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Public Investment in Rural Infrastructure: Some Political Economy Considerations

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Abstract

We have constructed a unique dataset to study the extent of the relationship between political marginalisation, public investment in transport infrastructure, and food security in Benin, Ghana, Mali and Senegal. We first show a strong relation between food security and road infrastructures after controlling for other factors known to affect food security, including climate and land productivity. To trace a potential mechanism by which political marginalisation impacts on food security, we then look at its relation with the allocation of roads within countries. We find support for the argument that political factors affect the location of roads after controlling for the economic importance of the areas, as well as many other factors. This finding is robust to a number of alternative specifications. We conclude that politically marginalised areas have significantly fewer roads, thus supporting our claim that political marginalisation indirectly affects food security, by undermining the quality and the allocation of transport infrastructures. Although we do not establish a causal effect here, this study is the first to empirically substantiate this relationship at the micro-level.

JEL classification: O12, O18, O38, O55, H54

1. Introduction

According to Amartya Sen, political freedom has been one of the most effective remedies against famines. Yet, there is evidence to suggest that democratic reforms have failed to prevent severe forms of food shortage and malnutrition in a wide range of countries, particularly in Africa. Indeed, there is little indication of a correlation between the level of democracy and food security in Africa. For example, the food crisis in Niger in 2005–06 occurred at a time when that country was widely regarded as democratic, and the 2010 Sahel famine likewise affected democratic Mali and Nigeria, among others. Voting and political participation therefore seem to have scant relevance for the prevention of food crises. One potential cause of this may be the political marginalisation of vulnerable voters; politicians and policy-makers ignore certain groups of citizens because they have little weight in determining political outcomes. Therefore, in this paper, we consider the possible impact of political marginalisation on food security.

However, although marginalisation may be linked to food security, this link may not be direct. Even if policy-makers focus their efforts away from marginal voters, this may not affect policies designed to reduce malnutrition directly, because if political effort in these policy areas is not visible then its electoral benefits will be limited. Instead, there may be an indirect effect whereby political action in more visible areas, like transport infrastructure, has implications for food security. It is widely accepted that investment in roads has a major impact on the development and maintenance of safe and reliable food supplies. Therefore, we suggest that a possible mechanism linking political marginalisation to food security may be that marginalisation affects the distribution of investment in roads, which are crucial for food supplies. The data we present in this paper indicates that some of the most politically marginalised areas also contain fewer roads and suffer more food insecurity. These include well-known areas such as Timbuktu in northern Mali or Casamance in southern Senegal.

We investigate the validity of this mechanism in four West African countries. More specifically, we study the relationship between political marginalisation, public investment in transport infrastructure and food security in Benin, Ghana, Mali and Senegal, in order to trace the potential relationship between political marginalisation and food security. First, we investigate the determinants of food insecurity. Using data on stunted children, we show that the density of roads per square kilometre has a significant negative relationship to food insecurity. Moreover, this relationship holds when we control for other factors known to affect food security, including climate and land productivity. Following this, we then look at the factors that determine the presence of roads. Specifically, we find that politically marginalised areas have significantly fewer roads, even after controlling for the economic importance of the areas, and many other factors. These findings support our claim that political marginalisation indirectly affects food security, via its impact on the quality of transport infrastructure.

In the following section, we discuss the existing literature on the political economy of human development, in particular with regard to health and longevity. We then outline our argument for the indirect effect of political marginalisation on food security in greater detail. In Section 3, we discuss our empirical strategy, describing the data that we use, and how we use it. We present the results in Section 4, and in Section 5 we conclude.

2. Literature and motivation

Although studies of human development have focused predominantly on income as a measure of welfare, this is only one dimension of the concept. Conceived more broadly, there are three essential elements of human life—longevity, knowledge and decent living standards. Keeping this in mind, it is clear that food security—or the condition where all people at all times have access to sufficient, safe and nutritious food to maintain a healthy and active life—is a crucial aspect of human development. Where food security is threatened, not only do individuals' living standards fall, but also their life expectancy is reduced. This issue has been reprioritised within the global development debate in recent years, as rising food prices and the global economic downturn have reversed the steady reduction in the proportion of developing countries' populations who are undernourished. In this paper, we offer some political economy considerations of this issue, by investigating a potential mechanism linking political marginalisation with food security. As such, this research contributes to a broader literature on the impact of political institutions on health and longevity. In this section, we present a brief review of this literature, before developing an argument about the impact of political marginalisation on food security.

2.1 The political economy of human development: health and longevity

A number of studies have considered the relationship between political institutions and longevity, with the vast weight of evidence suggesting a positive impact of democracy. The United Nations Development Program's human development index incorporates data on life expectancy at birth as a measure of longevity, and a number of studies have used this indicator to show a positive effect of democracy (Lake and Baum, 2001; Besley and Kudamatsu, 2006; Tsai, 2006; Vollmer and Ziegler, 2009). For the most part, these studies have taken a fairly straightforward approach to demonstrating the existence of a positive relationship between a country's political institutions and the average life expectancy of its citizens, although some do a better job than others of controlling for time trends and unobserved country-specific factors.

Democracy has also been shown to have a positive effect on other indicators of health—for example, compared with dictatorships democracies have lower mortality rates, and fewer women die in childbirth (Przeworski, 2004). In addition, another popular health indicator is infant mortality, which has been found to be significantly lower in democracies (Zweifel and Navia, 2000; Shandra *et al*., 2004; Siegle *et al*., 2004). Indeed, Lake and Baum (2001) find that a full transition to democracy reduces infant mortality by five deaths per thousand, and Przeworski (2004) finds that the positive effect of democracy on infant survival rates remains after controlling for selection effects.

This evidence strongly suggests that political institutions do matter for longevity, although the findings have been questioned on the basis that many of these studies have used biased samples (Ross, 2006). One way to overcome these problems is to shift the analysis down from the national to the individual level. Doing just this, Kudamatsu (2012) uses individual-level data from the Demographic and Health Surveys to analyse the 'within-mother' effect of democratisation on infant mortality across twenty-eight countries in Sub-Saharan Africa. By comparing the survival probabilities of infants born with the same mothers before and after a democratic transition, Kudamatsu identifies the effect of institutional change much more precisely, and in so doing he finds a positive and significant effect—infants are more likely to survive under democracy. Moving on from mortality rates, Blaydes and Kayser (2011) use data on average daily calorie consumption to investigate whether certain regime types are better at translating economic growth into consumption for the poorest citizens. With these data, they provide evidence that democracies are indeed better than autocracies at converting economic growth into calorie consumption.

Moving from the question of whether to why electoral institutions should affect health and other aspects of human development has led to a focus on the role of accountability (Harding and Wantchekon, 2010). The argument, most simply stated, is that electoral competition encourages an increase in the provision of public goods, because elections render politicians accountable to the electorate. As a result, politicians are required to distribute public goods to a wide segment of the population in order to stay in office (Bates, 1981; Bueno de Mesquita *et al*., 2001; Lake and Baum, 2001). In an interesting refinement on the accountability explanation, Mani and

Mukand (2007) have argued that the incentives for elites to provide public goods vary across types of goods according to their 'visibility', where visibility refers to the likelihood that elites will gain credit from voters for the provision of the good. One example they offer is that reducing mortality through famine relief is much more visible than doing so by preventing malnutrition, even if the overall impact on mortality is much lower.[1]

The key point to note is that democratic political institutions alter incentives to provide different types of public goods, so not all public goods will be improved by democracy. For the question at hand, this highlights the fact that democracy may not necessarily lead directly to policies that are designed specifically to increase food security. Rather, electoral institutions may impact on food security indirectly, by altering the incentives for politicians to provide specific goods and services that they affect access to sufficient, safe and nutritious food. In the following section, we suggest that one such potential mechanism linking political considerations to food security in West Africa may be the provision of transport infrastructure.

2.2 Political marginalisation, transport infrastructure and food security

Electoral institutions create incentives for governments to provide public goods in order to win votes. As such, they give citizens power, in the sense that citizens can use their votes to hold politicians accountable for the goods and services they provide. However, this power is not distributed equally among all citizens. Instead, some citizens have little influence over political outcomes and are thus marginal to the political process. Where citizens have less impact on electoral outcomes, they are likely to be ignored by politicians and policy-makers, and as a result they may be expected to receive lower levels of public goods and services.

Moreover, following the recognition that politicians' incentives may vary over different types of goods, we might also expect that the under provision of goods to politically marginalised citizens should be particularly severe with regard to more visible or attributable goods; since politicians gain credit for providing visible goods, they have an incentive to target them towards voters who have influence over electoral outcomes, rather than to politically marginalised citizens. In many African countries, one such visible good is transport infrastructure, and in particular roads, the presence of which has an enormous impact on the daily lives of all citizens. Following Mani and

[1] See also Harding and Stasavage (2013), who highlight the abolition of user fees in primary education as an example of a verifiable education policy.

Mukand (2007), we might expect that governments have stronger incentives to provide roads, relative to other less-visible goods. However, they should have little incentive to provide roads to politically marginalised areas, where citizens have less influence over political outcomes.

It is worth noting here that the extent to which citizens are able to directly attribute roads to executive actions varies across countries. In Ghana, the establishment of a road fund and a highly centralised road agency (the Ghana Highways Authority—GHA) not only implies a high level of state capacity with regard to the development and maintenance of the road network, but also makes it possible for citizens to attribute road outcomes directly to political action by the executive (Harding, 2011). This capacity may not be as high in other countries. In Mali, for example, while recent reforms have now led to the creation of a road authority and road fund, state capacity with regard to roads in Mali is somewhat short of that in Ghana (Briceno-Garmendia *et al*., 2011). That said, the visibility and importance of roads mean there is good reason to think that their provision may be related to political marginalisation everywhere, even if the intensity of this relationship varies across countries.

This matters for the issue at hand, because roads affect food security. A common conclusion from almost all studies of agricultural development in Africa is that a lack of quality roads is a major constraint on agricultural markets (deGrassi, 2005). As a result, it is widely accepted that roads encourage agricultural productivity and foster development of cereals production and marketing (Gladwin *et al*., 2001; Clover, 2003; Rosegrant and Cline, 2003). Moreover, detailed studies have shown that the quantity and quality of roads have a direct impact on the availability and accessibility of food. For example, transportation costs have been shown to explain most of the variation in food prices between producer regions in the former Zaire (Minten and Kyle, 1999). Where transport infrastructure is limited, not only is agricultural development constrained, but also food prices are increased, further limiting access to food.

Taken together, this implies a link between political marginalisation and food security. Moreover, it suggests that the mechanism underlying this link is the development of transport infrastructure; political marginalisation should indirectly affect food security, because it has a negative impact on the provision of roads, which themselves are crucial for the availability of safe and reliable food supplies. In the following section, we discuss the empirical strategy that we use to evaluate this link, describing first the data and then the estimation strategy that we employ.

Before we do so, however, it is important to acknowledge that political marginalisation is by no means the only determinant of roads. Rather, factors such as external funding and the economic importance of a particular area (factors which themselves are inter-related) also play an important role. For instance, it is likely that economically important areas receive a greater share of infrastructure investment from the government. Moreover, the factors that make such areas important, such as the presence of minerals and other natural resources, are likely to drive external and internal investments. Therefore, it is important to recognise the potential importance of such factors in any analysis of the determinants of roads in Africa.

It is also important to recognise that roads are not the only determinant of food security, nor is the mere presence of roads likely to be sufficient to ensure that all people have access to enough safe and nutritious food. Many factors affect food security, not least climate, and the productivity of the land, and as such it is important to control for as many of these factors as possible when analysing the determinants of food security. Finally, it is also worth stating that our goal here is not to provide exhaustive explanations for food security and the distribution of roads in Africa, nor do we claim to provide estimates of causal effects. Instead, our expressed goal is much more modest; we aim to provide significant evidence of the existence of a relationship between political marginalisation, roads and food security, in order to support the validity of the argument outlined above. It is to this that we now turn.

3. Empirical strategy

We employ a two-stage strategy in order to evaluate the claim that political marginalisation affects food security indirectly, through its impact of transport infrastructure. We start by looking at the link between food security and roads in four West African countries (Benin, Ghana, Mali and Senegal). We then shift the analysis back, and look at the factors that determine roads. Our aim was to illuminate the link between political marginalisation and food security by showing: (1) that roads matter for food security; and (2) that roads themselves are influenced by political marginalisation. In this section, we describe the data and estimation strategy in detail.

3.1 Data

We focus our analysis on four countries in West Africa—Benin, Ghana, Mali and Senegal. Limiting the study to countries within a single geographic region allows us to control for a great deal of variation that would otherwise be introduced if we were to broaden the study across the whole of Africa. At the same time, there are still important differences between these four countries, for example, in terms of political history, economic status and the nature of political competition, which allow for interesting comparisons across them. Although our sample contains four countries, our unit of observation is sub-national. This is necessary because we are interested in variations in the distribution of transport infrastructure by national governments, within countries.

Therefore, we have constructed a cross-sectional dataset, with our observations being the lowest level administrative units in each country (Communes in Benin, Districts in Ghana and Arrondissements in Mali and Senegal). For each observation, our dataset contains measures of political marginalisation, transport infrastructure and food security, along with a number of relevant control variables, all of which are described below, and in even greater detail in the Appendix 2. In the analysis, we include country fixed effects to control for any unobserved factors at the national level, as we discuss in Section 3.2. Maps of the sample are presented in Figures 1 and 2, which are shaded by political marginalisation and food security, respectively.

The first empirical issue that we face is defining political marginalisation. There is a multitude of ways to conceptualise marginalisation, but for our purposes we are interested in citizens who have little weight in determining political outcomes, and are thus essentially politically 'ignorable'. We identify these citizens using a dataset of 'ethnopolitical' groups constructed by Scarritt and Mozaffar (1999). This dataset identifies groups 'having a base in ethnic identity but constantly moulded by political interaction with other groups and the state' (Scarritt and Mozaffar, 1999, p. 83). As such, for each country in Africa, the dataset lists all of the groups that are, have been or have the potential to be politically relevant. This approach is biased towards inclusivity, which means we are less likely to spuriously code groups as being marginalised when in fact they are not.

We take political irrelevance as a proxy for marginalisation in Africa, because political competition therein is predominantly based on ethno-regional identities (Mohamed Salih, 2003; van de Walle, 2003). Therefore, where groups are not politically relevant, we take this as a sign that they are essentially ignorable in political terms.

For each of the four countries, we code all groups that are not listed in the index of ethnopolitical groups as being politically marginalised. We then locate these groups geographically using the Geo-Referencing of Ethnic Groups (GREGs) database, which geo-references ethnic groups around the world using maps and data drawn from the classical Soviet Atlas Narodov

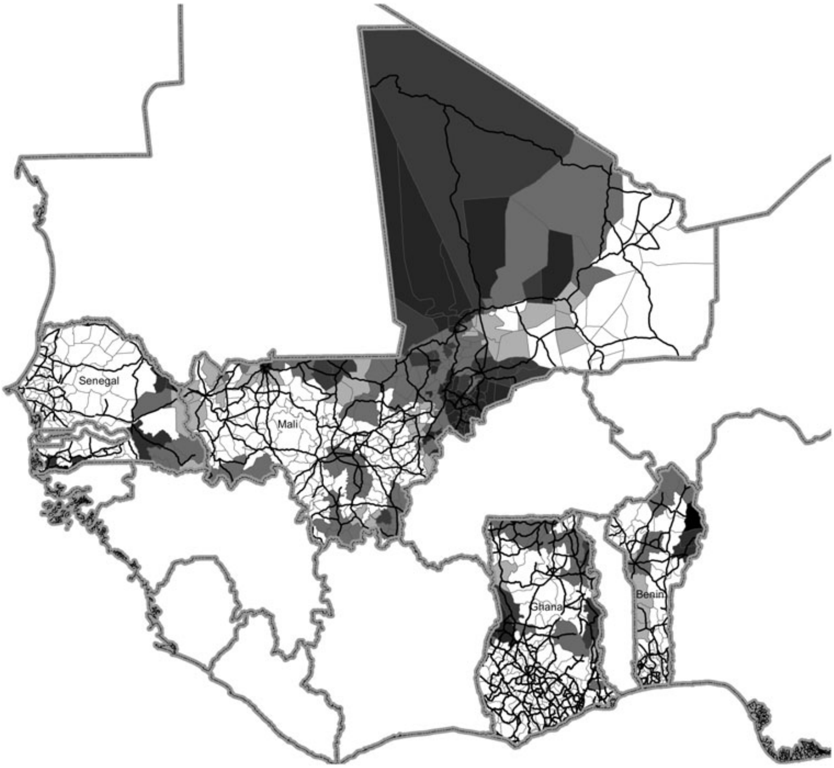

Figure 1: Map of sample distribution, by political marginalisation. *Notes*: Thick grey lines with dashed inner are national black lines are national boundaries. Thin grey lines are sub-national administrative boundaries. Black lines are roads. Shading reflects marginalisation, with darker areas being more marginalised

Mira (Weidmann *et al*., 2010). Because our observations are administrative units, which do not conform to the GREG boundaries, we then spatially join the GREG data to digital maps of the administrative boundaries, available from http://www.gadm.org/country. Doing so gives us a measure of average marginalisation in each administrative unit (ranging from 0 to 1). Summary statistics are presented in Table 1.

As with the conceptualisation, there are also many ways in which these ignorable citizens could be empirically identified. We could, for instance, try to use electoral outcomes to identify citizens whose votes make no difference to electoral outcomes. However, for presidential elections with direct popular voting systems, in which all votes count equally irrespective of geographic location, there is no obvious way to identify such citizens. Alternatively, we could

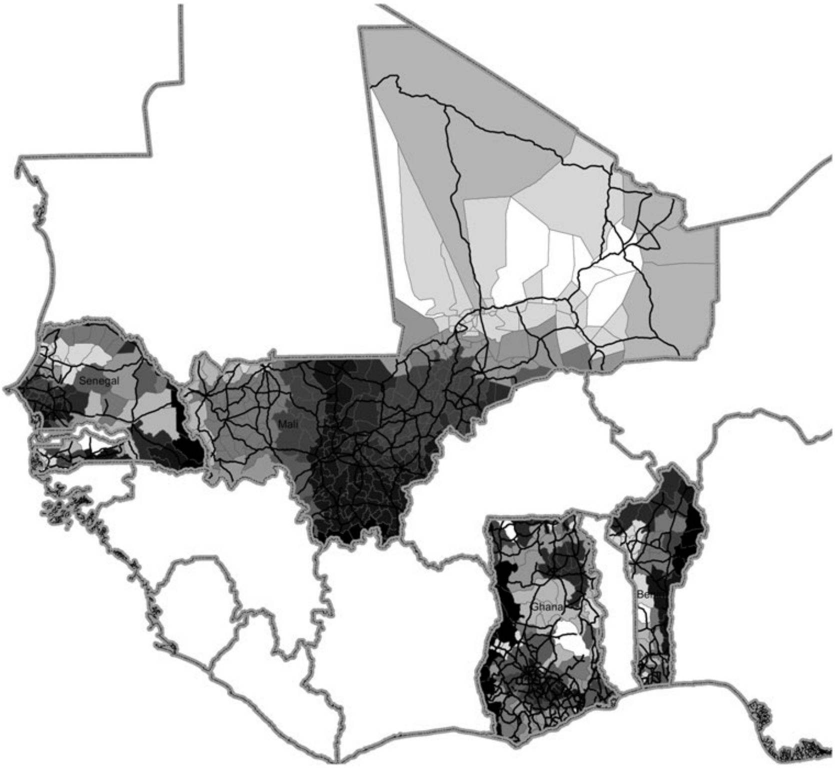

Figure 2: Map of sample distribution, by food security. *Notes*: Thick grey lines with dashed inner are national black lines are national boundaries. Thin grey lines are sub-national administrative boundaries. Black lines are roads. Shading reflects food security, with darker areas having lower food security

Table 1: Summary Statistics

Country	Administrative unit	*N*	Mean marginal-isation	Mean road (km p/sqkm)	Mean stunted children by population density (in 1,000s)
Benin	Communes	76	0.092	0.113	3.124
Ghana	Districts	137	0.105	0.109	1.116
Mali	Arrondissements	287	0.329	0.059	6.639
Senegal	Arrondissements	93	0.059	0.054	1.255
Total		593	0.204	0.077	4.055

Notes: Summary statistics for measures of political marginalisation, road density and food security, across administrative units in Benin, Ghana, Mali and Senegal.

attempt to identify areas where participation is low and take this as an indicator of marginalisation, but such a measure would risk conflating marginalisation with the many other possible determinants of political participation. Therefore given the alternatives, we feel that using the measure of political irrelevance, as a proxy for marginalisation is the best option available.

The second empirical issue is measuring transport infrastructure. For this we use data on infrastructure in Benin, Mali and Senegal from the Africa Infrastructure Country Diagnostic (AICD) programme implemented by the World Bank, which provides detailed economic and technical data on African infrastructure. These data include digital maps of the road networks for these three countries, as well as for a number of other countries in Africa, which contain information on the location, lengths, classification, surface type and condition of these countries' road networks. Similar data were collected for Ghana from the GHA in Accra. Using these digital maps, we calculated the density of primary and secondary roads within each administrative unit in our sample (where the density is equal to kilometres of road per square kilometre of land).

The third empirical issue that we faced was obtaining a measure of food security for each of the administrative units in our sample. We did this using data on the number of stunted children under the age of five, contained in the Food Insecurity, Poverty and Environment Global GIS Database (FGGD) constructed by the Food and Agriculture Organization.[2] This provides a good measure of food security, because malnutrition resulting from limited access to sufficient nutritious food is a primary cause of stunted growth in children. Therefore, we used these data to calculate the number of stunted children in each administrative unit, which we then weighted by each unit's population density using data from the Gridded Population of the World (GPW) dataset. Unfortunately, calculated in this way the measure is hard to interpret substantively, in terms of concrete numbers of stunted children. However, given the large variations in population density, and the absence of reliable data on population numbers by administrative units, this is the best way to specify the measure with the available data. Importantly, it is reasonable to assume that this measure is decreasing with greater food security.

We also required data on other potential determinants of food security and roads, in order to control for potentially confounding factors in our analysis. As noted in Section 2.2, food security is likely to be affected by climate and land

[2] We are grateful to Ricardo Fuentes for suggesting these data, which are available at http://www.fao.org/geonetwork/srv/en/main.home.

productivity. To control for the former, we collected data on rainfall. Measures of rainfall are calculated either by using data from weather stations, or by blending weather station data with additional satellite data. We use various measures of both types, from the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA). Since we have cross-sectional data, we calculated measures of long-term monthly mean precipitation, for each of the administrative units in our sample.

In order to control for land productivity, we use data on the amount of land used for crops and pasture, from the Socioeconomic Data and Applications Center (Ramankutty *et al.*, 2010a, b). By joining this to our spatial database, we were able to construct measures of the extent of cropland and pasture in each of the administrative units across the four countries in our dataset. In addition, we also needed a measure of economic importance, because investment in transport infrastructure is likely to be affected by the economic importance of a given area. Therefore, we used data on the location of mineral operations in Africa, created by the US Geological Survey (Eros and Candelario-Quintana, 2006). With these data, we were able to construct a count variable of the number of mines and processing plants in each administrative unit in our sample.

Finally, we also include a measure of terrain slope. The nature of the terrain is likely to affect food security in a given area, because it is harder to produce and access food where the terrain is rougher. It is also possible that terrain slope affects the location of roads, because it is harder to build roads in areas where terrain is rough. Therefore, we use data also contained in the FGGD database to construct a measure of terrain slope throughout our sample.[3]

Taken together then, we have a cross-sectional dataset containing 593 observations at the level of administrative units, across four countries in West Africa. For each unit, we have measures of political marginalisation, transport infrastructure and food security, as well as controls for climate, land productivity, economic importance and terrain slope. We also include controls for the size of the administrative unit, and population density. This provides us with a powerful tool with which to evaluate the argument outlined in Section 2.2, that political marginalisation indirectly affects food security because it has a negative impact on the provision of roads, which are necessary for the availability of food supplies.

[3] The data come from the 'Terrain slope classes of the world' dataset, which is available at http://www.fao.org/geonetwork/srv/en/main.home.

3.2 Estimation strategy

Using this dataset, we undertake a two-stage strategy to evaluate the argument. First, we investigate the relationship between food security and transport infrastructure, by estimating the OLS model:

$$Y_{ij} = \beta_1 \text{marginalised}_{ij} + \beta_2 \text{roads}_{ij} + \lambda_j + \gamma X_{ij} + \varepsilon_{ij}, \tag{1}$$

where Y_{ij} is the number of stunted children under five in administrative unit i within country j, λ_j, a fixed effect that absorbs any unobservable factors for country j and X_{ij}, a matrix of control variables for unit i that includes population density, area in square kilometres, terrain slope, usage of land for crops and pasture as well as long-term mean monthly rainfall. What we are interested in are β_1 and β_2, which represent the coefficients for political marginalisation and kilometres of road per square kilometre of land, respectively. If food insecurity were directly affected by marginalisation, we would expect the β_1 coefficient to be negative and significant. Likewise, if food insecurity is moderated by the presence of transport infrastructure, we should expect the β_2 coefficient to be negative and significant.

Following this, the second step is to investigate the determinants of roads. The logic of our argument suggests that marginalised citizens should face lower levels of food security because food supplies are undermined by poor transport infrastructure, which itself is affected by political marginalisation. We evaluate this logic by estimating the OLS model:

$$Y_{ij} = \beta_1 \ \text{marginalised}_{ij} + \lambda_j + \gamma X_{ij} + \varepsilon_{ij}, \tag{2}$$

where this time Y_{ij} is kilometres of road per square kilometre of land in administrative unit i within country j, and marginalised ij denotes the political marginalisation score for unit i. Again, we include country fixed effects (λ_j) and the same matrix of control variables at the administrative unit level (X_{ij}), but this time we also include a control for the number of mineral mines and processing plants in unit i. What we are interested in then is β, which represents the coefficient on the political marginalisation variable. If politically marginalised citizens are ignorable when it comes to the distribution of public goods, this coefficient should be negative and significant.

In Section 2.2, we argued that food security should be indirectly affected by political marginalisation, because marginalised areas receive lower levels of investment in transport infrastructure, which in turn undermines food security. Therefore, our expectation from estimating equation (1) is that the coefficient on roads will be negative and significant, but that the coefficient on marginalisation should be insignificant, because marginalisation has no direct effect on food security. Rather, the effect operates through roads. As such, we should expect the coefficient on marginalisation in equation (2) to be negative and significant. In the following section, we present the results.

4. Results

The results from estimates of equation (1) are presented in Table 2. From columns 1 and 2, it is clear that political marginalisation has no direct effect on food insecurity. As we would expect, the coefficients are positive, suggesting that marginalised areas have higher numbers of stunted children under the age of five. However, these coefficients are not significant at standard levels. In contrast, from the results in columns 3 and 4, we can see that the density of roads is significantly related to food insecurity. The coefficient on roads per square kilometre is negative and significant at the 1% level, which implies that areas with more roads have significantly fewer stunted children. The results in columns 5 and 6 show that these findings hold when both the marginalisation and roads measures are included at the same time.[4] Moreover, when both variables are included simultaneously, the coefficient for political marginalisation reduces substantially, and actually becomes negative when all of the control variables are included, although it is never significant. This suggests that roads may in fact mediate any relationship between political marginalisation and food security.

The estimates presented in columns 2, 4 and 6 include the matrix of control variables. The coefficient on population density is always negative and significant, suggesting that more densely populated areas, which are likely to be urban areas, have lower levels of food insecurity. Similarly, the measures of land usage are both significantly related to food insecurity, suggesting that food insecurity is lower where land can be used productively, for either crops of pasture. The coefficient for rainfall is not significant, irrespective of which measure we use.

As expected then, while the presence of roads is significantly related to food security, there appears to be no direct relationship between political marginalisation and food security. Moreover, the impact of roads is substantial—a 1 standard deviation increase in kilometres of road per square kilometre of land relates to a reduction in the number of stunted children that is roughly four times bigger than the reduction related to a 1 standard deviation increase in use of land for crops, and more than twice as large as

[4] The correlation between these two variables is -0.1939.

Table 2: Estimates of Food Insecurity

	1	2	3	4	5	6
Marginalised	1.085 (0.989)	0.511 (1.168)			0.383 (0.941)	−0.150 (1.138)
Road per km			−24.430*** (3.814)	−24.218*** (3.765)	−24.206*** (3.849)	−23.298*** (3.845)
Cropland		−3.784** (1.464)		−2.587** (1.289)		−2.540* (1.406)
Pasture		−2.240* (1.282)		−2.649** (1.204)		−2.670** (1.226)
Rainfall (NASA)		−0.769 (0.543)		−0.763 (0.471)		−0.782 (0.532)
Population density		−0.069*** (0.023)		−0.039*** (0.012)		−0.039*** (0.013)
Area (km^2)		0.010 (0.034)		−0.004 (0.026)		−0.004 (0.026)
Terrain slope		0.017 (0.295)		−0.027 (0.283)		−0.029 (0.286)
R^2	0.148	0.167	0.199	0.212	0.199	0.213
N	590	590	590	590	590	590

Notes: Dependent variable is stunted children. All models include country fixed effects. Robust standard errors in parentheses.
*$P < 0.1$.
**$P < 0.05$.
***$P < 0.01$.

that related to a 1 standard deviation increase in use of land for pasture. Figure 3 presents a visual representation of this result. It shows that instances of extreme food insecurity, as proxied by the presence of high numbers of stunted children, occur only in areas where road infrastructure is lacking (to the left of the red vertical line).

Table A1 presents the same results but with alternative measures of the key variables. Specifically, for the dependent variable we used the number of stunted children per (log) population. For the main explanatory variable of interest, we used the length of roads per population density in model 1, per square kilometre in model 2 and the length alone in model 3. The results remained robust. Clearly then, roads matter for food security. The question that remains is, what determines roads?

Table 3 contains results from three different estimates of equation (2), where the dependent variable is road density. From these results, it is clear that political marginalisation is significantly related to roads. In all specifications, the coefficient for political marginalisation is negative and significant, which implies that politically marginalised areas have significantly fewer kilometres of road per square kilometre of land. This relationship is robust to the inclusion of the matrix of control variables used in the estimates of equation (1), plus a count variable for the number of mineral mines and

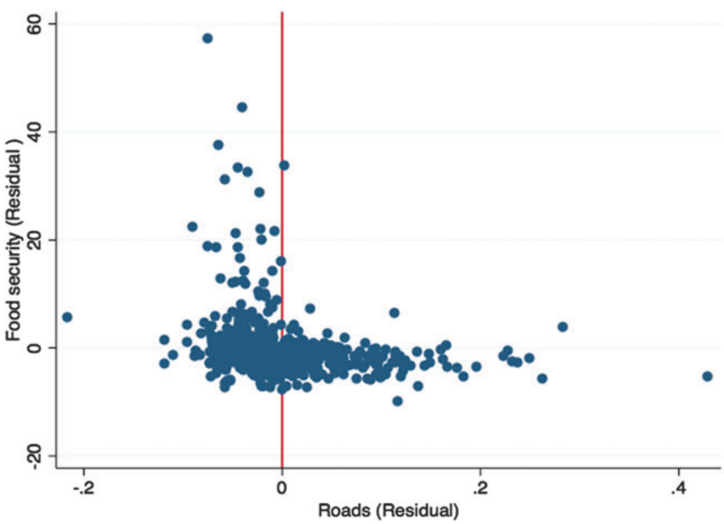

Figure 3: Partial scatter between food security and roads. *Notes*: This figure of partial correlation controls for rainfall, cropland, pasture, population density, terrain slope and the size of the area

Table 3: Estimates of Road Density

	1	2	3
Political marginalisation	−0.028*** (0.009)	−0.024*** (0.009)	−0.025*** (0.009)
Cropland		0.057*** (0.018)	0.055*** (0.018)
Pasture		−0.012 (0.014)	−0.014 (0.014)
Rainfall (NASA)		−0.000 (0.003)	0.0002 (0.003)
Minerals		0.026** (0.011)	
Mines			0.016* (0.009)
Plants			0.036 (0.023)
Population density		0.001 (0.001)	0.001 (0.001)
Area (km^2)		−0.0006* (0.0004)	−0.0006* (0.0004)
Terrain slope		−0.001 (0.004)	−0.001 (0.004)
R^2	0.186	0.217	0.219
N	593	593	593

Notes: Dependent variable is the length of road per square km. All models include country fixed effects. Robust standard errors in parentheses.
*$P < 0.1$.
**$P < 0.05$.
***$P < 0.0$.

plants combined, as a measure of economic importance (column 2). It remains significant when this combined minerals variable is broken up into two separate variables for the numbers of mines and plants (column 3).

Figure 4 presents a visual representation of this relationship, showing that higher levels of road density are clustered to the left-hand side of the red vertical line, in correlation with lower levels of political marginalisation. Although this relationship may not be quite as apparent as that between food security and road density, this visual representation highlights the existence of a clear correlation between political marginalisation and road density.

One possible confounding factor that we considered is that the presence of just one or a few roads in a particular area might matter much more than the additional presence of subsequent roads. For example, one single road could open up a large area to outside markets. To check the robustness of our results to this possibility, we ran an alternative specification with the road variable replaced by a dummy variable indicating whether the defined road exists or not. Our findings remained robust to this specification, the results of which are presented in Table A2.

As we might expect, the presence of mineral facilities is positively related to road density, as is the use of land for crop production. This supports the

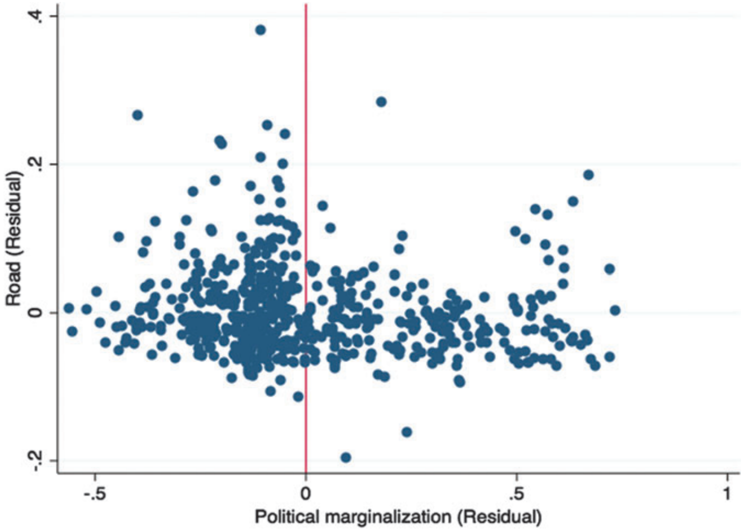

Figure 4: Partial scatter between political marginalisation and roads. *Notes*: This figure of partial correlation controls for minerals, mines and plants in addition to rainfall, cropland, pasture, population density, terrain slope and the size of the area

expectation that economically important areas receive higher levels of infrastructure investment. Yet, even controlling for these factors, politically marginalised areas have fewer roads. In addition, the size of this relationship is substantial. A 1 standard deviation increase in the measure of political marginalisation relates to a change in the density of roads that is only marginally smaller than the change related to 1 standard deviation increases in the minerals and cropland variables.

Taken together, these findings support the argument that political marginalisation indirectly affects food security, through its impact on transport infrastructure. In Table 2, the positive coefficient in column 1 implies that food security, as measured by the prevalence of stunted children, is lower in marginalised areas, although this relationship is not significant. What is significant though is the relationship between transport infrastructure and food security; areas with more roads per square kilometre have significantly greater food security.

Interestingly, the fact that the coefficient on the marginalisation variable drops so substantially when the road density variable is included suggests that roads may indeed be the mechanism linking marginalisation to food security, because the relationship between marginalisation and food security is mediated by the measure of transport infrastructure. The results presented in

Table 3 provide further support for this claim—politically marginalised areas have significantly fewer roads. In summary, these results support the claim that political marginalisation indirectly affects food security, through its negative impact on transport infrastructure.

5. Conclusion

In this paper, we have begun to investigate the political economy of food security in Africa. Despite the spread of democratic politics throughout the continent over the last two decades, crises of food security continue and have worsened in recent years with the global economic downturn and rising food prices. In an effort to understand the political determinants of food security, we started by considering the incentives faced by politicians who are subject to the constraints of democratic electoral institutions. In so doing, we recognised that some citizens may be marginalised from the political process, because they have little weight in determining electoral outcomes. As a result, areas with higher concentrations of these marginalised citizens are likely to be ignored in the distribution of public goods, particularly when it comes to visible and attributable goods, the provision of which has a greater impact on electoral outcomes.

In Africa, one such visible and attributable good is roads, and therefore, we claim that politically marginalised areas should do worse in terms of transport infrastructure. This is important for food security, because it is widely accepted that roads have a major impact on the availability of, and access to, reliable sources of food. What this suggests therefore is that political marginalisation should indirectly reduce food security, because marginalised areas should have poorer transport infrastructures, which in turn undermines the availability of food.

In order to evaluate this claim, we have constructed an original spatial dataset at the level of administrative units across four countries in West Africa—Benin, Ghana, Mali and Senegal—which contains measures of political marginalisation, transport infrastructure and food security. Using this dataset, we have provided evidence that the density of roads is indeed related to food security—areas with fewer roads have higher numbers of stunted children. Moreover, we have shown that while political marginalisation has no direct affect on food security, it is significantly related to transport infrastructure—marginalised areas have significantly fewer roads per square kilometre. Therefore taken together, these results suggest that political marginalisation indirectly affects food security, through its negative impact on transport infrastructure.

These findings have important implications for food security in Africa. First, they lend further support to the claim that transport infrastructure plays a crucial role in providing safe, nutritious and reliable food supplies. Even controlling for factors such as population density and terrain slope, the amount of road per square kilometre of land has a significant and substantial impact on the number of stunted children in an area. Secondly, they suggest that political marginalisation affects the provision of public goods, at least in terms of a visible and verifiable good such as roads, which are crucial for the provision of reliable food supplies. As such, one way to improve food security for marginalised groups may be by helping them to help themselves, perhaps through efforts to encourage political efficacy and enable marginalised citizens to make their votes count. Finally, these findings suggest that, despite Sen's optimism, when it comes to preventing food crises, electoral institutions alone may not be sufficient. Rather, it may be necessary to consider the incentives that these institutions create, and the consequences of these incentives for different types of citizens. By doing so, we may be able to better understand the impact of electoral institutions on the vulnerable and marginalised, particularly with regard to the provision of reliable sources of food.

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Appendix A: Robustness checks

Table A1: Additional Estimates of Food Insecurity

	1	2	3
Marginalised	12.27** (5.63)	10.15* (5.3)	12.50** (5.6)
Roads[a]	−0.024** (0.01)	−94.77*** (18.78)	−0.02 (0.01)
Cropland	−11.58 (10.07)	−6.12 (9.93)	−11.56 (10.07)
Pasture	5.82 (4.08)	5.23 (4.06)	7.37* (4.16)
Rainfall (NASA)	6.15*** (1.82)	6.51*** (1.83)	6.33*** (1.81)
Population density	−0.30 (0.15)	−0.172* (0.09)	−0.31** (0.14)
Area (km^2)	0.000 (0.06)	−0.06** (0.02)	0.116 (0.109)
Terrain slope	0.32 (1.56)	0.31 (1.32)	0.68 (1.35)
R^2	0.20	0.24	0.27
N	590	590	590

Notes: Dependent variable is stunted children. All models include country fixed effects. Robust standard errors in parentheses.

[a]The variable road is the length of road per population density in model 1, per square kilometre in model 2 and the length only in model 3. The dependent variable is the number of stunted children per log population size of the area.

*$P < 0.1$.

**$P < 0.05$.

***$P < 0.01$.

Table A2: Additional Estimates of Road Density

	1	2	3
Political marginalisation	−0.10*** (0.04)	−0.10*** (0.04)	−0.117*** (0.04)
Cropland		0.24 (0.18)	0.226 (0.18)
Pasture		0.04 (0.06)	0.029 (0.06)
Rainfall (NASA)			−0.015 (0.019)
Minerals			
Mines			
Plants			()
Population density		0.002 (0.001)	−0.002 (0.001)
Area (km^2)		0.0004 (0.0004)	0.0029 (0.003)
Terrain slope		0.03 (0.01)	0.031 (0.018)
Pseudo-R^2	0.07	0.09	0.09
N	590	590	590

Notes: Dependent variable is a dummy variable indicating the presence or not of the defined road regardless of its length. The specification is a marginal probit model. All models include country fixed effects. Robust standard errors in parentheses. The variables mines, minerals and plants are dropped because they predict one of the outcomes on roads perfectly.

***$P < 0.01$.

Appendix B: Data

B.1 Food security

We measure food security using data on the number of stunted children under the age of five, contained in the FGGD constructed by the FAO, which is available from http://www.fao. org/geonetwork/srv/en/main. home. The FGGD estimated number of stunted children map is a global raster datalayer with a resolution of 5 arc-minutes, and the number of stunted children is estimated according to the lowest available sub-national administrative units. We used these data to calculate the number of stunted children in each administrative unit, by joining the raster file of stunted children to the shape files of administrative units using ArcGIS software. We then weighted the number of stunted children by each unit's population density using data from the GPW dataset, available from http://sedac.ciesin. columbia.edu/gpw/.

B.2 Political marginalization

We define as politically marginalised those citizens who have historically been irrelevant to political competition. We identify these citizens using the dataset of 'ethnopolitical' groups constructed by Scarritt and Mozaffar (1999). This dataset identifies groups 'having a base in ethnic identity but constantly moulded by political interaction with other groups and the state' (Scarritt and Mozaffar, 1999, p. 83). As such, for each country in Africa, the dataset lists all of the groups that are, have been or have the potential to be politically relevant. This approach is biased towards inclusivity, which means we are less likely to spuriously code groups as being marginalised when in fact they are not. We take political irrelevance as a proxy for marginalisation in Africa, because political competition therein is predominantly based on ethno-regional identities (Mohamed Salih, 2003; van de Walle, 2003). Therefore, where groups are not politically relevant, we take this as a sign that they are essentially ignorable in political terms.

For each of the four countries, we code all groups that are not listed in the index of ethnopolitical groups as being politically marginalised. We then locate these groups geographically using the GREG database, which geo-references ethnic groups around the world using maps and data drawn from the classical Soviet Atlas Narodov Mira (Weidmann *et al.*, 2010). Because our observations are administrative units, which do not conform to the GREG boundaries, we then spatially join the GREG data to digital maps of the administrative boundaries, available from http://www.gadm.org/country, using ArcGIS software. Doing so gives us a measure of average marginalisation in each administrative unit (ranging from 0 to 1).

B.3 Transport infrastructure

To measure transport infrastructure, we use data on the road networks in Benin, Mali and Senegal from the Africa Infrastructure Country Diagnostic (AICD) programme implemented by the World Bank, which provides detailed economic and technical data on African infrastructure. The data are available from http://www.infrastructureafrica.org/. These data include digital maps of the road networks for these three countries, as well as for a number of other countries in Africa, which contain information on the location, lengths, classification, surface type and condition of these countries' road networks. Similar data were collected for Ghana from the Ghana Highways Authority in Accra. Using these digital maps, we calculated the density of primary and secondary roads within each administrative unit in our sample, where the density is equal to kilometres of road per square kilometre of land, using ArcGIS software. This measure includes all national and regional roads, but does not include local urban or rural roads.

B.4 Climate

We used data on rainfall to measure variations in climate across the units in our sample. Measures of rainfall are calculated either by using data from weather stations, or by blending weather station data with additional satellite data. We constructed measures of both types. For the former, we use data from the CRU TS 2.0 dataset, provided by the NASA and available from http://data.giss.nasa.gov/precip_cru/ maps.html. While the original CRU data are provided on a 0.5-degree grid, the maps provided by the NASA are based on a copy of that data, which were re-gridded to a coarser 2.0-degree resolution. We use long-term annual mean precipitation data calculated over the period 1901–2000.

In order to check that the results are not affected by the coarseness of the measure, we constructed a second measure using data from the University of Delaware Air Temperature and Precipitation dataset, which is also based solely on weather station data, and which we used to construct an annual long-term mean precipitation measure for the years 1951–99. This dataset is provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their website at http://www.esrl.noaa.gov/psd/, and is derived from a 0.5-degree grid.

Finally, to construct a measure of rainfall calculated from a blend of both weather station data and additional satellite data, we used data from the Global Precipitation Climatology Project (GPCP), also provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their website at http://www.esrl.noaa.gov/psd/. These data use a 2.5 degree grid, and give long-term monthly means for the period 1981–2010, which we used to construct an annual long-term mean precipitation measure. The results presented in the paper use the NASA variable, but are unaffected when this is replaced by either of the other two measures described here.

B.5 Terrain slope

We measure terrain slope using data contained in the FGGD database. The data come from the 'Terrain slope classes of the world' map, available from http://www.fao.org/geonetwork/srv/en/main.home, which is a global raster datalayer with a resolution of 5 arc-minutes. Each pixel of the map contains a terrain slope class value for the pixel area. The data are from the 1993 US Geological Survey.

B.6 Land productivity

In order to construct measures of land productivity, we used data on the amount of land used for crops and pasture, from the Global Agricultural Lands in the year 2000 dataset, provided by the Socioeconomic Data and Applications Center (SEDAC) and available from http://sedac.ciesin.columbia.edu/es/aglands.html (Ramankutty *et al*., 2010a,b). The dataset represents the proportion of land area used as cropland (land used for the cultivation of food) and pasture (land used for grazing) in the year 2000, and is based on satellite data combined with agricultural inventory data. By joining this to our spatial dataset using ArcGIS software, we were able to construct measures of the extent of cropland and pasture in each of the administrative units across the four countries in our dataset.

B.7 Economic importance

We measure economic importance with data on the location of mineral operations in Africa, created by the US Geological Survey (USGS; Eros and

Candelario-Quintana 2006). This dataset consists of records for over 1,500 mineral facilities in Africa and the Middle East. The mineral facilities include mines, plants, mills or refineries of aluminium, cement, coal, copper, diamond, gold, iron and steel, nickel, platinum-group metals, salt and silver, among others. The data were compiled from multiple sources, including the 2004 USGS Minerals Yearbook (Africa and Middle East volume), minerals statistics and information from the USGS minerals information website (http://minerals.usgs.gov/minerals/), and data collected by USGS minerals information country specialists. The dataset contains the most recent published data available for each country at the time of its construction. With these data, we were able to construct count variables of the numbers of mines and processing plants in each administrative unit in our sample, as well as a combined count of all facilities (both mines and plants together).