# Appendices

#### **Table A1.** Stochastic meta-frontier results for maize production in Ghana (1987-2017)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|   | **Sudan Savanna** | **Guinea Savanna** | **Transitional zone** | **Forest zone** | **Coastal Savanna** |
| **Production function** |  |  |  |  |  |
| Land(ln[ha]) {lnI1} | 0.28\*\*\* (0.068) | 0.45\*\*\* (0.042) | 0.49\*\*\* (0.043) |  0.43\*\*\* (0.026) | 0.41\*\*\* (0.049) |
| Seed (ln[kg]) {lnI2} | 0.51\*\*\* (0.055) | 0.32\*\*\* (0.042) | 0.29\*\*\* (0.036) |  0.26\*\*\* (0.025) | 0.23\*\*\* (0.044) |
| Hired labor(ln[days]) {lnI3} |  0.11 (0.117) |  -0.06 (0.071) |  0.01 (0.072) |  0.01 (0.052) |  0.16\* (0.089) |
| Household labor(ln[days]) {lnI4} | -0.13\*\*\* (0.047) | 0.18\*\*\* (0.037) | 0.11\*\*\* (0.037) |  0.15\*\*\* (0.025) |  0.05 (0.043) |
| Fertilizer(ln[kg]) {lnI5} |  0.32\*\*\* (0.064) |  -0.04 (0.040) |  0.06 (0.053) | -0.05 (0.045) |  -0.01 (0.072) |
| Pesticide(ln[liter]) {lnI6} |  0.14\* (0.083) |  -0.04 (0.074) |  -0.03 (0.055) | -0.01 (0.032) |  0.26\*\*\* (0.081) |
| Trend(year) {lnI7} | -0.05\*\*\* (0.014) | -0.05\*\*\* (0.008) | -0.07\*\*\* (0.009) | -0.07\*\*\* (0.007) | -0.06\*\*\* (0.013) |
| P5∙lnI1∙lnI1 |  0.00 (0.019) |  -0.01 (0.019) |  0.04 (0.027) |  0.04\*\* (0.018) | 0.05\*\* (0.026) |
| P5∙lnI2∙lnI2 | -0.03\*\* (0.011) |  0.00 (0.013) | -0.02\* (0.012) |  0.02\*\* (0.008) | 0.04\*\*\* (0.012) |
| P5∙lnI3∙lnI3 | -0.09 (0.062) |  0.10 (0.061) |  0.19\*\* (0.089) |  0.01 (0.068) | -0.24\*\* (0.109) |
| P5∙lnI4∙lnI4 | -0.05\*\*\* (0.016) |  0.01 (0.011) | 0.01 (0.019) |  0.02\*\* (0.011) |  0.03 (0.022) |
| P5∙lnI5∙lnI5 |  0.02 (0.014) |  0.00 (0.013) | 0.01 (0.023) |  0.02 (0.014) |  -0.06\* (0.031) |
| P5∙lnI6∙lnI6 | -0.03\* (0.015) |  -0.01 (0.013) |  0.05\* (0.028) |  0.00 (0.010) | -0.05\*\* (0.025) |
| P5∙lnI7∙lnI7 | 0.00\*\*\* (0.001) | 0.00\*\* (0.000) | 0.00\*\*\* (0.001) |  0.00\*\*\* (0.000) |  0.00\*\*\* (0.001) |
| lnI1.lnI2 | 0.06\*\*\* (0.012) |  0.02 (0.014) | 0.07\*\*\* (0.013) | 0.03\*\*\* (0.010) |  0.02 (0.014) |
| lnI1.lnI3 | -0.05\*\* (0.025) |  -0.01 (0.028) |  0.00 (0.036) | -0.05\* (0.024) |  -0.05 (0.038) |
| lnI1.lnI4 |  0.01 (0.013) |  0.00 (0.012) | 0.01 (0.021) | -0.01 (0.012) |  -0.06\*\*\* (0.016) |
| lnI1.lnI5 |  0.05\*\*\* (0.013) |  0.00 (0.014) | 0.00 (0.021) |  0.01 (0.019) | -0.06\*\* (0.029) |
| lnI1.lnI6 | 0.05\*\*\* (0.012) |  0.08\*\*\* (0.013) |  -0.03 (0.021) |  0.00 (0.012) |  0.03 (0.022) |
| lnI1.lnI7 | 0.02\*\*\* (0.003) | 0.01\*\*\* (0.002) | 0.01\*\*\* (0.002) |  0.01\*\*\* (0.001) | 0.01\*\*\* (0.002) |
| lnI2.lnI3 |  0.04\*\* (0.018) |  0.02 (0.020) |  -0.05\*\* (0.023) |  0.01 (0.017) |  -0.02 (0.026) |
| lnI2.lnI4 | -0.01 (0.010) | -0.03\*\*\* (0.009) |  -0.01 (0.012) | -0.01 (0.008) |  0.00 (0.014) |
| lnI2.lnI5 | -0.02 (0.012) |  -0.02 (0.011) |  -0.01 (0.015) | -0.01 (0.010) |  0.03\* (0.017) |
| lnI2.lnI6 | -0.02\* (0.009) |  -0.01 (0.011) |  0.00 (0.012) | -0.01\* (0.008) | -0.04\*\*\* (0.015) |
| lnI2.lnI7 | -0.01\*\*\* (0.002) | -0.01\*\*\* (0.002) | -0.01\*\*\* (0.002) |  0.00\*\*\* (0.001) |  0.00 (0.002) |
| lnI3.lnI4 |  0.00 (0.020) |  -0.01 (0.020) | -0.09\*\*\* (0.033) |  0.05\*\* (0.020) |  0.02 (0.034) |
| lnI3.lnI5 |  0.01 (0.022) |  -0.04 (0.023) | 0.01 (0.039) |  0.02 (0.029) | -0.10\*\* (0.051) |
| lnI3.lnI6 | -0.06\*\*\* (0.020) |  -0.04\* (0.022) | 0.03 (0.033) | -0.03 (0.022) |  0.07 (0.042) |
| lnI3.lnI7 |  0.00 (0.005) |  0.01\* (0.003) | 0.00 (0.004) |  0.00 (0.003) |  -0.01 (0.004) |
| lnI4.lnI5 |  0.00 (0.009) | 0.02\*\* (0.010) | 0.02 (0.017) |  0.00 (0.010) |  0.03 (0.023) |
| lnI4.lnI6 |  0.00 (0.008) |  -0.02\* (0.008) |  -0.01 (0.016) | -0.01 (0.009) |  0.03 (0.018) |
| lnI4.lnI7 | 0.01\*\*\* (0.002) | -0.01\*\*\* (0.002) | 0.00 (0.002) |  0.00\*\* (0.001) |  0.00 (0.002) |
| lnI5.lnI6 |  0.02\* (0.010) |  0.00 (0.011) |  -0.02 (0.018) | -0.02 (0.011) |  0.04\* (0.024) |
| lnI5.lnI7 | -0.01\* (0.003) |  0.01\*\*\* (0.002) | 0.00 (0.003) |  0.00 (0.002) |  0.00 (0.004) |
| lnI6.lnI7 |  0.00 (0.003) |  0.00 (0.003) | 0.00 (0.002) |  0.00\*\* (0.002) | -0.01\*\*\* (0.004) |
| Constant | 0.81\*\*\* (0.283) |  1.14\*\*\* (0.092) | 1.46\*\*\* (0.097) |  0.90\*\*\* (0.079) |  0.32\* (0.175) |
| Dummies for zero inputs |  |  |  |  |  |
| I2 | -0.30\*\*\* (0.055) |  -0.01 (0.042) | -0.29\*\*\* (0.049) | -0.41\*\*\* (0.031) | -0.33\*\*\* (0.059) |
| I4 | -0.16\*\*\* (0.027) | -0.21\*\*\* (0.025) | -0.18\*\*\* (0.037) | -0.18\*\*\* (0.027) |  -0.05 (0.042) |
| I5 | -0.28\*\*\* (0.027) | -0.27\*\*\* (0.024) | -0.22\*\*\* (0.039) | -0.07\*\* (0.031) |  -0.10\* (0.058) |
| I6 | -0.24\*\*\* (0.035) |  0.02 (0.033) |  -0.09\*\* (0.044) | -0.11\*\*\* (0.031) |  0.04 (0.053) |
| **Uncertainty function** |  |  |  |  |  |
| Variance | -0.90\*\*\* (0.058) | -0.99\*\*\* (0.055) | -0.95\*\*\* (0.096) | -0.34\*\*\* (0.028) | -0.33\*\*\* (0.045) |

Significance levels: \* p<0.10, \*\* p<0.05, \*\*\*p<0.01

Data Sources: Ghana Living Standards Surveys [wave 1-7], Ghana Socioeconomic Panel Survey [wave 1-2], and Africa RISING Ghana Baseline Evaluation Survey [2013/14]

#### **Table A1.** Stochastic meta-frontier results for maize production in Ghana (1987-2017) – continued

|  |  |  |
| --- | --- | --- |
|   | **National** | **Meta-frontier** |
| **Production function** |  |   |
| Land(ln[ha]) {lnI1} | 0.46\*\*\* (0.018) | 0.47\*\*\* (0.005) |
| Seed (ln[kg]) {lnI2} | 0.25\*\*\* (0.016) | 0.26\*\*\* (0.004) |
| Hired labor(ln[days]) {lnI3} | 0.09\*\*\* (0.033) | 0.12\*\*\* (0.011) |
| Household labor(ln[days]) {lnI4} | 0.10\*\*\* (0.016) | 0.12\*\*\* (0.005) |
| Fertilizer(ln[kg]) {lnI5} | 0.06\*\*\* (0.022) | 0.07\*\*\* (0.010) |
| Pesticide(ln[liter]) {lnI6} | -0.02 (0.024) | -0.04\*\*\* (0.009) |
| Trend(year) {lnI7} | -0.07\*\*\* (0.004) | -0.07\*\*\* (0.001) |
| P5∙lnI1∙lnI1 | 0.03\*\*\* (0.010) | 0.04\*\*\* (0.003) |
| P5∙lnI2∙lnI2 |  0.01\* (0.005) | 0.01\*\*\* (0.002) |
| P5∙lnI3∙lnI3 |  0.04 (0.033) | 0.03\*\* (0.012) |
| P5∙lnI4∙lnI4 |  0.01 (0.006) | 0.01\*\*\* (0.002) |
| P5∙lnI5∙lnI5 |  0.02\*\* (0.007) | 0.02\*\*\* (0.003) |
| P5∙lnI6∙lnI6 | -0.01 (0.007) | -0.01\*\*\* (0.003) |
| P5∙lnI7∙lnI7 | 0.00\*\*\* (0.000) | 0.00\*\*\* (0.000) |
| lnI1.lnI2 | 0.04\*\*\* (0.006) | 0.04\*\*\* (0.002) |
| lnI1.lnI3 | -0.04\*\*\* (0.013) | -0.04\*\*\* (0.004) |
| lnI1.lnI4 | -0.01\* (0.007) | -0.01\*\*\* (0.002) |
| lnI1.lnI5 |  0.01 (0.008) |  0.01\* (0.003) |
| lnI1.lnI6 | 0.03\*\*\* (0.007) | 0.03\*\*\* (0.003) |
| lnI1.lnI7 | 0.01\*\*\* (0.001) | 0.01\*\*\* (0.000) |
| lnI2.lnI3 |  0.02 (0.009) | 0.02\*\*\* (0.003) |
| lnI2.lnI4 | -0.02\*\*\* (0.005) | -0.02\*\*\* (0.002) |
| lnI2.lnI5 | -0.01 (0.006) | -0.01\*\*\* (0.002) |
| lnI2.lnI6 | -0.01\* (0.005) | -0.01\*\*\* (0.002) |
| lnI2.lnI7 | 0.00\*\*\* (0.001) | 0.00\*\*\* (0.000) |
| lnI3.lnI4 |  0.01 (0.011) |  0.00 (0.004) |
| lnI3.lnI5 |  0.00 (0.013) | -0.01 (0.006) |
| lnI3.lnI6 | -0.03\*\* (0.011) | -0.03\*\*\* (0.005) |
| lnI3.lnI7 |  0.00 (0.001) | 0.00\*\*\* (0.000) |
| lnI4.lnI5 |  0.00 (0.005) |  0.00 (0.002) |
| lnI4.lnI6 |  0.00 (0.005) |  0.00\*\* (0.002) |
| lnI4.lnI7 |  0.00\*\* (0.001) | 0.00\*\*\* (0.000) |
| lnI5.lnI6 |  0.00 (0.005) |  0.00 (0.002) |
| lnI5.lnI7 | 0.00\*\*\* (0.001) | 0.00\*\*\* (0.000) |
| lnI6.lnI7 | 0.00\*\* (0.001) | 0.00\*\*\* (0.000) |
| Constant | 1.19\*\*\* (0.046) | 1.28\*\*\* (0.017) |
| Dummies for zero inputs |  |  |
| I2 | -0.31\*\*\* (0.020) | -0.31\*\*\* (0.006) |
| I4 | -0.18\*\*\* (0.013) | -0.21\*\*\* (0.004) |
| I5 | -0.16\*\*\* (0.014) | -0.15\*\*\* (0.005) |
| I6 | -0.15\*\*\* (0.015) | -0.19\*\*\* (0.005) |
| **Uncertainty function** |  |   |
| Variance | -0.61\*\*\* (0.022) | -2.75\*\*\* (0.016) |

Significance levels: \* p<0.10, \*\* p<0.05, \*\*\*p<0.01

Data Sources: Ghana Living Standards Surveys [wave 1-7], Ghana Socioeconomic Panel Survey [wave 1-2], and Africa RISING Ghana Baseline Evaluation Survey [2013/14]

**Table A2.** Stochastic meta-frontier results for rice production in Ghana (1987-2017)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   | **Sudan Savanna** | **Guinea Savanna** | **Transitional zone** | **Forest zone** |
| **Production function** |  |  |  |  |
| Land(ln[ha]) {lnI1} |  0.13 (0.085) |  0.75\*\*\* (0.137) | 0.34\*\*\* (0.100) | 0.36\*\*\* (0.102) |
| Seed (ln[kg]) {lnI2} | 0.53\*\*\* (0.055) |  0.00 (0.098) |  0.16 (0.146) |  0.08 (0.114) |
| Hired labor(ln[days]) {lnI3} |  0.07 (0.125) | -0.03 (0.204) |  0.60\* (0.346) | -0.17 (0.204) |
| Household labor(ln[days]) {lnI4} |  0.11\*\* (0.050) | 0.27\*\*\* (0.090) |  0.17 (0.128) |  0.49\*\*\* (0.097) |
| Fertilizer(ln[kg]) {lnI5} |  0.27\*\*\* (0.073) | -0.17 (0.113) | -0.11 (0.271) | -0.15 (0.217) |
| Pesticide(ln[liter]) {lnI6} |  0.20\* (0.117) |  0.25\* (0.147) | 0.79\*\*\* (0.218) |  0.00 (0.156) |
| Trend(year) {lnI7} | -0.08\*\*\* (0.016) | -0.05\*\* (0.020) | -0.11\*\* (0.047) |  0.05 (0.036) |
| P5∙lnI1∙lnI1 | 0.07\*\*\* (0.027) |  0.10\*\* (0.045) |  0.18\* (0.092) |  0.16\*\* (0.068) |
| P5∙lnI2∙lnI2 | 0.07\*\*\* (0.013) | 0.07\*\*\* (0.024) | 0.09\*\*\* (0.025) |  0.02 (0.026) |
| P5∙lnI3∙lnI3 | -0.20\*\* (0.083) | -0.10 (0.143) | -0.47 (0.306) |  0.32 (0.334) |
| P5∙lnI4∙lnI4 |  0.02 (0.013) | 0.04\*\*\* (0.014) |  0.08\*\* (0.042) | 0.11\*\*\* (0.033) |
| P5∙lnI5∙lnI5 |  0.03 (0.019) |  0.06\* (0.032) |  0.07 (0.108) |  0.03 (0.065) |
| P5∙lnI6∙lnI6 | -0.06\*\*\* (0.020) | -0.05 (0.032) | -0.06 (0.127) |  0.05 (0.061) |
| P5∙lnI7∙lnI7 | 0.00\*\*\* (0.001) |  0.00 (0.001) |  0.01\*\* (0.003) |  0.00 (0.002) |
| lnI1.lnI2 | -0.01 (0.016) | -0.02 (0.030) |  0.04 (0.060) |  0.01 (0.037) |
| lnI1.lnI3 | -0.05 (0.035) | -0.02 (0.058) |  0.10 (0.110) |  0.00 (0.123) |
| lnI1.lnI4 | -0.05\*\*\* (0.014) | -0.08\*\*\* (0.024) | -0.07 (0.058) |  0.04 (0.036) |
| lnI1.lnI5 |  0.05\*\* (0.021) | -0.06\* (0.033) | 0.22\*\*\* (0.085) | -0.10\* (0.055) |
| lnI1.lnI6 |  0.02 (0.017) |  0.05\* (0.027) | -0.26\*\*\* (0.091) | -0.13\*\* (0.065) |
| lnI1.lnI7 | 0.01\*\*\* (0.003) | -0.01\* (0.005) | 0.02\*\*\* (0.007) | 0.02\*\*\* (0.006) |
| lnI2.lnI3 |  0.02 (0.026) | -0.02 (0.043) | -0.01 (0.075) | -0.13 (0.088) |
| lnI2.lnI4 | -0.01 (0.009) | -0.03 (0.020) | -0.01 (0.024) | -0.01 (0.025) |
| lnI2.lnI5 | -0.03\*\* (0.012) | -0.03 (0.026) | -0.09 (0.067) | -0.03 (0.039) |
| lnI2.lnI6 |  0.01 (0.014) |  0.02 (0.023) |  0.06 (0.072) | -0.03 (0.034) |
| lnI2.lnI7 |  0.00 (0.002) |  0.01\*\*\* (0.004) |  0.01 (0.008) |  0.01 (0.005) |
| lnI3.lnI4 |  0.01 (0.024) |  0.06\* (0.037) | -0.20\*\* (0.087) |  0.03 (0.085) |
| lnI3.lnI5 |  0.02 (0.034) | -0.04 (0.061) | -0.40\*\*\* (0.131) | -0.12 (0.149) |
| lnI3.lnI6 | -0.01 (0.031) |  0.00 (0.052) |  0.11 (0.125) |  0.17\*\* (0.078) |
| lnI3.lnI7 |  0.00 (0.005) |  0.00 (0.008) | -0.04\*\* (0.016) |  0.00 (0.011) |
| lnI4.lnI5 | -0.01 (0.011) |  0.00 (0.023) |  0.10 (0.071) |  0.01 (0.047) |
| lnI4.lnI6 |  0.01 (0.010) |  0.00 (0.019) | -0.12\* (0.069) | -0.09\*\*\* (0.032) |
| lnI4.lnI7 |  0.00 (0.002) | -0.01\*\* (0.004) | -0.01 (0.007) | -0.01 (0.005) |
| lnI5.lnI6 |  0.02 (0.013) |  0.00 (0.025) | -0.03 (0.075) |  0.04 (0.057) |
| lnI5.lnI7 |  0.00 (0.003) |  0.01\*\*\* (0.005) |  0.00 (0.010) |  0.00 (0.009) |
| lnI6.lnI7 | -0.01 (0.005) |  0.00 (0.006) | -0.02\*\*\* (0.007) |  0.00 (0.005) |
| Constant | 1.23\*\*\* (0.171) | 1.47\*\*\* (0.251) |  0.54 (0.455) | -0.03 (0.387) |
| Dummies for zero inputs |  |  |  |  |
| I2 | -0.92\*\*\* (0.068) | -0.48\*\*\* (0.075) | -0.52\*\*\* (0.181) | -0.71\*\*\* (0.137) |
| I4 | -0.24\*\*\* (0.040) | -0.23\*\*\* (0.048) | -0.05 (0.131) | -0.12 (0.130) |
| I5 | -0.27\*\*\* (0.036) | -0.21\*\*\* (0.055) | -0.20 (0.186) | -0.02 (0.120) |
| I6 | -0.22\*\*\* (0.047) | -0.08 (0.079) |  0.04 (0.165) | -0.24 (0.151) |
| **Uncertainty function** |  |  |  |  |
| Variance | -0.62\*\*\* (0.052) | -0.58\*\*\* (0.086) | -0.86\*\*\* (0.120) | -0.45\*\*\* (0.123) |

Significance levels: \* p<0.10, \*\* p<0.05, \*\*\*p<0.01

Data Sources: Ghana Living Standards Surveys [wave 1-7], Ghana Socioeconomic Panel Survey [wave 1-2], and Africa RISING Ghana Baseline Evaluation Survey [2013/14]

**Table A2.** Stochastic meta-frontier results for rice production in Ghana (1987-2017) – continued

|  |  |  |
| --- | --- | --- |
|   | **National** | **Meta-frontier** |
| **Production function** |  |   |
| Land(ln[ha]) {lnI1} | 0.33\*\*\* (0.054) | 0.40\*\*\* (0.027) |
| Seed (ln[kg]) {lnI2} | 0.36\*\*\* (0.041) |  0.35\*\*\* (0.024) |
| Hired labor(ln[days]) {lnI3} |  0.06 (0.093) |  0.07 (0.045) |
| Household labor(ln[days]) {lnI4} | 0.20\*\*\* (0.034) | 0.21\*\*\* (0.018) |
| Fertilizer(ln[kg]) {lnI5} | 0.18\*\*\* (0.054) | 0.22\*\*\* (0.027) |
| Pesticide(ln[liter]) {lnI6} |  0.11\* (0.060) |  0.08\* (0.040) |
| Trend(year) {lnI7} | -0.07\*\*\* (0.012) | -0.09\*\*\* (0.006) |
| P5∙lnI1∙lnI1 | 0.10\*\*\* (0.023) | 0.10\*\*\* (0.010) |
| P5∙lnI2∙lnI2 | 0.06\*\*\* (0.010) | 0.05\*\*\* (0.005) |
| P5∙lnI3∙lnI3 | -0.12 (0.075) | -0.13\*\*\* (0.031) |
| P5∙lnI4∙lnI4 | 0.04\*\*\* (0.009) | 0.04\*\*\* (0.005) |
| P5∙lnI5∙lnI5 | 0.04\*\* (0.016) | 0.04\*\*\* (0.006) |
| P5∙lnI6∙lnI6 | -0.04\*\* (0.015) | -0.03\*\*\* (0.008) |
| P5∙lnI7∙lnI7 | 0.00\*\*\* (0.001) | 0.00\*\*\* (0.000) |
| lnI1.lnI2 |  0.00 (0.013) |  0.01 (0.006) |
| lnI1.lnI3 | -0.05 (0.031) | -0.04\*\*\* (0.013) |
| lnI1.lnI4 | -0.05\*\*\* (0.012) | -0.05\*\*\* (0.005) |
| lnI1.lnI5 |  0.01 (0.016) |  0.00 (0.007) |
| lnI1.lnI6 |  0.01 (0.015) |  0.02\*\* (0.007) |
| lnI1.lnI7 |  0.01\*\* (0.002) |  0.00\*\*\* (0.001) |
| lnI2.lnI3 | -0.01 (0.022) |  0.00 (0.010) |
| lnI2.lnI4 | -0.03\*\*\* (0.008) | -0.03\*\*\* (0.004) |
| lnI2.lnI5 | -0.03\*\* (0.011) | -0.02\*\*\* (0.005) |
| lnI2.lnI6 |  0.01 (0.011) |  0.01\*\* (0.005) |
| lnI2.lnI7 |  0.00 (0.002) |  0.00 (0.001) |
| lnI3.lnI4 |  0.01 (0.020) |  0.01 (0.010) |
| lnI3.lnI5 | -0.01 (0.031) | -0.01 (0.013) |
| lnI3.lnI6 |  0.00 (0.026) |  0.00 (0.013) |
| lnI3.lnI7 |  0.00 (0.004) |  0.00 (0.002) |
| lnI4.lnI5 | -0.02\*\* (0.009) | -0.02\*\*\* (0.005) |
| lnI4.lnI6 |  0.00 (0.009) |  0.00 (0.004) |
| lnI4.lnI7 |  0.00\*\* (0.001) |  0.00\*\*\* (0.001) |
| lnI5.lnI6 |  0.00 (0.011) |  0.01 (0.006) |
| lnI5.lnI7 |  0.00 (0.002) | 0.00\*\*\* (0.001) |
| lnI6.lnI7 |  0.00 (0.003) |  0.00 (0.002) |
| Constant | 1.28\*\*\* (0.126) | 1.81\*\*\* (0.063) |
| Dummies for zero inputs |  |  |
| I2 | -0.65\*\*\* (0.049) | -0.64\*\*\* (0.016) |
| I4 | -0.25\*\*\* (0.029) | -0.26\*\*\* (0.010) |
| I5 | -0.18\*\*\* (0.029) | -0.19\*\*\* (0.010) |
| I6 | -0.28\*\*\* (0.036) | -0.34\*\*\* (0.016) |
| **Uncertainty function** |  |   |
| Variance | -0.46\*\*\* (0.040) | -2.31\*\*\* (0.044) |

Significance levels: \* p<0.10, \*\* p<0.05, \*\*\*p<0.01

Data Sources: Ghana Living Standards Surveys [wave 1-7], Ghana Socioeconomic Panel Survey [wave 1-2], and Africa RISING Ghana Baseline Evaluation Survey [2013/14]

#### **Table A3.**  Stochastic meta-frontier results for millet production in Ghana (1987-2017)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   | **Sudan Savanna** | **Guinea Savanna** |  **National** | **Meta-frontier** |
| **Production function** |  |  |  |   |
| Land(ln[ha]) {lnI1} | 0.35\*\*\* (0.046) | 0.42\*\*\* (0.063) | 0.38\*\*\* (0.040) | 0.37\*\*\* (0.011) |
| Seed (ln[kg]) {lnI2} | 0.22\*\*\* (0.036) | 0.20\*\*\* (0.061) | 0.21\*\*\* (0.033) | 0.22\*\*\* (0.011) |
| Hired labor(ln[days]) {lnI3} | 0.28\*\*\* (0.066) |  0.25\*\* (0.100) | 0.25\*\*\* (0.059) | 0.25\*\*\* (0.022) |
| Household labor(ln[days]) {lnI4} |  0.07 (0.048) | 0.21\*\*\* (0.051) | 0.16\*\*\* (0.035) | 0.21\*\*\* (0.011) |
| Fertilizer(ln[kg]) {lnI5} |  0.16\*\*\* (0.044) | -0.03 (0.063) |  0.08\*\* (0.034) | 0.05\*\*\* (0.013) |
| Pesticide(ln[liter]) {lnI6} |  0.00 (0.064) |  0.12 (0.083) |  0.01 (0.058) |  0.00 (0.031) |
| Trend(year) {lnI7} | -0.01 (0.007) | -0.04\*\*\* (0.011) | -0.02\*\*\* (0.006) | -0.06\*\*\* (0.002) |
| P5∙lnI1∙lnI1 |  0.00 (0.024) | -0.06\* (0.032) | -0.02 (0.018) | -0.01\* (0.003) |
| P5∙lnI2∙lnI2 |  0.02 (0.015) |  0.02 (0.019) |  0.02 (0.012) | 0.02\*\*\* (0.003) |
| P5∙lnI3∙lnI3 | -0.09 (0.070) |  0.16 (0.109) | -0.01 (0.058) |  0.00 (0.014) |
| P5∙lnI4∙lnI4 |  0.00 (0.021) |  0.03\* (0.016) |  0.03\*\* (0.012) |  0.03\*\*\* (0.003) |
| P5∙lnI5∙lnI5 |  0.03\*\* (0.015) |  0.04 (0.027) |  0.03\*\* (0.013) |  0.04\*\*\* (0.004) |
| P5∙lnI6∙lnI6 | -0.04\* (0.022) | -0.06\*\* (0.030) | -0.04\*\* (0.019) | -0.04\*\*\* (0.007) |
| P5∙lnI7∙lnI7 |  0.00 (0.000) |  0.00\*\*\* (0.001) |  0.00\*\*\* (0.000) | 0.00\*\*\* (0.000) |
| lnI1.lnI2 |  0.00 (0.015) | -0.02 (0.021) | -0.01 (0.012) | -0.01\*\*\* (0.003) |
| lnI1.lnI3 |  0.04 (0.033) |  0.05 (0.044) |  0.04 (0.026) | 0.04\*\*\* (0.005) |
| lnI1.lnI4 | -0.01 (0.019) | -0.02 (0.019) | -0.01 (0.013) | -0.01\*\*\* (0.003) |
| lnI1.lnI5 |  0.03 (0.017) |  0.01 (0.030) |  0.02 (0.015) | 0.02\*\*\* (0.003) |
| lnI1.lnI6 | -0.02 (0.021) |  0.07\*\*\* (0.023) |  0.02 (0.016) | 0.02\*\*\* (0.005) |
| lnI1.lnI7 |  0.00\*\* (0.002) |  0.00 (0.003) |  0.00 (0.002) | 0.00\*\*\* (0.000) |
| lnI2.lnI3 |  0.04 (0.026) |  0.04 (0.040) |  0.04\* (0.022) | 0.04\*\*\* (0.005) |
| lnI2.lnI4 |  0.00 (0.014) | -0.01 (0.018) | -0.01 (0.011) | -0.01\*\*\* (0.003) |
| lnI2.lnI5 | -0.04\*\* (0.017) | -0.01 (0.025) | -0.03\*\* (0.014) | -0.03\*\*\* (0.003) |
| lnI2.lnI6 |  0.04\* (0.019) | -0.02 (0.021) |  0.02 (0.015) | 0.02\*\*\* (0.005) |
| lnI2.lnI7 |  0.00 (0.002) |  0.00 (0.003) |  0.00 (0.001) |  0.00\*\* (0.000) |
| lnI3.lnI4 | -0.05 (0.030) | -0.07\* (0.037) | -0.06\*\*\* (0.023) | -0.06\*\*\* (0.006) |
| lnI3.lnI5 | -0.01 (0.029) | -0.08 (0.050) | -0.04 (0.025) | -0.03\*\*\* (0.006) |
| lnI3.lnI6 | -0.06\* (0.036) | -0.07 (0.043) | -0.06\*\* (0.029) | -0.06\*\*\* (0.009) |
| lnI3.lnI7 | -0.01\*\*\* (0.003) | -0.01 (0.004) | -0.01\*\* (0.003) | -0.01\*\*\* (0.001) |
| lnI4.lnI5 | -0.03\*\* (0.016) | -0.03 (0.024) | -0.04\*\*\* (0.013) | -0.04\*\*\* (0.004) |
| lnI4.lnI6 | -0.02 (0.016) |  0.03 (0.019) |  0.00 (0.013) |  0.00 (0.006) |
| lnI4.lnI7 |  0.00 (0.002) | -0.01\*\*\* (0.002) |  0.00\*\*\* (0.002) | -0.01\*\*\* (0.000) |
| lnI5.lnI6 |  0.01 (0.017) | 0.08\*\*\* (0.023) |  0.02 (0.014) | 0.02\*\*\* (0.005) |
| lnI5.lnI7 |  0.00 (0.002) | 0.01\*\*\* (0.003) |  0.00\*\* (0.001) | 0.00\*\*\* (0.001) |
| lnI6.lnI7 |  0.00 (0.003) |  0.00 (0.003) |  0.00\* (0.002) | 0.00\*\*\* (0.001) |
| Constant | 0.35\*\*\* (0.086) | 0.66\*\*\* (0.120) |  0.29\*\*\* (0.109) | 1.04\*\*\* (0.020) |
| Dummies for zero inputs |  |  |  |  |
| I2 | -0.21\*\*\* (0.056) | -0.23\*\*\* (0.081) | -0.23\*\*\* (0.045) | -0.20\*\*\* (0.009) |
| I4 | -0.12\*\*\* (0.026) | -0.09\*\* (0.038) | -0.10\*\*\* (0.021) | -0.09\*\*\* (0.004) |
| I5 | -0.18\*\*\* (0.028) | -0.01 (0.043) | -0.13\*\*\* (0.024) | -0.12\*\*\* (0.005) |
| I6 | -0.09\*\*\* (0.036) |  0.14\*\*\* (0.050) | -0.06\*\* (0.028) | -0.09\*\*\* (0.006) |
| **Uncertainty function** |  |  |  |   |
| Variance | -0.98\*\*\* (0.088) | -1.19\*\*\* (0.139) | -0.84\*\*\* (0.052) | -3.99\*\*\* (0.039) |

Significance levels: \* p<0.10, \*\* p<0.05, \*\*\*p<0.01

Data Sources: Ghana Living Standards Surveys [wave 1-7], Ghana Socioeconomic Panel Survey [wave 1-2], and Africa RISING Ghana Baseline Evaluation Survey [2013/14]

#### **Table A4.** Stochastic meta-frontier results for sorghum production in Ghana (1987-2017)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   | **Sudan Savanna** | **Guinea Savanna** | **National** | **Meta-frontier** |
| **Production function** |  |  |  |   |
| Land(ln[ha]) {lnI1} | 0.36\*\*\* (0.048) |  0.48\*\*\* (0.062) | 0.42\*\*\* (0.040) | 0.42\*\*\* (0.009) |
| Seed (ln[kg]) {lnI2} | 0.24\*\*\* (0.039) | 0.24\*\*\* (0.063) | 0.26\*\*\* (0.036) | 0.25\*\*\* (0.008) |
| Hired labor(ln[days]) {lnI3} | 0.29\*\*\* (0.069) |  0.12 (0.112) | 0.19\*\*\* (0.064) | 0.19\*\*\* (0.018) |
| Household labor(ln[days]) {lnI4} |  0.08\* (0.047) | 0.15\*\*\* (0.057) | 0.14\*\*\* (0.038) | 0.14\*\*\* (0.009) |
| Fertilizer(ln[kg]) {lnI5} | 0.15\*\*\* (0.046) | -0.09 (0.066) |  0.04 (0.038) |  0.02 (0.013) |
| Pesticide(ln[liter]) {lnI6} | -0.26\*\*\* (0.063) |  0.18\*\* (0.079) | -0.08 (0.053) | -0.07\* (0.036) |
| Trend(year) {lnI7} | -0.06\*\*\* (0.007) | -0.04\*\*\* (0.010) | -0.05\*\*\* (0.007) | -0.06\*\*\* (0.002) |
| P5∙lnI1∙lnI1 | 0.06\*\*\* (0.019) | -0.07\*\* (0.034) |  0.01 (0.018) |  0.01\* (0.005) |
| P5∙lnI2∙lnI2 | 0.04\*\*\* (0.013) |  0.01 (0.017) |  0.03\*\* (0.011) | 0.03\*\*\* (0.004) |
| P5∙lnI3∙lnI3 | -0.12 (0.080) |  0.07 (0.118) | -0.03 (0.069) | -0.06\*\*\* (0.016) |
| P5∙lnI4∙lnI4 |  0.00 (0.017) |  0.02 (0.013) |  0.02 (0.011) | 0.02\*\*\* (0.003) |
| P5∙lnI5∙lnI5 |  0.03 (0.016) | -0.01 (0.021) |  0.01 (0.014) |  0.01\* (0.006) |
| P5∙lnI6∙lnI6 |  0.00 (0.022) | -0.06\*\*\* (0.022) | -0.03\* (0.017) | -0.03\*\*\* (0.008) |
| P5∙lnI7∙lnI7 | 0.00\*\*\* (0.000) | 0.00\*\*\* (0.001) | 0.00\*\*\* (0.000) | 0.00\*\*\* (0.000) |
| lnI1.lnI2 |  0.01 (0.015) | 0.07\*\*\* (0.023) | 0.04\*\*\* (0.013) | 0.05\*\*\* (0.004) |
| lnI1.lnI3 |  0.02 (0.034) |  0.09\* (0.048) |  0.05\* (0.028) | 0.05\*\*\* (0.007) |
| lnI1.lnI4 |  0.01 (0.015) | -0.04\*\* (0.019) | -0.02\* (0.012) | -0.02\*\*\* (0.004) |
| lnI1.lnI5 |  0.00 (0.020) |  0.00 (0.021) |  0.00 (0.016) |  0.00 (0.006) |
| lnI1.lnI6 | -0.01 (0.018) |  0.07\*\*\* (0.021) |  0.03\*\* (0.014) | 0.03\*\*\* (0.007) |
| lnI1.lnI7 |  0.00 (0.002) |  0.00 (0.003) |  0.00 (0.002) | 0.00\*\*\* (0.000) |
| lnI2.lnI3 |  0.03 (0.029) | -0.02 (0.040) |  0.01 (0.025) |  0.00 (0.006) |
| lnI2.lnI4 | -0.01 (0.015) | -0.03\* (0.014) | -0.01 (0.011) | -0.01\*\* (0.005) |
| lnI2.lnI5 | -0.05\*\* (0.020) |  0.01 (0.023) | -0.01 (0.016) | -0.02\*\*\* (0.006) |
| lnI2.lnI6 | -0.01 (0.020) | -0.04\* (0.021) | -0.03\*\* (0.015) | -0.04\*\*\* (0.006) |
| lnI2.lnI7 |  0.00\* (0.002) |  0.00 (0.003) |  0.00 (0.002) | 0.00\*\*\* (0.000) |
| lnI3.lnI4 | -0.01 (0.029) | -0.08\* (0.040) | -0.05\*\* (0.023) | -0.05\*\*\* (0.006) |
| lnI3.lnI5 |  0.04 (0.035) | -0.01 (0.052) |  0.02 (0.030) |  0.02\*\* (0.010) |
| lnI3.lnI6 |  0.00 (0.036) | -0.05 (0.039) | -0.02 (0.027) | -0.02\* (0.012) |
| lnI3.lnI7 | -0.01\*\*\* (0.003) |  0.00 (0.005) |  0.00 (0.003) | 0.00\*\*\* (0.001) |
| lnI4.lnI5 | -0.01 (0.017) |  0.00 (0.021) |  0.00 (0.014) |  0.00 (0.004) |
| lnI4.lnI6 |  0.00 (0.017) | -0.01 (0.015) | -0.01 (0.011) | -0.02\*\*\* (0.004) |
| lnI4.lnI7 |  0.00 (0.002) |  0.00\* (0.002) |  0.00 (0.002) | 0.00\*\*\* (0.000) |
| lnI5.lnI6 |  0.02 (0.019) | -0.02 (0.023) |  0.01 (0.016) |  0.02\*\* (0.007) |
| lnI5.lnI7 |  0.00 (0.002) | 0.01\*\*\* (0.003) | 0.00\*\*\* (0.002) |  0.01\*\*\* (0.001) |
| lnI6.lnI7 | 0.01\*\*\* (0.003) |  0.00 (0.003) | 0.01\*\*\* (0.002) |  0.01\*\*\* (0.001) |
| Constant | 0.97\*\*\* (0.104) | 0.82\*\*\* (0.140) | 0.85\*\*\* (0.124) |  1.05\*\*\* (0.025) |
| Dummies for zero inputs |  |  |  |  |
| I2 | -0.39\*\*\* (0.057) | -0.11 (0.068) | -0.20\*\*\* (0.046) | -0.21\*\*\* (0.016) |
| I4 | -0.15\*\*\* (0.029) | -0.06 (0.039) | -0.12\*\*\* (0.023) | -0.13\*\*\* (0.005) |
| I5 | -0.15\*\*\* (0.032) | -0.16\*\*\* (0.043) | -0.15\*\*\* (0.026) | -0.15\*\*\* (0.006) |
| I6 | -0.29\*\*\* (0.040) |  0.04 (0.053) | -0.18\*\*\* (0.031) | -0.15\*\*\* (0.007) |
| **Uncertainty function** |  |  |  |   |
| Variance | -1.11\*\*\* (0.098) | -0.78\*\*\* (0.098) | -0.81\*\*\* (0.114) | -3.79\*\*\* (0.034) |

Significance levels: \* p<0.10, \*\* p<0.05, \*\*\*p<0.01

Data Sources: Ghana Living Standards Surveys [wave 1-7], Ghana Socioeconomic Panel Survey [wave 1-2], and Africa RISING Ghana Baseline Evaluation Survey [2013/14]



#### **Figure A1.** Ecological variation in cereal yield, input, and enabling environment factors in Ghana (1987-2017).



#### **Figure A2.** Seasonal variation in cereal yield, input, and enabling environment factors in Ghana (1987-2017).