“Distributional Implications of Climate Change in Rural India: A General Equilibrium Approach”

H. G. Jacoby, M. Rabassa, E.. Skoufias

Presenter: Emmanuel Skoufias
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Motivation

- Scarcity of evidence on the potential distributional consequences of climate change.

- Identifying the biggest losers from warming is essential for targeting policies aimed at ameliorating these negative impacts or promoting adaptation.

- What would one expect?
  - Impacts of climate change unequally distributed across income groups,
    - even w/in rural areas (farmland controlled by least poor of the rural population.
  - CC→ global decline in agricultural productivity, → world food P → could benefit net sellers of food (farmers)
  - BUT decline in productivity and higher food P→ MAY increase rural Wages→ not obvious who will lose and who will gain on balance

Why India?

- A wide range of agro-ecological zones,
- Variation in agricultural productivity
- Variation in climate across the sub-continent.

- CC→ increase Temp → heterogeneous impacts on Indian agriculture
  - Rural areas, home to about 3/4 of the country's huge population.
  - Agriculture in India: about a fifth of GDP, and absorbs about 70 % of the rural labor force.

Model--1

- Global warming→ two exogenous shocks
  - agricultural productivity shock
    - Predicted temperature in 2039 : predicted by the HadCM3-A1FI (high emissions path) scenario
  - a food P shock (India a price-taker in international agricultural markets)
    - Hertel, Burke, and Lobell (2010) forecast changes in the prices of major agricultural commodities after 30 years of climate change (2000-2030). Medium scenario

- 2 key assumptions:
  - Rural economy= many separate (district-level) labor markets across which labor does not migrate;
    - Empirically this assumption can also be relaxed

  - within a labor market, workers are perfectly mobile across production sectors but capital (land, in agriculture) is not
    - (factor-specific model from trade theory)

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Model--2

Get predictions for how these 2 shocks (productivity decline and higher food P)

- Impact on land values and wages (factor prices)
  - Response of land values and wages depends on
    - shares of labor in Agr, Manuf, Serv (NonTrade) sectors (vary by district)
    - the share of land, labor, and intermediate inputs (fertilizer) in agriculture (vary by hh)

- Consequences for household welfare measures by PCE
  - % change in hh PCE = elasticity of welfare wrt to agricultural productivity * (% change in Ag productivity) + net consumption ratio * (% change in food P)

- NOTE: Elasticity of welfare wrt to agricultural productivity DEPENDS ON:
  - shares of labor in Agr, Manuf, Serv (NonTrade) sectors (vary by district)
  - the share of land, labor, and intermediate inputs (fertilizer) in agriculture (varies by hh)
  - Income share from land (varies by hh)
  - Income share from manual labor (varies by hh)

Model--3

- ADVANTAGE:
  - can estimate impacts under different assumption (e.g. ignoring impacts of CC on wages)

Step #1:

estimate the climate sensitivity of agricultural productivity in rural India

- ➢ Neo-Ricardian model in a manner consistent with the general equilibrium framework.

Step #2 :

predict the welfare consequences of climate change for rural Indian households at each point along the distribution of current welfare (PCE)

Summary of Main Results:

- Rural wage adjustment will be the key mechanism for redistributing the potentially substantial costs of climate change from (wealthier) landowners to the rest of the rural economy.
  - in proportional terms, the household welfare impacts of a combined fall in agricultural productivity
  - and a (possible) rise in world food prices induced by global warming will be roughly the same across income groups.

- Conclusion holds whether
  - geographical labor mobility in the future is restricted to rural areas of the same district or
  - is allowed across rural and urban areas of much broader regions.

Some Caveats

- Abstract from shifts in capital across economic sectors due to global warming
  - Analysis is only valid for a horizon over which capital (and land) fixed in its present uses;
- First-order welfare analysis, which ignores substitution effects, may not be accurate for non-marginal changes.
  - Based on 30-year climate projections, we estimate a TFP decline in Indian agriculture on the order of 10 percent and we consider, as a worst-case scenario, an agricultural price shock of around 25 percent.
- Do not take into account the future dynamics of river basin flows and ground-water due to
  - , e.g. changes in Himalayan glacier melt,
  - changes in precipitation and the frequency of extreme weather.
- Zero out carbon fertilization effects→
  - productivity impacts worst-case scenarios of global warming as far as agriculture is concerned.

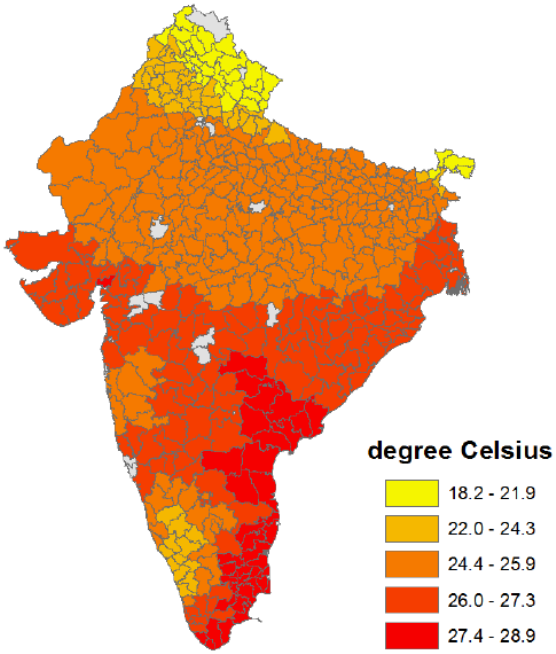
Key household-specific parameters

- household income share from land, manual labor
- Non-manual labor income (exogenous)

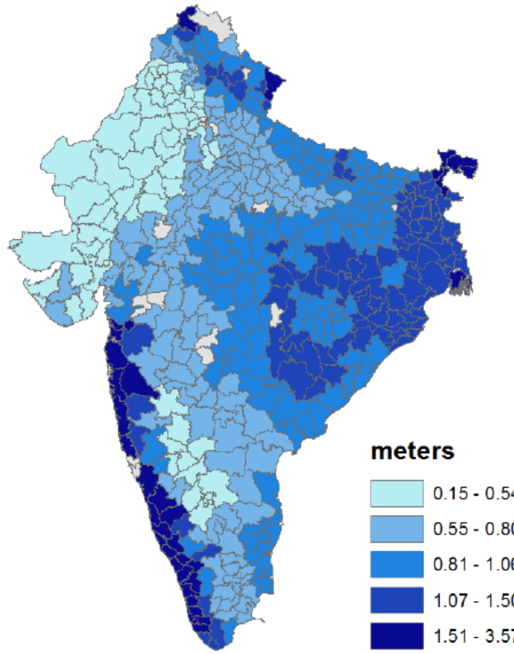
- Sectoral labor shares (A, M, S) in each district
  - The larger agriculture is in relation to non-agriculture, the less elastic is the supply of labor to agriculture and hence the more responsive is the wage to the exogenous shock.

- Cost share of land, intermediate inputs (fertilizers) and labor

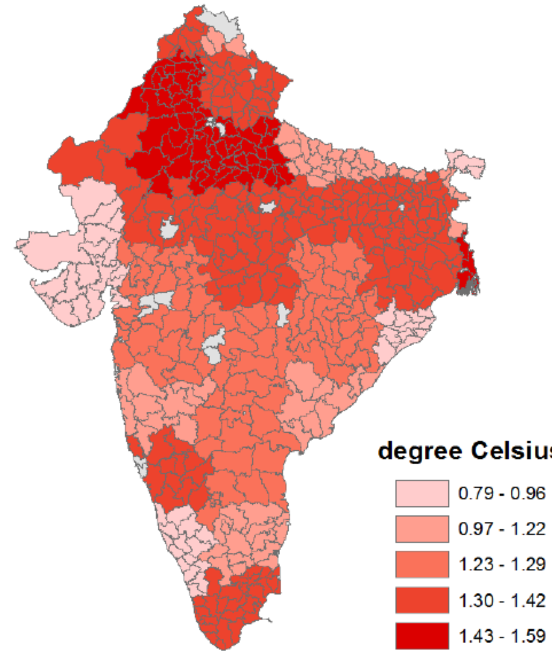
- Welfare productivity elasticity-



(a) Temperature 1969-1999

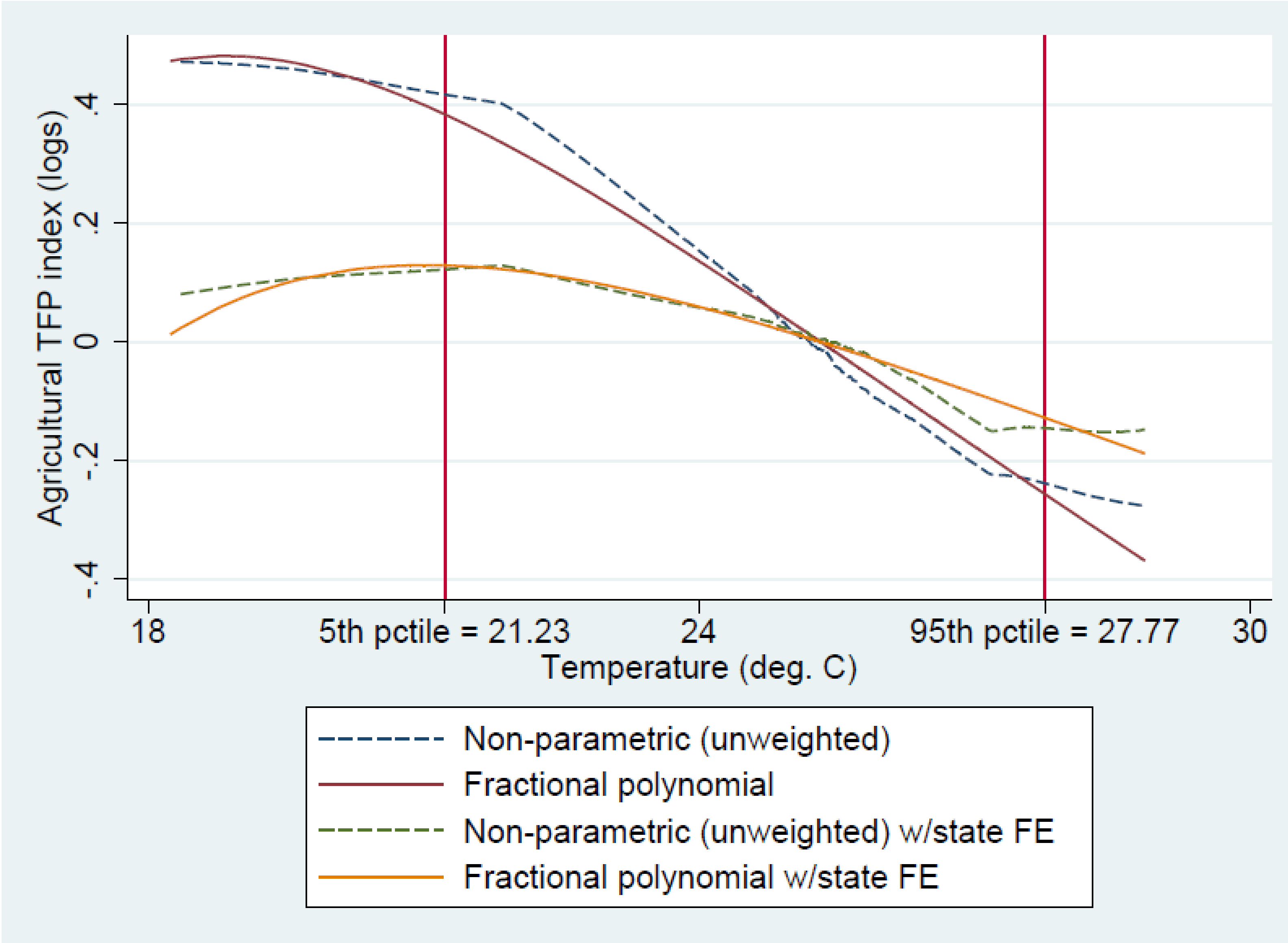


(b) Rainfall 1960-1999



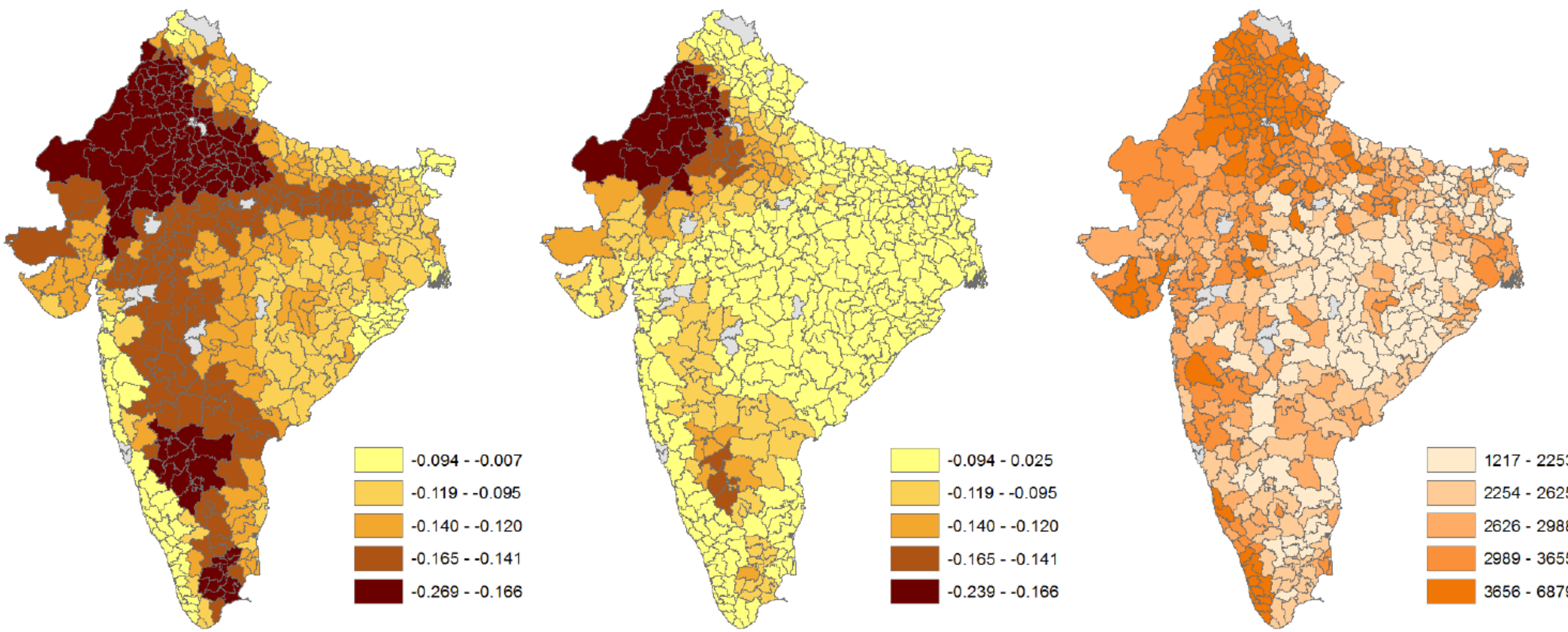
(c) Change in temperature 2039

Figure C.1: Climate and Predicted Temperature Change across 18 Major States of India



Note: Alternative estimates of the relationship between agricultural TFP (θ) and mean temperature (T).

Figure 1: Nonlinearities in Temperature

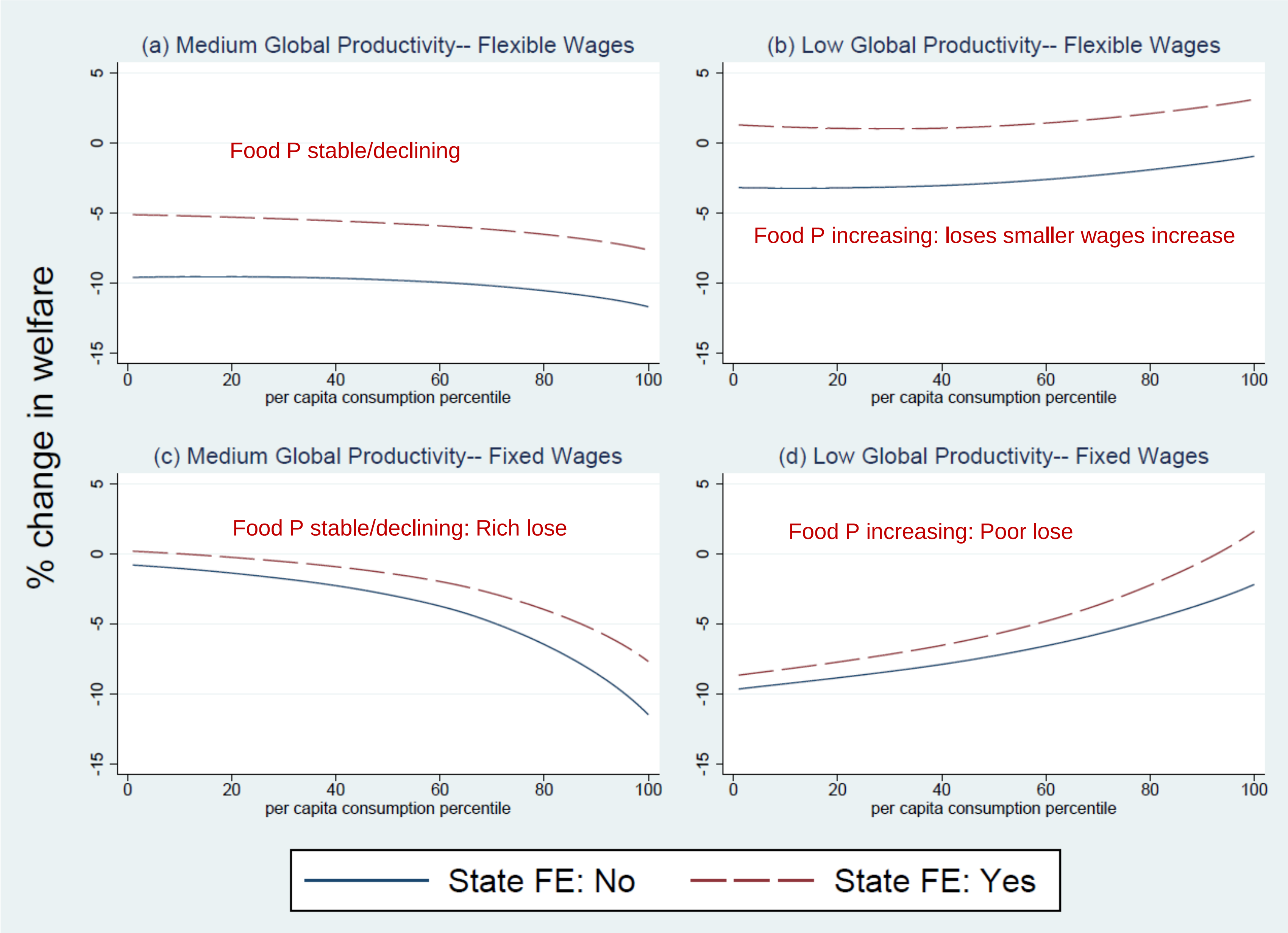


(a) $\widehat{\Theta}$ without State FE

(b) $\widehat{\Theta}$ with State FE

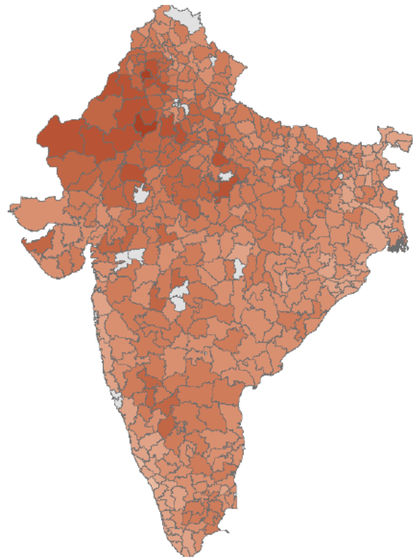
(c) Per-Capita Exp. (2005 Rupees)

Figure 5: TFP Shock ($\widehat{\Theta}$) and Mean Per-Capita Household Expenditures across 18 Major States of India

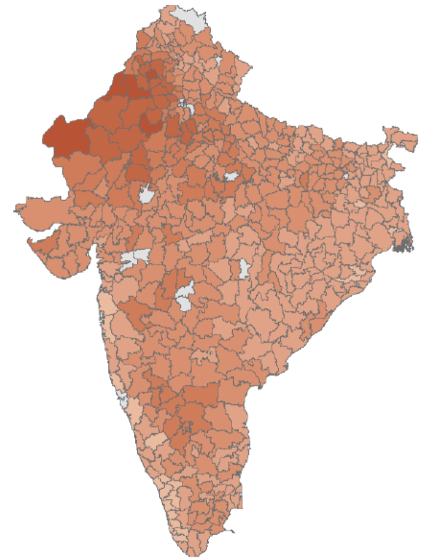


Note: Smoothed relationship between mean (within-percentile) predicted welfare change ($\widehat{m}_h$) and per-capita expenditure percentile.

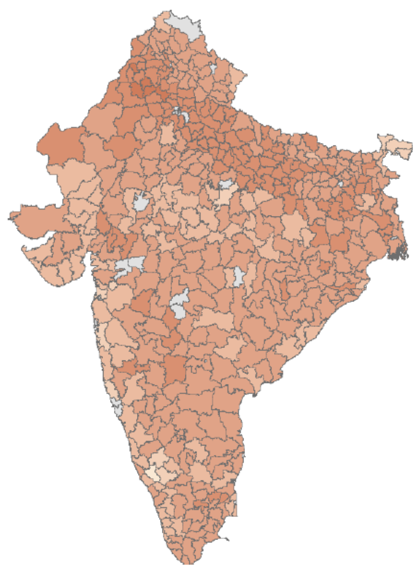
FIGURE 7: CLIMATE CHANGE INCIDENCE CURVES



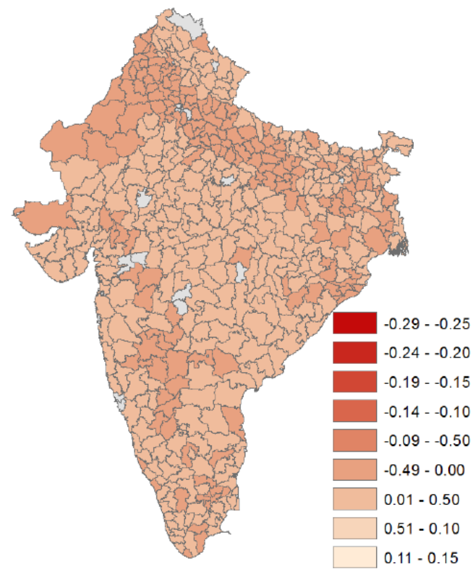
(a) Medium Global Productivity - No State FE



(b) Medium Global Productivity - State FE

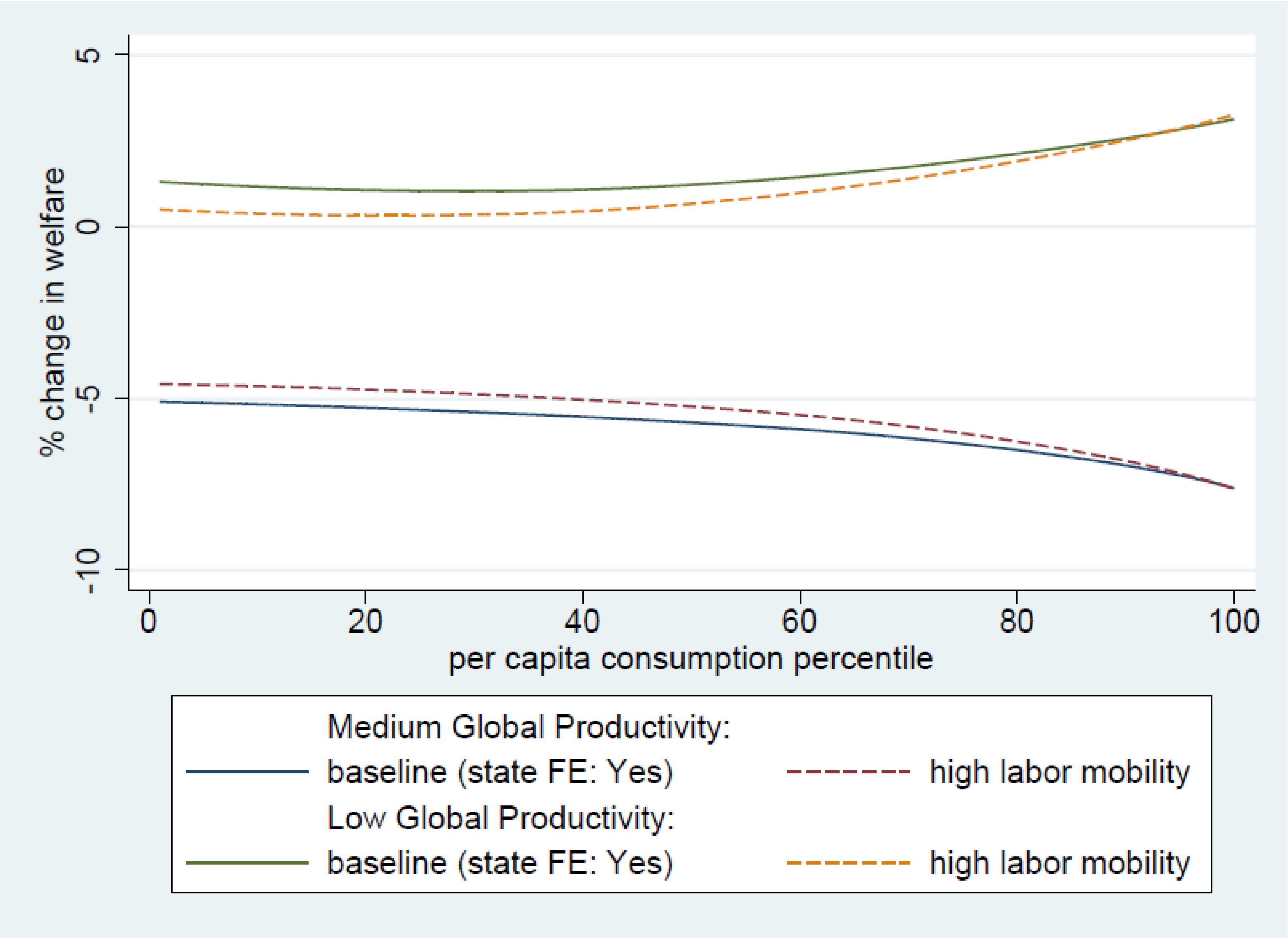


(c) Low Global Productivity - No State FE



(d) Low Global Productivity - State FE

Figure 9: Distribution of Welfare Changes ($\widehat{m}_h$) across 18 Major States of India



Note: Smoothed relationship between mean (within-percentile) predicted welfare change ($\widehat{m}_h$) and per-capita expenditure percentile under alternative assumptions about geographic labor mobility.

Figure 8: Robustness to Labor Mobility

Take-Aways

- 3 decades of warming will reduce agricultural productivity in the range of 7-13 percent, with the arid northwest of India especially hard-hit.
- The proportional welfare costs of climate change is likely to be both modest
- and evenly distributed across percentiles of the per-capita income distribution,
- but this latter conclusion emerges only when the flexibility of rural wages is taken into account.

THANK YOU

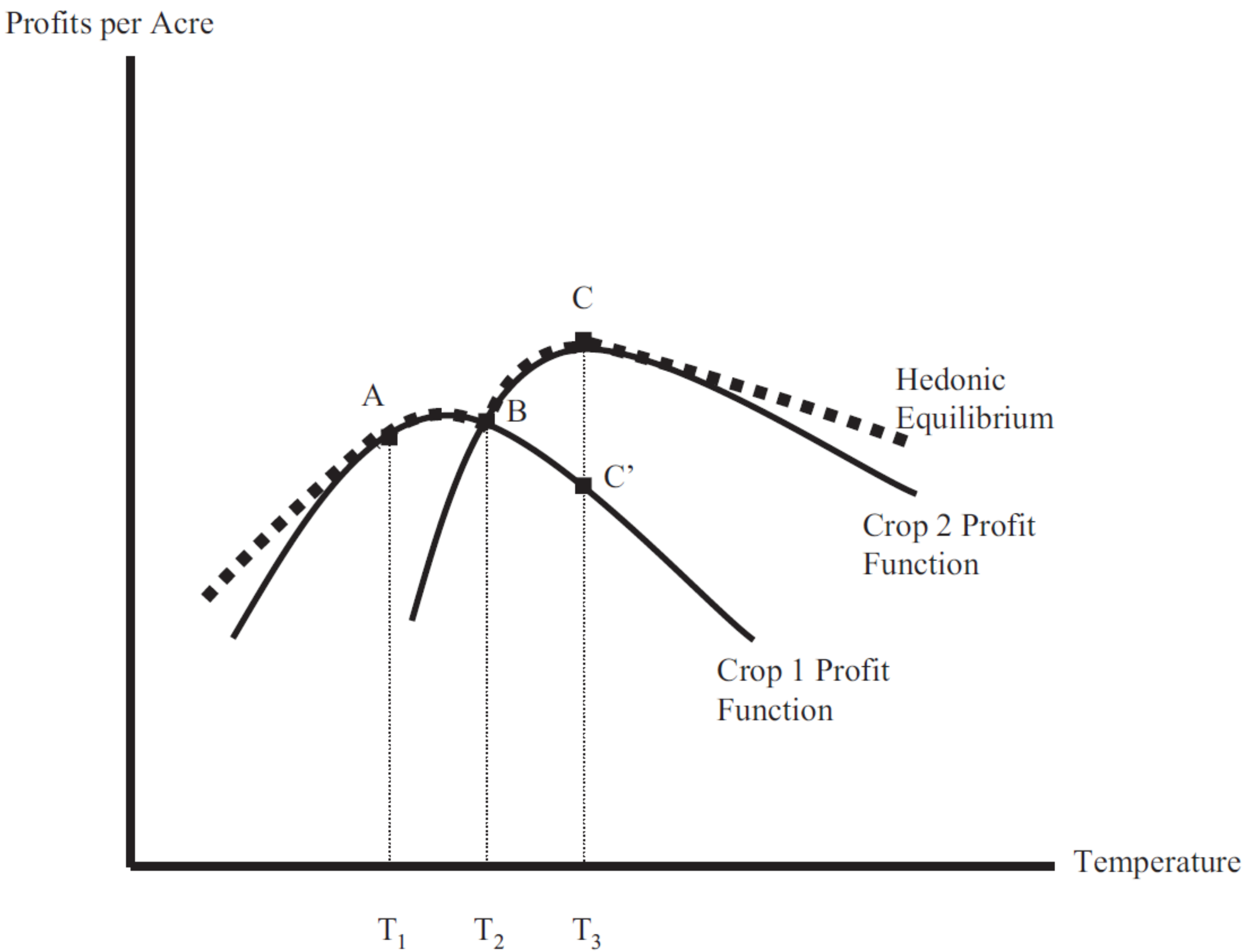
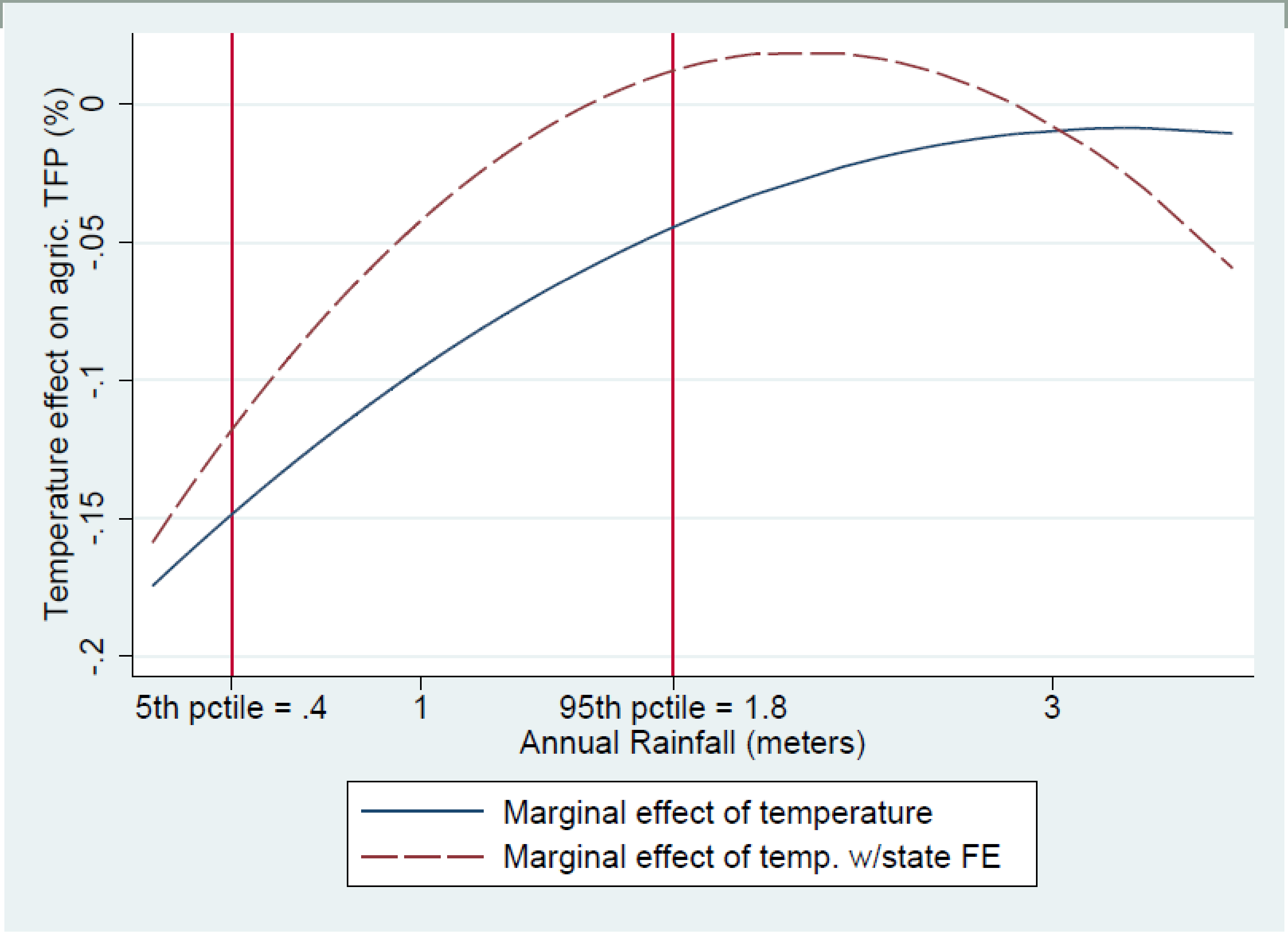
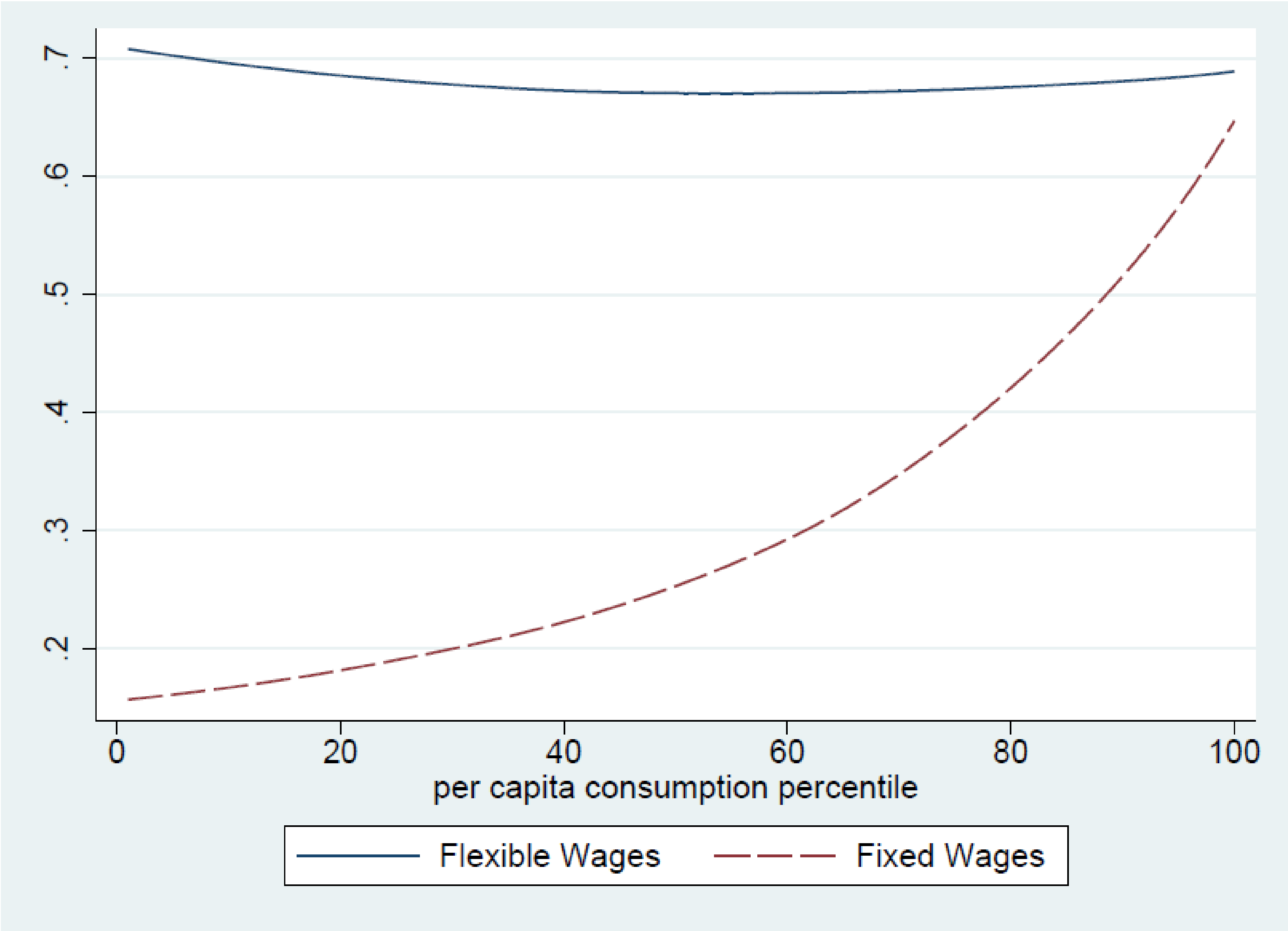


FIGURE 2. THEORETICAL RELATIONSHIP BETWEEN PROFITS PER ACRE AND TEMPERATURE



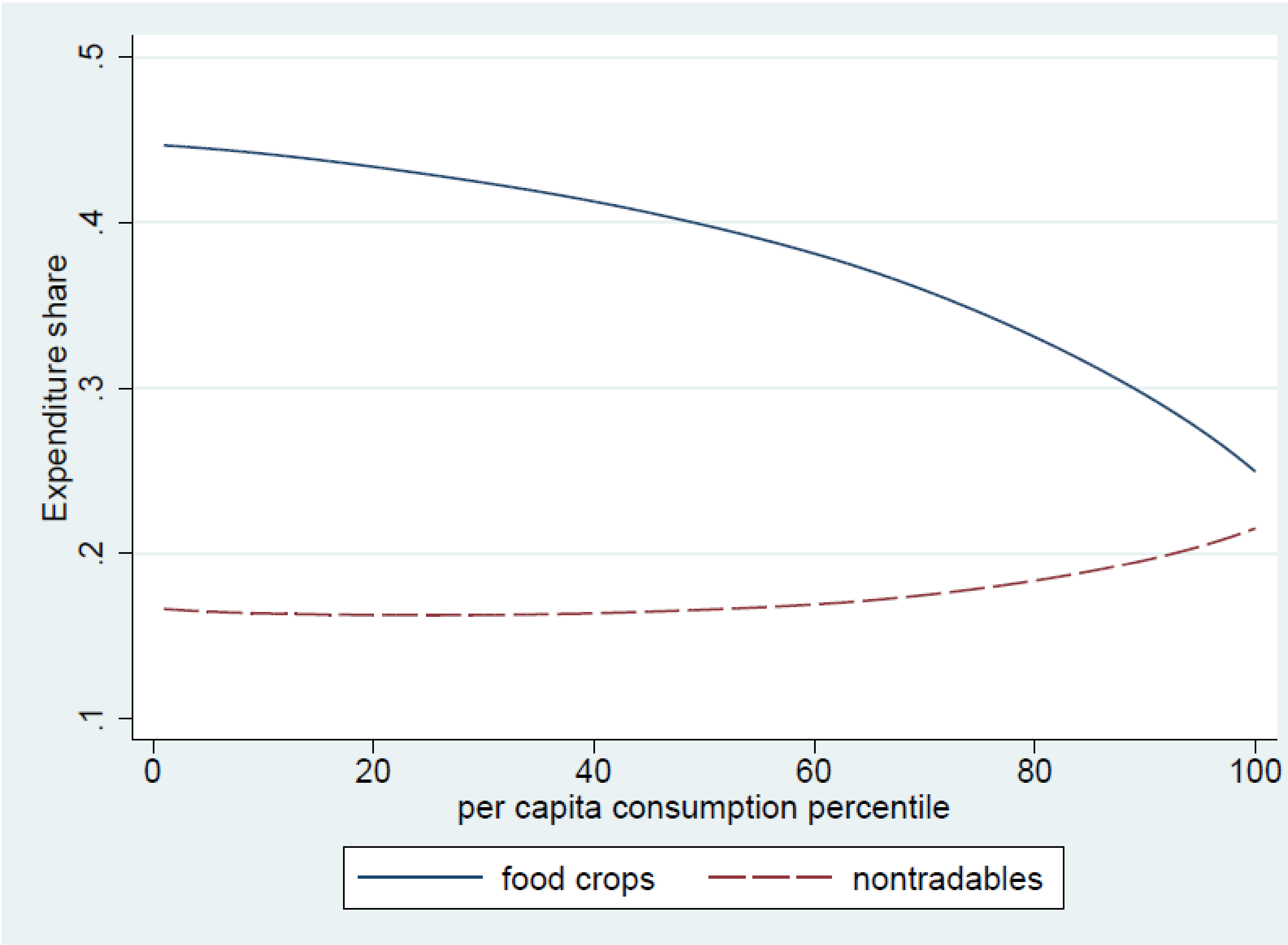
Note: Marginal effects of mean temperature (T) on agricultural TFP (θ) evaluated at different values of mean precipitation (P).

Figure 2: Marginal Effect of Temp. by Precip. Level



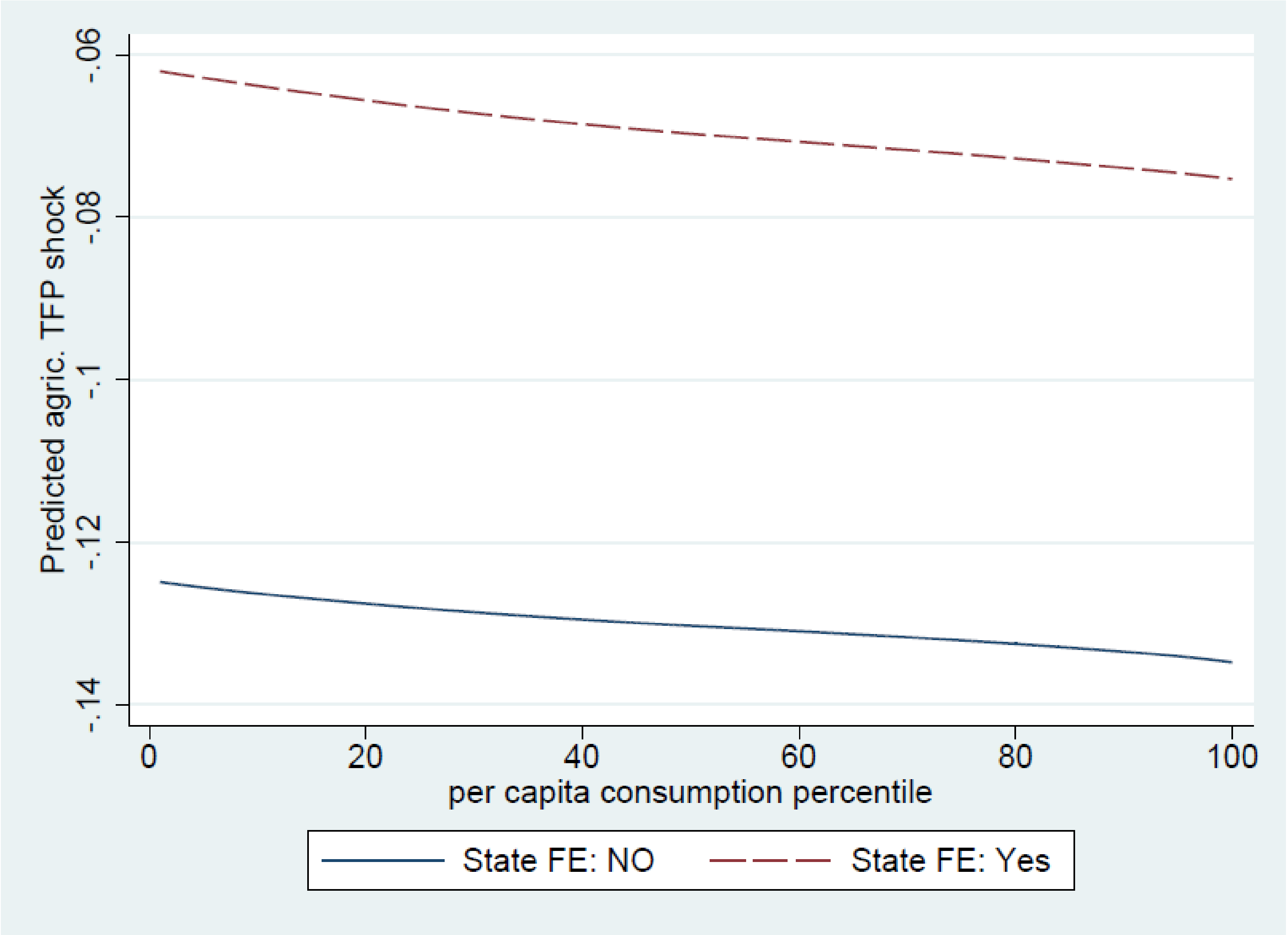
Note: Smoothed relationship between mean (within-percentile) Ω_h (elasticity of welfare w.r.t. agricultural productivity) and per-capita expenditure percentile under alternative assumptions about rural wage flexibility.

Figure 4: Distribution of Welfare-Productivity Elasticity (Ω_h)



Note: Smoothed relationship between mean (within-percentile) expenditure share and per-capita expenditure percentile.

Figure 3: Distribution of Expenditure Shares



Note: Smoothed relationship between mean (within-percentile) predicted agricultural TFP shock ($\widehat{\Theta}$) and per-capita expenditure percentile. Each household assigned shock corresponding to district of residence.

FIGURE 6: DISTRIBUTION OF $\widehat{\Theta}$