**Appendix A**

*A1. Benefits by tier based on model parameterization*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Table A1**. Benefits from reaching each tier | | | | |
| Tier 1 | Tier 2 | Tier 3 | Tier 4 | Tier 5 |
| * Lighting * Phone charging * Emissions * Radio\* | * Phone charging\*\* * Study time (G)\* * Fan * TV * Refrigerator | * Study time (B)\* * TV * Refrigerator | * TV * Business expenditures related to power outages | * Study time (G)\* * TV\* |
| *Notes:* Source authors’ calculations using data from Luzi et al. (2020). \*Benefit accrued to urban households only; \*\*Benefit accrued to rural households only. | | | | |

*A2. Parameters used for Electrified EAD*

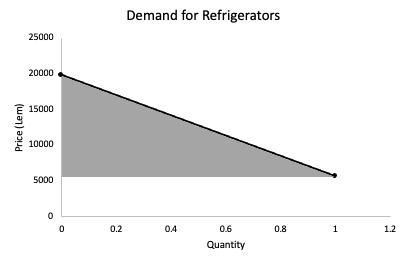
|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Table A2**. Parameters used for Electrified EAD | | | | | |
| **Parameter description** | **Units** | **Value used** | | **Method** | **Data Source** |
| **U** | **R** |
| Change in kerosene | l/year |  | -18.36 | Estimated by regression | Luzi et al. (2020) |
| Change in cell phone charging | L/month | -0.87 | -24.59 | Estimated by regression | Luzi et al. (2020) |
| Change in study time (girls) | minutes/day |  |  | Estimated by regression | Luzi et al. (2020) |
| Change in study time (boys) | minutes/day |  |  | Estimated by regression | Luzi et al. (2020) |
| Change in radio ownership | Radios | 0.20 |  | Estimated by regression | Luzi et al. (2020) |
| Change in fan ownership | Fans | 0.34 | 0.34 | Estimated by regression | Luzi et al. (2020) |
| Change in TV ownership | TVs | 0.77 | 0.44 | Estimated by regression | Luzi et al. (2020) |
| Change in refrigerator ownership | refrigerators | 0.60 | 0.41 | Estimated by regression | Luzi et al. (2020) |
| Change in income loss | L/month |  |  | Estimated by regression | Luzi et al. (2020) |
| *Notes:* Any parameters not listed in this table take the value of parameters used for all other EAD calculations available in Table 2. | | | | | |

*A3. Regression results*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***Table A3****. Regression results* | | | | | | |
|  | (1) | (2) | (3) | (4) | (5) | (6) |
|  | Tier 0 to Tier 1 | Tier 1 to Tier 2 | Tier 2 to Tier 3 | Tier 3 to Tier 4 | Tier 4 to Tier 5 | Binary |
| *Panel A: Annual kerosene consumption (liters)* | | | | | | |
| Higher tier | -16.41\*\*\* | 0.53 | 0.04 | 0.86 | 5.26 | -18.36\*\*\* |
|  | (4.57) | (1.63) | (1.73) | (3.11) | (7.11) | (6.87) |
| Higher tier X Urban | 12.00\*\* | 1.63 | -0.28 | -0.84 | -1.24 | 18.72\*\*\* |
|  | (5.78) | (2.21) | (1.99) | (3.10) | (7.18) | (6.67) |
| Observations | 532 | 175 | 844 | 976 | 1217 | 2582 |
| R2 | 0.02 | 0.04 | 0.02 | 0.02 | 0.002 | 0.01 |
| *Panel B: Monthly expenditures on cell phone charging outside the home (Lempiras)* | | | | | | |
| Higher tier | -15.65\*\* | -8.38\*\* | N/A | N/A | N/A | -24.59\*\*\* |
|  | (6.66) | (3.39) |  |  |  | (6.29) |
| Higher tier X Urban | 19.67 | 9.45\*\* |  |  |  | 23.72\*\*\* |
|  | (11.92) | (3.79) |  |  |  | (6.52) |
| Observations | 523 | 175 |  |  |  | 2582 |
| R2 | 0.08 | 0.07 |  |  |  | 0.09 |
| *Panel C: Daily study time among girls (minutes)* | | | | | | |
| Higher tier | -2.14 | 21.32 | 8.97 | 1.77 | -24.20 | 0.16 |
|  | (13.29) | (13.53) | (18.11) | (19.57) | (17.16) | (9.67) |
| Higher tier X Urban | -31.36 | 53.97\*\*\* | -40.27 | -20.54 | 30.86\* | 16.51 |
|  | (24.92) | (19.52) | (28.96) | (22.50) | (18.04) | (19.03) |
| Observations | 244 | 65 | 295 | 334 | 402 | 920 |
| R2 | 0.06 | 0.35 | 0.05 | 0.06 | 0.08 | 0.05 |
| *Panel D: Daily study time among boys (minutes)* | | | | | | |
| Higher tier | 7.39 | 5.16 | -4.60 | 13.73 | 0.49 | 2.37 |
|  | (15.03) | (14.44) | (15.20) | (17.72) | (18.58) | (10.69) |
| Higher tier X Urban | -28.61 | -40.77\* | 60.34\*\*\* | 2.06 | -9.03 | -16.06 |
|  | (35.12) | (23.69) | (19.76) | (21.67) | (23.05) | (39.27) |
| Observations | 235 | 66 | 287 | 344 | 433 | 953 |
| R2 | 0.07 | 0.30 | 0.11 | 0.09 | 0.08 | 0.04 |
| *Panel E: Number of radios* | | | | | | |
| Higher tier | 0.10 | -0.07 | 0.04 | 0.04 | -0.01 | 0.08 |
|  | (0.09) | (0.13) | (0.10) | (0.08) | (0.07) | (0.06) |
| Higher tier X Urban | 0.29\* | -0.15 | -0.02 | -0.12 | 0.15 | 0.20\*\* |
|  | (0.15) | (0.18) | (0.13) | (0.10) | (0.14) | (0.08) |
| Observations | 523 | 175 | 844 | 976 | 1217 | 2582 |
| R2 | 0.05 | 0.05 | 0.06 | 0.05 | 0.06 | 0.06 |
| *Panel F: Number of fans* | | | | | | |
| Higher tier | -0.01 | 0.36\*\*\* | 0.23 | -0.05 | -0.10 | 0.34\*\*\* |
|  | (0.02) | (0.10) | (0.14) | (0.19) | (0.11) | (0.08) |
| Higher tier X Urban | 0.01 | 0.40\* | -0.24 | 0.27 | -0.07 | 0.27 |
|  | (0.18) | (0.24) | 0.37 | (0.30) | (0.21) | (0.23) |
| Observations | 523 | 175 | 844 | 976 | 1217 | 2582 |
| R2 | 0.13 | 0.39 | 0.11 | 0.10 | 0.23 | 0.22 |
| *Panel G: Number of TVs* | | | | | | |
| Higher tier | -0.06 | 0.68\*\*\* | -0.11 | 0.31\* | -0.29\* | 0.45\*\*\* |
|  | (0.04) | (0.08) | (0.13) | (0.17) | (0.16) | (0.06) |
| Higher tier X Urban | 0.37 | -0.65 | 0.53\*\*\* | -0.20 | 0.34\* | 0.33\*\* |
|  | (0.42) | (0.43) | (0.20) | (0.18) | (0.20) | (0.14) |
| Observations | 523 | 175 | 844 | 976 | 1217 | 2582 |
| R2 | 0.12 | 0.35 | 0.33 | 0.26 | 0.20 | 0.32 |
| *Panel H: Number of refrigerators* | | | | | | |
| Higher tier | -0.01 | 0.25\*\*\* | 0.37\*\*\* | -0.02 | -0.02 | 0.41\*\*\* |
|  | (0.02) | (0.07) | (0.11) | (0.07) | (0.05) | (0.05) |
| Higher tier X Urban | -0.02 | 0.18 | -0.04 | 0.07 | 0.09 | 0.19\*\*\* |
|  | (0.09) | (0.13) | (0.19) | (0.09) | (0.12) | (0.06) |
| Observations | 523 | 175 | 844 | 976 | 1217 | 2582 |
| R2 | 0.09 | 0.28 | 0.17 | 0.11 | 0.09 | 0.18 |
| *Panel I: Extra operating expenses (Lempiras)* | | | | | | |
| Higher tier | -55.15 | 8.63 | -12.83 | -93.48\*\* | 10.34 | 10.05 |
|  | (52.31) | (8.16) | (53.76) | (43.60) | (7.34) | (15.89) |
| Higher tier X Urban |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| Observations | 523 | 175 | 844 | 976 | 1217 | 2582 |
| R2 | 0.11 | 0.11 | 0.01 | 0.01 | 0.01 | 0.01 |
| *Table notes:* Standard errors, clustered at the municipality level, in parentheses. For Columns (1)-(5), “Higher tier” refers to the higher tier in the household subsample (i.e., an indicator for Tier 1 households in Column (1)). For column (6), “Higher tier” refers to households with electricity (i.e., an indicator for electricity access). All regressions control for gender and age of the household head, household size, number of children under the age of five, annual household income, a household asset index, and an urban indicator. Regressions are weighted using probability weights. N/A indicates insufficient observations to estimate the regression. Asterisks denote statistical significance: \*p<0.10, \*\*p<0.05, \*\*\*p<0.01 | | | | | | |

**Appendix B**

**Figure B1**. Consumer surplus estimation



|  |  |  |
| --- | --- | --- |
| **Figure B2**. Urban and rural EAD comparisons across electrification scenarios | | |
|  | Baseline 1 (Slow tier progression) | Baseline 2 (Fast tier progression) |
| Scenario 1  Tier 5 EAD |  |  |
| Scenario 2  Tier 3 EAD |  |  |
| Scenario 3  Hybrid EAD |  |  |

**Figure B3**. Distribution of benefit categories in the EAD using Baseline 2

**A graph of different colored bars

Description automatically generated**

**Appendix C**

*Back-of-the-envelope cost comparisons*

We provide some indicative cost calculations to facilitate comparison of the costs and benefits of electrification in the Honduran case. Considering household level costs, which are partly subsidized and, therefore, incomplete, households face both initial fixed costs of electrification (connection and wiring costs) as well as monthly use fees. Just as with the benefits estimation, additional costs could be considered depending on the context and data availability. Based on the 2017 MTF survey for Honduras, for grid-based electricity, the median Honduran household faces a one-time connection fee of $17.39 along with other fixed connection costs (primarily wiring) of $108.70, for a combined fixed connection investment of approximately $126 (Luzi et al., 2020). These connection costs exclude transmission and distribution infrastructure investment costs that may be required to reach households, as these are incurred by the government or private providers. In addition, the median electrified household in Honduras pays about $14.35 per month for electricity use (Luzi et al., 2020). Applying these values over the 2021-2050 time horizon used in the EAD calculations suggests that the median electrified household will allocate a present value of $2905 towards electricity access over the next three decades. The benefits included in the Tier 5 EAD suggest a present value of electricity benefits of $2098 and $1704 for urban and rural households, respectively, over this same time horizon.

Comparing the EAD and these illustrative cost estimates suggests that costs may outweigh benefits in this case. This could explain, at least in areas where grid connections are technically feasible, why some Honduran households remain unelectrified. However, on the modeling side, there may be other benefits to electrification, over and above those included in the Honduran case study presented in this paper, that would alter the net benefits calculation. This points to future research to further refine the EAD across contexts to incorporate additional benefits of electrification—such as health, productivity, or additional assets, among others—to make EAD calculations contextually appropriate and when data allow for accurate valuation. Moreover, there are many other objectives at play in electrification decisions that go beyond simple economic efficiency, including political objectives and fairness and justice arguments about the need to provide a certain level of basic services to the entire population.

There are a wide range of estimates of the investments needed to expand electricity access. These estimates vary across and within countries, and specific data on connection costs are limited. In Africa, for example, grid expansion has been estimated to cost $800-4600 per connection, depending on geography and remoteness (Levin and Thomas, 2016). Minigrids generally offer a cheaper option for connection, with connection costs ranging from $1000-2100 (Energy Sector Management Assistance Program, 2019). For household-level infrastructure, solar home systems capable of providing a tier 1-2 electrification experience cost approximately $150 and are typically paid for in installments over 6-36 months, with up-front deposits of 10-25 percent. Larger systems with batteries that can power refrigerators and other appliances requiring uninterrupted power can cost up to $1,000 (Dahlke, 2011; IRENA, 2020).

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