# Additional file 1

Appendix 1 : the association between the hidden spatial effect and sign.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Equation (7) | (8) | Magnitude | (9) |
| Sign | + | + | (7) > (8) | + |
|  | - | - | (7) < (8) | - |

**Appendix 2 : Spatial level variables used in the spatial model.**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Women** | **N** | **Mean** | **Standard deviation** | **Min** | **Max** | **Men** | **N** | **Mean** | **Standard deviation** | **Min** | **Max** |
| **Cluster** | 7,289 | 425.8 | 241.1 | 1 | 850 | **Cluster** | 17,273 | 425.1 | 245.6 | 1 | 850 |
| **Longitude** | 7,289 | 34.6 | 0.7 | 32.8 | 35.8 | **Longitude** | 17,273 | 34.5 | 0.7 | 32.8 | 35.8 |
| **Latitude** | 7,289 | -14.3 | 1.7 | -17.1 | -9.5 | **Latitude** | 17,273 | -14 | 1.8 | -17.1 | -9.5 |

**Appendix 3 : Results of decomposed index by district for women**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **Lilongwe** |  | **Blantyre** |  | **Kasungu** |  | **Machinga** | | **Mangochi** | | **Mulanje** |  | **Mzimba** |  | | **Salima** |  | **Thyolo** |  | **Zomba** |  | **Other** |  |
|  |  |  | **Probit** | **Spatial** | **Probit** | **Spatial** | **Probit** | **Spatial** | **Probit** | **Spatial** | **Probit** | **Spatial** | **Probit** | **Spatial** | **Probit** | **Spatial** | | **Probit** | **Spatial** | **Probit** | **Spatial** | **Probit** | **Spatial** | **Probit** | **Spatial** |
| **Need** | **Any STI last 12 month** | **Elasticity** |  |  |  |  |  |  | 0.0355 | 0.0320 |  |  |  |  |  |  | |  |  | 0.0155 | 0.0167 | 0.0615 | 0.0611 | 0.0022 | 0.0018 |
|  |  | **CI** |  |  |  |  |  |  | -0.1804 | -0.1804 |  |  |  |  |  |  | |  |  | 0.0683 | 0.0683 | 0.0182 | 0.0182 | 0.0419 | 0.0419 |
|  |  | **Contribution** | |  |  |  |  |  | -0.0064 | -0.0058 |  |  |  |  |  |  | |  |  | 0.0011 | 0.0011 | 0.0011 | 0.0011 | 0.0001 | 0.0001 |
|  | **Genital sore/ulcer** | **Elasticity** | 0.0124 | 0.0125 | 0.0432 | 0.0433 | 0.0654 | 0.0648 | 0.1012 | 0.1044 | 0.0769 | 0.0754 | 0.0842 | 0.0845 |  |  | | -0.0132 | -0.0142 | 0.0812 | 0.0764 | 0.0767 | 0.0767 | 0.0535 | 0.0538 |
|  |  | **CI** | 0.0328 | 0.0328 | 0.0974 | 0.0974 | -0.3128 | -0.3128 | -0.0710 | -0.0710 | 0.0451 | 0.0451 | -0.0297 | -0.0297 |  |  | | 0.2789 | 0.2789 | 0.0572 | 0.0572 | 0.0618 | 0.0618 | -0.0429 | -0.0429 |
|  |  | **Contribution** | 0.0004 | 0.0004 | 0.0042 | 0.0042 | -0.0204 | -0.0203 | -0.0072 | -0.0074 | 0.0035 | 0.0034 | -0.0025 | -0.0025 |  |  | | -0.0037 | -0.0040 | 0.0046 | 0.0044 | 0.0047 | 0.0047 | -0.0023 | -0.0023 |
|  | **Genital discharge** | **Elasticity** | 0.0619 | 0.0631 |  |  | 0.0020 | 0.0024 |  |  | 0.0159 | 0.0143 | 0.0330 | 0.0336 | 0.0195 | 0.0212 | |  |  | -0.0180 | -0.0181 |  |  | 0.0039 | 0.0032 |
|  |  | **CI** | 0.1190 | 0.1190 |  |  | -0.1930 | -0.1930 |  |  | -0.1388 | -0.1388 | -0.1705 | -0.1705 | -0.0992 | -0.0992 | |  |  | -0.1860 | -0.1860 |  |  | -0.0953 | -0.0953 |
|  |  | **Contribution** | 0.0074 | 0.0075 |  |  | -0.0004 | -0.0005 |  |  | -0.0022 | -0.0020 | -0.0056 | -0.0057 | -0.0019 | -0.0021 | |  |  | 0.0033 | 0.0034 |  |  | -0.0004 | -0.0003 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |
| **Non-need** | **Literacy** | **Elasticity** | 0.0023 | 0.0021 | -0.0052 | -0.0077 | -0.0314 | -0.0318 | -0.0484 | -0.0520 | 0.0644 | 0.0590 | -0.0301 | -0.0294 | 0.0067 | 0.0069 | | -0.0263 | -0.0243 | -0.0281 | -0.0292 | -0.0849 | -0.0847 | -0.0255 | -0.0233 |
|  |  | **CI** | 0.1385 | 0.1385 | 0.0607 | 0.0607 | 0.0856 | 0.0856 | 0.1538 | 0.1538 | 0.1415 | 0.1415 | 0.0907 | 0.0907 | 0.1092 | 0.1092 | | 0.2220 | 0.2220 | 0.0693 | 0.0693 | 0.0989 | 0.0989 | 0.1139 | 0.1139 |
|  |  | **Contribution** | 0.0003 | 0.0003 | -0.0003 | -0.0005 | -0.0027 | -0.0027 | -0.0074 | -0.0080 | 0.0091 | 0.0083 | -0.0027 | -0.0027 | 0.0007 | 0.0008 | | -0.0058 | -0.0054 | -0.0019 | -0.0020 | -0.0084 | -0.0084 | -0.0029 | -0.0026 |
|  | **Education** | **Elasticity** | 0.1223 | 0.1226 | 0.0227 | 0.0241 | 0.0692 | 0.0633 | -0.0234 | -0.0198 | 0.0225 | 0.0126 | -0.0939 | -0.0936 | 0.1649 | 0.1627 | | -0.0164 | -0.0210 | 0.0079 | 0.0047 | 0.0270 | 0.0268 | 0.0483 | 0.0501 |
|  |  | **CI** | 0.1944 | 0.1944 | 0.1305 | 0.1305 | 0.1309 | 0.1309 | 0.1738 | 0.1738 | 0.1405 | 0.1405 | 0.1254 | 0.1254 | 0.1228 | 0.1228 | | 0.1855 | 0.1855 | 0.1106 | 0.1106 | 0.1479 | 0.1479 | 0.1407 | 0.1407 |
|  |  | **Contribution** | 0.0238 | 0.0238 | 0.0030 | 0.0031 | 0.0091 | 0.0083 | -0.0041 | -0.0034 | 0.0032 | 0.0018 | -0.0118 | -0.0117 | 0.0203 | 0.0200 | | -0.0030 | -0.0039 | 0.0009 | 0.0005 | 0.0040 | 0.0040 | 0.0068 | 0.0070 |
|  | **Marriage** | **Elasticity** | 0.0591 | 0.0598 | 0.0637 | 0.0634 | 0.0660 | 0.0665 | 0.0547 | 0.0556 | 0.1329 | 0.1310 | 0.0281 | 0.0282 | 0.0726 | 0.0756 | | 0.0741 | 0.0698 | 0.0524 | 0.0514 | 0.0536 | 0.0536 | 0.0673 | 0.0674 |
|  |  | **CI** | -0.0264 | -0.0264 | -0.0045 | -0.0045 | -0.0492 | -0.0492 | 0.1160 | 0.1160 | 0.0071 | 0.0071 | 0.0456 | 0.0456 | -0.0945 | -0.0945 | | 0.0320 | 0.0320 | -0.0372 | -0.0372 | -0.0062 | -0.0062 | 0.0055 | 0.0055 |
|  |  | **Contribution** | -0.0016 | -0.0016 | -0.0003 | -0.0003 | -0.0032 | -0.0033 | 0.0063 | 0.0065 | 0.0009 | 0.0009 | 0.0013 | 0.0013 | -0.0069 | -0.0071 | | 0.0024 | 0.0022 | -0.0020 | -0.0019 | -0.0003 | -0.0003 | 0.0004 | 0.0004 |
|  | **Wealth** | **Elasticity** | 0.0218 | 0.0247 | -0.0103 | -0.0018 | 0.0950 | 0.0947 | 0.0153 | 0.0132 | -0.0726 | -0.0819 | 0.0931 | 0.0944 | -0.0018 | -0.0187 | | 0.0068 | 0.0009 | 0.0311 | 0.0274 | -0.0105 | -0.0102 | 0.0199 | 0.0074 |
|  |  | **CI** | 0.3060 | 0.3060 | 0.1975 | 0.1975 | 0.2513 | 0.2513 | 0.3253 | 0.3253 | 0.3109 | 0.3109 | 0.2556 | 0.2556 | 0.2169 | 0.2169 | | 0.3168 | 0.3168 | 0.2479 | 0.2479 | 0.2660 | 0.2660 | 0.2893 | 0.2893 |
|  |  | **Contribution** | 0.0067 | 0.0076 | -0.0020 | -0.0004 | 0.0239 | 0.0238 | 0.0050 | 0.0043 | -0.0226 | -0.0255 | 0.0238 | 0.0241 | -0.0004 | -0.0041 | | 0.0022 | 0.0003 | 0.0077 | 0.0068 | -0.0028 | -0.0027 | 0.0058 | 0.0021 |
|  | **Inequality\_need** | | 0.0078 | 0.0079 | 0.0042 | 0.0042 | -0.0208 | -0.0207 | -0.0136 | -0.0132 | 0.0009 | 0.0010 | -0.0081 | -0.0082 | -0.0019 | -0.0021 | | -0.0037 | -0.0040 | 0.0090 | 0.0089 | 0.0059 | 0.0059 | -0.0026 | -0.0025 |
|  | **Inequality\_nonneed** | | 0.0292 | 0.0301 | 0.0003 | 0.0020 | 0.0270 | 0.0261 | -0.0002 | -0.0007 | -0.0093 | -0.0144 | 0.0106 | 0.0110 | 0.0137 | 0.0095 | | -0.0043 | -0.0068 | 0.0047 | 0.0034 | -0.0075 | -0.0074 | 0.0100 | 0.0069 |
|  | **Horizontal inequity** | | 0.0177 | 0.0176 | 0.0015 | 0.0015 | 0.0606 | 0.0605 | 0.0158 | 0.0154 | -0.0101 | -0.0102 | 0.0140 | 0.0141 | 0.0070 | 0.0071 | | -0.0001 | 0.0002 | -0.0060 | -0.0058 | -0.0163 | -0.0163 | 0.0113 | 0.0113 |
| Inequality due to need = contribution of need factors to the whole concentration index | | | | | | | | | | | | | | | | |
| Inequality due to non need Concentration index= contribution of non need factors to the whole concentration index | | | | | | | | | | | | | | | | |
| Horizontal inequity = whole CI - inequality due to need | | | | | | | | | | | | | | | | |

**Appendix 4 : Results of decomposed index by district for men**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Lilongwe** | | **Blantyre** | | **Kasungu** | | **Machinga** | | **Mangochi** | | **Mulanje** | | **Mzimba** | | | **Salima** | | **Thyolo** | | **Zomba** | | **Other** | |
|  |  | **Probit** | **Spatial** | **Probit** | **Spatial** | **Probit** | **Spatial** | **Probit** | **Spatial** | **Probit** | **Spatial** | **Probit** | **Spatial** | **Probit** | **Spatial** | | **Probit** | **Spatial** | **Probit** | **Spatial** | **Probit** | **Spatial** | **Probit** | **Spatial** |
| **Need** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |
| **Any STI last 12 month** | **Elasticity** |  |  |  |  | -0.0053 | -0.0057 |  |  | 0.0617 | 0.0610 |  |  | -0.0111 | -0.0109 | | 0.0018 | 0.0009 | -0.0141 | -0.0140 | -0.0037 | -0.0012 | -0.0023 | -0.0023 |
|  | **CI** |  |  |  |  | 0.1308 | 0.1308 |  |  | -0.0060 | -0.0060 |  |  | 0.0012 | 0.0012 | | 0.3301 | 0.3301 | -0.1838 | -0.1838 | -0.1128 | -0.1128 | -0.0328 | -0.0328 |
|  | **Contribution** |  |  |  |  | -0.0007 | -0.0007 |  |  | -0.0004 | -0.0004 |  |  | 0.0000 | 0.0000 | | 0.0006 | 0.0003 | 0.0026 | 0.0026 | 0.0004 | 0.0001 | 0.0001 | 0.0001 |
| **Genital sore/ulcer** | **Elasticity** | 0.0784 | 0.0732 | 0.0103 | 0.0111 | 0.0189 | 0.0117 |  |  | 0.0030 | 0.0014 | 0.1375 | 0.1369 |  |  | | 0.0000 | 0.0001 | -0.0123 | -0.0177 |  |  | -0.0035 | -0.0028 |
|  | **CI** | -0.1082 | -0.1082 | -0.1308 | -0.1308 | 0.0166 | 0.0166 |  |  | -0.3257 | -0.3257 | -0.0968 | -0.0968 |  |  | | 0.0071 | 0.0071 | -0.0593 | -0.0593 |  |  | -0.0185 | -0.0185 |
|  | **Contribution** | -0.0085 | -0.0079 | -0.0013 | -0.0014 | 0.0003 | 0.0002 |  |  | -0.0010 | -0.0004 | -0.0133 | -0.0133 |  |  | | 0.0000 | 0.0000 | 0.0007 | 0.0011 |  |  | 0.0001 | 0.0001 |
| **Genital discharge** | **Elasticity** | -0.0037 | -0.0044 | 0.0511 | 0.0513 | 0.0499 | 0.0500 |  |  | -0.0124 | -0.0113 | 0.0529 | 0.0548 | -0.0029 | -0.0022 | | 0.0101 | 0.0099 | -0.0032 | -0.0038 | 0.1083 | 0.1145 | 0.0036 | 0.0031 |
|  | **CI** | 0.0753 | 0.0753 | -0.1910 | -0.1910 | 0.0248 | 0.0248 |  |  | 0.1237 | 0.1237 | -0.0753 | -0.0753 | -0.1413 | -0.1413 | | -0.1068 | -0.1068 | -0.0596 | -0.0596 | -0.0571 | -0.0571 | -0.0988 | -0.0988 |
|  | **Contribution** | -0.0003 | -0.0003 | -0.0098 | -0.0098 | 0.0012 | 0.0012 |  |  | -0.0015 | -0.0014 | -0.0040 | -0.0041 | 0.0004 | 0.0003 | | -0.0011 | -0.0011 | 0.0002 | 0.0002 | -0.0062 | -0.0065 | -0.0004 | -0.0003 |
| **Non-need** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  |
| **Literacy** | **Elasticity** | 0.0055 | 0.0052 | 0.0223 | 0.0237 | 0.0316 | 0.0291 | 0.0336 | 0.0322 | -0.0290 | -0.0309 | -0.0197 | -0.0185 | 0.0396 | 0.0435 | | 0.0301 | 0.0319 | -0.0112 | -0.0121 | -0.0086 | -0.0080 | 0.0033 | 0.0031 |
|  | **CI** | 0.1194 | 0.1194 | 0.0649 | 0.0649 | 0.0747 | 0.0747 | 0.1881 | 0.1881 | 0.1226 | 0.1226 | 0.0946 | 0.0946 | 0.0795 | 0.0795 | | 0.1502 | 0.1502 | 0.1036 | 0.1036 | 0.1101 | 0.1101 | 0.1092 | 0.1092 |
|  | **Contribution** | 0.0007 | 0.0006 | 0.0014 | 0.0015 | 0.0024 | 0.0022 | 0.0063 | 0.0061 | -0.0036 | -0.0038 | -0.0019 | -0.0017 | 0.0031 | 0.0035 | | 0.0045 | 0.0048 | -0.0012 | -0.0013 | -0.0009 | -0.0009 | 0.0004 | 0.0003 |
| **Education** | **Elasticity** | 0.1152 | 0.1105 | 0.1054 | 0.1063 | 0.0923 | 0.0848 | 0.0197 | 0.0150 | 0.0575 | 0.0520 | -0.0124 | -0.0192 | 0.0488 | 0.0405 | | 0.0267 | 0.0282 | 0.0933 | 0.1006 | 0.0734 | 0.0708 | 0.1065 | 0.1046 |
|  | **CI** | 0.1679 | 0.1679 | 0.0947 | 0.0947 | 0.1151 | 0.1151 | 0.1572 | 0.1572 | 0.1378 | 0.1378 | 0.0788 | 0.0788 | 0.1089 | 0.1089 | | 0.1700 | 0.1700 | 0.1261 | 0.1261 | 0.1217 | 0.1217 | 0.1275 | 0.1275 |
|  | **Contribution** | 0.0193 | 0.0186 | 0.0100 | 0.0101 | 0.0106 | 0.0098 | 0.0031 | 0.0024 | 0.0079 | 0.0072 | -0.0010 | -0.0015 | 0.0053 | 0.0044 | | 0.0045 | 0.0048 | 0.0118 | 0.0127 | 0.0089 | 0.0086 | 0.0136 | 0.0133 |
| **Marriage** | **Elasticity** | 0.4939 | 0.4997 | 0.3520 | 0.3558 | 0.5545 | 0.5553 | 0.5521 | 0.5474 |  |  |  |  | 0.3613 | 0.3628 | | 0.4509 | 0.4521 | 0.2994 | 0.3121 | 0.4886 | 0.4895 | 0.4783 | 0.4780 |
|  | **CI** | -0.0804 | -0.0804 | -0.0401 | -0.0401 | -0.0425 | -0.0425 | -0.0590 | -0.0590 |  |  |  |  | -0.0591 | -0.0591 | | -0.0694 | -0.0694 | -0.0374 | -0.0374 | -0.0707 | -0.0707 | -0.0540 | -0.0540 |
|  | **Contribution** | -0.0397 | -0.0402 | -0.0141 | -0.0143 | -0.0236 | -0.0236 | -0.0326 | -0.0323 |  |  |  |  | -0.0214 | -0.0214 | | -0.0313 | -0.0314 | -0.0112 | -0.0117 | -0.0345 | -0.0346 | -0.0258 | -0.0258 |
| **Wealth** | **Elasticity** | 0.1045 | 0.0842 | 0.0002 | 0.0000 | 0.0800 | 0.0611 | -0.0088 | -0.0310 | 0.0740 | 0.0349 | -0.0031 | -0.0161 | 0.0455 | 0.0236 | | -0.0438 | -0.0363 | 0.0149 | 0.0428 | -0.0073 | -0.0107 | 0.0155 | 0.0127 |
|  | **CI** | 0.2168 | 0.2168 | 0.1300 | 0.1300 | 0.2526 | 0.2526 | 0.2778 | 0.2778 | 0.2473 | 0.2473 | 0.2153 | 0.2153 | 0.2226 | 0.2226 | | 0.2789 | 0.2789 | 0.2439 | 0.2439 | 0.2347 | 0.2347 | 0.2403 | 0.2403 |
|  | **Contribution** | 0.0227 | 0.0183 | 0.0000 | 0.0000 | 0.0202 | 0.0154 | -0.0024 | -0.0086 | 0.0183 | 0.0086 | -0.0007 | -0.0035 | 0.0101 | 0.0053 | | -0.0122 | -0.0101 | 0.0036 | 0.0104 | -0.0017 | -0.0025 | 0.0037 | 0.0030 |
| **Inequality\_need** |  | -0.0088 | -0.0083 | -0.0111 | -0.0112 | 0.0009 | 0.0007 |  | 0.0000 | -0.0029 | -0.0022 | -0.0173 | -0.0174 | 0.0004 | 0.0003 | | -0.0005 | -0.0008 | 0.0035 | 0.0039 | -0.0058 | -0.0064 | -0.0002 | -0.0002 |
| **Inequality\_nonneed** | | 0.0029 | -0.0027 | -0.0027 | -0.0027 | 0.0096 | 0.0038 | -0.0256 | -0.0325 | 0.0227 | 0.0120 | -0.0035 | -0.0067 | -0.0028 | -0.0083 | | -0.0344 | -0.0319 | 0.0030 | 0.0102 | -0.0283 | -0.0294 | -0.0082 | -0.0091 |
| **Horizontal inequity** | | 0.0173 | 0.0168 | -0.0058 | -0.0056 | 0.0067 | 0.0068 | -0.0253 | -0.0253 | 0.0256 | 0.0250 | 0.0152 | 0.0153 | -0.0003 | -0.0002 | | -0.0313 | -0.0310 | 0.0033 | 0.0029 | -0.0162 | -0.0156 | -0.0083 | -0.0083 |
| Inequality due to need = contribution of need factors to the whole concentration index | | | | | | | | | | | | | | | |
| Inequality due to non need Concentration index= contribution of non need factors to the whole concentration index | | | | | | | | | | | | | | | |
| Horizontal inequity = whole CI - inequality due to need | | | | | | | | | | | | | | | |

**Appendix 5 : Moran’s I**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Simulation** | **Moran's I** | **Standard deviation** | **-1/(n-1)** |
| **Men** | 1,000 | 0.0019 | 0.0059 | -0.0001 |
| **Women** | 1,000 | 0.0023 | 0.0050 | -0.0001 |

**Appendix 6 :** Calculation of the concentration index

A standard concentration index (CI) is calculated as

|  |  |  |
| --- | --- | --- |
|  |  | (1) |

where is CIy is the concentration index for health service use y. it can be calculated by estimating covariance between y and fractional socio-economic rank of individual. is health service use for individual i, is the mean of health service use, and is individual i’s fractional socio-economic rank. The value of this indicator ranges -1 to 1. CIy shows a positive sign if the health service use is pro- rich in terms of ; but shows a negative sign if the health service use is pro-poor in terms of .

It can be assumed that health service use is decided by a set of k independent variables ()

|  |  |  |
| --- | --- | --- |
|  |  | (2) |

where is a set of coefficients and is the error term. The concentration index for y (health service use) can be presented as

|  |  |  |
| --- | --- | --- |
|  |  | (3) |

where is the concentration index of and is the mean of the independent variable. is the generalized concentration index for the error term. This error term is the remaining unexplained inequality in the model [16].