Seasonality in Food Prices and the Cost of a Nutritious Diet in Tanzania

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Tanzania is among the world’s poorest countries, whose population experiences severe deprivation including seasonal fluctuations in market prices and consumption of staple foods (Kaminski et al. 2016). Seasonality of food prices is widespread in Africa (Gilbert et al. 2017), and the resulting fluctuations in consumption have been linked to permanent deficits in health and human development (Christian and Dillion 2018).

Previous work has focused on seasonality in specific staples or in total food expenditure. Here we compare seasonality in the cost of calories to seasonality in the overall cost of a healthy diet, allowing for substitution between foods to meet nutrient needs (Masters et al. 2018). Measuring fluctuations in the affordability of nutrients beyond calories allows us to distinguish nutrition security from food security, identifying which foods contribute the most to seasonality in the cost of a nutritious diet.

Materials and Methods

The data used here are monthly prices for 46 distinct foods in local markets across 21 districts of Tanzania, observed from January 2011 through December 2015. Data were collected by field agents for the National Bureau of Statistics, for the purpose of monitoring inflation, poverty rates and national income.

Our method employs market prices to compute the Cost of Nutrient Adequacy (CoNA) at each time and place, using linear programming to identify the least-cost combination of foods needed to meet nutrient needs for comparison with the cost of meeting only daily energy needs, which we call the Cost of Caloric Adequacy (CoCA).

This identifies the difference in seasonality between the cost of day-to-day survival and the cost of adequate nutrients for long-run health in terms of protein plus 7 essential minerals (Calcium, Iron, Magnesium, Phosphorus, Zinc, Copper, Selenium) and 9 essential vitamins (A, C, E, Thiamin, Riboflavin, Niacin, B6, Folate, B12). On each month and location we calculate:

\[ \text{Cost of Nutrient Adequacy (CoNA)} = \min C_{\text{NA}} = \min \sum_{i} p_{i} q_{i} \quad \text{s.t.} \quad \sum_{i} \gamma_{i} q_{i} \geq EY \quad \text{and} \quad \sum_{i} q_{i} = E \]

(1)

\[ \text{Cost of Caloric Adequacy (CoCA)} = \min C_{\text{CA}} = \min \sum_{i} p_{i} q_{i} \quad \text{s.t.} \quad \sum_{i} q_{i} = E \]

(2)

where \( q_{i} \) is nutrient content in food \( i \) of nutrient \( j \), for 46 foods and 17 nutrients; \( E \) is nutrient requirement of nutrient \( j \), for an adult woman of reproductive age; and \( C_{\text{i}} \) is energy content of food \( i \), and \( E \) is daily energy needs of 2,000kcal per day.

To measure the seasonal component of month-to-month changes we use harmonic (trigonometric) regression:

\[ \text{Individual foods : } C_{\text{NA}}(t) = \alpha_{0} + \beta_{0} \sin(2\pi t/12) + \sum_{j} \beta_{j} \cos(2\pi j t/12) + \gamma q_{j} + \delta_{j} \]

(3)

\[ \text{Diet-cost indices : } \sum_{i} q_{i} = \alpha_{0} + \beta_{0} \sin(2\pi t/12) + \sum_{j} \beta_{j} \cos(2\pi j t/12) + \gamma Y + \delta \]

(4)

where \( \alpha_{0} \) is the cost of food \( i \) in region \( k \) at time \( t \) in a monthly time series, \( \alpha_{0} \) is the indexes of CoNA and CoCA in region \( k \) at time \( t \), \( \alpha_{0} \) is a constant equal to 1/12 indicating 12 months per annual cycle.

For overall diet costs there is significant seasonality in the Cost of Nutrient Adequacy (CoNA), but not in the Cost of Caloric Adequacy (CoCA).

Results

The food group with prices that have the sharpest seasonality is fruits and vegetables (F&V), whose prices peak just before harvest at the start of the dry season.

Figure 1. Seasonal variation in the cost of individual foods in 21 regions of Tanzania, 2011-15

For overall diet costs there is significant seasonality in the Cost of Nutrient Adequacy (CoNA), but not in the Cost of Caloric Adequacy (CoCA).

Figure 2. Seasonal variation of Cost of Nutrient Adequacy (CoNA) and Cost of Calorie Adequacy (CoCA) over 21 regions in Tanzania, 2011-15

Conclusions

This paper uses a novel combination of techniques to measure seasonality in a comprehensive list of food items and overall diet costs in Tanzania, with three important findings:

• Most food items display significant seasonality in retail prices. Fruits and vegetables (F&V) have the most extreme seasonality, with different seasonal peaks according to the harvesting time;

• The least-cost combination of foods needed to reach nutrient adequacy has significant seasonality, while the cost of calories as such fluctuates less predictably. Most regions within Tanzania face their peak cost of nutrient adequacy towards the end of the rainy season in March/April, but a few regions like Kilimanjaro have later peaks;

• Each region’s cost of nutritious diets is highly correlated with seasonality in prices of its nutrient dense F&V. This suggests a need for more targeted investments in market infrastructure for storage and transport of those foods among markets over time to lower and smooth the cost of healthier diets, alongside continued investments to meet daily energy needs in places with high food insecurity.

This finding is specific to the types of prices used, which are collected at the principal food markets in each region. Seasonal scarcity at even more remote locations is likely to be even more severe, for which additional data on local prices would be needed.

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