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Measurement invariance in comparative Internet use research

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ABSTRACT

Comparative studies in communication and Internet research call for equivalent measures of key constructs that are comparable across populations. This article details and applies the concept of measurement invariance within a cross-nationally comparative context. Multi-group confirmatory factor analysis is used to test configural, metric, and scalar invariance in an empirical example and structural equation modeling introduces exogenous predictors of Internet use types. Results support metric invariance for a four-factor Internet usage model in three English-speaking countries. The significance of measurement invariance testing for unbiased comparative research is discussed.

1. Introduction

There have been notable developments in comparative research in the social and behavioral sciences such as psychology and sociology (e.g. Berry, Poortinga, Breugelmans, Chasiotis, & Sam, 2011; Davidov, Schmidt, & Billiet, 2011; Horn & McArdle, 1992; Inglehart & Baker, 2000; Kohn, 1987; Poortinga, Van De Vijver, & Van Hemert, 2002) or political science (e.g. Boix & Stokes, 2007; Stegmueller, 2011; Van Deth, 1998)—but also in media and communication research that specifically analyzes communication processes in social systems (see Esser & Hanitzsch, 2012 for an overview). Comparative communication research deals with diverse questions such as how election campaigning, climate change reporting, or information seeking behavior differ across countries. Comparative Internet use research, in particular, is concerned with cross-country differences in various types of usage, along with their social antecedents and effects. It is likely that the development of user-friendly statistical software combined with the increasing availability of multi-country datasets will lead to a rise in comparative research and the validity of such studies will crucially depend on the cross-national comparability of constructs.

This article exemplifies practical methodological challenges in analyzing Internet usage patterns across multiple countries. If one is interested in the concept of, for example, informational uses of the Internet in country *A*, a comparison with country *B* requires the existence of an *equivalent* concept. Since the concept of informational use is not directly observable or measurable but rather a latent construct, operationalizations into manifest variables are necessary: In a survey of Internet users, one of several indicators to measure informational use may be how often the respondent checks facts online. How multiple indicators are then combined needs to be equivalent across populations for meaningful comparisons. However, not only latent constructs can be challenging in comparative research. Even manifest variables such as age may cause problems. The straightforward question "how old are you?" is probably universally comprehensible, but not necessarily interpreted in the same way. As Baron (2010) reports, a Korean and American adult may specify ages two years apart despite having the exact same "actual" age (in Korea, a baby is considered one year old at birth and everyone turns one year older on 1 January). In this case, culturally knowledgeable researchers could simply transform the age variable in their data accordingly to achieve equivalence. For latent constructs with multiple indicators the issue is more complex. In this case, in addition to securing equivalence at the indicator level, the way these single items reflect the underlying latent construct is key (Fontaine, 2005). As Wirth and Kolb (2012) point out, comparative research projects may employ strategies oriented toward avoiding bias ex ante. For example, the questionnaire should avoid ambiguous terms or collaborators in multiple countries should collect data within the same time frame using the same instrument. Due to theoretical interests and practical constraints, many of these strategies may in part prove unfeasible. Once data have been collected, ex post strategies of testing and

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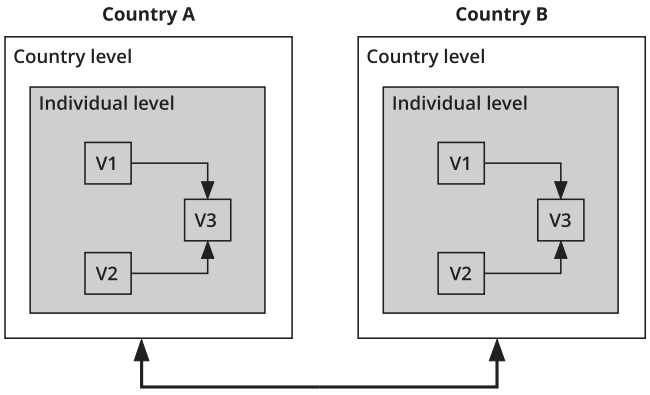

Fig. 1. Comparative logic of country as a context of study.
Source: Modified from Hasebrink (2012, p. 385).

optimizing equivalence come into play (Davidov, Meuleman, Cieciuch, Schmidt, & Billiet, 2014).

1.1. Comparative logic: countries as context

Comparative communication research contrasts different macro-level units such as countries using different analytical strategies in dealing with the objects of investigation (Esser & Hanitzsch, 2012). In an influential address to the American Sociological Association, Kohn (1987) argued for the usefulness of cross-country research in testing and developing social theory. Based on this, Hasebrink (2012) described four comparative logics: "(1) countries as objects of study; (2) countries as context of study; (3) countries as unit of analysis; and (4) countries as part of a larger international/global system" (p. 384). The second option, country as context, was used in the empirical example below. In this approach, hypotheses regarding correlations between variables of theoretical interest are tested across a sample of countries (Fig. 1). The comparative logic of "country as context of study" aims to provide insights into the similarities and differences of the hypothesized relationships and overall model fit for the selected countries. In Fig. 1, V1 and V2 could be sociodemographic attributes (e.g. age and education) that influence the level of a specific type of Internet use (V3; e.g. informational Internet use).

1.2. Comparative Internet use research

Ever since the use of the Internet has disseminated outside its academic and military origins, researchers have analyzed the patterns of diffusion and adoption (see e.g. Nie & Erbring, 2000). Internet use as a global phenomenon calls for international and comparative research. While early analyses focused mainly on the United States, there now exist numerous comparative studies of diffusion at the country level (e.g. Andrés, Cuberes, Diouf, & Serebrisky, 2010) and the user level (e.g. Brandtzæg, Heim, & Karahasanović, 2011). In connection with analyses of diffusion and unequal access, the literature has also assessed differentiated uses across social subgroups revealing further digital divides (e.g. Bonfadelli, 2002; DiMaggio, Hargittai, Celeste, & Shafer, 2004; Norris, 2001; Teo, 2001; Van Dijk, 2005), while current research has shifted to the social outcomes and impacts of Internet use. Amichai-Hamburger and Hayat (2011), for example, conclude from their 13-country comparative study that the Internet can enhance the social lives of its users. Van Deursen and Helsper (2015) note that the Internet is more beneficial to those in higher social positions in terms of what they achieve through their use. From the (comparative) literature on Internet use and the digital divide it becomes clear that inequalities in various domains need to be addressed in societies where vital resources for the participation in social life are exclusively or most readily available online (see e.g. Hargittai, 2008; Witte & Mannon, 2010).

Because the Internet is technically merely a network of networks, the applications and uses supported by this infrastructure are extremely broad and diverse. Consequently, several typologies have been suggested for the types and purposes of individual's everyday Internet use. The reduction of the usage dimensionality has frequently been addressed by exploratory as well as confirmatory factor analysis (EFA and CFA). Conceptually a step before actual use, LaRose and Eastin (2004) formulated expected outcomes of use such as finding similar people, finding information, feeling entertained, or finding bargains online. Using EFA and principal component analysis, Blank and Groselj (2014) derived 10 usage factors from more than 40 activity variables. Similarly, Van Deursen and Van Dijk (2014) reduced 18 activities to seven usage factors. The theoretical background of such classifications is predominantly based on the uses and gratifications literature developed for traditional media (see Katz, Haas, & Gurevitch, 1973). Helsper and Gerber (2012) specifically addressed the potential pitfalls of cross-national comparisons of Internet use types. They constructed and tested a measurement model of Internet use comprising communication, information, entertainment, and finance and were able to demonstrate its general applicability in a diverse set of 12 countries (Helsper & Gerber, 2012).

The literature shows that refined measures of Internet use have been developed, yet explicit tests of equivalence remain rare when these are applied in comparative research. Following the comparative logic visualized in Fig. 1, the empirical models below deal with individual-level Internet usage differences—within the context of different countries—rather than global comparisons based on macro-level indicators (such as Internet diffusion rates in different countries; see Kiiski & Pohjola, 2002). Aimed at supporting the methodological rigor of future comparative Internet use research, the following sections present the concept of measurement invariance, detail its statistical assessment, and apply the procedures to an empirical example.

2. Evaluating measurement invariance in multi-group confirmatory factor analysis and structural equation modeling

2.1. Latent variable modeling

This section describes the analytical steps involved in testing cross-country measurement invariance of latent Internet usage types using quantitative survey data in multi-group structural equation modeling (MGSEM). MGSEM expands multi-group confirmatory factor analysis (MGCFA; see Jöreskog, 1971). While MGCFA focuses on measurement models across samples, MGSEM additionally incorporates structural modeling. In CFA, an individual's observable response (x_i) to an item (i) is considered to be made up of an intercept (τ_i), a slope (λ_{ij}) of the regression of x_i on a latent construct (ξ_j), and a stochastic error term (δ_i) (Brown, 2015; Steenkamp & Baumgartner, 1998). Each item score is essentially treated like an outcome variable in a simple regression model of the type $y_i = \alpha + \beta x_i + \varepsilon_i$:

$$x_i = \tau_i + \lambda_{ij}\xi_j + \delta_i$$

For reflective measurement models it is important to note the implied causal flow: The latent construct is responsible for the answers in the manifest indicator items—it is not the items that form the latent construct (see Edwards, 2011). For example, people who are very conscientious would likely agree with the item "I pay attention to details." Here, conscientiousness as

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