate).
- Not directly addressed here but can amplify the MDER issue.
  - Interaction between PAL and BMRs.
  - See Henry (2005) and Swaminathan et al. (2018)

The MDER and Our Placement

- MDERs:
  - Based on weighted sum across population sub-groups of:
    - Basal metabolic rate_sub-group*1.55.
    - 1.55 is the PAL **(we will modify it!)**.
  - Computed 1.55 PAL reflects a sedentary lifestyle *in 1985*.
  - Point of contention: sedentary in 1985 vs 2020s.
- We fit in the survey-based measures.
  - Oldest of the 3 main measures of food insecurity.
  - Survey-based, FIES, cost of healthy diets.

How We Do It

- We construct a household model rationalizing sedentary behavior at work and leisure.
  - Comparative-statics inform the empirical approach.
- We build a unique pseudo-panel dataset with sitting time as a proxy for sedentarism.
  - Explained by covariates determining sedentary time.
- We econometrically estimate transfer functions.
  - Link sedentarism to these widely available covariates.
- Estimated sedentary time changes (1985-2020) are used to adjust physical activity level (PAL) reflected in current MDERs.
  - Used to re-evaluate food insecurity estimates via revised MDERs.

Conceptual Model

- Household Model:
    - Four labor types across:
        - Non-market and market production.
        - Physical and cognitive human capital-intensive types ("brainy human capital" henceforth).
- Comparative Statics:
    - Increasing productivity of brainy human capital:
        - Leads to increased time allocated to brainy activities (market and non-market).
        - "Brainy" activities are sedentary types of activities.
    - Increasing wage rates of brainy activities:
        - Also leads to increased time in brainy activities (less strongly than productivity change).

Empirics: Our Sitting Time Data

- Constructed unique pseudo-panel dataset covering 136 countries and territories.
  - 2002-2019, 2022 timeframe.
- Average adult sitting time per day for a nation/territory proxies for sedentarism.
- Sources:
  - WHO STEPS surveys.
  - Eurobarometer surveys (2002, 2005, 2013, 2017, and 2022).
  - Rezende et al. (2016).
  - Mclaughlin et al. (2020).

Mean Sitting Over Time by Source
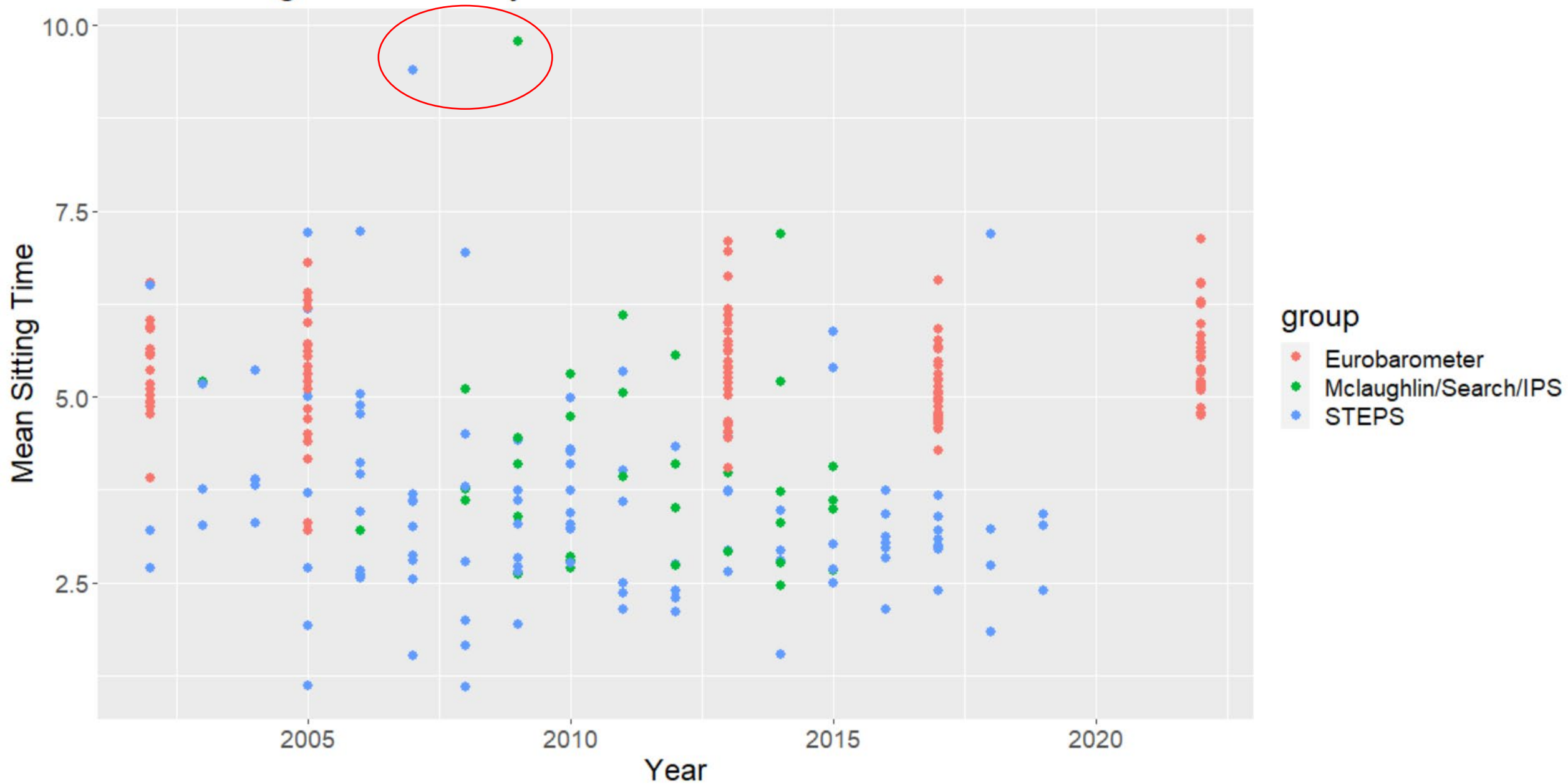
Regressions

- Used four common functional forms in an "agnostic" approach.
  - Level-level, level-log, log-level, log-log.
  - Level-level and log-level included models with one variable squared.
- Initially tested quadratic forms.
  - Some evidence for squaring "proportion on the web" covariate.
- Estimated coefficients of 24 runs.
  - Aggregated using meta-analysis methods.
  - Used aggregates for transfer functions to predict sitting time.
- Selected a subset consisting of 5 preferred models.
  - Based on goodness of fit and consistency of signs of effects.

Table 5b. Significance results of five preferred regressions

Variable	Count of Models Variable Appears in	Negative Not Significant	Negative Significant	Positive Significant	Positive Not Significant
Prop on Web	2	0	0	0	2
Prop on Web Squared	3	0	0	3	0
Rural Pop Percentage	5	0	5	0	0
Theil	5	4	0	0	1
Upper Secondary Completion Rate	5	0	0	5	0
GDP Per Capita	5	0	0	2	3
Data Source-McLaughlin/Search/IPS	3	2	0	0	1
Data Source-STEPS	3	1	0	0	2
Theil Imputed	3	0	0	3	0
Year FE	5				

Table 6. Aggregated estimates in slope and elasticity forms (five best models)

Variable	Average Value Slope Form	Average Value Elasticity Form
prop_on_web	0.00155257	0.01598409
rural_pop_percent	-0.01534265	-0.13869909
theil	-0.45133782	-0.02161740
upper_secondary_completion	0.99188630	0.14512952
gdp_per_capita	0.00001197	0.05295006
prop_on_web^2	0.00014684	0.10269896
theil_imputed	0.52086014	1.12025878
beta_0 (constant term)	4.095808216	1.40802571
Note: theil_imputed reports a first difference and semi-elasticity, respectively.		

Sitting Time Transfer Functions

- Predict sitting time through 1st order Taylor approx. models.
  - Deviations from mean using slopes but also an elasticity version.
  - Versions with prop on web and alternatives with prop on web squared.
- Aggregated regression form (additive) and aggregated multiplicative forms (elasticity).
  - Prop on web and prop on web squared versions as well.
- Eight model specifications total.
  - Six of which are used to generate example of next slide, averaging their predictions for changes in sitting time.
  - Two unused due to zero and division by zero issues in multiplicative model forms (a drawback).

Table 7. 1985 to 2020 MDER correction with PAL and BMR adjustments (reduced version)	
	Ethiopia
Inflation via PAL alone (i) in %	2.11%
Inflation via BMR alone (ii) in %	5.00%
Inflation interaction (iii) in %	0.11%
Sum of inflation (i)+(ii)+(iii)	7.21%
Inflation from PAL total (i)+(iii)	2.21%
Male age 18-30 65 kg	
MDER Schofield (Kcal)	2555.092
MDER without BMR inflation (Kcal)	2433.421
MDER without PAL & BMR inflation (Kcal)	2383.181
Inflation via PAL (i) (Kcal)	50.240
Inflation via BMR (ii) (Kcal)	119.159
Inflation interaction (iii) (Kcal)	2.512
Sum of inflation (i)+(ii)+(iii) (Kcal)	171.911
Inflation from PAL total (i)+(iii) (Kcal)	52.752

Conclusion

- We construct a method to endogenize changes in sedentarism in MDERs.

- An ancillary contribution is construction of a unique pseudo-panel dataset of sitting times.

- Our approach allows for country and time specific MDER values.
  - Can be applied to average dietary energy requirement (ADER) used by FAO as well. ADER used as reference for adequate nutrition in a population.
  - Could apply to other morbidities such as obesity.

- We have constructed a full set of adjusted MDERS.
  - We will recalculate food insecurity estimates, examining current bias.
  - Partnering with USDA ERS Economist Yacob Zereyesus.

Thank You!

References

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Prevalence of Undernourishment (PoU)

- PoU is a probability on randomly selected, or average, individual falling below MDER.
- MDER: For a subgroup, PAL*BMR.
  - Schofield equations estimate BMR by gender, age group, and weight.
    - About 50% of adult male obs. from 1940s young, active Italians.
  - Physical Activity Level (PAL) computed for sedentary lifestyle.
    - As defined in 1985.
  - Our approach endogenizes the PAL that BMR is multiplied against.
- We construct a BMR and PAL interaction example (shown later).
- We can customize our work to an individual country and year. It is scalable.
  - MDER can be tailored to be time and country specific.

Outliers and Influential Observations

- Made use of Cook's D, DFBETAS, DFFITS, and studentized residuals.
  - Investigated most offending observations.
- Lebanon 2009 and Nepal 2007 were removed.
    - Sitting times over 2 hours higher than next highest in dataset.
    - Vastly exceeded other observations for these nations.
- US and China influential on regressions.
  - We use population weighted regressions.
  - Left these observations alone.

Table 2. Data sources and definitions for variables

Variable	Source(s)	Mean	Standard Deviation	Min	Max
Mean Sitting Time (hours/day)	WHO STEPS, Eurobarometer surveys, Rezende et al., Mclaughlin et al.	4.38	1.32	1.09	7.23
Sample Standard Deviation of Sitting Time (hours/day)	WHO STEPS, Eurobarometer surveys, Rezende et al., Mclaughlin et al.	3.19	1.99	0.32	21.20
GDP Per Capita in 2015 USD	World Bank World Development Indicators	19375.70	21110.30	334.73	107792.19
Cellphone Subscriptions Per 100 Population	World Bank World Development Indicators	88.40	42.76	0.09	205.91
Proportion of Population Using the Internet	World Bank World Development Indicators	45.10	32.09	0.22	98.87
Upper Secondary Education Completion Rate	UNESCO	0.64	0.30	0.02	0.98
Rural Population Percentage	World Bank World Development Indicators	39.60	22.77	0.00	84.57
Percentage of Labor Employed in Agriculture, Forestry, and Fishing	FAOSTAT	21.16	22.91	0.60	82.00
Theil Index	World Bank Poverty and Inequality Platform	0.21	0.09	0.07	0.63
Population	World Bank Health Nutrition and Population Statistics	24720068	85870996	1208	1337705000

Notes for Food Insecurity Estimate Criticisms Slide

- SOFI (FAO and others): The State of Food Security and Nutrition in the World

- IFSA (USDA): International Food Security Assessment

- Svedberg (2002) argues FAO model for PoU is biased, that they could use an unbiased version with the data they claim to possess, but don't.

- Many papers criticizing SOFI-types of measures.
  - Henry (2005): Schofield equations for BMR inflated, overestimate food insecure. Equations underly FAO methodology, estimated alternatives, Oxford equations.
  - Schofield equations estimate BMR by gender, age group, and weight.
    - About 50% of adult male obs. from 1940s young, active Italians.
  - Swaminathan et al. (2018): argues BMR overestimated in Indians by 5%-12%, Leads to overestimates of undernourished (as MDER = f(PAL, BMR,…).
  - Poudel and Gopinath (2021) and De Haen et al. (2011) focus on the disparity and inconsistency in estimates of food insecurity across measures and agencies.

Notes on Sitting Data Slide

- Rezende doesn't appear on the grouping as it is comprised of Eurobarometer, STEPS, and the Search and IPS. There is an overlap, so only parts of Rezende appear here.
  - Search is Rezende specifically searching for data on a given country. Brazil and Canada data was found this way, among others.
  - IPS, International Prevalence Study, is where the Rezende Argentina data came from.
- Mclaughlin acknowledges most of their data came from the Eurobarometer and the STEPS, but don't provide their source observation by observation like Rezende does. One can infer most of the observations as coming from either Eurobarometer or STEPS, but not all. STEPS seemed to vary in availability of data from some countries over time. Some observations were noted as being from STEPS but no longer had the data available from the repository.

Notes on Table 7.

- We redid a PAL factorial method calculation example to adjust for more low energy use leisure time and reduced walking time to create these numbers. We used our transfer function models, 6 of the 8 due to zeros issue in the multiplicative for the web covariate in 1985. We averaged the predicted sitting times and compared our new PAL to the FAO value of 1.53. Our values were closer to 1.5, some above and some a bit less. A few tenths on the PAL matters! Assume 5% BMR inflation, low end of the estimates of the inflation (5% to 12%).