Configurational Analysis of Access to Basic Infrastructure Services: Evidence from Turkish Provinces

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Abstract *In many developing countries, access to basic infrastructure services, such as sewerage and waste disposal varies considerably across different areas. In this study, Fuzzy-set Qualitative Comparative Analysis identifies configurations of economic and political conditions (population density, population size, income and political participation), associated with good and poor access to sewerage and waste disposal in Turkish provinces. The findings suggest there is a core configuration of conditions associated with good access to both types of infrastructure service – high income and high political participation. A single core configuration is associated with poor access to both types of service – low population density, small population size and low political participation. Other configurations are observed relating specifically to good and poor access to sewerage and to waste disposal services, respectively. We theorise the different pathways that we identify, emphasizing that economic measures to support development may offer the best prospect of improving infrastructure access.*

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Introduction

Infrastructure services play a vital role in sustaining economic growth in developed and developing countries alike (Yu *et al*, 2015). Roads and transportation hubs, sewerage and water piping systems, waste management services, and communication networks, all enlarge the markets for labour, goods and ideas and lower barriers to trade (Estache and Fay, 2009). Despite widespread recognition of the economic and social value of basic infrastructure services, considerable variations in access to such services are still experienced by populations in low and middle-income countries (Steckel *et al*, 2017). Critically, local conditions may play a key role in shaping access to basic infrastructure (Andres *et al*, 2014). To cast further light on the salience of such conditions, we examine the configurations of population density, population size, income level and political participation, associated with good and poor access to sewerage and waste services in Turkish provinces.

Researchers have given increasing consideration to cross-country differences in access to basic infrastructure services (e.g. Zezza *et al*, 2011). However, to date, surprisingly little systematic attention has been given to the conditions responsible for variations in infrastructure access within developing countries (for rare examples, see Barde, 2017; Rivas, 2012), even though the damaging effects of poor access to basic sanitation and waste services are well-known (Parienté, 2017). We bring together economic and political perspectives on the production of public goods to identify configurations of conditions that influence basic infrastructure access in Turkish provinces.

Economic theories of production identify a number of conditions likely to shape access to infrastructure services in low and middle income countries, especially levels of *population density*, because rural areas are more remote and therefore suffer from lower investment and diseconomies of scope (Rivas, 2012). In addition, communities with a larger *population size* may be able to capture scale economies that enable them to develop better quality infrastructure services (Bird and Bahl, 2013). At the same time, poor households, with a low ability to pay for basic infrastructure services, may be unwilling to subsidise those services, whereas communities with a high *income* level may uphold basic water and waste provision themselves (Sohail *et al*, 2005). From a political perspective, communities with high level of *political participation* may be better able to resolve the collective action problems associated with influencing decision-makers, and so elicit greater support for the provision of critical infrastructure than more disengaged communities (Unger, 1998).

Although the emerging research investigating sub-national determinants of access to basic infrastructure services sheds light on variations in this issue, it has not fully accounted for the ways in which different combinations of economic and political conditions might account for variations. In this paper, we explore 'What configurations of economic and political conditions are associated with good and poor access to basic infrastructure services in Turkish provinces?' To answer this research question, we employ fuzzy-set Qualitative Comparative Analysis (fsQCA – Ragin, 2008). FsQCA can derive configurational combinations of conditions associated with an outcome. Furthermore, in fsQCA 'causal asymmetry is assumed, meaning that the presence and the absence of the outcome, respectively, may require different explanations' (Berg-Schlosser *et al,* 2009, 9). This means that we are potentially able to identify configurations of economic and political conditions associated with good and poor access to basic infrastructure services. By capturing different combinations of conditions associated with an outcome, researchers using fsQCA are able to capture the complexity of infrastructure development in ways that can help policy-makers make more context-sensitive decisions (Verweij and Gerrits, 2012).

In the next part of the paper, we introduce economic and political explanations for variations in access to basic infrastructure services in developing countries. Thereafter, the economic and political conditions included in our configurational analysis of access to sewerage and waste services are described and the data coding and processing for the fsQCA are explained. Finally, we discuss the results of our analysis and conclude by reflecting on their implications.

Literature Review

During the past twenty years, policy-makers and researchers have shown increasing interest in the reasons behind variations in access to basic infrastructure within, as well as across, low and middle-income countries (e.g. Briceño-Garmendia *et al*, 2004; Lin, 2011). Recently, scholars have begun to move beyond linear accounts of the determinants of infrastructure access in sub-national administrative units (e.g. Barde, 2017; Rivas, 2012), to investigate the combinations of conditions responsible for access to infrastructure (e.g. Chai and Schoon, 2016; Roland *et al*, 2018). These studies have cast valuable light on alternative pathways to improved infrastructure access, but are often limited to small samples of organizations, including schools (e.g. Chatterley *et al*, 2013; 2014) or community-based projects, especially water wells (Gasparro and Walters, 2017; see Gerrits and Verweij 2018, for a review). To better understand the complex combinations of context at the heart of the geography of economic and human development (Gallup *et al*, 1999), we need to know more about the salience of different configurations of economic and political circumstances across multiple major administrative units. In this study, we seek to add to the growing literature on infrastructure access that applies configurational analytical techniques, by drawing on four key economic and political conditions to capture the variety of provincial geographies that are found in Turkey: *economic* – population density, population size, income level; *political* – political participation.

Economic Influences on Infrastructure Access

Across the developing world, people living in rural, or more remote, areas have poorer access to basic infrastructure services, such as water, sanitation and sewerage systems (Briceño-Garmendia *et al*, 2004). Aside from the technical difficulties of developing infrastructure services in inaccessible places (Gerlitz *et al*, 2012), more sparsely populated regions generally represent a less economically attractive or sustainable market for those services (Wallsten and Clarke, 2002). In particular, whereas the provision of basic infrastructure in densely populated areas is assumed to benefit from economies of scope and density, the costs of developing infrastructure away from urban centres may be higher and susceptible to rapid depreciation (Nauges and Van den Berg, 2008).

Although much of the empirical literature on access to basic services has focused on infrastructure provision in rural areas (e.g. Zezza *et al*, 2011), studies of the relationship between population density and basic infrastructure access confirm the basic assumption that less densely populated areas have poor service access. For example, Cleary (2007) finds that sewerage and water access is better in densely populated Mexican municipalities – a finding confirmed in Rivas' (2012) subsequent study in Mexico focused on water access.

In addition to the potential scope economies found in more densely populated areas, the provision of infrastructure services to larger populations may make infrastructure investments more politically and financially attractive to public authorities and private contractors (Bahl and Linn, 1992). Coupled with the economic benefits of size, it is also suggested that more populous areas are able to mobilise greater political capacity, and clout, than smaller regions, and could be less susceptible to corruption and capture by local elites (Prud'Homme, 1995). Against the standard arguments in favour of large size, though, proposals for fiscal decentralisation in developing countries assume that smaller units of sub-national administration are more efficient and responsive to citizens' needs (Sow and Razafimahefa, 2015). Hence, it is conceivable that in some jurisdictions, diseconomies of scale in infrastructure provision may predominate.

A small number of studies furnish evidence of the presence of scale diseconomies in infrastructure access (e.g. Cleary, 2007). However, most empirical research tends to support the contention that larger territories have the financial and political resources needed for infrastructure projects (e.g. Adida and Girod, 2011; Barde, 2017). There is, then, good reason to anticipate that conventional arguments about scale economies are likely to be confirmed.

The relative income level within developing countries may be an important determinant of infrastructure access. Wealthy communities have the resources needed to establish and maintain basic infrastructure services (Briceño-Garmendia *et al*, 2004). By contrast, poor households may have scant appetite for paying for basic infrastructure (Sohail *et al*, 2005), and less of the human and social capital needed to coproduce its design and maintenance (Button, 2016; though see Isham and Kähkönen, 1998). In poorer communities, public and private actors may therefore have little incentive for developing better basic infrastructure, since citizens in economic difficulty may not value it sufficiently to pay for it with either their money or votes (Bird and Bahl, 2013).

The empirical evidence on the link between income and infrastructure access at the subnational level in low and middle-income countries is unequivocal: poorer communities have much worse access to basic infrastructure. Cleary (2007) finds that sewerage and water access is considerably worse in economically disadvantaged Mexican municipalities, while Rivas' (2012) analysis of water access in the same municipalities points towards vast disparities between the very poorest and the very richest communities. At the same time, several studies highlight how wealthier communities are more likely to participate in the development of infrastructure projects (e.g. Prokopy, 2009; Sun *et al*, 2010), making a positive connection between income and infrastructure access seem likely.

Political Influences on Infrastructure Access

Providers of public goods require the support of citizens and service users (Hirschman, 1970). By co-producing public goods and bestowing legitimacy on the providers of goods, people can play a vital role in ensuring the on-going sustainability and survival of basic infrastructure projects (Isham and Kähkönen, 1998). For this reason, political participation may be an especially potent influence on the decision-making of those providers (Azfar *et al*, 1999). In particular, a more active and engaged citizenry may dictate agenda-setting or constrain the options available by policy makers (Elkins and Simeon, 1979).

Numerous studies indicate that direct participation in, and engagement with, infrastructure development projects can be a critical factor influencing success (see Holcombe *et al*, 2018; Isham *et al*, 1995). Beyond residents' direct involvement in projects themselves, the social capital present within an area has been shown to have a positive influence on infrastructure development (e.g. Sun *et al*, 2010), especially through its effect on participation in formal democratic processes. For example, Cleary (2007) finds that electoral turnout is positively related to sewerage and water access in Mexican municipalities (see also Adida and Girod, 2011). Hence, we assume a positive participation-infrastructure access relationship.

Combined Effects of Economic and Political Influences

From a configurational perspective, it is necessary to go beyond a straightforward linear approach to understand how different combinations of conditions generate contexts that are more or less receptive to infrastructure developments (Gerrits and Verweij, 2016). Hence, configurations of different economic and political conditions within developing countries seem more likely to be an important influence on infrastructure access than the qualities of any given condition in itself - an assumption that lies behind much of the research analysing cross-country differences in infrastructure policy (Estache, 2016).

Although separate economic and political conditions may have important independent effects on the provision of infrastructure services, access to those services is likely to depend upon the conjunctions between different contextual conditions (Barde, 2017). This is particularly likely to be so for population density and size. The scope and scale economies associated with the provision of infrastructure services to densely populated and more populous areas may vary considerably, depending upon the presence of other favourable economic and political conditions. For example, economies of scope may conceivably be more easily realised in urban areas with high political participation, because citizens in such areas may be better able to resolve the collective action problems required to effectively press public authorities and private firms to provide services at a lower cost (Olson, 1989). At the same time, it is conceivable that economies of scale will be even greater in wealthy areas, due to the higher levels of human capital and technology that can be brought to bear on service development and provision (Freeman, 2004).

Aside from a general expectation that the effects of population density and population are particularly likely to be found in combination with other conditions, we have no preconceived ideas about the possible combined effects of the economic and political conditions that we analyze. Gerrits and Verwij (2016, 18) note that QCA can be used to "both explore and test patterns". Hence, we follow the practice of other researchers employing fsQCA (e.g. Schneider and Wagemann, 2010) and adopt an inductive approach to identifying configurational relationships between our selected conditions (population density, population size, income and political participation) and good and poor access to sewerage and waste management services.

Data and Methods

Data for this study were drawn from information collected by the Turkish Statistical Institute in 2014 across all 81 provinces of Turkey. Turkish provinces are administered by a provincial governor appointed by the national Ministry of Interior who is accorded the right to issue a 'general command' to harmonise provincial policies and practice with those established at the national level. Governors are constitutionally required to be politically neutral and have authority over a wide range of public institutions within their province, including the police force, schools, primary healthcare services, and hospitals. They also have the right to inspect the local governments within their province, and to reorganise those administrative units if they deem it to be necessary for achieving national policy goals (Akilli and Akilli, 2014).

In recent times, Turkey has sought to modernise in line with European standards, as part of its drive to gain membership of the European Union. Within this context of modernisation, reforms intended to encourage regional development, by bringing together key actors from within and outside government, have played a critical role. As a result, much of the basic infrastructure provision within Turkey has become privatised, giving rise to trenchant questions about the equity with which basic services, such as water and sewerage, are provided to the population (Cinar, 2009).

Outcomes – Access to Basic Infrastructure Services

Access to basic infrastructure is still little documented within many low and middle-income countries. We are therefore fortunate in being able to draw upon two indicators of access to basic infrastructure services within Turkish provinces for our analysis. The first indicator measures the percentage of the population provided with a piped system of sewerage. This indicator is drawn from the municipal water and wastewater statistics for 2014 published by the Turkish Statistical Institute. The second indicator measures the percentage of the population in each province receiving waste collection services. This indicator is drawn from the municipal waste statistics for 2014 published by the Turkish Statistical Institute.

Conditions – Economic and Political Factors

A measure of *population density* is constructed by dividing information on the population living within Turkish provinces from the national census of 2011 by the area of each province in square kilometres. This indicator captures potential economies of scope in the delivery of infrastructure services. In more densely populated provinces, infrastructure services can be shared by local administrations or private firms, and coordinated from a smaller number of core sites (Nauges and Van den Berg, 2008).

The *population size* of each Turkish province was measured using the census figures of 2011. Larger provinces may benefit from economies of scale, whereby public and private organisations can spread fixed infrastructure costs, and governments themselves may benefit from the greater purchasing power accruing to larger entities (Boyne, 1995). Due to the scale of their needs and demands, citizens in more populous provinces may also wield greater influence over decision-makers than those in smaller communities (Lyons *et al*, 1992).

To capture the relationship between wealth and infrastructure access, we measure the *income* level within each Turkish province as the average daily earnings for 2014 in Turkish Lira. Higher social needs and lower capacity for the co-production of infrastructure among the population may increase the cost of providing infrastructure services in poor communities (Briceño-Garmendia *et al*, 2004).

Following Putnam (2000) and Cleary (2007), the relative influence of *political participation* on infrastructure access was measured in 2014, as the average turnout in the most recent Turkish local government elections within each province. The measure is a useful proxy for political participation in the absence of detailed data on attitudes toward engagement with infrastructure development across all Turkish provinces. Descriptive statistics for all the outcomes and conditions used for the fsQCA are shown in Table 1.

[Table 1]

Method

Here, fsQCA is used to identify the different configurations of economic and political conditions associated with good or poor access to sewerage and waste services in the 81 provinces of Turkey. QCA was initially developed to compare small sets of qualitative cases (Ragin, 1987), but its mathematical grounding means it can handle many more units of analysis than a purely qualitative case-based approach (Gerrits and Verweij, 2016). For this reason, QCA is especially valuable for investigating complex issues in infrastructure provision, because it "strikes a balance between the single-n case study and the qualities of the large-n study" (Gerrits and Verweij, 2018, 12). As a set-theoretical analysis technique, it also offers a distinctive analytical focus, as stated in Jordan *et al* (2011, 1171):

> "*Statistical regression methods are focused on determining the net, independent effect of each variable [condition] on an outcome. In contrast, QCA focuses on combinations of configurations that lead to an outcome, not how frequent or likely these configurations are*."

Structural equation modelling and the use of interaction terms in regression modelling permit the estimation of complex combined effects of variables on specified outcomes, but to do so robustly requires the collection of large quantities of data. Unlike conventional statistical techniques, QCA can utilise a comparatively small to medium number of cases to model "conjunctural causation" – combinations of causal conditions (e.g. population density and political participation), that are linked to an outcome. In addition, QCA facilitates the identification of equifinality, where more than one combination may be linked to the same outcome; and causal asymmetry, when appropriate and deficient performance have different explanations (Fiss, 2011). It can also identify necessary causal conditions, such that an outcome cannot occur without them, as well as sufficient conditions, such that the outcome always occurs when a condition is present (Rihoux and Ragin, 2009). Importantly, the technique can incorporate INUS logic, whereby it can capture insufficient but necessary conditions which may be unnecessary but sufficient for an outcome to occur, such as an electrical short-circuit in the case of a house fire (Mackie, 1965).

FsQCA v2.5 (Ragin *et al*, 2008) and the QCA-package in R software (see Duşa, 2019) were employed to carry out the analysis. Data pre-processing was undertaken using the direct method approach to coding (Ragin, 2008). Conditions and outcomes were calibrated to create fuzzy membership scores ranging from 0.0 to 1.0. These membership scores were then assessed to evaluate the degree to which each province displayed each condition and outcome. Following Rihoux and Ragin (2009), qualitative anchors for membership to a condition or outcome were initially derived as the, 5th percentile ($x^{\perp}$ - lower-threshold – e.g. definitely poor access to waste services), 95th percentile (x^{T} - upper-threshold – e.g. definitely good access to waste services) and 50th percentile values ($x^{\times}$ - crossover point – e.g. maximum ambiguity about whether access to waste services is good or not). These anchors are depicted in probability density function (pdf) graphs in Figure 1. Following Andrews et al. (2016), the authors evaluated and confirmed the appropriateness of the anchors.

[Figure 1]

In Figure 1, the solid line shows the constructed pdf for either a condition (a – d) or outcome (e and f), with the left hand-side y-axis scale being associated with this pdf. The three vertical dotted lines denote the three threshold and crossover values required for the subsequent fuzzy membership score. The dashed line in each graph shows the actual fuzzy membership function, based on the log-odds approach to deriving membership scores from qualitative anchor values, with the right hand-side y-axis scale being the 0.0 to 1.0 fuzzy scale. These constructed fuzzy membership score values are analysed using fsQCA, next described.

FsQCA Analysis

Following Ragin (2008), the fsQCA of Turkish provincial infrastructure access is broken down into the necessity and sufficiency analyses, the latter including the construction of a truth table.

Necessity Analysis

The necessity analysis is premised on the identification of those conditions such that whenever the outcome is present the condition is also present, in other words, the outcome cannot be achieved without the condition (see Schneider and Wagemann, 2012). It was conducted prior to sufficiency analysis, to avoid inappropriately declaring conditions as necessary. The analysis presented in Table 2 indicates that we are unable to identify any one condition as a prerequisite for any of the outcomes to occur (determined by a consistency value above 0.900 in Table 2, see Roig-Tierno *et al*, 2017). This underlines that it is the combination of different conditions that determines infrastructure access.

[Table 2]

Truth Table Construction

Following the necessity analysis, sufficiency analysis is undertaken to consider multiple conditions (termed conjunctions), which requires establishment of a truth table listing the logically possible combinations of causal conditions and the empirical outcomes (here two) associated with each configuration (see Ragin, 2008). With four conditions considered (i.e. population density, population size, income and political participation), there are $2^4 = 16$

different possible configurations, based on the absence/low (0) or presence/high (1) of the condition (in strong membership terms - see Ragin, 2008). The truth table shown in Table 3 indicates that 15 of the 16 possible configurations have at least one province associated with them.

[Table 3]

To illustrate the relative similarity/difference between the configurations they can be plotted in a Venn diagram (see Figure 2). Here, each pair of neighbour configurations differs by the absence (0)/ presence (1) of only one condition; for example, the difference between configuration 1 (0000) and configuration 2 (0001) is the change from absence to presence of high political participation within a province. The Venn diagram clarifies the distribution of the provinces associated with each configuration in set-theoretic space, with for example, no provinces associated with configuration 12 (1011) and thirteen associated with configuration 16 (1111).

[Figure 2]

To understand the spatial variations in configurations of economic and political conditions, the geographical distribution of each configuration across Turkey (in terms of strong membership) is plotted in Figure 3. The figure suggests that configurations incorporating either the absence or presence of all our indicators of favourable economic and political conditions tend to be located in Eastern and Western Turkey respectively, reflecting, to some extent, the East-West divide in development within the country (Celebioglu and Dall'erba, 2010).

[Figure 3]

Following Greckhamer (2011), we use fsQCA to investigate those configurations (causal combinations) associated with either good or poor access to sewerage and waste services (causal asymmetry). This analysis produces consistency (and PRI) scores, shown in the far right four columns in Table 3, indicating the strength of the relationship of a configuration separately to the high and low outcome forms (see Ragin, 2008; Schneider and Wagemann, 2012). To preclude a configuration from being associated with both good and poor infrastructure access, as per Table 3, a consistency threshold is applied (following Andrews *et al*, 2016). Configurations with consistency values above the respective thresholds are shown in bold in the truth table. Following this we also apply a PRI score threshold of 0.700 (Greckhamer *et al*, 2018), with pertinent values shown in bold.

In addition, we apply a frequency threshold of more than one case per configuration to ensure that multiple provinces are considered for each solution in the sufficiency analysis (see Kraus *et al*, 2018). The frequency threshold increases our number of remainders, truth table rows (configurations) that lack the evidence needed for a test of sufficiency (see Schneider and Wagemann, 2012, 152). Alternative assumptions regarding the remainders underpin the parsimonious and complex solutions are discussed below.

Sufficiency Analysis

The sufficiency analysis undertaken here considers those conditions, or sets of conditions, which always lead to the outcome, but may not be the only causal combination to achieve the outcome (see Roig-Tierno *et al*, 2017). Sufficiency analyses are presented in Tables 4 and 5 showing good and poor access to sewerage and waste services, respectively.

Each of the columns shown in the top part of the tables represents an alternative causal combination of conditions linked to the respective high (good) or low (poor) outcome. Both the parsimonious and complex fsQCA solutions are presented. Specifically, for the complex solutions, GSC1-3 and PSC1-2 are the combinations associated with good and poor sewerage access and GWC1-5 and PWC1-2 with good and poor waste services (similar combinations exist for parsimonious solutions). While the parsimonious solution relies on the simplifying assumption that all remainders are potential counter-factual cases, the complex solution treats them as "false" cases as they are not present within the data (see Ragin, 2008).

Within the combinations shown in Tables 4 and 5, full circles (●) indicate the presence of a condition, while barred circles (⊖) indicate a condition's absence. Further, larger circles indicate core conditions that are part of both parsimonious and complex solutions, with smaller circles indicating peripheral conditions that only occur in complex solutions. The middle parts of the table detail the consistency (and PRI) and coverage values for the complex solution. The bottom part of a table offers similar information based on the parsimonious solutions (e.g. incorporating only core conditions, indicated by large circles).

Fiss (2011) argues that it is important to distinguish between the core and peripheral combinations of causal conditions in a set-theoretic analysis. Core causal conditions are those "for which the evidence indicates a strong causal relationship with the outcome of interest" (Fiss, 2011, 398). By contrast, peripheral causal conditions are those for which the causal relationship is weaker. We draw upon the notion of core and peripheral conditions in causal combinations to explore the results of our sufficiency analyses in more detail.

The sufficiency analysis presented in Table 4 identifies three parsimonious solutions for good access to sewerage. The first causal combination (GSP1 - GSC1) incorporates the two core conditions of high income and political participation. The second causal combination (GSP2 - GSC2) incorporates the core conditions of a high population density and large population size, while the third combination (GSP3 - GSC3) comprises a large population size and high political participation. These findings highlight that there may be more than one path towards better infrastructure access within the sub-national regions of developing countries.

[Table 4]

In terms of peripheral conditions associated with good sewerage access, Table 4 suggests that in GSC1, provinces that are wealthy and politically active are also likely to have good access if they are sparsely populated. Figure 4a maps the eleven provinces that exhibit this complex solution, highlighting that they tend to be located in the Western more developed part of Turkey, inland of densely populated coastal areas. This implies that *rural, wealthy, activist* provinces may be able to overcome diseconomies of scope and inland transportation costs if they are located near to core (in this case European) markets (Gallup *et al*, 1999). For GSC2, the large number of densely and heavily populated provinces with good sewerage access are mostly located around the coast of Turkey (see Figure 4b). The improved productivity and better transportation links associated with coastal proximity (Rappaport and Sachs, 2003) may therefore be especially beneficial for infrastructure access in *large, urban* provinces. Finally, for GSC3, the core conditions of a large population and high political participation are not supplemented with any peripheral conditions. For this reason, numerous provinces (twenty-six in total) exhibit this pathway to good sewerage access. Figure 4c indicates that while these provinces are distributed across coastal and inland parts of Turkey, they are mostly located in the Western more developed half of the country, pointing towards the potential for strong institutional path dependency to matter for infrastructure services in *large, activist* provinces (Rodrik *et al*, 2004).

[Figure 4]

Turning to the configurations associated with poor sewerage access, Table 4 highlights that the complex and parsimonious solutions are identical for poor sewerage access, and so will be discussed simultaneously. PSC1 is composed of three core conditions: low population density, small population size and weak political participation. For PSC2, there are two core conditions: small population size and low income. These results again draw particular attention to the issue of scale economies in the provision of basic infrastructure.

There are seventeen *small, rural, non-activist* provinces associated with PSC1. Figure 4d indicates that these provinces are largely located in the less developed north-eastern part of Turkey, underlining the challenges of improving infrastructure provision in areas distant from core markets (Gallup *et al*, 1999). Figure 4e shows that the fifteen *small, poor* provinces associated with PSC2 are largely located away from the coast and in the more mountainous central parts of the country that may be less accessible or financially attractive for large-scale development projects (Gerlitz *et al*, 2012).

The sufficiency analysis presented in Table 5 reveals four parsimonious solutions for good access to waste services. The first causal combination (GWP1 - GWC1) precisely mirrors that for sewerage access, comprising the two core conditions of high income and political participation, signalling that *wealthy, activist* provinces are likely to have the best infrastructure access overall – something that would be interesting to explore in other settings in developing countries. GWP2 (GWC2) incorporates the core conditions of high population density and political participation, while GWP3 (GWC3) comprises high population density and high income. The fourth causal combination (GWP4 - GWC4 and GWC5) consists solely of the core condition of a large population size. Hence, it would seem that in some areas the potential presence of scale economies may be enough to generate efforts to improve basic infrastructure access, while economies of scope may only influence such decisions when other considerations are also factored in.

[Table 5]

In terms of peripheral conditions associated with good waste access, Table 5 confirms that for GWC1, like GSC1, eleven *rural, wealthy, activist* provinces appear to have good access to waste services (see also Figure 5a). For GWC2, there are twenty-four politically active and densely populated provinces, but with low income that have good waste access. Nearly all these *poor, urban, activist* provinces are located on the Western coastal belt of Turkey, though there are some important exceptions, especially Ankara (see Figure 5b). These findings point to the role that transportation and communication links and a strong capacity for political mobilisation may play in shaping infrastructure access in urban areas (Schubeler, 1996).

In the case of GWC3, the core conditions of high population and high income are supplemented with the peripheral condition of low political participation. Only five *large, wealthy, non-activist* provinces exhibit this causal combination, all of which are located towards the Eastern part of Turkey (see Figure 5c). For areas such as these located far from core markets and coastal communications, their economic clout may mean they are nonetheless attractive for infrastructure development (Freeman, 2004). Figure 5d indicates that GWC4 combines the peripheral condition of low income with the core one of high population, while Figure 5e shows that GWC5 combines high population with the peripheral condition of high political participation. Nearly all of the twenty-six *large, activist* provinces associated with GWC5 are located in the Western half of Turkey, but most of the eight *large, poor* provinces uniquely associated with GWC4 are found in the South-Eastern Anatolian region of the country that borders Syria and comprises a large Kurdish population. Despite the poverty of the region, the geopolitical complexities and conflict with which it has frequently been beset make it strategically important, and it has benefitted from large-scale investment in infrastructure through the GAP (Güneydoğu Anadolu Projesi) development project since the 1970s (Bilgen, 2018).

[Figure 5]

The results presented in Table 5 indicate that the configurations associated with poor waste service access are similar to those for poor sewerage access, with two causal combinations associated with weak access to both types of basic infrastructure service. Again, the complex and parsimonious solutions are the same, and so can be discussed simultaneously. PWP1 (PWC1) is identical to PSP1, with three core conditions: low population density, low population and weak political participation. For PWP2 (PWC2), the two core conditions of small population size and low income are supplemented with one further core conditions: low population density. While this latter finding is suggestive of the possibility that the absence of scope economies might make waste service provision unattractive, the provinces associated with PWP1 and PWP2 are the same as those associated with the two combinations associated with worse access to basic sewerage provision (see Figures 5f and 5g).

Discussion

In this paper, we find that the subnational conditions influencing access to basic infrastructure services are only associated with good or poor access when they are present in combination, most often as a pairing of two key conditions. In particular, *wealthy, activist* provinces in Turkey appear likely to have good access to both sewerage and waste services. By contrast, *rural, small, non-activist* provinces seem to have worse access to both types of basic infrastructure. Our mapping of the causal combinations produced by our fsQCA also revealed distinctive regional patterns in infrastructure access within Turkey. These findings have important theoretical and practical implications.

The study builds on the growing literature examining infrastructure access in low and middle-income countries in a number of important ways. First, it provides a comprehensive subnational analysis of the factors influencing access to basic infrastructure services within a single country. Previous research has tended to focus on large-scale aggregated cross-countrycomparisons of infrastructure access (e.g. Steckel *et al*, 2017) or evaluations of small samples of organizations (e.g. Chatterley *et al*, 2014). By identifying different configurations of economic and political factors shaping access to sewerage and waste services across all the provinces of Turkey, we are able to present an in-depth understanding of the context behind variations in infrastructure access within developing countries. Second, our study investigates the relationship between configurations of economic and political factors and infrastructure access. Most prior work at the subnational level has been limited to the analysis of linear relationships between selected factors (e.g. Rivas, 2012) or is focused solely on rural areas (e.g. Barde, 2017). Our approach provides a detailed picture of the complex combination of contextual influences on infrastructure access across all the administrative divisions of a middle-income country. Third, the analysis focuses on poor, as well as good, access to basic infrastructure services. By empirically testing the possibility that the conditions shaping infrastructure access may vary according to whether that access is at the top or the bottom of the distribution, we illustrate that good and poor access to basic infrastructure may have unique antecedents.

In addition to speaking to important theoretical and empirical concerns within the development literature, our findings cast valuable light on how contextual influences shape infrastructure decision-making within developing countries. In particular, because low and middle-income countries confront severe budget constraints, the political attractiveness of undertaking visible 'big development' projects, such as bridges and hydroelectric dams, may outweigh the economic costs associated with creating and maintaining basic infrastructure, such as sewerage and waste services. Econometric estimates suggest that social rates of return to water and sanitation infrastructure may be lower than for energy, transportation and communication (Briceño-Garmendia *et al*, 2004). Our analysis confirms that while political factors may play a role in the decision to develop basic infrastructure services, such decisions are unlikely to be made separate from wider economic factors, such as the income level of the population, and, critically, the potential for realising economies of scale and scope (see also Burrier, forthcoming). Initiatives to overcome the economic disadvantages experienced by small, rural or poor communities in low and middle-income countries may therefore hold the key to generating interest in and commitment to the enhancement of basic infrastructure (Barde, 2017). Nonetheless, efforts to support civic activism by provincial governments and Non-Governmental Organizations may help to ensure that local populations are able to effectively voice their concerns about infrastructure provision.

Although these findings offer insights into sub-national variations in infrastructure access, the study has limitations that could be addressed through further research. First, our results are based on a single cross-section of data. Longitudinal studies could examine the causal dynamics behind the pathways that we identify. For instance, by analysing whether good or poor infrastructure access lead to changes in economic and political conditions, which, in turn influence changes in access to basic infrastructure services. Second, we draw upon a measure of political participation that may not capture the actual engagement of citizens with policy decisions pertaining to infrastructure. Survey-based measures capturing the political behaviour of people across local areas could potentially address this limitation. Third, while we provide a parsimonious account of the different causal combinations that may account for variations in infrastructure access, other conditions may be important, such as economic growth, education level, or party control. Further analysis focused on these conditions could identify other pathways to access to basic infrastructure services. Finally, we focus on the case of Turkey, a middle-income country that has unique economic and political characteristics. In particular, high electoral participation and a unique transcontinental location between the East and the West. fsQCA investigations in other countries, would therefore illuminate the generalisability of the spatial configurations of access to basic infrastructure services that we identify here.

In summary, our study illustrates that complex combinations of context influence infrastructure access and that the salience of those combinations may varying according to whether access is good or poor. Future research should therefore develop a rounded picture of the multiple ways in which economic and political factors interact to contribute to, or detract from, the provision of basic infrastructure services in developing countries.

Conflicts of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

References

Adida, C.L. and Girod, D.M. (2011). Do migrants improve their hometowns? Remittances and access to public services in Mexico, 1995-2000. *Comparative Political Studies* 44: 3-27.

Akilli, H. and Akilli, H.S. (2014). Decentralization and recentralization of local governments in Turkey. *Procedia-Social and Behavioral Sciences* 140: 682-686.

Andres, L., Biller, D. and Dappe, M.H. (2014). Infrastructure gap in South Asia: Inequality of access to infrastructure services. World Bank Policy Research Working Paper 7033.

Andrews, R., Beynon, M.J. and McDermott, A.M. (2016). Organizational capability in the public sector: A configurational approach. *Journal of Public Administration Research Theory* 26: 239-258.

Azfar, O., Kahkonen, S., Lanyi, A., Meagher, P. and Rutherford, D. (1999). Decentralization, governance and public services: The impact of institutional arrangements. A review of the literature. Centre for Institutional Reform and the Informal Sector. University of Maryland, College Park: IRIS.

Bahl, R.W. and Linn, J.F. (1992). *Urban Public Finance in Developing Countries*. New York: Oxford University Press

Barde, J.A. (2017). What determines access to piped water in rural areas? Evidence from small-scale supply systems in rural Brazil. *World Development* 95: 88-110.

Berg-Schlosser, D., De Meur, G., Rihoux, B. and Ragin. C.C. (2009). Qualitative comparative analysis (QCA) as an approach. In *Configurational Comparative Methods*, ed. Benoit Rihoux and Charles C. Ragin, 1–18. Thousand Oaks, CA: Sage.

Bilgen, A. (2018). The Southeastern Anatolia Project (GAP) revisited: The evolution of GAP over forty years. *New Perspectives on Turkey* 58: 125-154

Bird, R. and Bahl, R. (2013). Decentralization and infrastructure in developing countries: Reconciling principles and practice. Institute on Municipal Finance and Governance Working Paper 16.

Boyne, G.A. (1995). Population size and economies of scale in local government. *Policy & Politics* 23: 213-222.

Briceno-Garmendia, C., Estache, A. and Shafik, N. (2004). Infrastructure services in developing countries: Access, quality, costs, and policy reform. World Bank Policy Research Working Paper 3468.

Burrier, G. (forthcoming). Politics or technical criteria? The determinants of infrastructure investments in Brazil. *Journal of Development Studies* 1-19.

Button, C. (2016). The co-production of a constant water supply in Mumbai’s middle-class apartments *Urban Research & Practice* 10: 102-119.

Celebioglu, F. and Dall’erba, S. (2010). Spatial disparities across the regions of Turkey: An exploratory spatial data analysis. *The Annals of Regional Science* 45: 379-400.

Chai, Y. and Schoon, M. (2016). Institutions and government efficiency: Decentralized irrigation management in China. International Journal of the Commons, 10(1), 21-44.

Chatterley, C., Linden, K.G. and Javernick-Will, A. (2013). Identifying pathways to continued maintenance of school sanitation in Belize. *Journal of Water, Sanitation and Hygiene for Development* 3(3): 441-2.

Chatterley, C., Javernick-Will, A., Linden, K.G., Alam, K. Bottinelli, L. and Venkatesh, M. (2014). A qualitative comparative analysis of well managed school sanitation in Bangladesh. *BMC Public Health* 14(1): 6.

Cinar, T. (2009). Privatisation of urban water and sewerage services in Turkey: Some trends. *Development in Practice* 19: 350-364.

Cleary, M.R. (2007). Electoral competition, participation, and government responsiveness in Mexico. *American Journal of Political Science* 51: 283–299

Duşa, A. (2019). The QCA Package. In *QCA with R* (pp. 19-46). Springer, Cham.

Elkins, D.J. and Simeon, E.B. (1979). A cause in search of its effect, or what does political culture explain? *Comparative Politics* 11: 127-145.

Estache, A. (2016). Institutions for infrastructure in developing countries: What we know and the lot we still need to know. EDI-RA1 Working Paper.

Estache, A. and Fay, M. (2009). Current debates on infrastructure policy. Working Paper No. 49. Washington, DC: Commission on Growth and Development.

Fiss, P. (2011). Building better causal theories: A fuzzy set approach to typologies in organization research. *Academy of Management Journal* 54: 393-420.

Freeman, C. (2004). Technological infrastructure and international competitiveness. *Industrial and Corporate Change* 13: 541-569.

Gallup, J.L., Sachs, J.D. and Mellinger, A.D. (1999). Geography and economic development. *International Regional Science Review* 22: 179-232.

Gasparro, K.E. and Walters, J.P. (2017). Revealing causal pathways to sustainable water service delivery using fsQCA. *Journal of Water, Sanitation and Hygiene for Development* 7(4): 546-556

Gerlitz, J-Y., Hunzai, K. and Hoermann, B. (2012). Mountain poverty in the Hindu-Kush Himalayas. *Canadian Journal of Development Studies/Revue canadienne d'études du développement* 33: 250-265.

Gerrits, L. and Verweij, S. (2016). Qualitative comparative analysis as a method for evaluating complex cases: An overview of literature and a stepwise guide with empirical application. *Zeitschrift für Evaluation* 15: 7-22.

Gerrits, L. and Verweij, S. (2018). *The Evaluation of Complex Infrastructure Projects: A Guide to Qualitative Comparative Analysis*. Cheltenham, UK: Edward Elgar

Greckhamer, T. (2011). Cross-cultural differences in compensation level and inequality across occupations: A set-theoretic analysis. *Organization Studies* 32: 85-115.

Greckhamer, T., Furnari, S., Fiss, P.C. and Aguilera, R.V. (2018). Studying configurations with qualitative comparative analysis: Best practices in strategy and organization research. *Strategic Organization* 16(4): 482-495.

Hirschman, A.O. (1970). *Exit, Voice and Loyalty: Responses to Decline in Firms, Organizations and States*. Cambridge, MA: Harvard University Press.

Holcombe, E.A., Berg, E., Smith, S., Anderson, M.G. and Holm-Nielsen, N. (2018). Does participation lead to ongoing infrastructure maintenance? Evidence from Caribbean landslide mitigation projects. *Journal of Development Studies* 54: 1374-1391.

Isham, J. and Kähkönen, S. (1998). Improving the delivery of water and sanitation: A model of coproduction of infrastructure services. Center for Institutional Reform and the Informal Sector, University of Maryland, College Park; IRIS.

Isham, J., Narayan, D. and Pritchett, L. (1995). Does participation improve performance? Establishing causality with subjective data. *World Bank Economic Review* 9: 175-200.

Jordan, E., Gross, M.E., Javernick-Will, A.N. and Garvin, M.J. (2011). Use and misuse of qualitative comparative analysis. *Construction Management and Economics* 29: 1159-1173.

Kraus, S., Ribeiro-Soriano, D. and Schüssler, M. (2018). Fuzzy-set qualitative comparative analysis (fsQCA) in entrepreneurship and innovation research–the rise of a method. *International Entrepreneurship and Management Journal* 14: 15-33.

Lin, J.Y. (2011). New structural economics: A framework for rethinking development. *The World Bank Research Observer* 26: 193-221.

Lyons, W.E., Lowery, D. and DeHoog, R.H. (1992). *The Politics of Dissatisfaction: Citizens, Services, and Urban Institutions*. New York: ME Sharpe.

Mackie, J.L. (1965). Causes and conditions. *American Philosophical Quarterly* 2(4): 245-64.

Nauges, C. and Van den Berg, C. (2008). Economies of density, scale and scope in the water supply and sewerage sector: A study of four developing and transition economies. *Journal of Regulatory Economics* 34: 144-163.

Olson, M. (1989). Collective action. In: Eatwell, J., Milgate, M. and Newman, P. (eds) *The Invisible Hand*. London: Palgrave Macmillan, pp. 61-69.

Parienté, W. (2017). Urbanization in sub-Saharan Africa and the challenge of access to basic services. *Journal of Demographic Economics* 83: 31-39.

Prokopy, L.S. (2009). Determinants and benefits of household level participation in rural drinking water projects in India. *Journal of Development Studies* 45: 471-495.

Prud'Homme, R. (1995). The dangers of decentralization. *The World Bank Research Observer* 10: 201-220.

Putnam, R.D. (2000). *Bowling Alone: The Collapse and Revival of American Community*. New York: Simon & Schuster.

Ragin, C.C. (1987). *The Comparative Method: Moving Beyond Qualitative and Quantitative Strategies*. Berkeley: University of California Press.

Ragin, C.C. (2008). *Redesigning Social Inquiry: Fuzzy Sets and Beyond*. Chicago, IL: University of Chicago Press.

Ragin, C.C., Strand, S.I. and Rubinson, C. (2008). *User's Guide to fuzzy-Set/Qualitative Comparative Analysis*. Department of Sociology, University of Arizona.

Rappaport, J. and Sachs, J.D. (2003). The United States as a coastal nation. *Journal of Economic Growth* 8: 5-46.

Rihoux, B. and Ragin, C.C. (eds). (2009). *Configurational Comparative Methods. Qualitative Comparative Analysis (QCA) and Related Techniques*. New York: Sage.

Rivas, M.G. (2012). Why do indigenous municipalities in Mexico have worse piped water coverage? *Development in Practice* 22: 31-43.

Rodrik, D., Subramanian, A. and Trebbi, F. (2004). Institutions rule: the primacy of institutions over geography and integration in economic development. *Journal of Economic Growth* 9: 131-165.

Roig-Tierno, N., Gonzalez-Cruz, T.F. and Llopis-Martinez, J. (2017). An overview of qualitative comparative analysis: A bibliometric analysis. *Journal of Innovation & Knowledge* 2: 15-23.

Roland, N., Rezende, S. and Heller, L. (2018). Application and critical assessment of qualitative comparative analysis: determinants for the presence of service provision models for water supply and sanitation services in Brazil. *Water Policy* 20(3): 546-564.

Schneider, C.Q. and Wagemann, C. (2010). Standards of good practice in Qualitative Comparative Analysis (QCA) and fuzzy-sets. *Comparative Sociology* 9: 397-418.

Schneider, C. Q. and Wagemann, C. (2012). *Set-theoretic methods for the social sciences: A guide to qualitative comparative analysis*. Cambridge University Press.

Schubeler, P. (1996). Participation and partnership in urban infrastructure management. Washington, DC: World Bank.

Sohail, K., Cavill, S. and Cotton, A.P. (2005). Sustainable operation and maintenance of urban infrastructure: Myth or reality? *Journal of Urban Planning and Development* 131: 39-49.

Sow, M. and Razafimahefa, I.F. (2015). Fiscal decentralization and the efficiency of public service delivery. IMF Working Paper, 15/59.

Steckel, J.C., Rao, N.D. and Jakob, M. (2017). Access to infrastructure services: Global trends and drivers. *Utilities Policy* 45: 109-117.

Sun, Y., Asante, F. and Birner, R. (2010). Opportunities and challenges of community-based rural drinking water supplies. International Food Policy Research Institute Discussion Paper 01026. Washington, DC: IFPRI.

Unger, D. (1998). *Building Social Capital in Thailand: Fibers, Finance and Infrastructure*. Cambridge: Cambridge University Press.

Verweij, S. and Gerrits, L.M. (2012). Assessing the applicability of Qualitative Comparative Analysis for the evaluation of complex projects. In: L.M. Gerrits and P.K. Marks (Eds), *Compact 1: Public Administration in Complexity*, 93-117. Litchfield Park: Emergent Publications

Wallsten, S. and Clarke, G. (2002). Universal (ly bad) service: Providing infrastructure services to rural and poor urban consumers. World Bank Policy Research Working Paper No.2868, Washington, DC: World Bank.

Yu, B., Fan, S. and Magalhães, E. (2015). Trends and composition of public expenditures: A global and regional perspective. *European Journal of Development Research* 27: 353-370.

Zezza, A., Winters, P., Davis, B., Carletto, G., Covarrubias, K., Tasciotti, L. and Quiñones, E. (2011). Rural household access to assets and markets: a cross-country comparison. *European Journal of Development Research* 23: 569-597.

Table 1: Descriptive statistics

	Mean	*Min*	*Max*	*SD*
Population with access to sewerage and pipe system (%)	74.370	31.11 (Ardahan)	100.00 (İstanbul)	15.827
Population receiving waste services (%)	78.729	35.71 (Ardahan)	100.00 (Kocaeli)	16.156
Population density*	124.728	12.000 (Tunceli)	2821.000 (İstanbul)	0.851
Population size*	920070.321	76859 (Bayburt)	13565798 (İstanbul)	0.941
Income – average daily earnings (TRY)	57.686	46.870 (Kilis)	85.550 (Zonguldak)	6.571
Political participation – average local election turnout (%)	88.157	77.100 (Ağrı)	93.100 (Manisa)	3.194

* In the analysis, logged values are used to account for skewness.

Table 2: Necessity analyses

Conditions	*Good sewerage access*		*Poor sewerage access*		*Good waste services access*		*Poor waste services access*	
	Cons	*Cov*	*Cons*	*Cov*	*Cons*	*Cov*	*Cons*	*Cov*
Population density	0.746	0.825	0.543	0.511	0.740	0.867	0.507	0.444
~Population density	0.558	0.589	0.814	0.732	0.526	0.588	0.848	0.709
Population size	0.796	0.886	0.498	0.471	0.768	0.904	0.471	0.415
~Population size	0.525	0.551	0.879	0.786	0.504	0.560	0.891	0.741
Income	0.672	0.775	0.565	0.554	0.631	0.770	0.571	0.521
~Income	0.613	0.624	0.771	0.666	0.608	0.655	0.749	0.602
Political participation	0.755	0.758	0.618	0.527	0.723	0.769	0.609	0.484
~Political participation	0.529	0.620	0.716	0.713	0.514	0.638	0.709	0.657

Table 3: Configurations and consistency values

Conditions						*Regions*	*Raw Consistency (and PRI) Values*			
							Access rate of population to sewerage and pipe system		*Percentage of population receiving waste services*	
Configuration	*Population density*	*Population size*	*Income*	*Political participation*	*Number*		*Access*	*~Access*	*Receive*	*~Receive*
1	0	0	0	0	8	Aksaray, Ardahan, Bayburt, Bingöl, Bitlis, Giresun, Iğdır, Sinop,	0.661 (0.153)	**0.937** (0.843)	0.673 (0.248)	**0.888** (0.743)
2	0	0	0	1	7	Amasya, Burdur, Isparta, Karaman, Kastamonu, Nevşehir, Niğde	0.814 (0.265)	**0.911** (0.646)	0.814 (0.392)	**0.848** (0.848)
3	0	0	1	0	9	Artvin, Erzincan, Gümüşhane, Hakkari, Kars, Muş, Siirt, Tunceli, Yozgat	0.720 (0.215)	**0.917** (0.768)	0.713 (0.285)	**0.885** (0.885)
4	0	0	1	1	8	Bilecik, Bolu, Çanakkale, Çankırı, Karabük, Kırıkkale, Kırklareli, Kırşehir,	**0.889** (0.582)	0.840 (0.399)	**0.869** (0.612)	0.793 (0.793)
5	0	1	0	0	2	Ağrı, Van	*0.856* (0.535)	*0.834* (0.465)	**0.867** (0.635)	0.767 (0.365)
6	0	1	0	1	4	Afyonkarahisar, Çorum, Konya, Tokat	**0.931** (0.734)	0.805 (0.244)	**0.919** (0.757)	0.740 (0.226)
~~7~~	~~0~~	~~1~~	~~1~~	~~0~~	~~1~~	~~Erzurum~~	~~0.873~~ (0.597)	~~0.811~~ (0.403)	~~0.873~~ (0.646)	~~0.767~~ (0.349)
8	0	1	1	1	3	Eskişehir, Kütahya, Sivas	**0.955** (0.837)	0.769 (0.156)	**0.940** (0.823)	0.716 (0.170)
9	1	0	0	0	2	Kilis, Şırnak	0.802 (0.301)	**0.914** (0.698)	*0.820* (0.499)	*0.821* (0.501)
10	1	0	0	1	5	Bartın, Düzce, Edirne, Osmaniye, Uşak	0.883 (0.381)	**0.928** (0.619)	**0.884** (0.588)	0.835 (0.412)
11	1	0	1	0	2	Rize, Yalova	*0.849* (0.464)	*0.869* (0.536)	**0.867** (0.516)	0.789 (0.386)
12	1	0	1	1	~~0~~					
13	1	1	0	0	8	Adıyaman, Diyarbakır, Gaziantep, Malatya, Mardin, Ordu, Şanlıurfa, Trabzon	0.880 (**0.706**)	0.708 (0.286)	**0.912** (0.824)	0.591 (0.176)
14	1	1	0	1	6	Aydın, Balıkesir, Denizli, Kahramanmaraş, Mersin, Samsun	**0.967** (0.897)	0.706 (0.096)	**0.962** (0.912)	0.606 (0.088)
15	1	1	1	0	3	Adana, Batman, Elazığ,	**0.904** (0.732)	0.740 (0.268)	**0.921** (0.813)	0.655 (0.187)
16	1	1	1	1	13	Ankara, Antalya, Bursa, Hatay, İstanbul, İzmir, Kayseri, Kocaeli, Manisa, Muğla, Sakarya, Tekirdağ, Zonguldak	**0.976** (0.952)	0.518 (0.046)	**0.974** (0.955)	0.450 (0.045)
Consistency threshold							> 0.883		> 0.835	
PRI threshold (after consistency threshold)							> 0.700		> 0.700	
Frequency Threshold							> 1		> 1	
Number configurations considered in bold							7	5	10	3

Table 4: Sufficiency analyses for sewerage access (including complex and parsimonious solutions)

Conditions	*Good sewerage access*			*Poor sewerage access**	
Population density	⊖	●		⊖	
Population size		●	●	⊖	⊖
Income	●				⊖
Political participation	●		●	⊖	
Complex Solution	**GSC1**	**GSC2**	**GSC3**	**PSC1**	**PSC 2**
Configurations	4, 8	13, 14, 15, 16	6, 8, 14, 16	1, 3	1, 2, 9, 10
Consistency (PRI)	0.889 (0.678)	0.911 (0.849)	0.943 (0.893)	0.906 (0.801)	0.888 (0.755)
Raw Coverage	0.378	0.678	0.622	0.577	0.712
Unique Coverage	0.080	0.125	0.043	0.091	0.227
Solution Consistency (PRI)	0.876 (0.790)			0.873 (0.745)	
Solution Coverage	0.828			0.804	
Parsimonious Solution	**GSP1**	**GSP2**	**GSP 3**	**PSP1**	**PSP2**
Configurations	4, 8, 16	13, 14, 15, 16	6, 8, 14, 16	1, 3	1, 2, 9, 10
Consistency	0.896 (0.802)	0.911 (0.849)	0.943 (0.893)	0.906 (0.801)	0.888 (0.755)
Raw Coverage	0.568	0.678	0.622	0.577	0.712
Unique Coverage	0.090	0.125	0.038	0.091	0.227
Solution Consistency (PRI)	0.865 (776)			0.873 (0.745)	
Solution Coverage	0.838			0.804	

* For poor sewerage access, there were two sets of prime implicants – the one chosen has a higher solution consistency value

Table 5: Sufficiency analyses for waste services access (including complex and parsimonious solutions)

Conditions	*Good waste services access*					*Poor waste services access**	
Population density	⊖	●	●			⊝	⊝
Population size				●	●	⊝	⊝
Income	●	⊖	●	⊖			⊝
Political participation	●	●	⊖		•	⊝	
Complex Solution	**GWC1**	**GWC2**	**GWC3**	**GWC4**	**GWC5**	**PWC1**	**PWC2**
Configurations	4, 8	10, 14	11, 15	5, 6, 13, 14	6, 8, 14, 16	1, 3	1, 2
Consistency (PRI)	0.867 (0.678)	0.902 (0.779)	0.886 (0.756)	0.887 (0.793)	0.939 (0.897)	0.872 (0.746)	0.863 (0.691)
Raw Coverage	0.349	0.396	0.300	0.507	0.585	0.596	0.643
Unique Coverage	0.061	0.023	0.020	0.082	0.139	0.102	0.149
Solution Consistency (PRI)			0.854 (0.771)			0.854 (0.706)	
Solution Coverage			0.812			0.745	
Parsimonious Solution	**GWP1**	**GWP2**	**GWP3**	**GWP4**		**PWP1**	**PWP2**
Configurations	4, 8, 16	10, 14, 16	11, 15, 16	5, 6, 8, 13, 14, 15, 16		1, 3	1,2
Consistency (PRI)	0.888 (0.809)	0.925 (0.868)	0.910 (0.855)	0.904 (0.857)		0.872	0.863
Raw Coverage	0.532	0.575	0.512	0.768		0.596	0.643
Unique Coverage	0.056	0.025	0.015	0.169		0.102	0.296
Solution Consistency (PRI)			0.844 (0.769)			0.854 (0.706)	
Solution Coverage			0.891			0.745	

* For poor waste services access, two sets of prime implicants found – the one chosen has a higher solution consistency value.

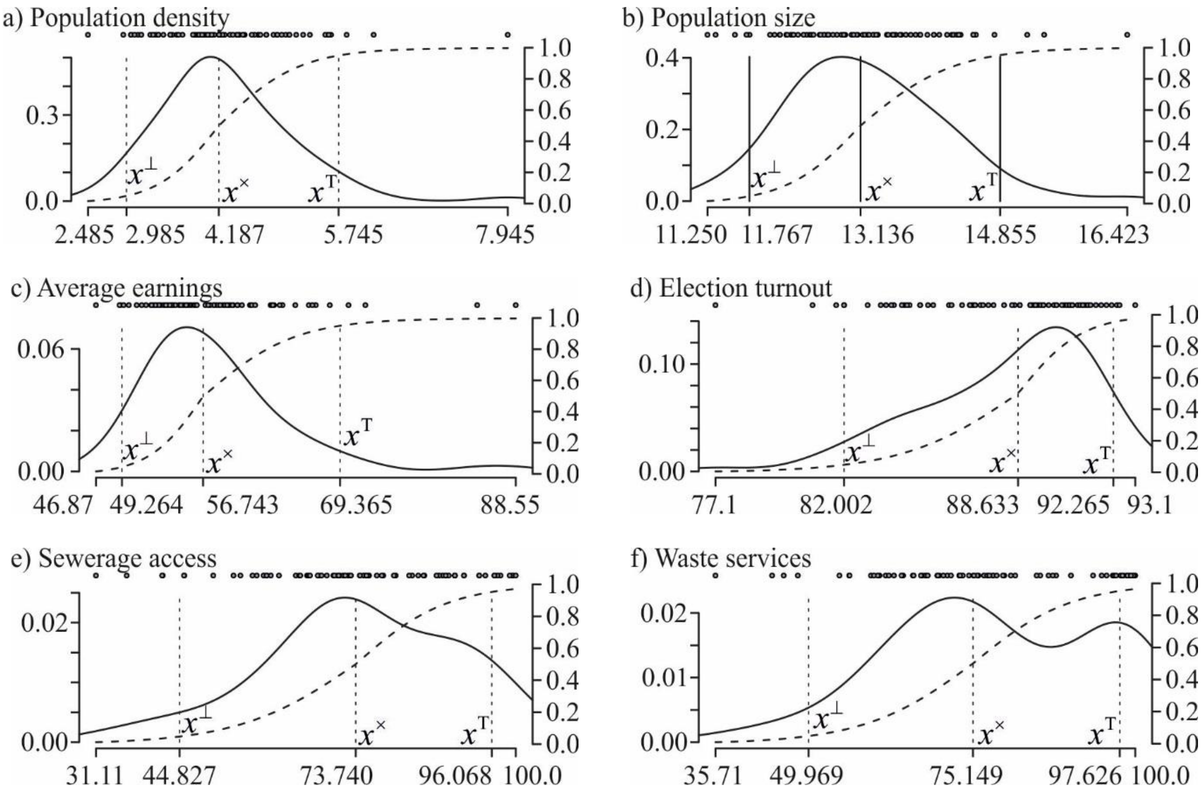

Figure 1: Pdf and membership function graphs

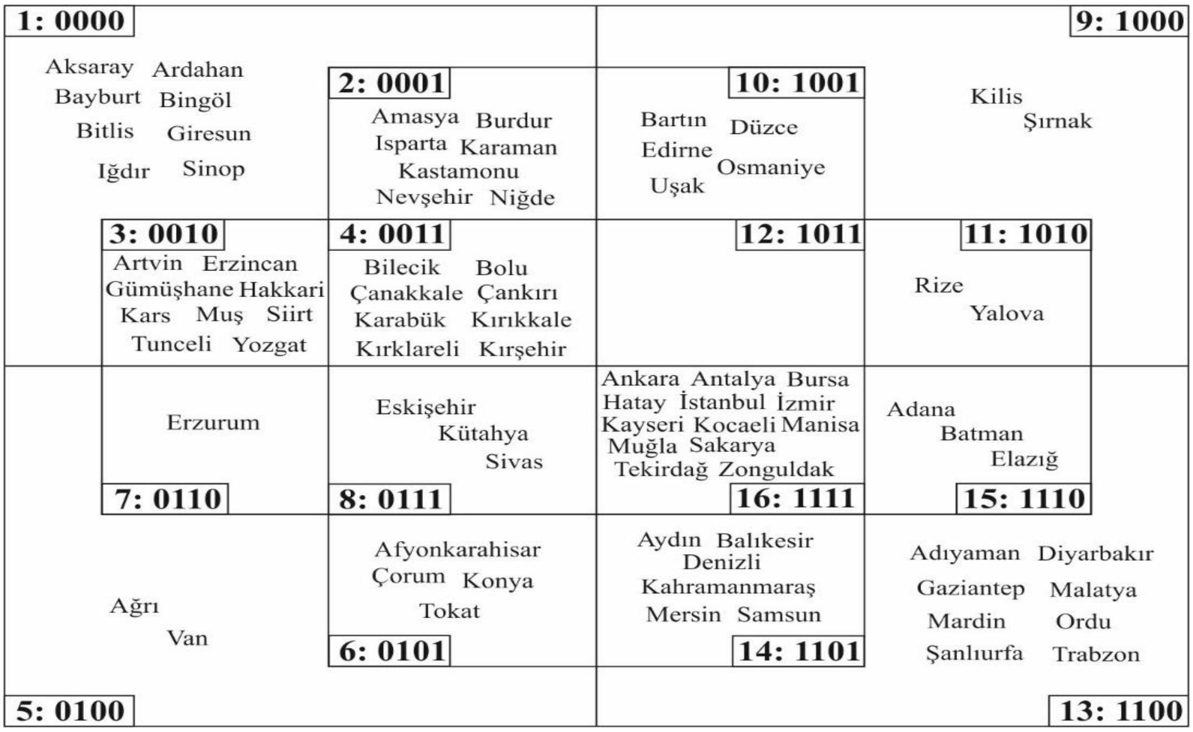

Figure 2: Venn diagram of configurations

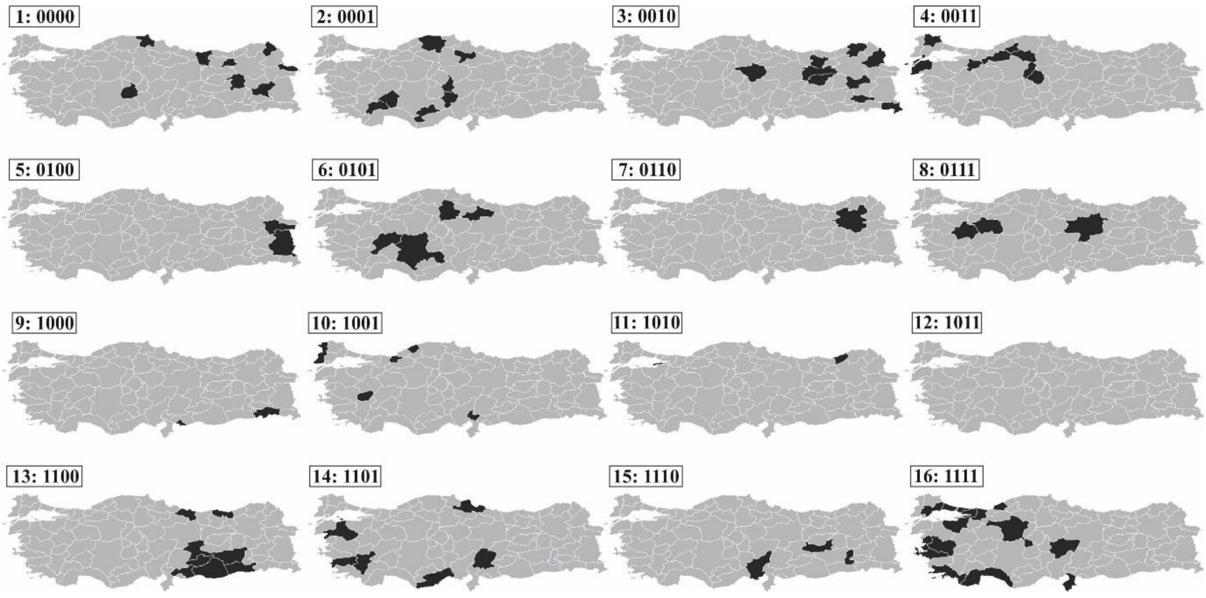

Figure 3: Geographical distribution of configurations

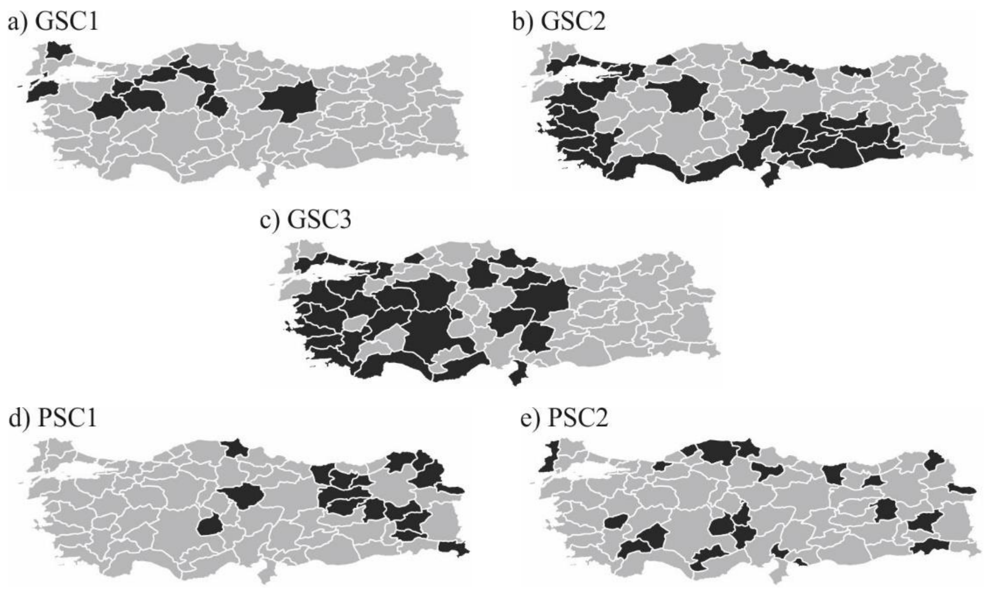

Figure 4: Geographical distribution of causal combinations for sewerage access

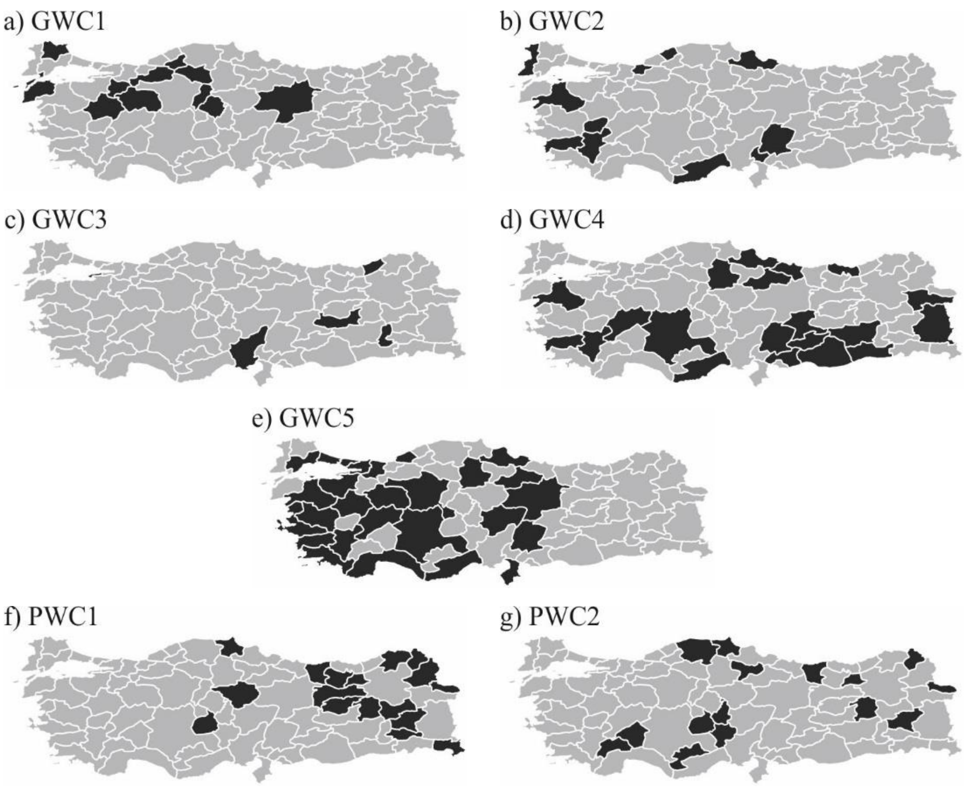

Figure 5: Geographical distribution of causal combinations for waste services access

Appendix

Table A1: Calibrated data matrix

Case	Population density	Population size	Income	Political turnout	Sewerage Access	Waste Service
1	0.842	0.923	0.634	0.440	0.916	0.954
2	0.626	0.569	0.197	0.343	0.349	0.250
3	0.335	0.638	0.243	0.942	0.452	0.438
4	0.313	0.538	0.437	0.005	0.081	0.095
5	0.346	0.346	0.393	0.354	0.425	0.527
6	0.411	0.272	0.233	0.893	0.379	0.351
7	0.907	0.981	0.960	0.867	0.961	0.962
8	0.729	0.919	0.659	0.724	0.886	0.959
9	0.055	0.032	0.254	0.123	0.012	0.009
10	0.068	0.080	0.910	0.396	0.147	0.154
11	0.797	0.766	0.242	0.846	0.899	0.956
12	0.610	0.808	0.428	0.901	0.879	0.881
13	0.656	0.101	0.295	0.514	0.051	0.031
14	0.766	0.512	0.644	0.134	0.523	0.600
15	0.055	0.016	0.213	0.313	0.213	0.169
16	0.324	0.119	0.922	0.957	0.707	0.703
17	0.142	0.190	0.266	0.119	0.180	0.150
18	0.313	0.289	0.322	0.105	0.156	0.134
19	0.171	0.210	0.587	0.846	0.406	0.284
20	0.202	0.176	0.376	0.950	0.265	0.295
21	0.939	0.947	0.851	0.835	0.970	0.964
22	0.357	0.481	0.574	0.846	0.304	0.218
23	0.075	0.089	0.608	0.690	0.422	0.343
24	0.235	0.524	0.152	0.634	0.431	0.385
25	0.621	0.746	0.173	0.961	0.899	0.962
26	0.729	0.877	0.339	0.047	0.958	0.921
27	0.810	0.297	0.165	0.885	0.191	0.191
28	0.501	0.374	0.191	0.771	0.473	0.503
29	0.516	0.543	0.512	0.313	0.614	0.684
30	0.043	0.132	0.825	0.485	0.544	0.602
31	0.123	0.681	0.680	0.233	0.970	0.654
32	0.442	0.679	0.916	0.846	0.946	0.960
33	0.943	0.896	0.163	0.188	0.916	0.963
34	0.463	0.399	0.045	0.323	0.172	0.213
35	0.075	0.047	0.639	0.070	0.432	0.297
36	0.213	0.203	0.593	0.028	0.020	0.141
37	0.935	0.865	0.618	0.595	0.872	0.953
38	0.379	0.102	0.079	0.156	0.051	0.177
39	0.346	0.389	0.293	0.811	0.557	0.522
40	0.999	0.997	0.972	0.634	0.971	0.964
41	0.961	0.973	0.843	0.798	0.955	0.960
42	0.569	0.782	0.358	0.756	0.819	0.946
43	0.422	0.139	0.736	0.653	0.573	0.556
44	0.098	0.156	0.190	0.835	0.468	0.572
45	0.114	0.249	0.560	0.093	0.036	0.025
46	0.106	0.322	0.418	0.672	0.123	0.095
47	0.587	0.829	0.532	0.824	0.955	0.963
48	0.651	0.044	0.019	0.474	0.479	0.438
49	0.442	0.296	0.941	0.595	0.863	0.824
50	0.390	0.141	0.814	0.876	0.647	0.648
51	0.181	0.210	0.655	0.615	0.568	0.619
52	0.980	0.881	0.998	0.885	0.968	0.965
53	0.390	0.919	0.306	0.771	0.938	0.960
54	0.313	0.547	0.701	0.921	0.523	0.482
55	0.501	0.664	0.127	0.323	0.856	0.955
56	0.711	0.845	0.817	0.976	0.938	0.959
57	0.646	0.669	0.044	0.101	0.799	0.939
58	0.739	0.888	0.424	0.634	0.899	0.947
59	0.536	0.706	0.558	0.835	0.776	0.933
60	0.346	0.389	0.633	0.047	0.036	0.039
61	0.368	0.220	0.060	0.835	0.447	0.505
62	0.301	0.291	0.139	0.932	0.310	0.445
63	0.766	0.645	0.094	0.304	0.344	0.845
64	0.853	0.475	0.226	0.690	0.455	0.583
65	0.615	0.271	0.539	0.175	0.180	0.279
66	0.892	0.726	0.822	0.901	0.699	0.964
67	0.813	0.829	0.349	0.595	0.559	0.798

68	0.695	0.892	0.141	0.304	0.639	0.786
69	0.432	0.253	0.528	0.375	0.309	0.305
70	0.171	0.119	0.108	0.304	0.111	0.080
71	0.523	0.440	0.050	0.241	0.314	0.401
72	0.061	0.592	0.744	0.514	0.479	0.439
73	0.828	0.700	0.883	0.846	0.879	0.964
74	0.442	0.568	0.146	0.690	0.428	0.453
75	0.854	0.669	0.201	0.276	0.764	0.962
76	0.014	0.020	0.758	0.086	0.276	0.253
77	0.501	0.295	0.129	0.908	0.358	0.441
78	0.411	0.784	0.443	0.042	0.899	0.949
79	0.940	0.122	0.679	0.156	0.817	0.836
80	0.123	0.453	0.629	0.128	0.410	0.368
81	0.874	0.584	0.999	0.514	0.280	0.345