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**Working Paper**

## Spatial and temporal multidimensional poverty in Nigeria

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30 YEARS OF RESEARCH  
FOR DEVELOPMENT

WIDER Working Paper 2015/132

**Spatial and temporal multidimensional poverty in Nigeria**

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**Abstract:** Nigeria has recorded impressive growth in the last decade, yet the impact of this growth on poverty reduction remains unclear. This paper appraises spatial and temporal non-monetary multidimensional poverty in Nigeria using the first-order dominance approach. It examines five welfare indicators: education, water, sanitation, shelter, and energy. While the analysis is sensitive to indicator definitions, the overall results are robust and lend support to the view that poverty reduction has not kept pace with the rapid economic growth attained in the last decade. The analyses indicate that regional inequalities remain profound with huge disparities between the urban and rural sectors as well as between the far south and the rest of the country.

**Keywords:** Nigeria, economic growth, poverty reduction, first-order dominance approach, multidimensional welfare

**JEL classification:** I30, I31, I32, O12

**Tables and Figures:** at the end of the paper.

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## 1 Introduction

Though Nigeria has achieved rapid economic growth, the extent to which poverty reduction has accompanied this growth remains uncertain. The economy grew strongly at an average annual rate in excess of six per cent over the last decade, even during the global financial crisis (IMF 2013), ranking Nigeria as one of the fastest growing economies globally. In spite of this strong growth performance, poverty remains widespread. Nigeria's National Bureau of Statistics (NBS) estimated consumption poverty to have risen from 27 per cent in 1980 to 66 per cent in 1996. With the onset of higher growth rates, estimated poverty initially dipped to 54 per cent in 2004 but then peaked at 69 per cent in 2010 (NBS 2012).<sup>1</sup>

In response to questions regarding the underestimation of consumption and inconsistencies between per capita GDP and poverty rates, the World Bank re-estimated Nigeria's consumption poverty (World Bank 2014).<sup>2</sup> These new estimates, which are significantly lower than NBS estimates, indicate national poverty rates of 35 per cent in 2011 and 33 per cent in 2013, respectively (World Bank 2014).<sup>3</sup> Though the NBS and World Bank estimates are not directly comparable, the World Bank estimates call into question the 2010 NBS estimates and the overall direction of change.

In this context, where consumption poverty estimates do not provide a clear perspective on poverty levels and trends, triangulating poverty analysis with alternative measures could be particularly informative. Ajakaiye et al. (2014) advance the discussion by estimating multidimensional, non-income poverty within Nigeria's six geopolitical zones and rural and urban areas between 1999 and 2008 using the first-order dominance (FOD) method developed by Arndt et al. (2012). Their analysis lends support to the view that poverty reduction in Nigeria has not kept pace with the rapid economic growth attained in the last decade. The analysis further indicates that regional inequalities remain profound with huge disparities between the urban and rural sectors as well as between the southern and northern geopolitical zones of the country.

In this paper, we expand upon the work of Ajakaiye et al. (2014) by introducing state level FOD analysis in 2008 and 2013. Additionally, we scrutinize indicator definitions and evaluate the sensitivity of outcomes to indicator welfare thresholds. The remainder of the paper is structured as follows. Section 2 presents the FOD methodology, data, and FOD indicators. Section 3 analyses spatial and temporal FOD results. Finally, Section 4 concludes.

## 2 Methodology

### 2.1 FOD

The FOD approach is adopted in this study to appraise multidimensional welfare in Nigeria across time and space. FOD analysis is a method of comparing populations using multiple,

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<sup>1</sup> Concerns have been expressed about the comparability of surveys through time and thus, these figures should be interpreted with caution.

<sup>2</sup> The 2004 and 2010 NBS poverty estimates are based upon the 2003-04 and 2009-10 Nigerian Living Standard Surveys, while the World Bank estimates are based upon the 2010-11 and 2012-13 General Household Surveys.

<sup>3</sup> The 2004 and 2010 NBS poverty estimates are based upon the 2003-04 and 2009-10 Nigerian Living Standard Surveys, while the World Bank estimates are based upon the 2010-11 and 2012-13 General Household Surveys.

binary welfare indicators without imposing weighting schemes or making assumptions about the preferences for each indicator. Multidimensional welfare comparisons are based on the simple criterion that it is better to be not deprived than deprived in any indicator. FOD comparisons of population A and B result in one of three outcomes: population A dominates population B; population B dominates population A; dominance is indeterminate. Indeterminate outcomes occur when two populations are too similar or too different for comparisons to be made. For example when comparing two individuals with outcomes (0, 1, 0) and (1, 0, 1), dominance cannot be established because we do not assume it is better to be not deprived in any given dimension. The same logic can be extended to populations.<sup>4</sup>

Dominant outcomes are all or nothing and thus, provide no information about the extent of domination. To overcome this shortcoming, we draw one hundred bootstrap samples and conduct FOD analysis for each sample.<sup>5</sup> The share of dominant outcomes for each pair of populations across all bootstrap samples can be interpreted as the probability of domination. Thus, while the welfare indicators are ordinal in nature, the application of bootstrap sampling produces probabilities of one population performing better than another does. For greater detail on the FOD methodology, see Arndt et al. (2012).

## 2.2 Data sources

FOD analysis is based on the 1999, 2003, 2008, 2013 Nigeria Demographic Health Surveys (DHS). All surveys are nationally representative covering both urban and rural households. The surveys follow a stratified cluster sampling design with the intention of statistical representation by zone and urban/rural area in 1999 and 2003 and state and urban/rural area in 2008 and 2013. Details of the sample design can be found in the final reports (NPC and ORC Macro 1999, 2004; NPC and IFC Macro 2009; NPC and IFC International 2014). As indicated in the reports, 7,647, 7,225, 34,070, and 40,320 households were surveyed in 1999, 2003, 2008, and 2013, respectively. After eliminating households with missing values, 7,323, 7,115, 32,888, and 36,016 households in 1999, 2003, 2008, and 2013 were utilized for the analysis.

Nigeria is divided into 36 states plus the Federal Capital Territory (FCT), Abuja. Ideally, analysis would be conducted at the politically relevant state level. However, because the DHS sampling scheme only permits state level analysis in 2008 and 2013, the analysis is conducted in two stages. First, spatial and temporal comparisons are made for the nation, urban, and rural areas, and six geopolitical zones (North Central, North East, North West, South East, South South, and South West) for all years. See Figure 1 for a map of zones. Next, spatial and temporal FOD comparisons are made for the 36 states and the FCT in 2008 and 2013.

## 2.3 FOD indicators

Poverty can be reflected in various broad dimensions and the selection of relevant indicators should be driven by the context and specificity of the exercise. The five welfare indicators chosen for this study reflect households' access to water, sanitation, energy, shelter, and education. Indicators and the associated poverty thresholds are motivated by the Nigerian context and internationally recognized standards such as those laid out in the Millennium

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<sup>4</sup> See Mahrt and Nanivazo (2015) for a discussion of indeterminate outcomes.

<sup>5</sup> Bootstrap sampling follows the same stratified cluster sample design used in the DHS sampling. Samples are drawn with replacement.

Development Goals (MDGs). However, available data does not always allow indicators to be defined as would be preferred. Ideally, we would follow the MDG definition of improved water, where water obtained from piped sources, protected wells, protected springs, and rainwater are deemed improved (WHO/UNICEF JMP 2015).<sup>6</sup> Unfortunately, the 1999 DHS does not distinguish between protected and unprotected wells and the 1999 and 2003 DHS do not distinguish between protected and unprotected springs. Likewise, the MDGs define improved sanitation to include most flush toilets, ventilated improved pits, and covered latrines (WHO/UNICEF JMP 2015). Again, this definition was not feasible, as the 1999 and 2003 surveys do not distinguish between covered and uncovered latrines.

Given the data restrictions, household level FOD welfare indicators are defined as follows where all indicators are binary variables such that a ‘1’ is assigned to households that are not deprived.<sup>7</sup>

Water: A household is not deprived if the household’s water source is piped water, well water, or rainwater.

Sanitation: A household is not deprived if the household uses a flush toilet, a ventilated, improved pit (VIP) latrine, or a composting toilet.

Access to electricity: A household is not deprived if the household has access to electricity.

Shelter: A household is not deprived if the household has flooring made of a material other than dirt, sand, or dung.

Education: A household is not deprived if any household member has completed three or more years of schooling at the primary level or above.

Given that the water and sanitation indicators may be defined in several ways, we seek to gain a greater understanding of the impact of alternative definitions on FOD outcomes. We re-estimate FOD comparisons with the above definitions of electricity, shelter, and education while varying the sanitation and water definitions. Specifically, we consider the following combinations of water and sanitation welfare thresholds such that household outcomes at or better than the threshold are deemed not deprived:

1. Piped water and flush toilets (1999, 2003, 2008, 2013).
2. Protected wells and covered latrines (2008, 2013).
3. Any well and any latrine (1999, 2003, 2008, 2013).

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<sup>6</sup> See WHO/UNICEF JMP (2015) for more detailed descriptions of specific water and sanitation categorization.

<sup>7</sup> Population weights are used throughout the analysis.

### 3 Results

#### 3.1 Welfare indicators

Table 1 presents the mean welfare levels of each indicator for the nation, rural, and urban areas, and the six zones. The overall picture varies considerably by area. As a whole, Nigeria achieved gains in water, sanitation, and electricity over the 14-year period, while both housing and education slightly deteriorated. Rural areas followed a similar pattern with more significant declines in housing and education. In contrast, urban areas achieved gains in sanitation, housing, and education but worsened in access to clean water and electricity.

Sanitation welfare increased substantially between 2003 and 2008. This apparent improvement is driven by the use of VIP latrines, which increased from 2.9 per cent in 2003 to 23.9 per cent in 2008. Comparing these figures to another nationally representative Nigerian household survey, the Multiple Indicator Cluster Survey (MICS), calls into question the likelihood of this large leap. In particular, MICS data indicate that household VIP latrine usage was merely .8 per cent in 2007 and 1.5 per cent in 2011 (NBS 2007, 2011). This uncertainty gives even greater importance to sensitivity analysis to evaluate the robustness of results.

Table 2 reports mean welfare levels for alternative water and sanitation thresholds and illustrates welfare sensitivity to these thresholds. Access to piped water greatly deteriorated over the full study period. However, the more relevant measure of poverty, *protected wells*, improved substantially between 2003 and 2013 in nearly every area—a pattern similar to our default FOD water indicator, *any well* over the same time range. Access to flush toilets steadily improved, while the more relevant indicator, *covered latrines*, stagnated or declined between 2008 and 2013—again, a pattern similar to the default *VIP latrine* indicator across these years. Discouragingly, access to *any latrine* declined in nearly every area, including urban areas, and in some cases quite substantially.

Overall, southern zones outperform northern zones in the default FOD indicators (Table 1). However, a few exceptions involving the North West zone stand out. North West zone has the highest average water welfare level in all years with 90.8 per cent of the population not deprived in water in 2013. This compares to 87.8 per cent in urban areas and 81.8 per cent in the next best performing zone, South West. Similarly, in 2008 and 2013, North West outperforms all zones in sanitation. These results are quite surprising given that the North West zone was one of the two poorest zones in terms of monetary poverty throughout the study period (NBS 2009). Turning to the alternative water and sanitation indicators (Table 2), North West's superior water performance does not hold up with either of the alternative water thresholds. However, North West's high sanitation performance does indeed remain with the *covered latrine* and *any latrine* indicators.

In order to gain greater understanding as to whether North West's relatively high sanitation performance is a robust outcome, applying the same definitions, we crosscheck the sanitation indicators with the 2011 MICS data. In contrast to the DHS outcomes, the MICS data indicates that North West is outperformed by all southern zones using the default *VIP* indicator and the *covered latrine* indicator (NBS 2011). However, the 2011 MICS supports the finding that North West outperformed all zones in the *any latrine* indicator with 82 per cent of households in North West zone not deprived in sanitation compared to 76, 68, and 71 per cent in South East, South South, and South West zones, respectively (NBS 2011). In essence, both the MICS and the DHS report that fewer households in North West have no sanitation

facility/open defecation than any other zone. Unfortunately, the inconsistency in the *VIP* and *covered latrines* indicator casts doubt on the validity of the sanitation data, and consequently, results must be interpreted accordingly.

### 3.2 Temporal FOD results

Examining average indicator gains and losses is a useful exercise. However, FOD analysis provides a more stringent measure of welfare advancement than can be gleaned from indicator averages. FOD domination requires improvements to be occurring throughout each population in every indicator. Thus, while the measure is quite strict and often results in indeterminate outcomes, a dominant outcome is robust.

Table 3 presents temporal net FOD results, which measure the likelihood an area advances between two time periods minus any probability of regression. Table values report the average outcome over 100 bootstrap iterations, which can be interpreted as probabilities of advancement. Values in bold indicate net domination prior to bootstrapping (i.e., the static case).

Consistent with a lack of progress across all indicators, FOD comparisons do not suggest that the nation or rural areas have attained welfare gains or losses over the 14-year study period. Both static and bootstrap FOD comparisons suggest that urban welfare deteriorated between 1999 and 2003, improved between 2003 and 2008, and stagnated between 2008 and 2013. Within the zones, only South East and South South exhibit strong evidence, in both the bootstrap and static comparisons, of achieving welfare gains. Furthermore, South South is the only area likely to have improved between 1999 and 2013, with a probability of 92 per cent. The North East, North West, and South West zones have weak probabilities of gains in at least one period.

FOD comparisons in the South South zone illustrate the strength of a dominant outcome. Though average welfare in every indicator improves in each time period between 1999 and 2013, static net FOD gains are not registered between 2003 and 2008, or between 2008 and 2013. This failure to dominate in the static case indicates that although welfare improved on average, the improvements were not sufficiently distributed throughout the population to meet the FOD criterion.

### 3.3 Temporal sensitivity analysis

This section tests the sensitivity of FOD temporal results to the choice of water and sanitation indicator thresholds. This exercise is motivated by data restrictions in defining the indicators, questionably high gains in the sanitation indicator between 2003 and 2008, unexpectedly high welfare in the North West zone, and sensitivity of average welfare to indicator thresholds.

Table 4 presents temporal results from changing the water and sanitation thresholds to *protected wells* and *covered latrines*, respectively, for the limited period for which data are available (2008 and 2013). Outcomes are similar to those with the default indicators (Table 3). However, now North East, South South, and South West have probabilities greater than 20 per cent of advancing. Lowering the sanitation threshold further to include *any latrine* and reverting to the original water indicator encompassing *any well*, temporal patterns are quite different. Now urban areas and South South are no longer likely to have advanced in any period and evidence of advancement and decline is isolated. Finally, increasing the water and

sanitation thresholds to *piped water and flush toilets* again produces only scattered evidence of dominant outcomes, though the decline in urban areas (1999-2003) and advancements in South East (1999-2003) and South South (2003-08, 2003-13) are consistent with the default indicators.

### 3.4 Spatial FOD results

Tables 5-8 present the results of spatial FOD comparisons. Table values indicate the probability that row areas dominate column areas. Row averages indicate the probabilities that row areas dominate all other areas and column averages indicate the probabilities that all other areas dominate column areas. In other words, relatively large row or column averages imply relatively better or worse performing areas.

In 1999, all domination in the static case and significant bootstrap probabilities of domination occur when rural areas are dominated or urban areas dominate. In 2003, zonal advantages and disadvantages emerge with all domination resulting from urban areas, South East and South West dominating rural areas, North East, and North Central. Similar outcomes occur in 2008 and 2013 with increasing domination by South West and South South, and decreasing domination by South East. North West is only dominated in the static case or with substantial bootstrap probability in 1999 by urban areas. Though this outcome is not consistent with North West's relatively high poverty rate, it is consistent with its surprisingly high average welfare in sanitation and water. However, due to questions surrounding the sanitation data, this outcome should be interpreted with caution.

Turning to Table 8, we focus on the South South zone to illustrate the usefulness of bootstrap sampling in assessing the extent of domination. Using the static approach, South South dominates rural areas, North Central, and South East, yet we have no information as to whether South South dominates each area with the same strength. Conducting FOD analysis on 100 bootstrap samples reveals that South South dominates South East in 24 bootstrap samples, rural areas in 59 samples and North Central in every sample. As such, bootstrap sampling distinguishes between static results and establishes probabilities of domination, which provide an indication of quite varied degrees of domination.

### 3.5 Spatial sensitivity analysis

We continue our sensitivity analysis by employing the alternative water and sanitation indicators in spatial FOD comparisons. Table 9 presents 2013 net domination scores for the default indicators and for various combinations of alternative indicators. Net domination scores measure the extent to which an area dominates all other areas net any probability of being dominated (spatial FOD row averages minus column averages). Net domination scores in a sense summarize spatial FOD tables as well as provide a basis for ranking areas. Table 9 provides a fairly consistent pattern across all indicator combinations. In each case urban areas are ranked first, rural areas are ranked at the bottom, and southern zones strongly outperform northern zones. The primary variation concerns the rankings of northern zones and the extent to which northern zones and the nation are dominated. For instance, North West, whose relative sanitation welfare is highly dependent on the choice of threshold, also exhibits net domination sensitivity to thresholds. North West has net domination scores close to zero for the *any well/VIP* and *any well/any latrine* thresholds. In contrast, the *piped/flush* and *protected well/covered latrine* thresholds produce net domination scores of -.35 and -.22, respectively, which are more in line with expectations based on monetary poverty.

Overall, while overall spatial domination patterns are robust, specific figures and rankings should be interpreted with caution.

### 3.6 State level FOD results

The 2008 and 2013 DHS surveys are stratified by state allowing FOD comparisons to be made between Nigeria's 36 states and Federal Capital Territory, Abuja. Maps provide a convenient method of displaying state level results and have the advantage of highlighting regional trends. Figure 2 presents spatial FOD rankings derived from net domination scores where better rankings are represented by lighter greys. Based on consumption poverty figures, we would expect a dark band, representing the worst ranked areas, to be present across the northern and central portions of the country. Rather, we find that states with the lowest welfare are most prevalent in eastern Nigeria, an area encompassing portions of North East, North Central, South South, and South East zones. As a whole, the southern band of the nation has the highest welfare. The relatively high rankings of the northwest states, particularly in 2008, suggest that unexpectedly high water and sanitation welfare in the North West zone is not dictated by a single state, but present throughout many northwest states.

Figure 3 presents the results of FOD comparisons using alternative water and sanitation indicator thresholds. FOD comparisons using the *piped/flush* water and sanitation indicators produces a welfare pattern more in line with monetary poverty figures with all states ranked in the bottom one third falling in northern zones and all states ranked in the top one-third in southern zones, with the exception of Abuja (2008, 2013) and Kaduna (2008). The *protected wells/covered latrines* combination also follows this pattern with the exception of Abuja, Cross River (2008), and Ebonyi. Recalling that the North West zone outperforms all other zones in the *any latrine* sanitation indicator, it is not surprising that the *any well/any latrine* FOD comparisons produce results similar to the default indicators with higher deprivation concentrated in the east.

Figure 4 compares temporal changes to spatial rank changes using the default indicators. In both maps, lighter greys indicate higher probabilities of advancement. Note that in temporal comparisons, the lowest category (10 per cent to -10 per cent) essentially represents stagnation—no state has significant probability of regression. General trends are quite consistent across the maps, which indicate that areas that advanced between 2008 and 2013 also improved relative to other states. States with a probability of advancement greater than 50 per cent include Kwara, Osun, and Ekiti in the west and Adamawa in the northeast. Sensitivity results are not presented; however, these patterns are quite similar in the *covered/protected* and *any well/any latrine* comparisons with the addition of Ogun and Borno showing greater likelihoods of advancing. FOD comparisons using the *piped/flush* thresholds indicate very little welfare advancement with only Lagos and Adamawa achieving probabilities of advancement greater than 50 per cent.

## 4 Conclusion

Despite recent high growth, trends in consumption poverty remain uncertain. This study set out to gain deeper insight into the evolution of Nigerian poverty between 1999 and 2013 by appraising multidimensional non-monetary poverty. Though the FOD approach produces a robust measure of broad-based multidimensional poverty, results may be sensitive to data issues and indicator choices. Motivated by data restrictions in defining the indicators,

questionably high gains in the sanitation indicator between 2003 and 2008, unexpectedly high welfare in the North West zone, and sensitivity of average welfare to indicator thresholds, this paper expanded upon the work of Ajakaiye et al. (2014) in its consideration of alternative water and sanitation indicators.

This analysis lends support to the view that poverty reduction in Nigeria has not kept pace with the rapid economic growth attained in the last decade. The distribution of positive economic performance has not translated to improvements in multidimensional welfare throughout the country over time. This conclusion is consistent with the lack of pro-poor growth observed by Ichoku et al. (2012). Nonetheless, a number of zones and states do display a positive probability of advancement over the study period, most notably South South zone and Kwara, Osun, Ekiti, and Adamawa states. Sensitivity analysis also suggests the possibility of advancement in Borno, Lagos, and Ogun. While the evolution of state level welfare using the MDG inspired water and sanitation indicators (*protected wells/covered latrines*) and the lower thresholds (*any well/any latrine*) do not differ substantially from the default indicators, welfare dynamics are sensitive to the higher deprivation thresholds (*piped/flush*). Nevertheless, the high degree of stagnation in welfare is the primary insight to be gleaned in every scenario.

The analysis further indicates that regional inequalities remain profound with large disparities between the urban and rural sectors as well as between the southern and northern geopolitical zones of the country. However, the extent of domination over northern zones is sensitive to indicator choices. State trends reveal greater sensitivity to the water and sanitation indicators with deprivation concentrated in either the north (*piped/flush* and *protected wells/covered latrines*) or the east (*any well/VIP latrine* or *any well/any latrine*). While specific state and zonal outcomes should be interpreted with a high degree of caution, the overall conclusion of limited welfare gains and vast regional disparities appears to be robust.

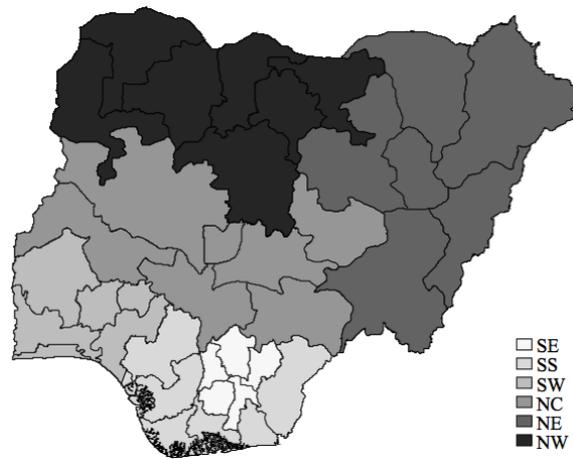
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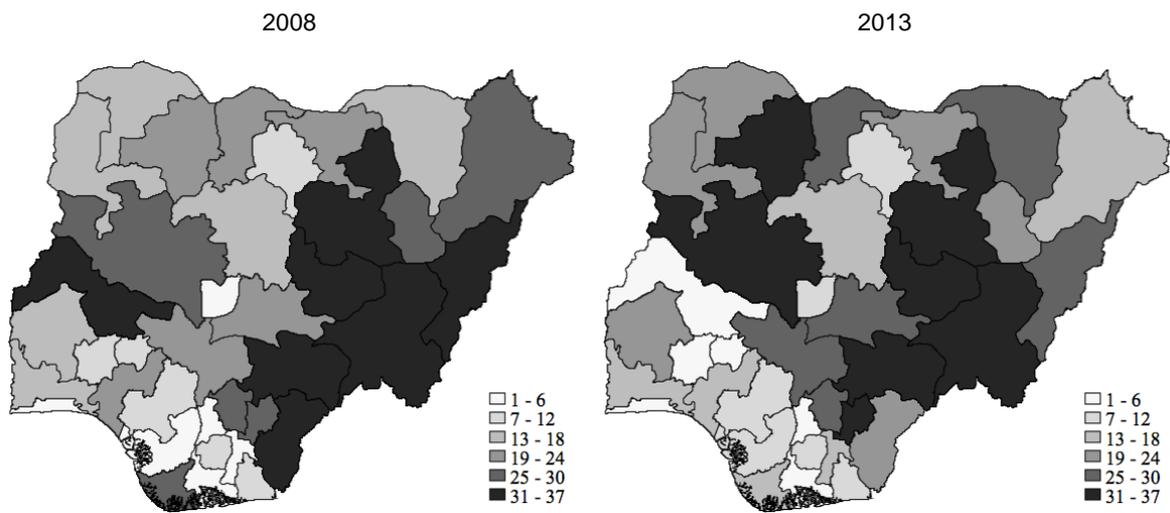
## Figures

Figure 1: Zones of Nigeria



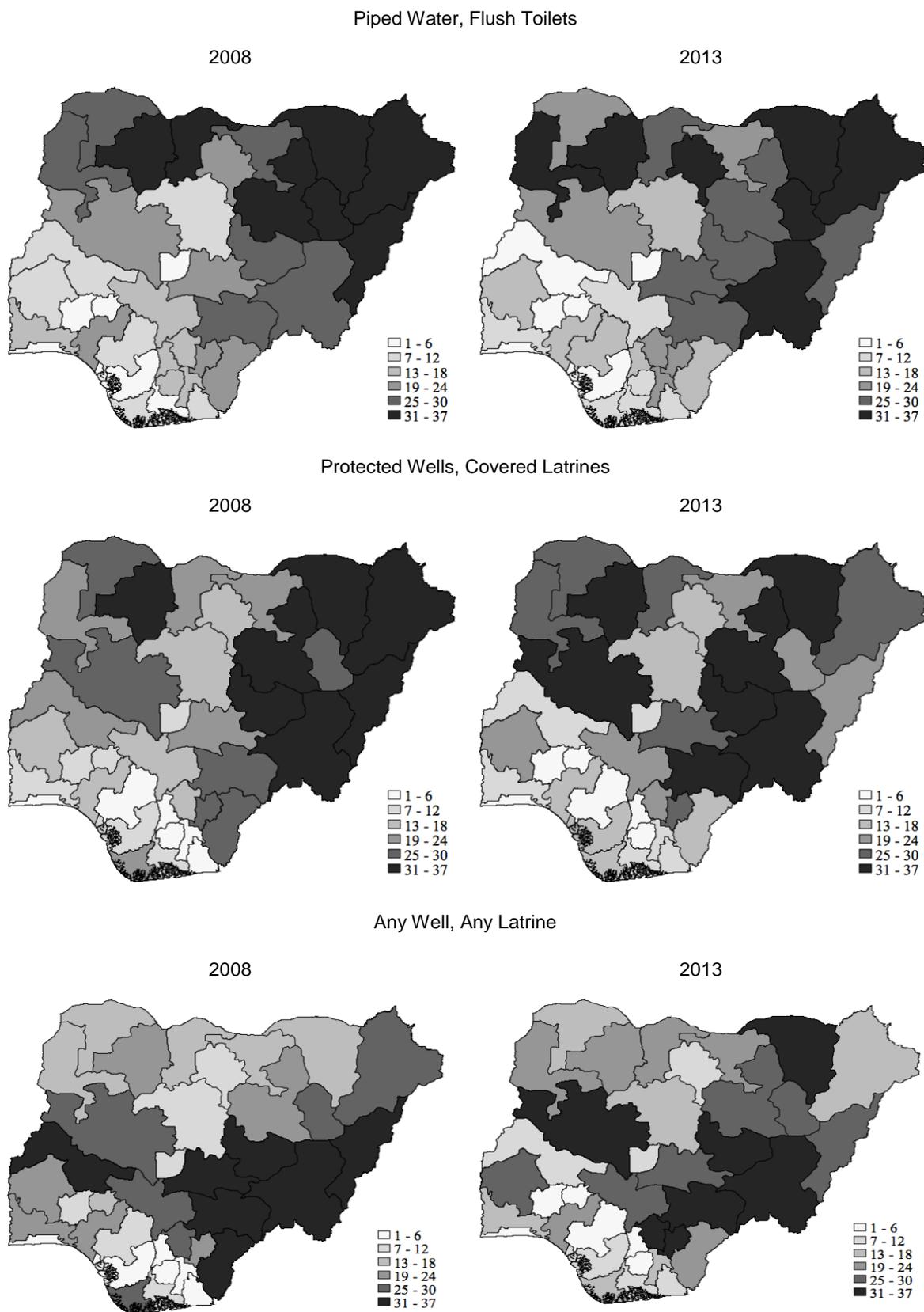
Source: Authors' compilation.

Figure 2: Spatial rankings by state



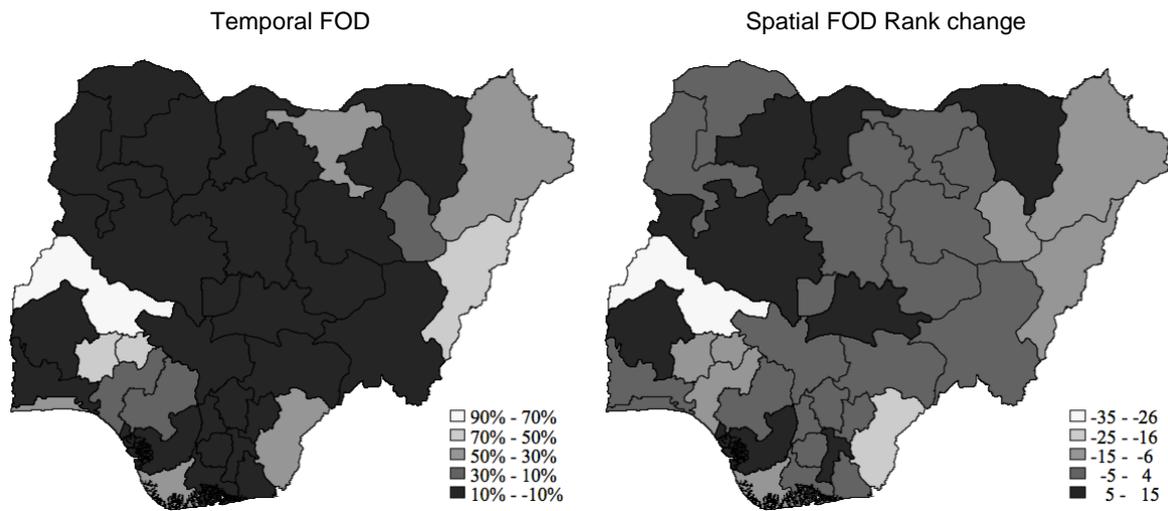
Source: Authors' calculations based on the 2008 and 2013 Nigeria DHS.

Figure 3: Sensitivity of spatial rankings to the water and sanitation indicators, by state



Source: Authors' calculations based on the 2008 and 2013 Nigeria DHS.

Figure 4: Temporal FOD change compared to spatial rank change by state, 2008-13



Source: Authors' calculations based on the 2008 and 2013 Nigeria DHS.

## Tables

Table 1: Households not deprived, by welfare indicator and year (per cent)

| Area     | Water |      |      |      | Sanitation |      |      |      | Electricity |      |      |      | Housing |      |      |      | Education |      |      |      |
|----------|-------|------|------|------|------------|------|------|------|-------------|------|------|------|---------|------|------|------|-----------|------|------|------|
|          | 1999  | 2003 | 2008 | 2013 | 1999       | 2003 | 2008 | 2013 | 1999        | 2003 | 2008 | 2013 | 1999    | 2003 | 2008 | 2013 | 1999      | 2003 | 2008 | 2013 |
| National | 68.9  | 70.0 | 73.5 | 79.1 | 18.6       | 15.8 | 40.2 | 41.4 | 44.7        | 51.1 | 47.8 | 51.1 | 61.4    | 64.4 | 61.8 | 59.7 | 78.9      | 78.0 | 78.9 | 77.1 |
| Rural    | 59.8  | 64.9 | 68.1 | 73.9 | 9.6        | 7.3  | 30.2 | 28.9 | 28.0        | 34.4 | 29.8 | 32.5 | 50.4    | 52.6 | 48.5 | 44.8 | 74.4      | 72.5 | 72.2 | 67.2 |
| Urban    | 90.9  | 80.0 | 84.7 | 87.8 | 40.6       | 32.5 | 60.6 | 61.9 | 85.3        | 83.9 | 84.6 | 81.8 | 88.1    | 87.6 | 88.9 | 84.1 | 90.1      | 88.9 | 92.5 | 93.5 |
| NC       | 66.3  | 50.7 | 60.5 | 63.8 | 18.7       | 10.1 | 32.6 | 31.3 | 51.0        | 47.2 | 32.3 | 44.8 | 73.9    | 69.3 | 62.4 | 62.6 | 86.5      | 87.7 | 84.8 | 87.1 |
| NE       | 76.7  | 68.9 | 71.9 | 75.6 | 10.6       | 5.6  | 25.3 | 34.4 | 23.1        | 34.4 | 24.7 | 30.7 | 32.5    | 39.4 | 30.8 | 44.5 | 57.2      | 61.7 | 57.0 | 55.6 |
| NW       | 89.6  | 84.3 | 87.5 | 90.8 | 8.1        | 5.8  | 48.4 | 47.1 | 30.8        | 45.1 | 38.3 | 43.5 | 43.2    | 56.1 | 39.1 | 42.6 | 52.4      | 61.0 | 59.2 | 62.9 |
| SE       | 44.5  | 73.7 | 70.8 | 71.3 | 18.6       | 37.1 | 44.2 | 43.2 | 43.9        | 66.0 | 64.4 | 63.2 | 76.6    | 85.4 | 84.4 | 73.9 | 95.2      | 96.3 | 95.6 | 96.2 |
| SS       | 47.0  | 59.5 | 67.1 | 75.7 | 21.2       | 28.2 | 35.3 | 44.7 | 48.4        | 55.8 | 56.9 | 67.8 | 67.4    | 76.0 | 79.5 | 77.3 | 96.0      | 96.5 | 96.8 | 97.8 |
| SW       | 74.6  | 76.2 | 72.5 | 81.8 | 34.5       | 31.4 | 46.4 | 43.5 | 67.3        | 80.7 | 71.2 | 77.9 | 77.3    | 87.4 | 85.9 | 89.8 | 94.1      | 93.4 | 92.2 | 92.9 |

Source: Authors' calculations based on the 1999, 2003, 2008, and 2013 Nigeria DHS.

Table 2: Households not deprived, by alternative water and sanitation welfare indicator and year (per cent)

| Area     | Piped Water |      |      |      | Protected Wells |      |      |      | Flush Toilet |      |      |      | Covered Latrines |      |      |      | Any Latrine |      |      |      |
|----------|-------------|------|------|------|-----------------|------|------|------|--------------|------|------|------|------------------|------|------|------|-------------|------|------|------|
|          | 1999        | 2003 | 2008 | 2013 | 1999            | 2003 | 2008 | 2013 | 1999         | 2003 | 2008 | 2013 | 1999             | 2003 | 2008 | 2013 | 1999        | 2003 | 2008 | 2013 |
| National | 24.1        | 16.3 | 10.3 | 9.6  | na              | 39.6 | 55.0 | 61.2 | 12.2         | 12.9 | 16.2 | 19.3 | na               | na   | 53.5 | 53.1 | 73.3        | 75.4 | 67.3 | 69.1 |
| Rural    | 13.2        | 8.0  | 5.2  | 5.5  | na              | 28.1 | 44.1 | 48.0 | 3.8          | 5.6  | 5.8  | 6.4  | na               | na   | 41.8 | 38.7 | 67.4        | 67.5 | 57.8 | 60.2 |
| Urban    | 50.7        | 32.6 | 20.7 | 15.8 | na              | 62.4 | 77.5 | 83.1 | 32.5         | 27.2 | 37.5 | 38.8 | na               | na   | 77.3 | 76.7 | 87.7        | 91.1 | 86.6 | 83.7 |
| NC       | 24.5        | 13.0 | 9.6  | 8.7  | na              | 29.0 | 47.7 | 54.5 | 8.7          | 8.6  | 12.6 | 16.6 | na               | na   | 38.3 | 37.3 | 64.6        | 61.3 | 44.3 | 42.9 |
| NE       | 23.8        | 13.7 | 5.5  | 7.3  | na              | 22.6 | 32.6 | 48.9 | 7.9          | 4.6  | 1.7  | 7.5  | na               | na   | 34.3 | 45.3 | 71.8        | 81.8 | 65.4 | 73.0 |
| NW       | 21.8        | 21.5 | 12.4 | 10.4 | na              | 35.9 | 50.4 | 57.4 | 3.6          | 4.2  | 4.8  | 5.3  | na               | na   | 62.1 | 59.9 | 87.9        | 82.6 | 82.5 | 85.0 |
| SE       | 14.9        | 18.5 | 4.3  | 5.7  | na              | 69.0 | 68.8 | 70.5 | 16.2         | 36.4 | 25.1 | 32.0 | na               | na   | 64.7 | 57.2 | 76.4        | 79.0 | 77.1 | 64.8 |
| SS       | 22.9        | 7.7  | 10.9 | 10.4 | na              | 51.7 | 59.8 | 69.9 | 16.0         | 20.7 | 26.4 | 35.6 | na               | na   | 54.3 | 55.1 | 75.9        | 71.7 | 64.8 | 66.2 |
| SW       | 32.8        | 23.6 | 14.3 | 13.2 | na              | 53.7 | 70.4 | 78.5 | 23.1         | 26.0 | 31.2 | 41.6 | na               | na   | 59.4 | 59.3 | 60.6        | 70.0 | 61.6 | 62.2 |

Source: Authors' calculations based on the 1999, 2003, 2008, and 2013 Nigeria DHS.

Table 3: Temporal net FOD comparisons (probabilities)

| Area     | 2003<br>FOD<br>1999 | 2008<br>FOD<br>1999 | 2008<br>FOD<br>2003 | 2013<br>FOD<br>1999 | 2013<br>FOD<br>2003 | 2013<br>FOD<br>2008 |
|----------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| National | 0.01                | 0.09                |                     | 0.04                | 0.01                |                     |
| Rural    | 0.01                | 0.01                |                     |                     |                     | -0.01               |
| Urban    | <b>-0.40</b>        |                     | <b>0.40</b>         | 0.01                | 0.04                |                     |
| NC       | -0.06               |                     |                     |                     |                     | 0.09                |
| NE       | 0.01                |                     |                     | 0.11                | 0.01                | 0.18                |
| NW       | 0.02                | 0.02                |                     | 0.15                |                     |                     |
| SE       | <b>0.45</b>         | <b>0.47</b>         | 0.05                | 0.20                | -0.08               | -0.03               |
| SS       | <b>0.39</b>         | <b>0.70</b>         | 0.25                | <b>0.92</b>         | <b>0.55</b>         | 0.14                |
| SW       | 0.04                | 0.03                |                     | 0.28                | 0.20                | 0.15                |

Note: Values in bold indicate domination in the static case (FOD without bootstrapping).

Source: Authors' calculations based on the 1999, 2003, 2008, and 2013 Nigeria DHS.

Table 4: Temporal net FOD comparisons with alternative water and sanitation welfare indicator (probabilities)

|          | Piped/Flush   |               |               |               |               |               | Protected Wells/<br>Covered latrines | Any Well/Any Latrine |               |               |               |               |               |
|----------|---------------|---------------|---------------|---------------|---------------|---------------|--------------------------------------|----------------------|---------------|---------------|---------------|---------------|---------------|
|          | 2003 FOD 1999 | 2008 FOD 1999 | 2008 FOD 2003 | 2013 FOD 1999 | 2013 FOD 2003 | 2013 FOD 2008 | 2013 FOD 2008                        | 2003 FOD 1999        | 2008 FOD 1999 | 2008 FOD 2003 | 2013 FOD 1999 | 2013 FOD 2003 | 2013 FOD 2008 |
| National |               |               | -0.01         |               |               |               |                                      | 0.03                 |               |               |               |               | 0.01          |
| Rural    | -0.01         | -0.04         | -0.16         | -0.01         | -0.14         |               | -0.01                                | 0.04                 |               | -0.02         |               |               |               |
| Urban    | <b>-0.36</b>  |               |               |               |               | -0.02         |                                      | -0.01                |               |               |               |               |               |
| NC       | -0.07         | -0.02         | -0.02         |               |               | 0.15          | 0.10                                 | -0.05                | <b>-0.41</b>  | -0.02         | -0.13         |               | 0.11          |
| NE       | 0.01          | -0.09         | <b>-0.59</b>  |               | 0.02          | 0.18          | 0.31                                 | 0.06                 | -0.06         | -0.10         | 0.01          |               | 0.18          |
| NW       | 0.23          | -0.01         | -0.22         |               | -0.02         | 0.02          | 0.02                                 |                      | -0.02         | -0.06         | 0.02          | -0.01         | <b>0.30</b>   |
| SE       | <b>0.31</b>   |               | -0.28         |               | -0.21         |               | -0.07                                | 0.23                 | 0.19          | -0.04         |               | -0.19         | -0.07         |
| SS       | -0.01         |               | <b>0.28</b>   | 0.01          | 0.35          | 0.01          | 0.20                                 | 0.05                 |               | -0.01         | 0.02          | 0.07          | 0.09          |
| SW       |               |               | -0.09         |               |               | 0.25          | 0.22                                 | 0.17                 | 0.03          | <b>-0.36</b>  | 0.12          | -0.02         | <b>0.31</b>   |

Note: Values in bold indicate domination in the static case (FOD without bootstrapping).

Source: Authors' calculations based on the 1999, 2003, 2008, and 2013 Nigeria DHS.

Table 5: 1999 Bootstrap spatial FOD comparisons (probabilities)

| Area     | National | Rural       | Urban | NC          | NE       | NW          | SE   | SS   | SW   | Avg  |
|----------|----------|-------------|-------|-------------|----------|-------------|------|------|------|------|
| National |          | <b>1</b>    |       |             | 0.03     |             |      |      |      | 0.13 |
| Rural    |          |             |       |             |          |             |      |      |      | 0.00 |
| Urban    | <b>1</b> | <b>1</b>    |       | <b>0.85</b> | <b>1</b> | <b>0.59</b> |      |      |      | 0.56 |
| NC       | 0.02     | <b>0.63</b> |       |             | 0.04     |             |      |      |      | 0.09 |
| NE       |          |             |       |             |          |             |      |      |      | 0.00 |
| NW       |          |             |       |             |          |             |      |      |      | 0.00 |
| SE       |          |             |       |             |          |             |      | 0.01 |      | 0.00 |
| SS       |          | 0.03        |       | 0.01        |          |             |      |      |      | 0.01 |
| SW       | 0.25     | <b>0.81</b> |       | 0.11        | 0.28     | 0.01        | 0.02 | 0.04 |      | 0.19 |
| Average  | 0.16     | 0.43        | 0.00  | 0.12        | 0.17     | 0.08        | 0.00 | 0.01 | 0.00 | 0.11 |

Note: Values in bold indicate domination in the static case (FOD without bootstrapping).

A '1' in the bootstrap FOD comparisons indicates that the row (column) province dominates (is dominated by) the column, provinces, 100 per cent of the time. An empty cell indicates that the FOD comparison of the row and column provinces is always indeterminate.

Source: Authors' calculations based on the 1999 Nigeria DHS.

Table 6: 2003 Bootstrap spatial FOD comparisons (probabilities)

| Area     | National    | Rural       | Urban | NC          | NE          | NW   | SE   | SS   | SW   | Avg  |
|----------|-------------|-------------|-------|-------------|-------------|------|------|------|------|------|
| National |             | <b>0.95</b> |       |             | <b>0.55</b> |      |      |      |      | 0.19 |
| Rural    |             |             |       |             | 0.11        |      |      |      |      | 0.01 |
| Urban    | <b>0.95</b> | <b>0.95</b> |       | <b>0.52</b> | <b>1</b>    | 0.15 |      |      |      | 0.45 |
| NC       |             |             |       |             | 0.02        |      |      |      |      | 0.00 |
| NE       |             |             |       |             |             |      |      |      |      | 0.00 |
| NW       |             |             |       |             | 0.21        |      |      |      |      | 0.03 |
| SE       | <b>0.65</b> | <b>0.86</b> |       | <b>0.85</b> | <b>0.67</b> |      |      | 0.28 |      | 0.41 |
| SS       | 0.02        | 0.08        |       | 0.33        | 0.1         |      |      |      |      | 0.07 |
| SW       | <b>0.60</b> | <b>0.84</b> |       | <b>0.54</b> | <b>0.85</b> | 0.04 |      |      |      | 0.36 |
| Average  | 0.28        | 0.46        | 0.00  | 0.28        | 0.44        | 0.02 | 0.00 | 0.04 | 0.00 | 0.17 |

Note: Values in bold indicate domination in the static case (FOD without bootstrapping).

A '1' in the bootstrap FOD comparisons indicates that the row (column) province dominates (is dominated by) the column, provinces, 100 per cent of the time. An empty cell indicates that the FOD comparison of the row and column provinces is always indeterminate.

Source: Authors' calculations based on the 2003 Nigeria DHS.

Table 7: 2008 Bootstrap spatial FOD comparisons

| Area     | National | Rural       | Urban | NC          | NE          | NW   | SE   | SS   | SW          | Avg  |
|----------|----------|-------------|-------|-------------|-------------|------|------|------|-------------|------|
| National |          | <b>1</b>    |       |             | <b>0.71</b> |      |      |      |             | 0.21 |
| Rural    |          |             |       |             | 0.09        |      |      |      |             | 0.01 |
| Urban    | <b>1</b> | <b>1</b>    |       | <b>1</b>    | <b>1</b>    | 0.08 |      |      | <b>0.47</b> | 0.57 |
| NC       |          |             |       |             |             |      |      |      |             | 0.00 |
| NE       |          |             |       |             |             |      |      |      |             | 0.00 |
| NW       |          |             |       |             | <b>0.65</b> |      |      |      |             | 0.08 |
| SE       | 0.21     | <b>0.86</b> |       | <b>0.97</b> | 0.46        |      |      | 0.01 |             | 0.31 |
| SS       |          | 0.17        |       | <b>0.74</b> | 0.09        |      |      |      |             | 0.13 |
| SW       | 0.14     | <b>0.95</b> |       | <b>0.98</b> | <b>0.59</b> |      |      |      |             | 0.33 |
| Average  | 0.17     | 0.50        | 0.00  | 0.46        | 0.45        | 0.01 | 0.00 | 0.00 | 0.06        | 0.18 |

Notes: A '1' in the bootstrap FOD comparisons indicates that the row (column) province dominates (is dominated by) the column, provinces, 100 per cent of the time. An empty cell indicates that the FOD comparison of the row and column provinces is always indeterminate.

Source: Authors' calculations based on the 2008 Nigeria DHS.

Table 8: 2013 Bootstrap spatial FOD comparisons (probabilities)

| Area     | National    | Rural       | Urban | NC          | NE          | NW   | SE          | SS   | SW   | Average |
|----------|-------------|-------------|-------|-------------|-------------|------|-------------|------|------|---------|
| National |             | <b>1</b>    |       |             | <b>0.59</b> |      |             |      |      | 0.20    |
| Rural    |             |             |       |             |             |      |             |      |      | 0.00    |
| Urban    | <b>1</b>    | <b>1</b>    |       | <b>1</b>    | <b>1</b>    | 0.07 |             |      |      | 0.51    |
| NC       |             |             |       |             |             |      |             |      |      | 0.00    |
| NE       |             |             |       |             |             |      |             |      |      | 0.00    |
| NW       |             | 0.01        |       |             | 0.13        |      |             |      |      | 0.02    |
| SE       |             | 0.2         |       | <b>0.84</b> | 0.07        |      |             |      |      | 0.14    |
| SS       | 0.05        | <b>0.69</b> |       | <b>1</b>    | 0.28        |      | <b>0.24</b> |      |      | 0.28    |
| SW       | <b>0.51</b> | <b>0.97</b> |       | <b>0.95</b> | <b>0.73</b> |      |             |      |      | 0.40    |
| Average  | 0.20        | 0.48        | 0.00  | 0.47        | 0.35        | 0.01 | 0.03        | 0.00 | 0.00 | 0.17    |

Notes: A '1' in the bootstrap FOD comparisons indicates that the row (column) province dominates (is dominated by) the column, provinces, 100 per cent of the time. An empty cell indicates that the FOD comparison of the row and column provinces is always indeterminate.

Source: Authors' calculations based on the 2013 Nigeria DHS.

Table 9: Areas ranked by net domination scores for various combinations of water and sanitation indicator thresholds (2013)

| Piped/Flush |          |      |        | Any Well/VIP (default) |          |        | Protected Wells/Covered Latrines |          |        | Any Well/Any Latrine |          |        |
|-------------|----------|------|--------|------------------------|----------|--------|----------------------------------|----------|--------|----------------------|----------|--------|
| 1999-2013   |          |      |        | 1999-2003              |          |        | 2008-2013                        |          |        | 1999-2013            |          |        |
| Area        | Net Dom. | Rank | Change | Area                   | Net Dom. | Change | Area                             | Net Dom. | Change | Area                 | Net Dom. | Change |
| Urban       | 0.62     | 1    | 0      | Urban                  | 0.51     | 0      | Urban                            | 0.63     | 0      | Urban                | 0.50     | 0      |
| SW          | 0.60     | 2    | 0      | SW                     | 0.40     | 0      | SW                               | 0.54     | -1     | SS                   | 0.23     | -2     |
| SS          | 0.42     | 3    | 0      | SS                     | 0.28     | -1     | SS                               | 0.51     | -1     | SW                   | 0.20     | -2     |
| SE          | 0.07     | 4    | 0      | SE                     | 0.11     | 1      | SE                               | 0.49     | 2      | SE                   | 0.11     | 1      |
| NC          | -0.02    | 5    | 0      | NW                     | 0.01     | -2     | National                         | -0.20    | 0      | NW                   | 0.02     | -1     |
| National    | -0.05    | 6    | 0      | National               | 0.00     | 1      | NW                               | -0.22    | 0      | National             | 0.00     | 4      |
| NW          | -0.35    | 7    | -1     | NE                     | -0.35    | -1     | NC                               | -0.47    | 0      | NE                   | -0.14    | -1     |
| NE          | -0.60    | 8    | 1      | NC                     | -0.47    | 2      | NE                               | -0.64    | -1     | Rural                | -0.43    | -1     |
| Rural       | -0.70    | 9    | 0      | Rural                  | -0.48    | 0      | Rural                            | -0.64    | 1      | NC                   | -0.48    | 2      |

Note: Rankings within shaded groups are highly sensitive to small perturbations and should be interpreted with caution.

Source: Authors' calculations based on the 1999, 2003, 2008, and 2013 Nigeria DHS.