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Configural theory for ICT development ☆

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ABSTRACT

This study intends to establish configural theory for ICT development by using fuzzy set/Qualitative Comparative Analysis (fsQCA) and to contrast the results with those from multivariate regression analysis (MRA). The fsQCA results support three propositions: the highly-developed countries, the highly-developed countries with low population density and the highly-developed countries with low corruption are the sufficient conditions for high ICT development. In addition, the improvement toward developed countries and increases in both population density and corruption are a sufficient condition for the improvement in ICT development. However, fsQCA finds a contrary case: the improvement toward developed countries and decreases in both population density and corruption are also a sufficient condition for the improvement in ICT development. MRA is good at model fitting. FsQCA is good at showing the causal complexities to explain the outcome and successfully predicts the withheld data sets.

1. Introduction

Information and communications technology (ICT) impacts countries all over the world (Huarng, 2010; Huarng & Yu, 2011). Some studies examine ICT adoption at the country level, while others on firm level (Kim & Huarng, 2011). Yu (2011) points out that the least squares method only considers the impact of the estimated coefficients on the means and she presents a quantile model to examine the impacts of each variable at different quantiles on ICT development. Hence, this study aims to establish configural theory for ICT development and to contrast the analysis with multiple regression analysis (MRA).

Woodside, Camacho, and Lai (2013) state that the evaluation of outcomes requires the development of the configuration of causes and processes that lead to the outcomes. Hence, the use of appropriate methods is important in identifying correct relationships. The conventional statistical methods tend to report the "net effects," that is the direct plus indirect influence of each independent variable on the dependent variable (Woodside, Schpektor, & Xia, 2013). These methods are suitable for symmetric data, such as in Fig. 1A, where there are high values of *X* (independent variable) for high values of *Y* (dependent variable), such as *a* and *b*, and low values of *X* for low values of *Y*, such as *c* and *d*. However, Ragin (2008) expresses two concerns. First, the combination of three to six independent variables presents a level of complexity that the statistical modeling of three- to six-way interactions in MRA cannot easily implement. Second, the real-life relationships of independent variables and dependent variables are asymmetric. Fig. 1B shows the asymmetric data relationships in that on top of the situation as in Fig. 1A, there are also low values of *X* for high values of *Y*, such as *e*, *f*, and *g*.

Hence, this study uses fuzzy set/Qualitative Comparative Analysis (fsQCA) to explore the relationships between the antecedents (the dependent variables) and the outcome (the independent variable). In addition, this study also explores the relationships between the improvements in the antecedents and the improvement in ICT development. FsQCA suits the problem with asymmetric data and identifies the relationships between different combinations of antecedents and the outcome. To compare fsQCA with MRA, this study also conducts similar analyses. This study then compares the results and discusses the different capabilities of and results of these two methods.

Section 2 proposes the relevant propositions. Section 3 introduces the methods, as well as the variables and data. Section 4 reports and compares the empirical analyses by using both fsQCA and MRA. This study also explores the meaning of each combination of antecedents. Section 5 concludes this article.

2. Propositions

Different factors may impact ICT development. Various studies associate developed countries with high ICT development (Kasikitsakunphon & Vanijja, 2013; Raghuprasad, Devaraja, & Gopala, 2013). The economic level and the level of industrialization are the two fundamental factors to determine whether a country is developed (Investopedia, 2014). Many studies use GDP per capita (Huarng, 2011; Huarng & Yu, 2014)

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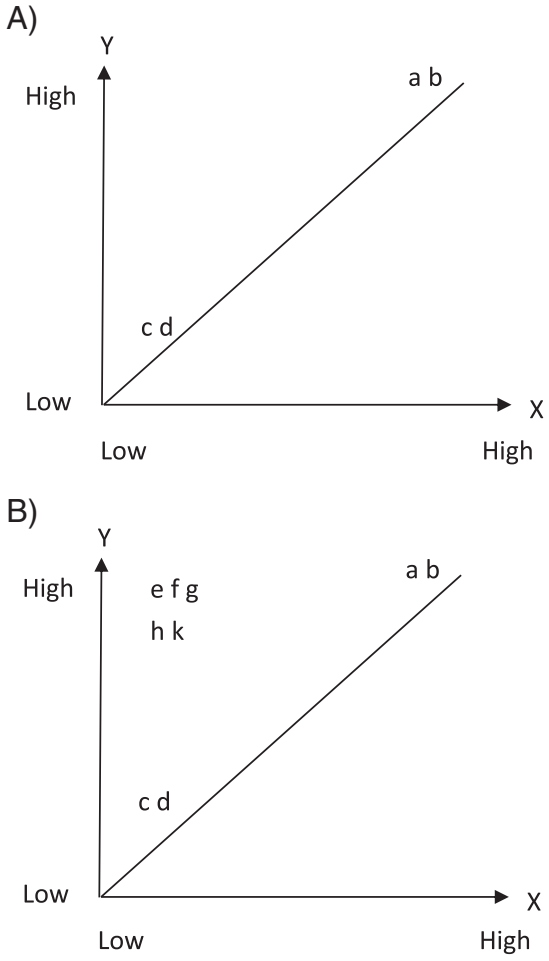

Fig. 1. A. Symmetric data. B. Asymmetric data.

or GDP per capita in purchasing power parity (PPP) terms (Balaban, 2012; Mehmood & Azim, 2013) to represent a country's economic level and explore the relationships with ICT development. Studies also use high numbers of telephone lines per 100 inhabitants to represent industrialization (Hudson, 1995; Hudson, 2000). Hence, this study proposes using PPP to represent a country's economic level and telephone lines per 100 inhabitants to represent the level of industrialization and puts forward the following propositions:

High PPP and high telephone lines per 100 inhabitants → highly-developed countries.

P1. Highly-developed countries → high ICT development where → means sufficient conditions.

Two other variables are also of interest. What is the relationship between population density and ICT development? Some studies suggest that low population density contributes to high ICT development (DeMaagd, 2009). The people in countries with low population densities may desire more communication from ICT. Hence, this study proposes

P2. Highly-developed countries with low population density → high ICT development.

Most studies focus on how ICT can reduce corruption (Charoensukmongkol & Moqbel, 2014; Ionescu, 2013). Hence, this study intends to explore how corruption may affect ICT development in different countries and proposes.

P3. Highly-developed countries with low corruption → high ICT development.

This study considers that similar antecedent combinations would apply to the improvement in ICT development. Following the above propositions, this study also puts forward a proposition for the improvement in ICT development:

P4. Improvement toward developed countries and decrease in population density and decrease in corruption → improvement in ICT development.

3. Research methods

3.1. Methods

This study compares the empirical results from both MRA and fsQCA. The MRA includes correlation analysis, regression analysis, and the analysis of variance. FsQCA is an analytical tool that uses fuzzy set theory and Boolean logic. FsQCA is different from the conventional statistical methods in the following ways: set-theoretic vs. correlational connections, calibration vs. measurement, configuration of conditions vs. independent variables, and analysis of causal complexity vs. the analysis of net effects (Ragin, 2008). FsQCA first calibrates the data into 0.0–1.0, where 0.0 means full non-membership and 1.0 means full membership. In considering the thresholds, this study takes <0.05 as full non-membership and >0.95 as full membership. Both Ragin (2008) and Woodside and Zhang (2013) provide more detail on how to perform the calibrations.

After processing the calibrated data, fsQCA provides the configuration of conditions, such as

$$A * \sim B \rightarrow C$$

where A and B are the antecedents, and C is the outcome. * represents logic AND, while ~ represents NOT. The equation means that A* ~ B (an antecedent combination) is the sufficient condition for C.

Both Ragin (2008) and Woodside (2013) stress the importance of achieving high consistency over the high coverage. Hence, this study focuses more on the consistency although also encompasses the coverage.

3.2. Variables and data

This study explains the variables in Table 1, including the outcome, namely, the Internet, and the antecedents, i.e., ppp, phone, pop, and cpi. To study the improvement in antecedents and outcome, this study adds a d in front of each antecedent to represent the difference; for example, d_ppp is the difference in the ppp of two time periods. This study also adds c to each antecedent to represent the calibrated antecedent; for example, c_ppp is the calibrated ppp.

The data for the Internet, phone, and pop are from the data set of the World Telecommunication/ICT Indicators database compiled by the

Table 1
Variable names for outcome and antecedents.

Outcome/variable name	Definition	Note
Internet	Internet users per 100 inhabitants to represent ICT development	High value indicates high ICT development.
Antecedents/variable names		
ppp	GDP per capita in purchasing power parity	
phone	Telephone lines per 100 inhabitants	
pop	Population density	
cpi	Corruption index	High value indicates low corruption