If You Fix it, They Will Come

Exploring relationships between seasonal travel time to markets and prevalence of underweight in Ethiopian children

Introduction

Ethiopia is a landlocked country located in the horn of Africa. It typically has a tropical climate, with a rainy season occurring from June to September. In 1997, the Ethiopian Road Authority (ERA) embarked on an ambitious Road Sector Development Programme, aimed at restoring and expanding the existing road network. Part of the focus of the program was to improve rural roads, with objectives of providing access to areas that had agricultural potential, and areas that were considered to have a deficit of food, and areas that were neglected. As over 81% of Ethiopians were rural in 2013, the potential impact of improving rural roads was great.

This program showed impressive progress by 2009, with the proportion of rural roads in good condition increasing to 50% from 21% at program start.

The purpose of this analysis is to determine if a decrease in access to markets in the rainy season is correlated with underweight. This analysis identifies areas that essentially lose access to markets during the rainy season due to the condition of the roads, which can be used to infer the ERA of roads that, if improved, would have a large impact on the health of households in those areas.

Methods

Four components were used to estimate the amount of time it takes to travel from each household to the nearest market: roads, land cover, market locations, and household locations. The data for roads and land cover included distinct categories of road and land cover type, and are listed in Table 1 with the estimated average travel speed during the dry and rainy seasons. A cost-distance analysis was then performed, calculating the travel time to the nearest market. Travel time during the dry and rainy seasons were extracted from this analysis and plotted with underweight data collected in the corresponding season. The dataset of households used in this analysis was obtained from the ENGINE study, which provided anthropometric measurements of children and geographic location for each household.

Results

The underlying context for this analysis is shown in Figure 3, including locations of markets, road type, and land cover type. Household locations were clustered in small areas, therefore a single household location was used for each household in the analysis. Figure 4 displays the travel time to the nearest market during the dry season, while Figure 5 displays rainy season travel time, taking into account the decrease in speed and road availability discussed in the methods section. This time was categorized into groups and displayed in Table 2, showing the number and percent of households in each time category, for each season.

According to this analysis, the mean travel time during the dry season is 2.3 hours and the majority of households need less than 1 hour to travel to the closest market. The rainy season analysis resulted in a mean travel time of 8.9 hours, with the majority of households requiring over 12 hours to travel to the closest market.

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Travel times in both seasons were extracted and plotted with underweight data for children under five in these households. Figure 6 shows the relationship between dry season travel time and underweight z-scores, while Figure 7 shows the relationship between rainy season travel time and underweight z-scores. Paired t-tests were conducted using Stata, and were used to determine the statistical significance of seasonal variation. This resulted in statistically significant p-values for travel time during the rainy season and underweight z-score at the 95% confidence level, indicating significantly higher travel time and lower underweight z-score during the rainy season.

A map displaying the difference in travel time was created using the raster calculator tool; reference Figure 8. The mean difference in travel time between seasons is 6.7 hours, however the majority of households only need less than 1 additional hour to travel to the closest market during the rainy season, compared to the dry season.

Limitations

The locations of markets were one noteworthy limitation of this analysis. Market locations were not well documented and informal markets that were not included in this analysis undoubtedly exist. However, because not all market locations are known, this analysis combined two reputable datasets of known markets, supplemented with locations of settlements. Previous work used locations of settlements over 5,000 people as a proxy for markets, as a settlement of this size would create high enough demand for agricultural and livestock products to generate informal markets in the absence of a more formal market location.

Another limitation is how speeds were assigned to roads and land cover. The model assumed that households used a motorized vehicle to travel and were walking over land, however a more comprehensive model would consider other means of travel, including motorcycle, horse or horse-drawn carts, bicycle, etc. Though defining road and land cover speeds would be difficult, the vast majority of Ethiopians do not own a car thus including alternative travel methods would provide a more accurate analysis.

Finally, the results of this analysis are not generalizable to the overall population in Ethiopia since only ENGINE households were included in the analysis. However, the same analysis could be done using fine-grain population density in place of ENGINE household locations. An analysis using population density would help determine which areas would be most impacted by construction of new and restoration of existing roads, making this a valuable decision-making aid and an effective tool for resource allocation.

References and Data Sources

Table 1. Road type and land cover speed assignments in dry and rainy seasons

<table>
<thead>
<tr>
<th>Road type</th>
<th>Speed (km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All-weather (asphalt)</td>
<td>80</td>
</tr>
<tr>
<td>All-weather (gravel)</td>
<td>45</td>
</tr>
<tr>
<td>Dry-weather roads</td>
<td>30</td>
</tr>
<tr>
<td>Movable tracks (status unknown)</td>
<td>30</td>
</tr>
</tbody>
</table>

Table 2. Underweight z-scores by travel time category

<table>
<thead>
<tr>
<th>Travel time (hours)</th>
<th>No.</th>
<th>%</th>
<th>Difference (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1 hour</td>
<td>499</td>
<td>48.0</td>
<td>181 17.8</td>
</tr>
<tr>
<td>1 to 3 hours</td>
<td>275</td>
<td>27.0</td>
<td>183 17.9</td>
</tr>
<tr>
<td>3 to 6 hours</td>
<td>147</td>
<td>14.4</td>
<td>106 10.4</td>
</tr>
<tr>
<td>6 to 12 hours</td>
<td>92</td>
<td>9.0</td>
<td>274 26.9</td>
</tr>
<tr>
<td>More than 12 hours</td>
<td>7</td>
<td>0.7</td>
<td>276 27.1</td>
</tr>
</tbody>
</table>

Tables and figures referenced:
- Figure 1: Location of Ethiopia and study area
- Figure 2: Methodology
- Figure 3: Contextual map of study area
- Figure 4: Map of travel time to markets in the dry season
- Figure 5: Map of travel time to markets in the rainy season
- Figure 6: Scatterplot of underweight and travel time in the dry season
- Figure 7: Scatterplot of underweight and travel time in the rainy season
- Figure 8: Map of travel time difference between dry and rainy seasons

Graphs and tables can be found in the supplementary materials.