Research Paper

Cultural preferences for the methods and motivation of sanitation infrastructure development

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ABSTRACT

Research has found that sanitation infrastructure is cultured, or is shaped by national level cultural preferences. This study expands on this past work to identify causal pathways showing combinations of cultural dimensions that explain sanitation infrastructure technology choice, including total access to improved sanitation facilities, sewerage connections and access to onsite treatment technologies. This analysis uses fuzzy-set qualitative comparative analysis to analyze all possible combinations of causal conditions which contribute to an outcome of interest. In doing so, pathways are discovered using Hofstede's cultural dimensions as causal conditions and national-level sanitation data as outcomes. Findings show that the cultural dimensions of power distance, individualism versus collectivism, and uncertainty avoidance play a dominant role in sanitation technology choice. These cultural preferences are used to create an analytic framework that maps the cultural dimensions to the methods and motivations of common sanitation infrastructure delivery methods.

Key words | culture, fuzzy-set, Hofstede, infrastructure, sanitation

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INTRODUCTION

On September 25, 2015, the United Nations (UN) hosted a summit to adopt post-2015 sustainability goals. Labeled the Global Goals for Sustainable Development, these 17 goals aim to end extreme poverty, fight inequality and injustice, and mitigate climate change. Specifically, Goal Six seeks to ensure the 'availability and sustainable management of water and sanitation for all' (Project Everyone 2015).

The need to provide sanitation is motivated by the direct relationship between the use of improved water, hygiene and sanitation infrastructure and a decrease in the incidence of diarrheal disease (USAID 2013). This is a significant public health challenge; in 2013 diarrheal disease was listed as the second leading cause of death for children under the age of five (WHO 2015). While various approaches have been taken to understand this gap in sanitation infrastructure, this study focuses on the relationship between national cultural descriptors and sanitation outcomes (White 2011). We seek global trends that (1) rigorously describe cultural preferences and (2) link them to sanitation infrastructure; when leveraged locally, these may help the development community systematically design and deliver more culturally appropriate infrastructure.

Previous research has empirically shown that culture affects the implementation of global sanitation infrastructure, showing statistically significant relationships between Hofstede's model of cross-cultural comparison (Hofstede 2001), sanitation construction technology (Kaminsky 2015), and environmental health indicators (Onel & Mukherjee 2013). Building on this past work, this study focuses on *combinations* of cultural descriptors that lead to the

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sanitation outcome. A fuzzy-set qualitative comparative method is used to analyze causal relationships between combinations of Hofstede's cultural dimensions (described further in the literature review) and sanitation metrics at a national level (Hofstede 2001; WHO/UNICEF 2016). The 32 analyses presented here represent data from 16 to 64 nations around the globe, detailed in the Methods section. Findings show four dominant combinations of cultural dimensions (or *pathways*) that lead to the sanitation outcomes. For example, one pathway links preferences for high power distance to low individualism, or collectivism. These results offer a point of departure for future investigations to localize these empirically discovered global trends to the project level. This will help researchers better understand how sanitation infrastructure embodies implicit cultural values, and will enable policy makers and engineers to adapt project design and delivery to better fit diverse cultural preferences.

POINT OF DEPARTURE: HOFSTEDE'S CULTURAL DIMENSIONS

Multiple tools for cross-national cultural assessments exist, including Hofstede's cultural dimensions, GLOBE and Trompenaars' model of national culture differences (Magnusson *et al.* 2008). Out of these assessments, Hofstede has been the most cited (Jones 2007) and is used as the basis for other cross-national cultural assessments because of its extensive dataset (Taras *et al.* 2009). Therefore, it was also selected for use in this study.

The Hofstede cultural dimensions originated from a survey distributed to over 116,000 IBM employees in global offices between 1967 and 1973 (Kirkman *et al.* 2006). Results from this survey identified how workplace interactions and organizational management are influenced by culture. Survey responses were categorized into four cultural dimensions: power distance, individualism, masculinity and uncertainty avoidance, detailed in Table 1. For further details on Hofstede's methodology we refer the reader to his previous work (Hofstede 2001). Two additional dimensions were added in 1991 and 2010: long-term orientation and indulgence versus restraint. Due to the decreased availability of national data for these dimensions, only the original four are used here.

Hofstede's scores are not intended to rank countries, but rather to describe aggregate preferences for diverse ways of being and doing. For example, the United States received a score of 40 for power distance, while China was scored at 80. These scores indicate that participants from China prefer a stronger establishment of hierarchy, whereas the United States prefers more communication between the various levels of authority. Although Hofstede's original study targeted organizational structure and management styles, other studies have shown that these cultural dimensions are statistically significant for engineering, construction and environmental applications (Pheng & Yuquan 2002; Kaminsky 2015, 2016).

Method vs. motivation

We explain the observed link between cultural dimensions and infrastructure technology type by proposing an analytic framework that maps a connection between culture and the *methods* and *motivations* by which sanitation projects are designed and constructed. Results of these analyses are discussed within the context of this framework. According to the Merriam-Webster Dictionary, *method* is 'a careful or organized plan that controls the way something is done' (Merriam-Webster 2016a). *Motivation* is 'the act or process of giving someone a reason for doing something, a force or influence that causes someone to do something' (Merriam-Webster 2016b). This framework emerged from analysis of the data in this study and was reinforced by Hofstede's cultural dimensions in studies analyzing construction, infrastructure, engineering practice and environmental health. A literature review confirmed that definitions of PDI typically meet the definition of methods, while MAS and UAI are typically defined as motivation, and IDV is regularly used for both, aligning with debates in the literature regarding this construct (Oyserman *et al.* 2002; Schimmack *et al.* 2005). For example, in a study focused on local government and transparency, the authors described PDI as the 'level of hierarchy in society' (Frías-Aceituno *et al.* 2013), corresponding with the definition of methods. In another publication, MAS is described as 'placing a low value on caring for others and quality of life' (Onel & Mukherjee 2013) which is associated with motivation. While

Table 1 | Hofstede cultural dimensions, defined

Cultural dimension	Definition	Selected applications from existing literature
Power distance index (PDI)	The extent to which the less powerful members of institutions and organizations within a country expect and accept that power is distributed unequally	For national and urban contexts, PDI is the statistically dominant factor for the construction of piped-to-premises water supply between 1990 and 2012 (Kaminsky 2016) Countries with a high PDI have a 'negative influence' on knowledge sharing in construction projects (Kivrak *et al.* 2014)
Individualism vs. collectivism (IDV)	Individualism stands for a society in which the ties between individuals are loose: everyone is expected to look after him/herself and his/her immediate family only. Collectivism stands for a society in which people from birth onwards are integrated into strong, cohesive in-groups, which throughout people's lifetime continue to protect them in exchange for unquestioning loyalty[a]	In rural contexts, nations with high IDV correlate with a higher increase in the percentage of national populations with piped water on premises (Kaminsky 2016) Countries with greater individualistic tendencies are more likely to have increased environmental health outcomes (Onel & Mukherjee 2013)
Masculinity vs. femininity (MAS)[b]	Masculinity is a society in which social gender roles are clearly distinct: Men are supposed to be assertive, tough, and focused on material success; women are supposed to be more modest, tender, and concerned with the quality of life. Femininity stands for a society in which social gender roles overlap: Both men and women are supposed to be modest, tender and concerned with the quality of life	Highly masculine cultures tend towards sewer connections and away from onsite technologies, while the opposite is true for more feminine cultures, based on linear regression analysis (Kaminsky 2015) Cultures with higher masculinity desire more strategic and economic information from public disclosure (Frías-Aceituno *et al.* 2013)
Uncertainty avoidance index (UAI)	The extent to which the members of a culture feel threatened by uncertain or unknown situations. Uncertainty avoidance is not the same as risk avoidance, but rather can be described as lead[ing] to an escape from ambiguity	In rural, urban and national contexts, high UAI scores correlate with a higher increase in the percentage of national populations with piped water on premises (Kaminsky 2016) Higher uncertainty avoidance correlates to greater problems with knowledge sharing in construction projects (Kivrak *et al.* 2014)

Source: Definitions from Hofstede (2001).

[a]There has been some debate as to whether individualism and collectivism exist as polar opposites rather than having overlapping qualities. For example, within religious organizations, both individualistic and collectivistic qualities, such as uniqueness and self-sacrifice, are encouraged (Schimmack *et al.* 2005). Regardless, studies have validated Hofstede's work to determine that IDV is adequate for comparison of culture (Schimmack *et al.* 2005).

[b]The author contends that these traits can be attributed to both men and women within a society; this dimension more accurately describes the styles of socialization rather than gender roles. However, to maintain consistency with published literature, the existing nomenclature will remain intact for the present analysis.

analytically useful, we note these categories are not absolute and should be applied with care.

METHODS

Fuzzy-set qualitative comparative analysis

This paper uses fuzzy-set qualitative comparative analysis (fsQCA), a set theoretic method used to find relationships between outcomes and sets of causal conditions. Using fsQCA provides the ability to analyze smaller datasets than conventional regression and reveals all possible combinations of factors (or pathways) which lead to the outcome (Ragin 2008). Each condition is measured by set membership on a calibrated scale. This calibration is important because it is frequently inaccurate to say that a case is at a place of absolute membership or lack thereof. For example, an individual typically does not have just two categories of food preferences (e.g. like vs. dislike) but rather varying categories of relative acceptability. Similarly, sanitation outcomes in this study have varying levels of membership. This is quantified on a 0 to 1 scale associated with the percentage of sanitation outcomes at the national level. Any

given combination (or pathway) of causal conditions is considered to be significant if it has a raw consistency of 80% or greater (Ragin 2008). *Consistency* measures the degree to which the causal conditions and specific pathways are subsets of the outcome (Ragin 2008). *Coverage* describes how broadly applicable a pathway is by detailing to what degree the countries (also known as *cases*) are represented by that specific pathway. Please refer to Kaminsky & Jordan (2017) for a more detailed discussion of fsQCA in water, sanitation and hygiene research.

Limitations

While Hofstede is widely used in academic research, there are shortcomings with the data which provide an opportunity for improvement in future studies. One of these limitations is lack of coverage. Owing to the nature of original data collection, Hofstede scores are not available for a large portion of African countries and other developing nations. For example, out of the 64 countries used for total access to improved sanitation facilities, only one African country had data available for analysis. For sewerage connections, just nine out of 37 countries were classified as developing according to UN definitions (UN DESA 2014). However, in the analysis of total access to improved sanitation facilities, data were available for 30 developing countries, contributing to just below 50% of the dataset. In addition to availability of data, the scope of the survey was limited to IBM employees and as such was not taken from a statistically representative sample of national populations. For example, it does not adequately reflect urban/rural populations, gender, education levels, or socioeconomic strata. This raises questions regarding the ability to generalize results. However, despite these limitations, Hofstede's metrics have been found to be useful and valid for cross-cultural comparisons in academic disciplines such as marketing, international development, and other subjects (Kirkman *et al.* 2006). In addition, reviews and meta-analyses of cross-cultural frameworks show that Hofstede's cultural dimensions compare favorably to other frameworks (Magnusson *et al.* 2008) and use similar methodology (Taras *et al.* 2009). Given this past validation, Hofstede's framework was selected as the best available for the present analysis.

Data retrieval

Data used for this study include Hofstede's cultural dimensions and national statistics for the percentage of population with access to improved sanitation infrastructure, access to sewerage connections, and access to onsite sanitation infrastructure. These data were retrieved from the WHO/UNICEF Joint Monitoring Programme (JMP) and the Hofstede Centre (Hofstede 2014; WHO/UNICEF 2016). Each cultural dimension is quantified as a value from 1 to 100 and used for cultural comparison between different countries. JMP data are from national household and census surveys in each country. All data between 1990 and 2013 were collected for sewerage connections and assessed to see which years had greatest availability. For sewerage connections and onsite treatment, these were data from 2001 and 2012. Onsite treatment was calculated from the difference between total access to improved sanitation sources and sewerage connections. Following initial data retrieval, cultural indicators were cross-referenced with the three sanitation technology categories and the years for which data were available. For example, nations with both Hofstede scores and 1990 JMP data for total access to improved sanitation were used in one analysis; this included 63 nations. In contrast, 64 nations had both Hofstede scores and 2010 JMP data for total access to improved sanitation; these were used in a separate analysis. The various combinations of available data considered in this paper are detailed in Table 4. The dataset includes all nations that had data for both the indicators and outcome; as described below, this number is different for the various runs. When analyzing change in sanitation, only countries with a change greater than 1% were included since we are interested in the difference and wanted to discard cases that have no change in outcome.

Data analysis

The data that were included in the analysis include national economic classification (e.g. developing, developed) according to the United Nations (UN DESA 2014), and type of sanitation outcome by year (e.g. total access to sanitation, sewerage connections, or onsite treatment) according to the WHO/UNICEF JMP (WHO/UNICEF 2016), all

measured at the national level. Hofstede's cultural dimensions were used as causal conditions in fsQCA, and the three sanitation technology types were analyzed at each of the three time steps. For example, total access to improved sanitation was analyzed with fsQCA first for 1990 data, second for the 2010 data, and then for the difference between the two years. Following this analysis, the cases were separated into developing and developed countries and the analysis was conducted again for the same years and difference. This was done to validate the work by checking if pathways remained the same regardless of the economic resources of the country. In this study, the fully complex QCA solution was used to avoid using any assumptions regarding the implications of cultural preferences on sanitation technology choices.

A standard component of the fsQCA method is calibration of both outcomes and causal conditions. Sanitation outcomes were calibrated with an indirect method using six increments (0.0, 0.2, 0.4, 0.6, 0.8, and 1.0) (Ragin 2008). Cultural dimensions were not calibrated because of the nature of the values provided. In his work, Hofstede retrieved qualitative data and coded them into scaled values (on a 1–100 range) for use in comparing values between different countries, encompassing the purpose of calibration.

RESULTS AND DISCUSSION

Fuzzy-set QCA identifies possible pathways which lead to specified outcomes. Comparable to a baking recipe, different combinations of the same ingredients can lead to many delicious outcomes. Similarly, resulting pathways are a combination of either high or low levels of membership in a cultural dimension, as shown in Table 2.

Twenty-seven pathways emerged from the analysis, all of which are included in the supplementary material (Tables S2 and S3, available with the online version of this paper). For this discussion, four dominant pathways have been selected for analysis having consistencies greater than 80%, an accepted level of consistency for fsQCA (Ragin 2008; Kaminsky & Jordan 2017), high coverage, and including both developed and developing economies in the trial runs, as shown in Table 3. The scope of analysis for each dominant pathway is presented in Table 4. For example, Pathway 1 encompasses membership from both developing and developed countries with a consistency ranging from 0.80 to 0.93 and a unique coverage from 0.23 to 0.84 (Table 3). This pathway was observed in five different runs (Table 4) with a maximum of 64 countries analyzed.

To reiterate, these pathways do not imply that cultural dimensions are exhibited in each individual project within

Table 2 | Summary of abbreviations for cultural dimensions in pathways being analyzed

pdi:	membership in high power distance index	~pdi:	membership in low power distance index
idv:	membership in individualism	~idv:	membership in collectivism
mas:	membership in masculinity	~mas:	membership in femininity
uai:	membership in high uncertainty avoidance index	~uai:	membership in low uncertainty avoidance index

Table 3 | Dominant fsQCA results

		Distribution of countries with membership			
Type of sanitation	**Pathway**	**% Developing**	**% Developed**	**Consistency**	**Unique coverage**
Total access (TA)	1: pdi* ~ idv	70–100	0–30	0.80–0.93	0.23–0.84
	2: pdi* ~ idv*mas*uai	86	14	0.81–0.83	0.61–0.63
Sewerage connection (SC)	3: pdi*uai	40	60	0.93	0.15
Onsite treatment (OT)	4: pdi* ~ idv*uai	58	42	0.90	0.30

Source: Country distribution membership from UN DESA (2014).

Table 4 | Description of conditions used in fsQCA for resulting dominant pathways

	Run characteristics			
Pathway	**Outcome**	**Time**	**Economic status**	**Number of cases analyzed**
1: pdi* ~ idv	TA	1990	All	63
	TA	2010	All	64
	TA	Δ(2010–1990)	Developed	27
	TA	1990	Developing	30
	TA	2010	Developing	30
2: pdi* ~ idv*mas*uai	TA	Δ(2010–1990)	All	37
3: pdi*uai	SC	2012	All	37
4: pdi* ~ idv*uai	OT	2012	All	37

TA, total access; SC, sewerage connection; OT, onsite treatment.

any given nation, but rather that these combinations of dimensions represent aggregate trends that the data show influence sanitation technology. This is interpreted to indicate that dominant sanitation project delivery methods and technologies are more appropriate fits for these cultural preferences. This suggests a need for research to develop appropriate technology options for nations with different cultural preferences. In this next section and the corresponding Figure 1, each of the dominant pathways are described with respect to the unique combination of Hofstede's cultural dimensions as well as methods and motivation. As an aid to the reader, we also provide descriptions of documented sanitation projects. It is important to note that the authors have not conducted case study analysis of these projects; they are intended merely as more concrete examples of how resulting cultural pathways may influence individual projects. As such, these examples may be understood as hypothesis generation for future case study research that may confirm the proposed explanations of the empirically observed relationships.

Total access to improved sanitation

Two pathways lead to increased total access to improved sanitation: PDI* ~ IDV and PDI* ~ IDV*MAS*UAI. One critical observation is both pathways include the combination of membership in power distance as well as collectivism, describing cultural preferences for strong hierarchical frameworks in combination with a collective mindset. Using the analytic framework proposed earlier,

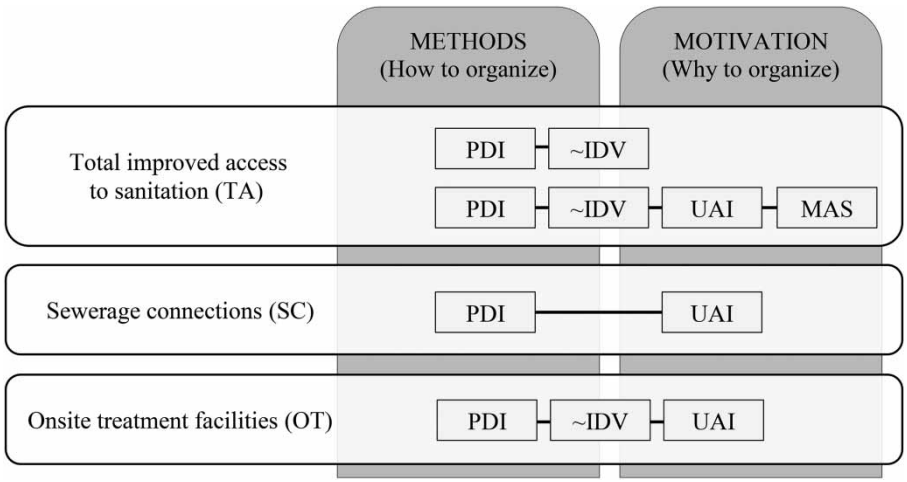

Figure 1 | Overview of dominant pathways for sanitation outcomes.

collectivism serves as a motivation that is executed through the methods of high power distance. One example of this pathway may be a centralized government project (PDI) to improve existing sanitation infrastructure, resulting in an increased percentage of households (low IDV) with centralized sanitation technology. Countries with membership include Guatemala, Malaysia and Vietnam. The second pathway shows that countries with increased total access to improved sanitation have a combination of high power distance, collectivism, masculine style of socialization and high uncertainty avoidance. This suggests societal preferences for a strong hierarchical system which emphasizes the importance of considering others' needs in combination with an aggressive, competitive style of socialization and a motivation to avoid uncertainty. A project delivery method exhibiting these dimensions is community-led total sanitation, where the hierarchy of a community is used to aggressively motivate community members to use sanitation facilities through peer pressure. This not only encompasses a collective attitude and a masculine approach, but also embodies the essence of methods and motivation. The utilization of hierarchy and community meetings acknowledges the importance of the type of approach while collective pressure accounts for using motivation to achieve the sanitation goal. Countries with membership in this second pathway include Mexico, Colombia and Greece.

Sewerage connections

The third dominant pathway observed increased frequency of sewerage connections related to PDI*UAI. This shows that the use of sewerage connections to provide sanitation services culturally fits best in nations preferring strong hierarchical systems and inclination to avoid uncertainty. Uncertainty avoidance serves as the motivation to develop sewerage connections, while power distance implies methods for implementing the technology. Distance between authority levels provides a clear structure that can catalyze the provision of these connections, especially in urban areas, where sewerage connections are more prevalent (WHO/UNICEF 2015). A recent infrastructure project in Mexico exemplifies this pathway; uncertainty created through settlement under the existing wastewater system and increased population (UAI, motivation) caused the government to implement an infrastructure improvement project (PDI, hierarchical method) in Mexico City (Roby & Gonzalez 2011). Mexico has membership in this pathway, along with Brazil and Spain. Again, more research is needed to explain the empirically observed relationships between sewerage connections and cultural dimensions.

Onsite treatment

The final dominant pathway relates to the coverage of onsite treatment facilities at a national level: PDI* ~ IDV*UAI. Table 4 shows that this pathway was analyzed for 37 countries from both developed and developing countries in 2012. Onsite treatment facilities culturally fit best in contexts preferring high power distance, collectivism and high uncertainty avoidance. We might have assumed onsite treatment would align with individualism, given the decentralized nature of this sanitation technology. However, the data show that a strong authority structure in combination with preferences for collectivism and uncertainty avoidance can also be used to describe nations with increased onsite treatment. A possible explanation for this empirically observed relationship is that a more highly centralized government system (associated with high PDI) may have the regulations and policy in place that allows homeowners to more easily construct onsite facilities to decrease uncertainty (high UAI) of sanitation coverage. Preferences for collectivism are evidenced by the government's motivation to create frameworks for a larger variety of users in society. Countries that have membership in this pathway include Mexico, Romania and Bulgaria. This pathway is exemplified in a government subsidy program for installation of pit latrines in Faridpur, Bangladesh (Ali & Stevens 2009). The subsidies and power distance in government involvement demonstrates the importance of methods while motivation to increase access to sanitation propelled the project. Unfortunately, Bangladesh was not included in the present analysis because of missing sanitation data. However, the Hofstede scores validate the results by placing Bangladesh firmly in the high PDI, low IDV, and high UAI pathway discussed here.

The reader might notice that some countries have membership in multiple pathways. These examples were consciously chosen to demonstrate that the utility of

Hofstede's cultural dimensions is to describe diverse and multiple pathways that help explain why nations tend to prefer certain types of sanitation infrastructure. As discussed here, we interpret this to mean that certain technology types and project delivery methods are better cultural fits for certain contexts, and solutions need to be developed to better meet these preferences. Finally, we note that these pathways are intended to serve as a point of departure for future research that will undoubtedly problematize these high-level trends with local context and more nuanced, qualitative research.

CONCLUSION AND POLICY IMPLICATIONS

The purpose of this study is twofold: to discover relationships between combinations of Hofstede's cultural dimensions and sanitation technology outcomes at a national level; and to propose methods and motivation as an analytic framework for integrating culture into sanitation infrastructure development. An fsQCA discovered 27 pathways describing ways that culture influences the technologies chosen to meet universally relevant sanitation service needs. Four dominant pathways (Table 4 and Figure 1) represent both developing and developed countries and had a consistency of over 80%. Another contribution of this paper is an analytic framework for motivation and methods as a new way of fitting sanitation infrastructure technologies and delivery methods to local cultural preferences. In this framework, the power distance index is associated with methods, while uncertainty avoidance and masculinity are related to motivation. Individualism maps to both methods and motivation, reinforcing insights from the literature that question the polarization of individualism and collectivism (Oyserman *et al.* 2002; Schimmack *et al.* 2005).

The most general contribution of this work is the identification of analytically robust cultural descriptors from the academic literature that provide a structure for understanding how culture influences sanitation infrastructure around the globe. However, and as cogently noted by a reviewer, the national unit of analysis used here is less than ideal for either the description of culture or application to individual sanitation projects. Still, we claim the relationships that emerged from the data represent global trends that may be practically applied at the project level. The caveat, of course, is that local cultural preferences must be rigorously understood before the more generalized relationships discovered in this analysis will be useful – these local preferences will often not be the same as the more aggregate, national preferences. For example, regardless of where a particular community falls on the spectrum of individualism vs. collectivism preferences, we now know that this is a cultural force that influences sanitation infrastructure and should be considered during project design and delivery. To aid these endeavors, future project-level research should continue to map project delivery methods and technologies to the analytic framework proposed here. In addition, future research is needed to create new project delivery methods that better fit cultural preferences that are poorly served by current approaches.

Additional information to support the contents of this document is available online. This includes comprehensive results and a sample truth table for the fsQCA (Table S1).

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