

# OG-ZAF: Current Calibration

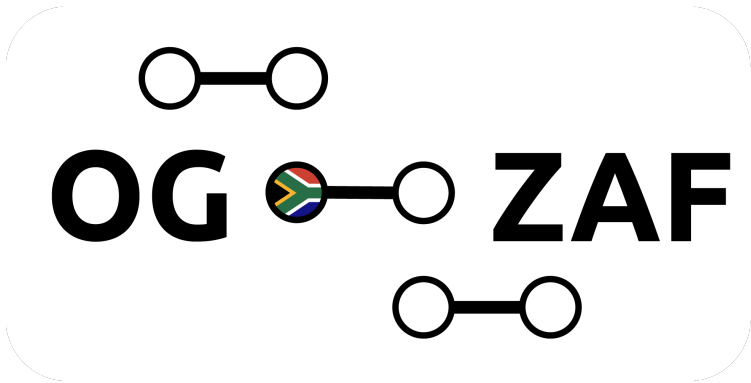
**Jason DeBacker**<sup>1</sup>    **Richard W. Evans**<sup>2</sup>

<sup>1</sup>University of South Carolina, Department of Economics

<sup>2</sup>Abundance Institute, Open Research Group, Inc.

**August 1, 2024**  
United Nations, South Africa

# OG-ZAF



- OG-ZAF is a calibration of the OG-Core model.

# OG-ZAF: A Calibration

What it means for OG-ZAF to be a “calibration” of OG-Core...

- OG-Core has all the underlying theory (e.g., different households, an arbitrary number of production sectors)
- But the parameters of the model are set to represent the South African economy
- E.g.,
  - The model matches South Africa’s (high) gini coefficient for the distribution of income
  - The size of production sectors represent the relative size in the South Africa economy
  - Policy parameters are set to represent South Africa’s tax system

NOTE: Any of these parameters can be changed to represent a counterfactual South Africa...

# Model Dimensions

- OG-Core allows for arbitrary sizes in the various model dimensions. In OG-ZAF, the defaults are:
  - Number of labor skill groups,  $J$ : 7
    - Representing the 0-25%, 25-50%, 50-70%, 70-80%, 80-90%, 90-99%, Top 1%
  - Age at which economically active,  $E$ : 20
  - Number of periods representing ages  $E$  to 100,  $S$ : 80
    - With this, a model period represents one year
  - Number of model periods until assume reach steady-state,  $T$ :  $4 \times S = 320$ 
    - Note, it's helpful to make  $T$  a bit larger than you think it needs to be since you need the economy to settle down before this point, but only computational cost if set it too high
  - Number of consumption goods,  $I$ : 1 (5)
  - Number of production industries,  $M$ : 1 (4)

# OG-ZAF Calibration

- The following parameters have been calibrated specifically to South Africa:
  - Demographics
  - Lifetime earnings processes for heterogeneous households
  - Firm production functions (labor share of output, TFP)
  - Household consumption parameters (expenditure shares on differentiated goods)
  - Input-output mapping between firm output and consumption categories
  - Macro parameters (long run growth rate, gov't interest rate haircut)

# OG-ZAF Calibration

- Other parameters such as:
  - Household preference parameters
  - Elasticity of substitution between capital and labor
- Are set to standard values used in the literature, due to a lack of research (to our knowledge) on these parameters in the South African context

Full documentation of the OG-ZAF calibration:

<https://EAPD-DRB.github.io/OG-ZAF/>

# OG-ZAF Demographics

- Demographic parameters include:
  - Fertility rates by age
  - Mortality rates age
  - Age distribution of the population in an initial period
  - *Not* immigration (to ensure things add up, immigration computed as a residual)
- The [UN World Population Prospects data](#) provide all of these for most countries from present with forecasts through 2100!

# Population Dynamics

The population evolves according to the following laws of motion, where  $\omega_{s,t}$  are the number of age  $s$  households at time  $t$ :

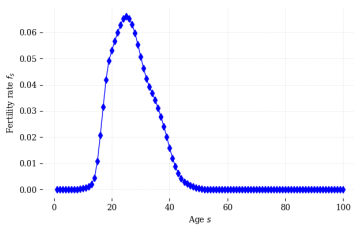
$$\omega_{1,t+1} = (1 - \rho_0) \sum_{s=1}^{E+S} f_s \omega_{s,t} + i_1 \omega_{1,t} \quad \forall t$$

$$\omega_{s+1,t+1} = (1 - \rho_s) \omega_{s,t} + i_{s+1} \omega_{s+1,t} \quad \forall t \quad \text{and} \quad 1 \leq s \leq E + S - 1$$

- The age-specific fertility rates,  $f_s$ , mortality rates,  $\rho_s$ , and immigration rates,  $i_s$  affect the distribution each period
- Given that these rates are constant, the population distribution will converge to a steady-state distribution

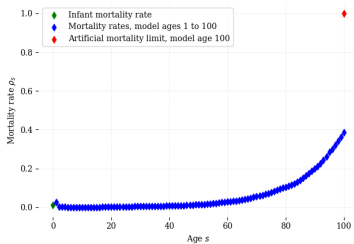


# South Africa: Fertility and Mortality



Source: UN Population Data

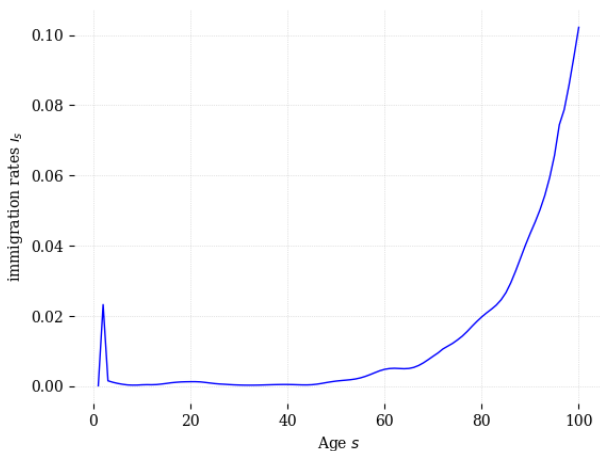
## Fertility Rates



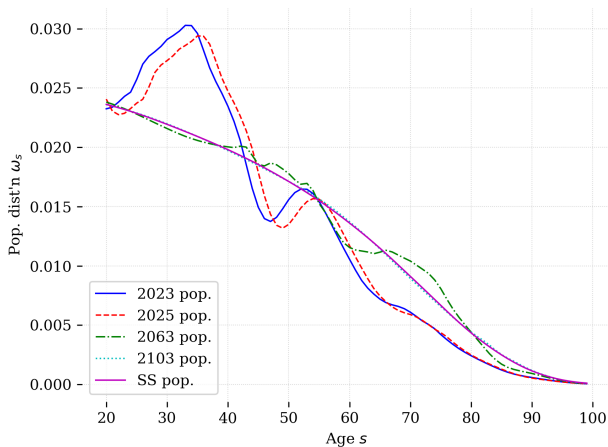
Source: UN Population Data

## Mortality Rates

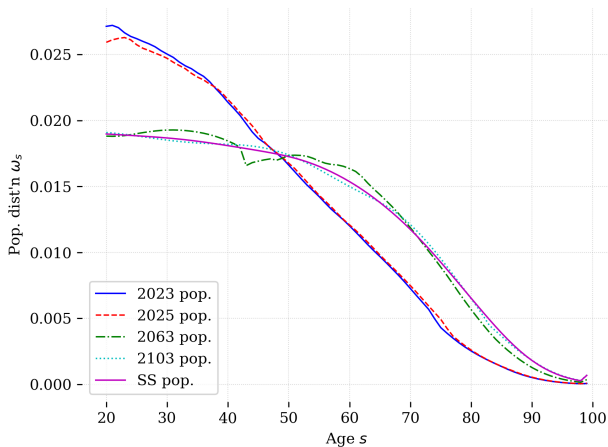
# South Africa: Demographics, immigration rates



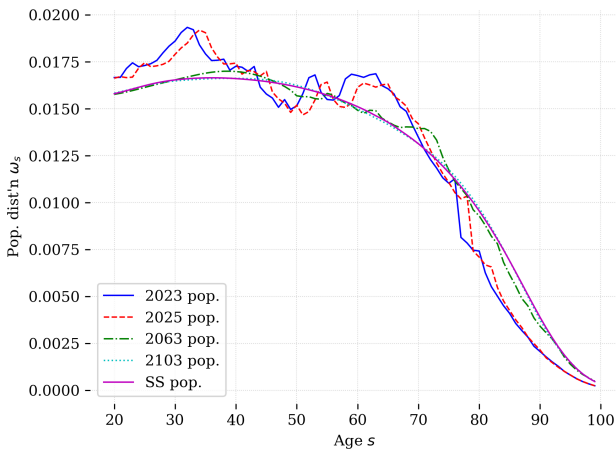
# South Africa: Demographics, pop. distribution



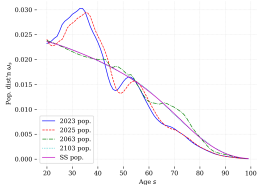
# Compare to India: Demographics, pop. distribution



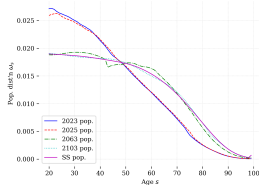
# Compare to USA: Demographics, pop. distribution



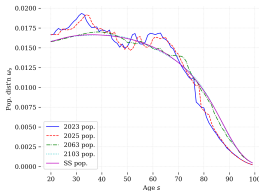
# Population Distribution Comparison



South Africa

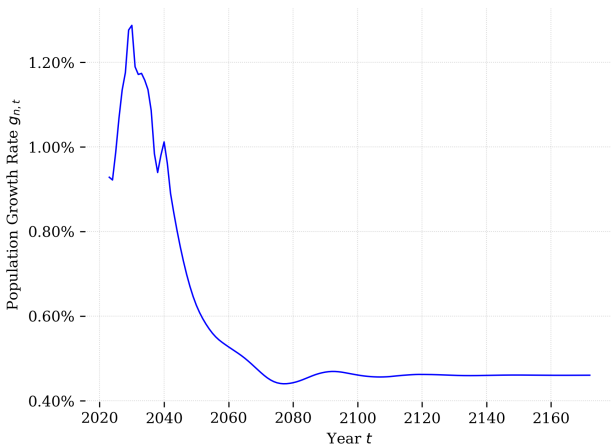


India



United States

# Demographics, pop. growth



# Earnings Ability

- Households are heterogeneous earnings ability/effective labor units
  - There is a (endogenously determined) common wage rate per effective unit of labor, but households vary in the effective units of labor per unit of labor supply, giving rise to differences in hourly earnings

$$c_{j,s,t} + b_{j,s+1,t+1} = (1 + r_t)b_{j,s,t} + w_t e_{j,s} n_{j,s,t} + \dots$$

- Earnings ability varies across households and over the lifecycle within a household
- There is no earnings risk: while earnings vary over the lifecycle, this process is completely deterministic
- Effective labor units are homogeneous from the point of view of firms
- No human capital accumulation decisions: earnings ability profiles are exogenous

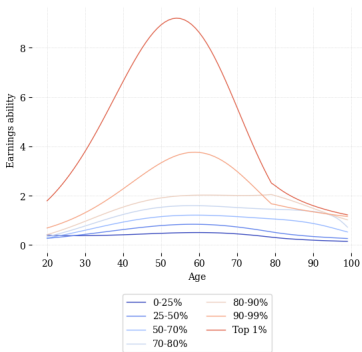


# Calibrating Lifetime Earnings Profiles

- Ideally, one can estimate the lifetime earnings profiles from microdata that represents a long panel of households (see e.g., Fullerton and Rogers (1993) or DeBacker et al. (2016))
- However, these data are often hard to come by
- Marcelo and Rick therefore devised a reasonable approximation that requires only minimal data:
  - Begin with the earnings profiles for U.S. household estimated by DeBacker et al. (2016)
  - Adjust the shape of the profiles for each earnings group to match ZAF's distribution of income by age
  - Adjust the average differences between the  $J$  earnings groups to match the Gini coefficient for income distribution in ZAF

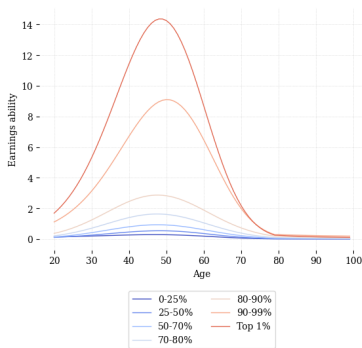
# OG-ZAF Lifetime Earnings Profiles

USA Gini = 41.0



Earnings Profiles, USA

ZAF Gini = 64.8



Earnings Profiles, ZAF

# Calibrating Firm Parameters

- Marcelo was able to use the ZAF national accounts data + industry-level data from the South African Reserve Bank to find:
  - Output, labor, capital by industry  $\implies$  industry TFP
  - Labor's share of output by industry

Production Sector	TFP ( $GVA/F(K, L)$ )	TFP (normalized)	Capital Share Income
Primary	396.80	0.11	0.67
Secondary (ex energy)	3474.10	1.00	0.50
Tertiary	6604.17	1.90	0.45
Energy	551.63	0.16	0.53

# Mapping Production Goods to Consumption Goods

- Model households consume differentiated consumption goods
- Consumption goods are composites of production goods, determined via fixed proportions
- This leaves two parameter objects to calibrate:
  - 1 Household preferences (expenditure shares) over the differentiated production goods
  - 2 A matrix representing the shares of each output good in the composition of each consumption good

# Data Mapping Production Goods to Consumption Goods

- Data for these are contained in standard “social accounting matrices” used in CGE modeling
- These are readily available for most countries from [GTAP](#) or other sources
- For the ZAF calibration, we use [data from the UN University-Wider](#)

# Calibration of IO Matrix and Consumption Shares

## Consumption-Production Bridge Matrix

Cons/Prod	Primary	Energy	Tertiary	Secondary (ex energy)
Food	0.060	0.001	0.247	0.692
Energy	0.092	0.089	0.044	0.776
Non-durables	0.105	0.007	0.370	0.518
Durables	0.095	0.018	0.327	0.560
Services	0.084	0.011	0.729	0.176

## Consumption Expenditure Shares

Food	Energy	Non-durables	Durables	Services
0.10	0.04	0.16	0.15	0.55

## Macroeconomic parameters:

- Long run growth rate,  $g_y = 0.0\%$  (no growth in GDP per capita since 2007)
- Initial period debt-to-GDP ratio, 73.4%
- Open economy parameters:
  - Initial percentage of debt held by foreigners, 26%
  - Percentage of newly issued debt purchased by foreigners, 23%
  - Openness of capital flow (0 to 1 scale), 0.9
- Government spending:
  - Non-pension transfers to GDP, 4%
  - Government consumption expenditures to GDP, 26.7%

## To come:

- More detail with tax and benefit system
- Match distribution of wealth
- Calibrate labor supply to match rates in South Africa
  - Note: model is of cohorts of agents, so unemployment not directly modeled, but we can get at it through, e.g., low labor supply of the young



# Matching labor supply, US Example

