**Table 1. Summary statistics of 2010 and 2013 Malawi food security measures and predictors for both household and cluster levels.** Ranges of possible values are in parentheses in column 1. Higher rCSI values indicates lower food security; lower HDDS and FCS values indicate lower food security. The 2010-11 LSMS sample is representative for each month and each district. The 2013 food security measures are used for the out-of-sample predictions. We present the cluster average of the household-level variables, which includes food security measures and asset measures.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | | Year 2010 (12270 households) | | | | | Year 2013 (3999 households) | | | |
| Variable | Mean | Median | Std. Dev. | | Min | Max | Mean | Median | | Std. Dev. | Min | Max |
| Household logFCS (0-4.72) | 3.82 | 3.83 | 0.37 | | 1.1 | 4.72 | 3.91 | 3.91 | | 0.36 | 2.2 | 4.72 |
| Household rCSI (0-42) | 3.68 | 0 | 6.51 | | 0 | 42 | 4.23 | 0 | | 6.95 | 0 | 42 |
| Household HDDS (0-12) | 5.18 | 5 | 1.27 | | 1 | 7 | 5.56 | 6 | | 1.15 | 1 | 7 |
|  | | | | Year 2010 (768 clusters) | | | | | Year 2013 (204 clusters) | | | |
| Cluster mean logFCS | 3.87 | 3.86 | 0.21 | | 3.23 | 4.53 | 3.96 | 3.95 | | 0.18 | 3.45 | 4.49 |
| Cluster mean rCSI | 3.68 | 2.88 | 3.05 | | 0.00 | 17.25 | 4.26 | 3.70 | | 2.66 | 0.00 | 16.28 |
| Cluster mean HDDS | 5.18 | 5.19 | 0.70 | | 3.00 | 6.75 | 5.55 | 5.55 | | 0.57 | 4.10 | 6.86 |
| Total rainfall (meters) | 1.00 | 0.99 | 0.18 | | 0.57 | 1.58 | 0.93 | 0.90 | | 0.17 | 0.59 | 1.58 |
| First day of rain | 45.02 | 41.00 | 10.25 | | 3.00 | 72.00 | 53.36 | 51.00 | | 13.26 | 30.00 | 72.00 |
| Max days without rain | 23.76 | 21.00 | 8.14 | | 10.00 | 52.00 | 24.30 | 24.00 | | 6.75 | 12.00 | 43.00 |
| Rainfall in flood prone regions (meters) | 2.04 | 0.00 | 9.66 | | 0.00 | 75.97 | 1.11 | 0.00 | | 7.34 | 0.00 | 69.15 |
| Number of cellphones owned | 0.60 | 0.44 | 0.60 | | 0.00 | 4.13 | 0.94 | 0.70 | | 0.71 | 0.05 | 4.40 |
| Maize price (log form) | 3.34 | 3.41 | 0.39 | | 2.40 | 5.19 | 4.46 | 4.50 | | 0.26 | 2.77 | 5.05 |
| Market thinness | 0.46 | 0.49 | 0.29 | | 0.00 | 1.00 | 0.27 | 0.25 | | 0.16 | 0.00 | 1.00 |
| Percent of non-natural roof | 0.36 | 0.49 | 0.25 | | 0.00 | 1.00 | 0.46 | 0.40 | | 0.27 | 0.00 | 1.00 |
| Household size | 4.56 | 4.56 | 0.68 | | 2.31 | 7.06 | 5.00 | 4.89 | | 0.72 | 3.58 | 7.53 |
| Household age | 42.15 | 42.06 | 4.65 | | 30.81 | 56.38 | 42.56 | 42.37 | | 4.06 | 33.63 | 56.19 |
| Household gender (1 for male, 2 for female) | 1.24 | 1.25 | 0.12 | | 1.00 | 1.69 | 1.23 | 1.22 | | 0.10 | 1.00 | 1.50 |
| Asset Index | 0.00 | -0.02 | 0.35 | | -0.83 | 1.05 | -0.02 | -0.30 | | 0.54 | -0.30 | 2.94 |
| Distance to road (km) | 8.37 | 4.36 | 10.15 | | 0.07 | 56.19 | 7.68 | 4.18 | | 8.40 | 0.06 | 44.68 |
| Distance to admarc market (km) | 8.06 | 6.56 | 5.77 | | 0.38 | 37.32 | 7.81 | 6.24 | | 5.04 | 1.20 | 32.89 |
| Percentage of agricultural land | 0.36 | 0.49 | 0.25 | | 0.00 | 1.00 | 0.34 | 0.41 | | 0.22 | 0.00 | 0.75 |
| Nutrition retention constrained | 0.28 | 0.00 | 0.44 | | 0.00 | 1.00 | 0.26 | 0.05 | | 0.38 | 0.00 | 1.00 |
| Elevation (km) | 0.87 | 0.90 | 0.35 | | 0.04 | 1.73 | 0.94 | 1.02 | | 0.29 | 0.12 | 1.55 |
| IPC Value (1 month lag) | 1.17 | 1.00 | 0.40 | | 1.00 | 3.00 | 1.08 | 1.00 | | 0.22 | 1.00 | 3.00 |

**Table 2: Regression results for each food security measure using 2010 LSMS data for Malawi confirms that food security measures are associated with common drivers.** The results are estimated at the cluster-level and include predictors from all Class 1 + Class 2 + Class 3. Standard errors are presented in parentheses and asterisks indicate level of statistical significance of coefficients where three asterisks indicate 1%; two indicate 5% and one indicates 10%.

|  |  |  |  |
| --- | --- | --- | --- |
| |  |  |  | | --- | --- | --- | | logFCS | HDDS | rCSI | |

|  |  |  |  |
| --- | --- | --- | --- |
| IPC Value (Previous month) | -0.023 | -0.081\* | 2.223\*\*\* |
|  | (0.015) | (0.047) | (0.274) |
| Total rainfall during rainy season | 0.104\*\*\* | 0.101 | -1.302\*\* |
|  | (0.032) | (0.103) | (0.598) |
| First day of rain | -0.001 | -0.002 | 0.017\* |
|  | (0.001) | (0.002) | (0.010) |
| Maximum days without rain | -0.0005 | -0.005\*\* | -0.047\*\*\* |
|  | (0.001) | (0.002) | (0.013) |
| Maize price | -0.001\*\* | -0.002\* | 0.025\*\*\* |
|  | (0.0004) | (0.001) | (0.007) |
| Maize Market Thinness | -0.010 | -0.085 | -0.272 |
|  | (0.017) | (0.055) | (0.317) |
| Percent of agricultural land | 0.011 | 0.034 | -0.117 |
|  | (0.020) | (0.066) | (0.382) |
| Elevation | -0.060\*\*\* | -0.048 | -1.216\*\*\* |
|  | (0.018) | (0.060) | (0.346) |
| Soil nutrient retention constrained | -0.014 | -0.079\*\* | 0.509\*\* |
|  | (0.012) | (0.040) | (0.229) |
| Distance to nearest road | -0.002\*\*\* | -0.010\*\*\* | -0.018\* |
|  | (0.001) | (0.002) | (0.010) |
| Distance to nearest admarc market | 0.003\*\*\* | 0.005\* | -0.007 |
|  | (0.001) | (0.003) | (0.017) |
| Roof type | 0.111\*\*\* | 0.572\*\*\* | 0.158 |
|  | (0.029) | (0.093) | (0.537) |
| Number of cellphones owned | 0.143\*\*\* | 0.332\*\*\* | -1.084\*\*\* |
|  | (0.014) | (0.046) | (0.266) |
| Household size | -0.015\* | -0.041 | 0.631\*\*\* |
|  | (0.008) | (0.025) | (0.146) |
| Household age | -0.003\*\* | -0.015\*\*\* | -0.016 |
|  | (0.001) | (0.004) | (0.021) |
| Household gender | -0.040 | 0.064 | 0.445 |
|  | (0.043) | (0.138) | (0.799) |
| Asset index | 0.123\*\*\* | 0.462\*\*\* | -0.704\*\* |
|  | (0.017) | (0.055) | (0.317) |
| Quarter 1 | -0.059\*\*\* | -0.193\*\*\* | -0.169 |
|  | (0.015) | (0.048) | (0.276) |
| Quarter 2 | -0.012 | -0.048 | -0.166 |
|  | (0.016) | (0.053) | (0.304) |
| Quarter 3 | 0.007 | -0.057 | -1.121\*\*\* |
|  | (0.013) | (0.043) | (0.248) |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  | | --- | --- | --- | --- | | Observations | 760 | 760 | 760 | | R2 | 0.605 | 0.623 | 0.337 | |

**Table 3: IPC value regression results indicate that the IPC is significantly associated with food insecurity but the explanatory power (R-squared) is quite low.** Standard errors are presented in parentheses and asterisks indicate level of statistical significance of coefficients where three asterisks indicate 1%; two indicate 5% and one indicates 10%.

|  |  |  |  |
| --- | --- | --- | --- |
|  | (1) | (2) | (3) |
|  | IPC Value | IPC Value | IPC Value |
| rCSI | 0.055\*\*\* |  |  |
|  | (0.004) |  |  |
|  |  |  |  |
| logFCS |  | -0.282\*\*\* |  |
|  |  | (0.069) |  |
|  |  |  |  |
| HDDS |  |  | -0.087\*\*\* |
|  |  |  | (0.021) |
|  |  |  |  |
| Constant | 0.963\*\*\* | 2.255\*\*\* | 1.616\*\*\* |
|  | (0.021) | (0.267) | (0.109) |
| Observations | 760 | 760 | 760 |
| R2 | 0.175 | 0.022 | 0.023 |

**Table 4: The percentage of food insecure clusters correctly predicted to be food insecure.** The results are out of sample predictions at the food insecure category in 2013. They are estimated at the cluster-level, using only the IPC value and include predictors from all Class 1 + Class 2 + Class 3, respectively. The percentage of food insecure clusters that are predicted to be in the insecure category is also known as the true positive rate or “sensitivity” of prediction.

|  |  |  |  |
| --- | --- | --- | --- |
| Model | HDDS | logFCS | rCSI |
| IPC only | 1.000 | 0.000 | 0.097 |
| Full model | 0.994 | 0.833 | 0.860 |

**Table 5: The comparison of model with different specifications.** The split by year results are out of sample predictions in 2013. Models are estimated at the cluster-level, using only the IPC value and include predictors from all Class 1 + Class 2 + Class 3, respectively. The percentage of food insecure clusters that are predicted to be in the insecure category is also known as the true positive rate or “sensitivity” of prediction. The categorical accuracy is the percentage of clusters that are correctly predicted to be the same as the actual food security category.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **R squared** | | | **Sensitivity of food** | | | **Categorical** | | | |
| **Insecure Category** | | | **accuracy** | | | |
|  | logFCS | | HDDS | rCSI | logFCS | HDDS | rCSI | logFCS | HDDS | rCSI |  |
| **Split by year** | | | | | | | | | | | |
| **Main model** | 0.649 | | 0.643 | 0.119 | 0.833 | 0.994 | 0.86 | 0.897 | 0.882 | 0.635 |  |
| **Main model**  **– cluster price**  **variables** | 0.638 | | 0.661 | 0.119 | 0.222 | 0.968 | 0.258 | 0.916 | 0.882 | 0.591 |  |
| **Main Model**  **+ region fixed effect**  **- cluster price variables** | | 0.557 | 0.554 | 0.073 | 0.278 | 0.955 | 0.290 | 0.916 | 0.862 | 0.616 |  |
| **Main Model**  **+ GIEWS price**  **- cluster price variables** | 0.634 | | 0.661 | 0.036 | 0.722 | 0.994 | 0.978 | 0.793 | 0.892 | 0.468 |  |
| **LASSO** | 0.640 | | 0.611 | 0.061 | 0.833 | 1 | 1 | 0.665 | 0.857 | 0.463 |  |

**Table S1: The cluster average tail food security measures are based on the cluster average of the remaining households at the tail.** The results are estimated at the cluster-level and include predictors from all Class 1 + Class 2 + Class 3. Standard errors are presented in parentheses and asterisks indicate level of statistical significance of coefficients where three asterisks indicate 1%; two indicate 5% and one indicates 10%.

|  |  |  |  |
| --- | --- | --- | --- |
| |  |  |  | | --- | --- | --- | | logFCS tail | HDDS tail | rCSI tail | |

|  |  |  |  |
| --- | --- | --- | --- |
| IPC Value (Previous month) | -0.012 | -0.078 | 0.553 |
|  | (0.020) | (0.051) | (0.381) |
| Total rainfall during rainy season | 0.049 | 0.086 | -2.419\*\* |
|  | (0.051) | (0.113) | (1.104) |
| First day of rain | -0.001 | -0.002 | 0.045\*\* |
|  | (0.001) | (0.002) | (0.019) |
| Maximum days without rain | -0.0002 | -0.005\*\* | -0.051\*\* |
|  | (0.001) | (0.002) | (0.024) |
| Maize price | -0.001 | -0.002 | 0.016 |
|  | (0.0005) | (0.001) | (0.010) |
| Maize Market Thinness | 0.004 | -0.088 | -0.909\* |
|  | (0.023) | (0.059) | (0.539) |
| Percent of agricultural land | 0.022 | 0.040 | -0.101 |
|  | (0.031) | (0.074) | (0.685) |
| Elevation | -0.020 | -0.048 | -1.591\*\*\* |
|  | (0.027) | (0.065) | (0.594) |
| Soil nutrient retention constrained | -0.006 | -0.076\* | 0.689\* |
|  | (0.017) | (0.043) | (0.396) |
| Distance to nearest road | -0.001 | -0.010\*\*\* | -0.013 |
|  | (0.001) | (0.002) | (0.016) |
| Distance to nearest admarc market | 0.001 | 0.007\*\* | 0.029 |
|  | (0.001) | (0.003) | (0.033) |
| Roof type | 0.036 | 0.441\*\*\* | 2.413\*\* |
|  | (0.055) | (0.110) | (0.989) |
| Number of cellphones owned | -0.017 | 0.310\*\*\* | -2.457\*\*\* |
|  | (0.046) | (0.074) | (0.698) |
| Household size | -0.003 | -0.032 | 0.987\*\*\* |
|  | (0.012) | (0.028) | (0.231) |
| Household age | -0.0001 | -0.011\*\*\* | -0.062\* |
|  | (0.002) | (0.004) | (0.037) |
| Household gender | -0.072 | 0.115 | -1.249 |
|  | (0.065) | (0.153) | (1.398) |
| Asset index | 0.070\*\*\* | 0.476\*\*\* | -0.895\* |
|  | (0.026) | (0.062) | (0.509) |
| Quarter 1 | -0.013 | -0.215\*\*\* | 0.933\*\* |
|  | (0.021) | (0.053) | (0.423) |
| Quarter 2 | -0.023 | -0.083 | 0.754 |
|  | (0.024) | (0.058) | (0.498) |
| Quarter 3 | 0.013 | -0.056 | 0.060 |
|  | (0.024) | (0.048) | (0.458) |
| Observations | 208 | 648 | 259 |
| R2 | 0.109 | 0.430 | 0.309 |

**Table S2: LASSO regression coefficients.** The results are estimated at the cluster-level and include predictors from all Class 1 + Class 2 + Class 3. The split by year results are out of sample predictions in 2013. The split by region results are out of sample prediction in the North region. Models are estimated at the cluster-level, using only the IPC value and include predictors from all Class 1 + Class 2 + Class 3, respectively.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Split by year | | | Split by region | | |
|  | logFCS | HDDS | rCSI | logFCS | HDDS | rCSI |
| Best Alpha | 1.000 | 0.000 | 0.000 | 0.100 | 0.100 | 0.000 |
| Best Lambda | 0.001 | 0.075 | 0.305 | 0.019 | 0.038 | 0.305 |
| IPC Value (Previous month) | -0.021 | -0.089 | 1.181 | -0.015 | -0.072 | 1.125 |
| Total rainfall during rainy season | 0.111 | 0.182 | -1.379 | 0.055 | 0.048 | -0.727 |
| First day of rain | -0.001 | -0.002 | 0.008 | 0.000 | -0.001 | 0.013 |
| Maximum rainfall in flood prone region | 0.000 | 0.003 | -0.018 | 0.000 | 0.003 | -0.025 |
| Maximum days without rain | . | -0.003 | -0.045 | . | -0.001 | -0.061 |
| Growing degree days | 0.001 | 0.001 | -0.053 | 0.001 | 0.003 | -0.051 |
| Mean temperature | 0.018 | 0.036 | 0.279 | 0.007 | 0.018 | 0.287 |
| Heat degree days | 0.000 | -0.002 | 0.052 | -0.001 | -0.002 | 0.050 |
| Maize price | -0.001 | -0.002 | 0.012 | . | 0.000 | 0.005 |
| Maize Market Thinness | -0.014 | -0.094 | -0.551 | -0.015 | -0.124 | -0.659 |
| Maize price (Previous month) | 0.000 | 0.000 | 0.020 | 0.000 | 0.001 | 0.005 |
| Maize Market Thinness (Previous month) | 0.006 | 0.101 | -0.051 | . | 0.050 | -0.290 |
| GIEWs Maize Price | -0.002 | -0.002 | 0.085 | 0.000 | 0.002 | 0.025 |
| Percent of agricultural land | 0.014 | 0.038 | -0.137 | . | 0.038 | 0.294 |
| Elevation | -0.010 | 0.054 | 0.145 | -0.018 | . | -0.366 |
| Soil nutrient retention constrained | -0.008 | -0.069 | 0.345 | -0.004 | -0.074 | 0.530 |
| Distance to nearest road | -0.002 | -0.011 | -0.006 | -0.002 | -0.009 | -0.005 |
| Distance to nearest admarc market | 0.003 | 0.004 | 0.009 | 0.004 | 0.007 | 0.017 |
| Roof type | 0.126 | 0.534 | -0.053 | 0.160 | 0.693 | 0.029 |
| Number of cellphones owned | 0.140 | 0.287 | -0.696 | 0.113 | 0.250 | -0.972 |
| Household size | -0.009 | -0.026 | 0.531 | 0.000 | -0.002 | 0.632 |
| Household age | -0.002 | -0.013 | -0.026 | -0.002 | -0.015 | -0.022 |
| Household gender | -0.064 | -0.039 | 1.476 | -0.084 | -0.032 | 2.459 |
| Asset index | 0.112 | 0.421 | -0.360 | 0.083 | 0.320 | -0.491 |
| Quarter 1 | -0.062 | -0.185 | 0.327 | -0.073 | -0.242 | 0.732 |
| Quarter 2 | -0.010 | -0.037 | -0.126 | . | . | -0.078 |
| Quarter 3 | 0.001 | -0.062 | -0.848 | 0.014 | . | -0.622 |
| Central Region | 0.017 | 0.005 | 0.587 | . | 0.023 | -0.158 |
| South Region | -0.012 | -0.154 | 0.841 | . | -0.021 | 0.157 |

**Table S3: The comparison of model with different specifications.** The split by year results are out of sample predictions in 2013. Models are estimated at the cluster-level, using only the IPC value and include predictors from all Class 1 + Class 2 + Class 3, respectively. The percentage of food insecure clusters that are predicted to be in the insecure category is also known as the true positive rate or “sensitivity” of prediction. The categorical accuracy is the percentage of clusters that are correctly predicted to be the same as the actual food security category.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **R squared** | | | **Sensitivity of food** | | | **Categorical** | | | |
| **Insecure Category** | | | **accuracy** | | | |
|  | logFCS | HDDS | rCSI | logFCS | HDDS | rCSI | logFCS | HDDS | rCSI |  |
| **Split by year** | | | | | | | | | | |
| **Main model** | 0.649 | 0.643 | 0.119 | 0.833 | 0.994 | 0.86 | 0.897 | 0.882 | 0.635 |  |
| **Main model**  **– MSD maize price**  **+ MSD maize price in previous month** | 0.634 | 0.663 | 0.089 | 0.722 | 1.000 | 0.892 | 0.877 | 0.882 | 0.611 |  |
| **Main Model**  **+ quarter by region fixed effect**  **– MSD maize price** | 0.558 | 0.550 | 0.073 | 0.444 | 0.968 | 0.548 | 0.887 | 0.862 | 0.571 |  |
| **Main Model**  **+ month fixed effect**  **+ region fixed effect**  **– MSD maize price** | 0.613 | 0.603 | 0.117 | 0.278 | 0.968 | 0.430 | 0.906 | 0.877 | 0.611 |  |
| **Main model**  **+ month fixed effect** | 0.625 | 0.655 | 0.126 | 0.222 | 0.955 | 0.624 | 0.916 | 0.887 | 0.596 |  |
|  |  | **Split by region** | | | |  |  |  |  |  |
| **Main model** | 0.574 | 0.660 | 0.115 | 0.313 | 0.772 | 0.417 | 0.943 | 0.769 | 0.736 |  |
| **Main model**  **– MSD maize price** | 0.576 | 0.676 | 0.063 | 0.313 | 0.748 | 0.222 | 0.934 | 0.764 | 0.693 |  |
| **LASSO Results** | 0.579 | 0.671 | 0.117 | 0.375 | 0.862 | 0.417 | 0.934 | 0.788 | 0.721 |  |