Comparing results of an exact versus an approximate (Bayesian) measurement invariance test: 
A cross-country illustration with a new scale to measure 19 human values

Jan Cieciuch*
University Research Priority Program ‘Social Networks’, University of Zürich, Switzerland
and Cardinal Stefan Wyszyński University in Warsaw, Poland

Eldad Davidov
Institute of Sociology, University of Zürich, Switzerland

Peter Schmidt
National Research University Higher School of Economics, Moscow, Russia
and University of Giessen, Germany

René Algesheimer
Department of Business Administration, University of Zürich, Switzerland

Shalom H. Schwartz
The Hebrew University of Jerusalem, Israel
and National Research University-Higher School of Economics, Moscow, Russia

* Corresponding author
Jan Cieciuch
University Research Priority Program ‘Social Networks’
Andreasstrasse 15; CH-8050 Zürich; Switzerland
jancieciuch@gmail.com
Acknowledgements: The work of the first, the second, and the fourth authors was supported by the University Research Priority Program Social Networks of the University of Zürich.
Abstract

One of the most frequently used procedures for measurement invariance testing is the multigroup confirmatory factor analysis (MGCFA). Muthén and Asparouhov (2013) recently proposed a new approach to test for approximate rather than exact measurement invariance using Bayesian MGCFA. Approximate measurement invariance permits small differences between parameters, otherwise constrained to be equal in the classical exact approach. However, extant knowledge about how results of approximate measurement invariance tests compare to the results of the exact measurement invariance test is missing. We address this gap by comparing results of exact versus approximate (Bayesian) cross-country measurement invariance tests of the revised scale to measure human values.

Several studies that measured basic human values with the Portrait Values Questionnaire (PVQ) reported problems of measurement noninvariance (especially scalar noninvariance) across countries (e.g., Davidov, Schmidt, Schwartz, 2008). Schwartz et al. (2012) proposed a refined value theory and an instrument (PVQ-5X) to measure 19 more narrowly defined values. Cieciuch, Davidov, Vecchione, Beierlein and Schwartz (2014) tested its measurement invariance properties across eight countries and showed that the PVQ-5X is substantially more cross-country invariant than the old PVQ version to measure 10 values. They established exact scalar measurement invariance for 10 values. The current study applied the approximate measurement invariance and established approximate scalar measurement invariance even for all 19 values.

Key words: multigroup confirmatory factor analysis, exact measurement invariance, approximate measurement invariance, configural metric scalar measurement invariance, Revised Portrait Values Questionnaire, Bayesian analysis
Measurement invariance

Measurement invariance is a psychometric property of a scale developed to measure a latent construct. The instrument is measurement invariant when the same construct is measured in the same way across different groups, such as countries, cultural units, time points or regions within countries (Davidov et al., 2014; Horn, McArdle, 1992; Meredith, 1993; Millsap, 2011; Vandenberg, 2002; Vandenberg, Lance, 2000). Measurement invariance is necessary for conducting meaningful comparisons across groups. The most widely used method to establish measurement invariance is multigroup confirmatory factor analysis (MGCFA; Bollen, 1989; Jöreskog, 1971). Usually (Vandenberg, Lance, 2000) one distinguishes between three levels of measurement invariance: configural (where all groups have the same pattern of factor loadings), metric (where the factor loadings are constrained to be equal across the compared groups), and scalar (where the factor loadings and the indicator intercepts are constrained to be equal across groups). Metric measurement invariance implies that respondents interpret question items in the same way across groups, although the construct may or may not be measured in the same way (Steenkamp, Baumgartner, 1998). Scalar invariance implies that the construct is measured in the same way, that is, respondents use the scale the same way across groups. Metric invariance is sufficient for comparing covariances and unstandardized regression coefficients across groups. A meaningful comparison of latent means across groups however requires a scalar level of measurement invariance.

Some researchers have argued that partial (metric or scalar) measurement invariance is sufficient for meaningful comparisons (Byrne, Shavelson, Muthen, 1989; Steenkamp, Baumgartner, 1998). Partial invariance is supported when the parameters of at least two indicators (loadings at the metric level and loadings plus intercepts at the scalar level of the measurement) are equal across groups.
Measurement invariance has become an increasingly important and disputed topic in the social sciences lately. In April 2014, the term ‘measurement invariance’ yielded about 239,000 hits in a Google Scholar search. This abundance of scientific papers falls into three categories. The first category includes methodological papers that introduce, discuss and evaluate various methods and approaches to measurement invariance. The second includes papers that test the measurement invariance of a given construct across groups as a precondition for further comparative analysis. These papers assess measurement invariance as a preliminary analysis that allows for a meaningful test of the substantive hypotheses. The third category of papers reports the measurement invariance properties of specific questionnaires that were developed to measure specific latent constructs. These papers assess the quality of the questionnaires for analyses within and across countries or time points. They seek to improve questionnaire validity and reliability by identifying weaknesses and problems in the formulation of questions, in translation, in culture appropriateness, and so on. Establishing measurement invariance in one study does not signify that a questionnaire is always measurement invariant. Measurement invariance should be repeatedly tested across groups, because noninvariance can be caused by external features of the study in addition to internal features of the instrument.

The aim of the present study is twofold. First, we try to establish the measurement invariance properties of Schwartz et al.’s (2012) newly developed scale to measure human values. This goal locates the study in the third category of studies listed above. Second, we apply two methods (exact and approximate) for establishing measurement invariance and compare their findings. This goal locates the study in the first category of studies listed above.

**Schwartz’s theory of basic human values**
Schwartz (1992; Schwartz et al., 2012) defines values as broad, trans-situational goals that vary in importance and serve as guiding principles in the life of a person or group. Schwartz distinguishes between value hierarchies and value structure. Value hierarchies refer to the relative importance of the set of values to different individuals. The central claim of Schwartz’s value theory concerns the value structure. It asserts that values form a circular motivational continuum. This means that values that are located in adjacent regions on the continuum are motivationally similar. Behavior that expresses one value is likely to express the adjacent values at the same time. In contrast, values that are located on opposing sides of the circle express conflicting motivations; behavior that expresses one value is likely to simultaneously challenge or block the expression of opposing values in the circle.

The claim that values form a continuum implies that the circle of values can be partitioned in any number of ways. Depending on the aims of a study, one can differentiate between fewer broadly defined values or many more narrowly defined values. There are two common ways of partitioning the circular continuum, the classic version and the refined version. The classic version (Schwartz, 1992) partitions the circle into ten basic human values. The refined version (Schwartz et al., 2012) partitions the circle into 19 narrowly defined values. The 19 values in the refined version are sub-dimensions of the ten basic human values (Cieciuch, Davidov, Vecchione, Schwartz, 2014). The values in both versions can be grouped into sets of four higher order values, of person-oriented versus socially-oriented values, or of self-protection versus growth values. Thus, the refined version of the theory and the classic version both describe the same circular motivational continuum. However, the refined theory partitions this continuum more finely, allowing for more fine-tuned predictions and explanations. Figure 1 presents the value circle with 19 narrowly defined values, and Table 1 defines each of the values.
Measurement of basic human values

The problem of measurement invariance is especially important for values because researchers often use them to describe differences between demographic, occupational, cultural, and national groups (Inglehart, Baker, 2000; Schwartz, 2006). Several methods have been developed to measure the values in Schwartz’s approach. Currently, the most commonly used questionnaires are versions of the Portrait Value Questionnaire (PVQ). The original version (PVQ-40) includes 40 items (Schwartz, 2003; Schwartz, Melech, Lehmann, Burgess, Harris, 2001). A shorter version, implemented in the European Social Survey (ESS), includes 21 items (PVQ-21, Schwartz, 2003). The most recent version, developed to measure the 19 values of the refined value theory, includes 57 items (PVQ-57, Schwartz et al., 2012).

Several studies have tested the measurement invariance across countries of the PVQ-21 with data collected in the ESS (e.g., Davidov, 2008, 2010; Davidov, Schmidt, Schwartz, 2008). These studies succeeded in identifying only seven values at the configural level; it was necessary to unify some pairs of adjacent values in the confirmatory factor analyses. Davidov et al. (2008) established metric invariance for these seven values, but not scalar invariance. The discrimination of only seven values at the configural level challenged the value theory, because it did not support the claim that there are ten basic human values. The lack of scalar invariance even for these seven was problematic because it meant that comparisons of means across cultures or countries may not be meaningful.

Analyses of Cieciuch and Schwartz (2012), and Cieciuch, Schwartz and Vecchione demonstrated that the ten values in the theory can be discriminated in CFA analyses when an appropriate measurement instrument is applied. They did not, however, resolve the problem.
of demonstrating scalar invariance which is necessary to legitimize comparative studies of value means. Cieciuch and Davidov (2012) addressed this problem when they compared the invariance properties between the PVQ-21 and PVQ-40 across Poland and Germany. They found that the PVQ-40 displayed a higher level of measurement invariance than the PVQ-21; it attained scalar invariance for all of the values except stimulation. They attributed the superiority of the PVQ-40 to the larger number of indicators available to measure the latent factors. With more items, the possibility of establishing partial scalar invariance increases.

To measure all of the narrowly defined values that are differentiated in the refined theory, Schwartz et al. (2012) developed the PVQ-57. This version introduced three important changes compared to previous versions of the PVQ: (1) Single sentences were used for all items, replacing the two-sentence items of earlier versions. This avoided the dangers associated with double-barreled questions and improved clarity. (2) All items referred to the “importance” of a valued goal or characteristic to the respondent, replacing terms that referred to desires and feelings in earlier versions. This increased consistency insured that all items fit the conception of values as goals that vary in importance. (3) Three items measured each of the 19 values, in contrast to the varying numbers for each value in the PVQ-40 and the two items in the PVQ-21.

CFA analyses of the revised PVQ instrument successfully identified all 19 values in eight countries (Finland, Germany, Israel, Italy, New Zealand, Poland, Portugal, and Switzerland), establishing both configural and metric invariance (Cieciuch et al., 2014). Moreover, Cieciuch et al. (2014) established scalar measurement invariance for 10 of the 19 values across the eight countries. Table 5 presents the detailed results. Encouraging as these findings are in allowing comparison of means across countries for 10 values, a problem remains with the other nine values for which scalar invariance was not established. Perhaps,
however, the method used to test measurement invariance test was overly strict. We therefore asked whether a more liberal test would yield better results.

The current study

Several researchers have recently argued that, although measurement invariance is necessary for meaningful comparisons across groups, the criteria for evaluating the appropriate level of measurement invariance are too strict (Muthén, Asparouhov, 2013; Muthén, 2014; van de Schoot, Kluytmans, Tummers, Lugtig, Hox, Muthén, 2014). This may lead to rejecting the possibility of comparison and needlessly discourage research in some cases. Adopting this view, Muthén and Asparouhov (2013) proposed the concept of approximate rather than exact measurement invariance, which is based on Bayesian analysis.

Approximate (Bayesian) measurement invariance. Bayesian analysis allows researchers to introduce existing knowledge into their analyses, especially the amount of uncertainty. The current practice within the dominant frequentist approach is to use existing knowledge in the theoretical introduction of papers and in the discussion but seldom in the analyses. Often the testing of null hypotheses ignores the existence of prior knowledge. Bayesian analysis allows testing informative hypotheses, that is, hypotheses that take prior knowledge into account. This logic may also be applied to testing measurement invariance.

In the Bayesian approach, parameters (e.g., loadings or intercepts) are considered to be variables with a specific distribution. The parameters of this distribution are called priors and can be defined by the researcher based on previous knowledge or assumptions (Muthén, Asparouhov, 2013). In the exact measurement invariance approach researchers assume that the differences between loadings (or intercepts) across groups are zero, or in another words that the loadings (or intercepts) are exactly equal across groups. The Bayesian measurement invariance approach introduces the concept of approximate equality. Thus, for testing
approximate measurement invariance, one can expect that some differences in loadings (or intercepts) can occur, however the mean of the differences between loadings (or intercepts) across groups is zero. Because the small variability is rather random, a normal distribution of the differences in loadings (or intercepts) with zero mean and small variance is assumed. Several simulation studies have shown that small variations (variance equal to .01 or .05) in the distribution of the differences in loadings or intercepts do not bias substantive conclusions for comparative research (Muthén, Asparouhov, 2013; van de Schoot et al., 2013). Consequently, it makes sense to regard a small amount of variation as acceptable.

Approximate measurement invariance differs from the partial measurement invariance approach, because in the latter some parameters are constrained to be exactly equal and others are entirely released, while in the former all parameters are constrained, however the restrictions are more liberal and refer to the concept of approximate equality.

In the next section we test for approximate measurement invariance of the 19 values from the refined value theory of Schwartz et al. (2012). We then compare the findings to those established in previous studies that used exact measurement invariance testing.

Approximate measurement invariance is a relatively new approach. Therefore, there are few comparisons in the literature of the results that this approach yields with those obtained by the classic, exact measurement, invariance approach. We expect that the new scale to measure 19 values will exhibit better measurement invariance properties than those reported by Cieciuch et al. (2014) when approximate measurement invariance is applied, because it allows for small differences between parameters that are otherwise constrained to be exactly equal in the exact measurement invariance approach. This would justify doing additional cross-cultural comparisons.

**Method**
Participants and procedure. We used the same data employed for testing exact measurement invariance in Cieciuch et al. (2014). Data were from the following countries: Finland (N = 334, 65% female, Mage = 42.3, SDage = 6.1), Germany (N = 325, 77% female, Mage = 23.4, SDage = 5.0), Israel (N = 394, 65% female, Mage = 25.7, SDage = 6.2), Italy (N = 388, 59% female, Mage = 35.6, SDage = 14.5), New Zealand (N = 527, 68% female, Mage = 19.5, SDage = 4.2), Poland (N = 547, 66% female, Mage = 27.0, SDage = 10.0), Portugal (N = 295, 58% female, Mage = 27.0, SDage = 10.4), and Switzerland (N = 201, 70% female, Mage = 28.8, SDage = 7.7). All participants were contacted by researchers or instructed assistants in person or online and completed the value instrument voluntarily and anonymously. Data were collected in a written format in Finland, Germany, Italy, Poland, and in half the Portuguese sample. Data were collected online in the remaining samples.

Questionnaire. Data were collected with the PVQ-5X (Schwartz et al., 2012) developed to measured 19 more narrowly defined values. Items described a person in terms of what is important for him or her. The respondents were asked to answer the question “How much is this person like you” on a scale ranging from 1 (not like me at all) to 6 (very much like me). We excluded 9 items which did not load satisfactorily on their corresponding value in the study of Schwartz et al. (2012). Thus, our analyses included exactly the same items included in the exact measurement invariance test of Cieciuch et al. (2014). Ten of the values were measured by three indicators and nine values by two indicators. Missing values for all items were below 0.7% with the exception of one achievement item (AC1) which had 2.9% missing values.

Analysis

Testing for approximate measurement invariance in Mplus. The approximate measurement invariance test procedure is included in Mplus (Muthén, Muthén, 1998-2012) in
the mixture analysis framework. Mixture modeling means that besides the latent variables included in the model, there are also one or more latent categorical variables that describe membership of respondents to a certain class. These latent categorical variables represent homogenous subpopulations of the studied heterogeneous population (Muthén, 2002). In principle, mixture modelling assumes that the division into subpopulations and subpopulation membership are not known but can be inferred from the data. However, in our case this was a straightforward inference, because the population membership was deduced by the country where data on the individuals were collected. Thus, this categorical variable was known, since it was simply the variable that described membership in groups (countries). In terms of mixture models, this situation is known as a single-class mixture model because there is only one class (one categorical variable). According to Asparouhov and Muthén (2010), if the categorical variable is observed, the single-class mixture model is essentially the same as a multigroup model. Kim, Mun, and Smith (2013) also argue that the two models (the multigroup model and the single-class mixture model with known class membership) are in principle the same.

Table 2 presents the syntax and briefly explains the various steps of the analysis and the meaning of the statements used in the syntax.

Table 2

**Evaluation of the model.** The fit of the Bayesian model can detect whether actual deviations are larger than those that the researcher allows in the prior distribution. The model fit can be evaluated based on the posterior predictive probability (ppp) value and the confidence interval (CI) for the difference between the observed and replicated chi-square values. According to Muthén and Asparouhov (2012) and van de Schoot et al. (2013), the
Bayesian model fits to the data when the ppp is not significant\(^1\) and the CI contains zero. We defined the mean of the differences in loadings and intercepts across countries as zero and the variance of these differences as .01 (van de Schoot et al., 2013). If the model was unacceptable based on the ppp and the CI, we slightly increased the variance to determine the level of allowed variation in the loadings and intercepts that would lead to acceptable model fit coefficients.\(^2\) Additionally, Mplus lists all parameters that significantly differ from the priors. This feature is equivalent to modification indices in the exact measurement invariance approach. While the model is assessed based on ppp and CI, these values provide global model fit criteria that are similar to the criteria in the exact approach (Chen, 2007).

**Results**

Table 3 presents fit coefficients of the approximate multigroup CFA for each value separately. For most of the values, the ppp was not significant and the 95% CI for the difference between the observed and replicated chi-square values contained zero, which means that the approximate scalar invariance models for these values are acceptable. The only three exceptions were achievement, benevolence-dependability and face. Therefore, we increased the variance prior for these values to .02. With this adjustment, all three approximate scalar invariance models were also acceptable for these values.

Table 3

Table 4 presents all deviations of loadings and intercepts from the defined priors. Despite the deviations listed in Table 4, the ppp and CI reached acceptable levels, which

---

\(^{1}\) Simulation studies are still required to determine what level of significance researchers may rely on.

\(^{2}\) This analysis was conducted similarly to determine which variance in the differences between loadings or intercepts across countries may be allowed. It was a sensitivity analysis, because there are still no established cut-off criteria in the literature.
suggests that approximate metric and scalar measurement invariance are supported by the data.

Table 4

Table 5 presents a comparison of Cieciuch et al.’s (2014) results using the exact approach and the results in the current study obtained using the approximate approach. Whereas exact scalar invariance was supported only for a subset of the 19 values, approximate measurement invariance was established for all values, including those values where exact measurement invariance testing failed to display scalar invariance.

Table 5

Finally, Table 6 presents the country mean rankings for each value using the exact (Cieciuch et al., 2014) and approximate measurement invariance procedures. In spite of great similarities, several differences in the country rankings for various values can be observed in the table.

Table 6

Summary and conclusions

Measurement invariance is a precondition for meaningful cross-group comparisons. Assuming rather than empirically testing that the precondition is satisfied can be dangerous and can lead to wrong conclusions. Therefore, an empirical test of measurement invariance of a study’s measures is necessary. However, the classic (exact) test is very demanding and very often leads to the rejection of measurement invariance and to precluding group comparisons. Van den Schoot et al. (2013) metaphorically described this situation as traveling between
Scylla and Charybdis. Scylla represents the situation in which a model lacks measurement invariance, whereas Charybdis represents the situation in which the model was not tested for measurement invariance. In both situations, the researcher cannot know whether the differences between groups are real and substantive or a result of methodological artefacts. We followed Van den Schoot et al.’s (2013) suggestion to choose a third option for traveling between Scylla and Charybdis. This option is the approximate Bayesian approach to measurement invariance.

The approximate approach established measurement invariance for the new PVQ-5X scale to measure human values even in cases in which the exact approach did not. These findings support the conclusion that the PVQ-5X scale is appropriate for conducting meaningful cross-cultural research with all 19 values. The exact approach to assessing invariance has often shed doubt on the invariance of many questionnaires. The current findings provide hope that empirical testing for measurement invariance in questionnaires is not necessarily doomed to failure.

In spite of our encouraging findings, an important unanswered question remains to be resolved: What is the magnitude of the variance that should be specified for the priors? Specifying a small variance may result in failure to establish invariance while specifying a larger variance may lead to establishing invariance. We set a magnitude of .01 and increased it to .02 in three cases in order to establish invariance. These seem like small magnitudes, but are they too liberal? This technical question is extremely important from an applied point of view. Further research and simulation studies should focus on this question to provide guidelines for applied researchers.
References

Asparouhov, T., & Muthén, B. O. (2010). Bayesian analysis using Mplus: Technical implementation. Technical Report. Los Angeles: Muthén & Muthén

Bollen, K. A. (1989). Structural Equations with Latent Variables. New York: Wiley

Byrne, B. M., Shavelson, R. J., & Muthén, B. O. (1989). Testing for the equivalence of factor covariance and mean structures - the issue of partial measurement invariance. Psychological Bulletin, 105(3), 456-466. doi: 10.1037/0033-2909.105.3.456

Chen, F. F. (2007). Sensitivity of goodness of fit indexes to lack of measurement invariance. Structural Equation Modeling, 14(3), 464-504. doi:10.1177/0734282911406661

Cieciuch, J., & Davidov, E. (2012). A comparison of the invariance properties of the PVQ-40 and the PVQ-21 to measure human values across German and Polish samples. Survey Research Methods, 6(1), 37-48.

Cieciuch, J., Davidov, E., Vecchione, M., Beierlein, C., Schwartz, S. H. (2014). The cross-national invariance properties of a new scale to measure 19 basic human values. A test across eight countries. Journal of Cross-Cultural Psychology, 45(5), 764-779. doi: 10.1177/0022022114527348

Cieciuch, J., Davidov, E., Vecchione, M., & Schwartz, S. H. (2014). A hierarchical structure of basic human values in a third-order confirmatory factor analysis. Swiss Journal of Psychology, in press.

Cieciuch, J., & Schwartz, S. H. (2012). The number of distinct basic values and their structure assessed by PVQ-40. Journal of Personality Assessment, 94(3), 321-328. doi:10.1080/00223891.2012.655817

Cieciuch, J., Schwartz, S. H., & Vecchione, M. (2013). Applying the refined values theory to past data: What can researchers gain? Journal of Cross-Cultural Psychology, 44(8), 1215-1234. doi:10.1177/0022022113487076
Davidov, E. (2008). A cross-country and cross-time comparison of the human values measurements with the second round of the European Social Survey. *Survey Research Methods*, 2(1), 33-46.

Davidov, E. (2010). Testing for comparability of human values across countries and time with the third round of the European Social Survey. *International Journal of Comparative Sociology*, 51(3), 171-191. doi: 10.1177/0020715210363534

Davidov, E., Meuleman, B., Cieciuch, J., Schmidt, P., & Billiet, J. (2014). Measurement equivalence in cross-national research. *Annual Review of Sociology*, in press.

Davidov, E., Schmidt, P., & Schwartz, S. (2008). Bringing values back in. The adequacy of the European Social Survey to measure values in 20 countries. *Public Opinion Quarterly*, 72(3), 420-445. doi: 10.1093/poq/nfn035

Horn, J. L., & McArdle, J. J. (1992). A practical and theoretical guide to measurement invariance in aging research. *Experimental Aging Research*, 18(3-4), 117-144. doi: 10.1080/03610739208253916

Inglehart, R., & Baker, W. E. (2000). Modernization, cultural change, and the persistence of traditional values. *American Sociological Review* 65, 19-51.

Jöreskog, K. G. (1971). Simultaneous factor analysis in several populations. *Psychometrika*, 36, 409-26.

Kim, S. Y., Mun, E. Y., & Smith, S. (2013). Using mixture models with known class membership to address incomplete covariance structures in multiple-group growth models. *British Journal of Mathematical and Statistical Psychology*. doi: 10.1111/bmsp.12008

Meredith, W. (1993). Measurement invariance, factor-analysis and factorial invariance. *Psychometrika*, 58(4), 525-543. doi: 10.1007/bf02294825
Millsap, R. E. 2011. *Statistical Approaches to Measurement Invariance*. Taylor and Francis Group: New York.

Muthén, B. O. (2002). Beyond SEM: General latent variable modeling. *Behaviormetrika*, 29(1), 81-117.

Muthén, B. O. (2014). IRT studies of many groups: The alignment method. *Frontiers in Psychology* 4 (in press).

Muthén, B. O., & Asparouhov, T. (2013). *BSEM Measurement invariance analysis*. Mplus Web Notes, 17.

Muthén L, & Muthén B. O. (1998-2012). *Mplus User's Guide. Version 7*. Los Angeles (CA): Muthén & Muthén

Schwartz, S. H. (1992). Universals in the content and structure of values: Theory and empirical tests in 20 countries. In M. Zanna (Ed.), *Advances in experimental social psychology*, Vol. 25 (pp. 1-65). New York: Academic Press.

Schwartz, S. H. (2003). A proposal for measuring value orientations across nations. In *Questionnaire Development Package of the European Social Survey* (pp. 259–319). Retrieved from www.europeansocialsurvey.org.

Schwartz, S. H. (2006). A theory of cultural value orientations: Explication and applications. *Comparative Sociology* 5(2-3), 137-182.

Schwartz, S. H., Cieciuch, J., Vecchione, M., Davidov, E., Fischer, R., Beierlein, C., Ramos, A., Verkasalo, M., Lönnqvist, J.-E., Demirutku, K., Dirilen-Gumus, O., Konty, M. (2012). Refining the theory of basic individual values. *Journal of Personality and Social Psychology, 103*(4), 663-688. doi: 10.1037/a0029393

Schwartz, S. H., Melech, G., Lehmann, A., Burgess, S., & Harris, M. (2001). Extending the cross-cultural validity of the theory of basic human values with a different method of
measurement. *Journal of Cross-Cultural Psychology, 32*, 519-542. doi: 10.1177/0022022101032005001

Steenkamp, J.-B. E. M., & Baumgartner, H. (1998). Assessing measurement invariance in cross-national consumer research. *Journal of Consumer Research, 25*(1), 78-90. doi: 10.1086/209528

van de Schoot, R., Kluytmans, A., Tummers, L., Lugtig, P., Hox, J., & Muthén, B. O. (2013). Facing off with Scylla and Charybdis: a comparison of scalar, partial, and the novel possibility of approximate measurement invariance. *Frontiers in Psychology, 4*, 770. doi: 10.3389/fpsyg.2013.00770

Vandenberg, R. J. (2002). Toward a further understanding of and improvement in measurement invariance methods and procedures. *Organizational Research Methods, 5*(2), 139-158. doi: 10.1177/1094428102005002001

Vandenberg, R. J., & Lance, C. E. (2000). A review and synthesis of the measurement invariance literature: suggestions, practices, and recommendations for organizational research. *Organizational Research Methods, 3*(1), 4-70. doi: 10.1177/109442810031002

Vecchione, M., Caprara, G., Schoen, H., Castro, J. L. G., & Schwartz, S. H. (2012). The role of personal values and basic traits in perception of the consequences of immigration: A three-nation study. *British Journal of Psychology, 102*, 359-377. Doi: 10.1111/j.2044-8295.2011.02079.x
Table 1

19 More Narrowly Defined Values in the Refined Theory of Values (Source: Schwartz et al., 2012)

| Value                  | Conceptual Definitions in terms of Motivational Goals |
|------------------------|--------------------------------------------------------|
| Self-Direction—Thought | Freedom to cultivate one’s own ideas and abilities      |
| Self-Direction—Action  | Freedom to determine one’s own actions                  |
| Stimulation            | Excitement, novelty, and change                         |
| Hedonism               | Pleasure and sensuous gratification                     |
| Achievement            | Success according to social standards                   |
| Power—Dominance        | Power through exercising control over people            |
| Power—Resources        | Power through control of material and social resources  |
| Face                   | Security and power through maintaining one’s public image and avoiding humiliation |
| Security—Personal      | Safety in one’s immediate environment                   |
| Security—Societal      | Safety and stability in the wider society               |
| Tradition              | Maintaining and preserving cultural, family or religious traditions |
| Conformity—Rules       | Compliance with rules, laws, and formal obligations      |
| Conformity—Interpersonal| Avoidance of upsetting or harming other people         |
| Humility               | Recognizing one’s insignificance in the larger scheme of things |
| Benevolence—Dependability| Being a reliable and trustworthy member of the ingroup |
| Benevolence—Caring     | Devotion to the welfare of ingroup members              |
| Universalism—Concern   | Commitment to equality, justice and protection for all people |
| Universalism—Nature    | Preservation of the natural environment                 |
| Universalism—Tolerance | Acceptance and understanding of those who are different from oneself |
Table 2

*Mplus syntax for approximate measurement invariance test and explanations*

| VARIABLE: | This indicates the variables in the data: the countries and the items for each value (Universalism-concern in this example). |
|-----------|-------------------------------------------------------------------------------------------------|
| Names are country UNC1 UNC2 UNC3; | This option specifies that there is one latent categorical variable (named c) that has eight latent classes. The number 8 refers to 8 countries in the analysis. |
| classes = c(8); | This option defines the categorical latent variable by the observed variable. There are eight classes and respondents with value 1 in variable ‘country’ belong to the first one; respondents with value 2 in variable ‘country’ belongs to the second country, etc. If all values from the variable are to be analyzed, the statement can be shortened: knownclas = c (country) |
| knownclass = c(country = 1 2 3 4 5 6 7 8); | Approximate measurement invariance is included in Mplus within the mixture modeling analysis framework. The number of classes is known because it corresponds to the number of groups to be compared. |
| ANALYSIS: | Bayesian analysis will be performed and priors can be defined |
| type = mixture; | estimator=bayes; |
### chains is5;
The number of chains in Markov chain Monte Carlo (MCMC) algorithms. The default in Mplus is 2 chains and the researcher can increase the number of chains by this statement.

### processor=5;
To increase the speed of computation, one can use more processors, if they are available in the hardware. It is possible to specify the number of processors that is equal to number of chains. In this case one can specify also eight processors. If that many processors are not available, each available processor carries out one chain and after it is completed starts with the next chain.

### biterations=500000(20000);
This option is used to specify the maximum and minimum number of iterations for each Markov chain Monte Carlo algorithm. In this case, it specifies that a minimum of 20,000 and a maximum of 50,000 iterations will be used.

### Bconvergence=0.01;
Specification of the convergence value criterion to be used for determining convergence of the Bayesian estimation.

### bseed 100;
Specification of the seed to be used for a random number generation in the Markov chain Monte Carlo (MCMC) algorithm (the default in Mplus is zero).

### model = allfree;
Factor means, variances, and covariances are
freely estimated across groups with the exception of factor means in the last group which are fixed to 0.

**MODEL:**

In the mixture models the label ‘%overall%’ introduces the model description which is common for all groups. In this case the latent variable is loaded by three indicators (UNC1, UNC2 and UNC3). The asterisk after UNC1 implies that the loadings of the first indicator, which is usually constrained by default to 1, is freed.

After the ‘by’ statement the names of the factor loadings are listed in parentheses. One row below, after the brackets, the names of the intercepts are listed. It is necessary to list these so that one can later define their priors.

**model priors:**

The statement defines priors for loadings and intercepts. The distribution of loadings and intercepts is normal with mean = 0 and variance = .01

Label %c#8% refers to the part of the model for class 8 that differs from the overall model. In this case the latent mean of UNC in the last group is constrained to 0 and the variance to 1 in order to identify the model according to the proposal of
Muthén and Asparouhov (2013).
Table 3

*Model fit coefficients of Bayesian multigroup confirmatory factor analysis for each value*

|                              | ppp  | 95% CI                |
|------------------------------|------|-----------------------|
| Self-direction-thought      | .201 | (-19.478) – (49.818)  |
| Self-direction-action       | .112 | (-12.931) – (57.474)  |
| Stimulation                 | .001 | (25.824) – (110.628)  |
| Stimulation, prior of variance = .02 | .081 | (-9.495) – (64.259)   |
| Hedonism                    | .258 | (-18.255) – (35.833)  |
| Achievement                 | .004 | (20.132) – (98.707)   |
| Achievement, prior of variance = .02 | .103 | (-13.481) – (62.092)  |
| Power-resources             | .367 | (-22.056) – (30.480)  |
| Power-dominance             | .208 | (-15.653) – (37.917)  |
| Face*                       | .128 | (-11.916) – (45.275)  |
| Security-personal           | .361 | (-20.384) – (32.179)  |
| Security-societal           | .135 | (-13.923) – (55.015)  |
| Tradition                   | .028 | (-0.594) – (76.570)   |
| Conformity-rules            | .352 | (-20.444) – (30.633)  |
| Conformity-interpersonal    | .083 | (-11.226) – (65.544)  |
| Humility*                   | .009 | (6.575) – (70.861)    |
| Humility, prior of variance = .02 | .121 | (-11.877) – (46.340)  |
| Benevolence-caring          | .506 | (-34.843) – (33.737)  |
| Benevolence-dependability*  | .149 | (-12.476) – (43.798)  |
| Universalism-concern        | .235 | (-25.179) – (47.297)  |
| Universalism-nature         | .167 | (-18.021) – (51.002)  |
| Universalism-tolerance      | .395 | (-23.183) – (31.304)  |

*Note.* Ppp = Posterior predictive p-value ; 95% CI = Confidence interval for the difference between the observed and the replicated chi-square values, * = because of estimation problems, the latent means were constrained to 0 and variances to 1 in two countries for this value rather than in one country. These additional constraints were not rejected by the model.
Table 4

Deviations of loadings and intercepts from prior defined parameters (mean = 0, variance = .01)

|                  | Finland | Israel | Italy | New Zealand | Poland | Portugal | Switzerland | Germany |
|------------------|---------|--------|-------|-------------|--------|----------|-------------|---------|
|                  | Lo      | Int    | Lo    | Int         | Lo     | Int      | Lo          | Int     |
| SDT1 Being creative is important to him | x       | x      | x     | x           | x      | x        |             |         |
| SDT2 It is important to him to form his own opinions and have original ideas. | x       | x      |       |             | x      | x        |             |         |
| SDT3 Learning things for himself and improving his abilities is important to him. | x       | x      | x     | x           | x      | x        |             |         |
| SDA1 It is important to him to make his own decisions about his life | x       | x      | x     | x           | x      | x        |             |         |
| SDA2 Doing everything independently is important to him | x       | x      | x     | x           |         | x        |             |         |
| SDA3 Freedom to choose what he does is important to him | x       | x      | x     | x           | x      | x        |             |         |
| ST1 He is always looking for different kinds of things to do | x       | x      | x     | x           | x      | x        |             |         |
| ST2 Excitement in life is important to him | x       | x      | x     | x           | x      | x        |             |         |
| ST3 He thinks it is important to have all sorts of new experiences | x       | x      | x     | x           | x      | x        |             |         |
| HE1 Having a good time is important to him | x       | x      |       |             | x      | x        |             |         |
| HE2 Enjoying life’s pleasures is important to him | x       | x      | x     |             | x      | x        |             |         |
| AC1 - He thinks it is important to be ambitious | x       | x      | x     | x           | x      | x        |             |         |
| AC2 - Being very successful is important to him | x       | x      | x     | x           |         | x        |             |         |
| AC3 - He wants people to admire his achievements | x       | x      | x     | x           | x      | x        |             |         |
| POR1 Having the feeling of power that money can bring is important to him | x       | x      | x     | x           | x      | x        | x           |         |
| POR2 Being wealthy is important to him | x       | x      | x     | x           |         | x        |             |         |
| POD1 He wants people to do what he says | x       | x      | x     | x           |         | x        |             |         |
| Code | Statement                                                                                   |
|------|--------------------------------------------------------------------------------------------|
| POD3 | It is important to him to be the one who tells others what to do                           |
| FAC1 | It is important to him that no one should ever shame him                                   |
| FAC2 | Protecting his public image is important to him                                             |
| SEP2 | His personal security is extremely important to him                                         |
| SEP3 | It is important to him to live in secure surroundings                                       |
| SES1 | It is important to him that his country protect itself against all threats.                 |
| SES2 | He wants the state to be strong so it can defend its citizens.                              |
| SES3 | Having order and stability in society is important to him                                   |
| TR1  | It is important to him to maintain traditional values or beliefs                            |
| TR2  | Following his family’s customs or the customs of a religion is important to him             |
| TR3  | He strongly values the traditional practices of his culture                                  |
| COR2 | It is important to him to follow rules even when no-one is watching                         |
| COR3 | Obeying all the laws is important to him                                                    |
| COI1 | It is important to him to avoid upsetting other people                                      |
| COI2 | He thinks it is important never to be annoying to anyone                                    |
| COI3 | He always tries to be tactful and avoid irritating people                                   |
| HU2  | It is important to him to be humble                                                         |
| Item Number | Description |
|-------------|-------------|
| HU3 | It is important to him to be satisfied with what he has and not to ask for more |
| BEC1 | It's very important to him to help the people dear to him |
| BEC2 | Caring for the well-being of people he is close to is important to him |
| BEC3 (bed1) | It is important to him to be loyal to those who are close to him |
| BED2 | He goes out of his way to be a dependable and trustworthy friend. |
| BED3 | He wants those he spends time with to be able to rely on him completely. |
| UNC1 | Protecting society’s weak and vulnerable members is important to him |
| UNC2 | He thinks it is important that every person in the world have equal opportunities in life |
| UNC3 | He wants everyone to be treated justly, even people he doesn’t know. |
| UNN1 | He strongly believes that he should care for nature |
| UNN2 | It is important to him to work against threats to the world of nature |
| UNN3 | Protecting the natural environment from destruction or pollution is important to him |
| UNT2 | It is important to him to listen to people who are different from him. |
| UNT3 | Even when he disagrees with people, it is important to him to understand them |

*Note. Lo = loading, Int = intercept, x – deviation of a given parameter in a given group from the defined priors (mean = 0, variance = .01)*
Table 5

*Comparison of exact and approximate measurement invariance of 19 values across eight countries*

| Value                                | Exact (Cieciuch et al., 2014)                                                                 | Approximate (the current study)                                                                 |
|--------------------------------------|--------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| Metric                               | Scalar                                                                                     | Metric                                                                                     | Scalar                                                                                     |
| Self-direction thought               | Full in all countries                                                                       | Partial in all countries                                                                    | Full in all countries                                                                       |
| Self-direction action                | Full in five countries, partial in Finland and Portugal, lack in Italy                       | Full in all countries                                                                       | Full in all countries                                                                       |
| Stimulation                          | Full in all countries                                                                       | Full in all countries                                                                       | Full in all countries                                                                       |
| Hedonism                             | Full in seven countries, lack in Switzerland Poland                                         | Full in six countries, absent in Switzerland Poland                                         | Full in all countries                                                                       |
| Achievement                          | Full in six countries, partial in Finland and Poland                                         | Absent in all countries                                                                     | Full in all countries                                                                       |
| Power dominance                      | Full in all countries                                                                       | Full in six countries, absent in Portugal, Italy                                            | Full in all countries                                                                       |
| Power resources                      | Full in all countries                                                                       | Full in seven countries, absent in Poland                                                   | Full in all countries                                                                       |
| Face                                 | Full in all countries                                                                       | Absent in all countries                                                                     | Full in all countries                                                                       |
| Security personal                    | Full in all countries                                                                       | Full in six countries, absent in Israel and Switzerland                                      | Full in all countries                                                                       |
| Societal security                    | Full in seven countries, partial in Portugal                                               | Partial in all countries                                                                    | Full in all countries                                                                       |
| Tradition                            | Full in all countries                                                                       | Absent in all countries                                                                     | Full in all countries                                                                       |
| Conformity rules                     | Full in all countries                                                                       | Absent in all countries                                                                     | Full in all countries                                                                       |
| Conformity interpersonal             | Full in all countries                                                                       | Absent in all countries                                                                     | Full in all countries                                                                       |
| Humility                             | Full in all countries                                                                       | Absent in all countries                                                                     | Full in all countries                                                                       |
| Universalism nature                  | Full in all countries                                                                       | Full in four countries, partial in Israel, Italy and New Zealand, absent in Switzerland     | Full in all countries                                                                       |
| Universalism concern                 | Full in all countries                                                                       | Full in five countries, partial in New Zealand Portugal, absent in Germany                  | Full in all countries                                                                       |
| Universalism tolerance               | Full in all countries                                                                       | Full in six countries, absent in Poland and Portugal                                        | Full in all countries                                                                       |
| Benevolence caring                   | Full in all countries                                                                       | Full in seven countries, partial in Finland                                                | Full in all countries                                                                       |
| Benevolence dependability            | Full in all countries                                                                       | Absent in all countries                                                                     | Full in all countries                                                                       |
Table 6

Ranking of countries in priorities of values. The numbers refer to the place of a given country in the ranking of value priority means. The first number refers to the ranking of means calculated in the exact (partial) scalar measurement invariance while the second number refers to the ranking of means calculated in the approximate measurement invariance.

|          | SES | SEP | COR | TR | COI | HU | FAC | AC | POR | POD | SDT | SDA | ST | HE | BED | BEC | UNC | UNN | UNT |
|----------|-----|-----|-----|----|-----|----|-----|----|-----|-----|-----|-----|----|----|-----|-----|-----|-----|-----|
| Finland  | 5/5 | 4/4 | 2/2 | 4/4| 8/8 | 2/5| 8/8 | 8/8| 7/7 | 4/6 | 8/8 | 8/8 | 8/8| 7/8 | 8/8 | 7/6 | 7/7 | 3/4 | 7/7 |
| Israel   | 1/2 | 1/2 | 3/3 | 3/3| 2/5 | 7/4| 4/3 | 1/1| 1/1 | 1/1 | 7/7 | 4/4 | 2/5 | 6/6 | 6/6 | 8/8 | 8/8 | 8/8 | 5/6 |
| Italy    | 2/1 | 2/1 | 1/1 | 1/1| 1/1 | 1/1| 1/3 | 4/5| 4/4 | 8/4 | 4/2 | 1/1 | 5/7 | 1/3 | 3/4 | 1/1 | 1/1 | 2/2 | 4/5 |
| N. Zealand| 6/6 | 6/6 | 6/4 | 7/6| 3/2 | 3/3| 7/7 | 2/2| 2/2 | 2/2 | 7/5 | 1/1 | 5/4 | 5/7 | 5/5 | 4/5 | 7/6 | 2/3 |
| Poland   | 3/3 | 3/3 | 5/5 | 2/2| 7/7 | 4/6| 6/4 | 3/4| 2/3 | 3/5 | 6/6 | 2/3 | 6/6 | 2/6 | 7/6 | 4/4 | 6/6 | 5/5 | 6/4 |
| Portugal | 4/4 | 5/5 | 4/6 | 5/7| 4/3 | 6/2| 2/2 | 6/3| 5/5 | 5/3 | 1/1 | 3/2 | 3/3 | 3/2 | 1/1 | 3/3 | 5/3 | 1/1 | 1/1 |
| Switzerland| 8/8 | 8/8 | 7/8 | 8/8| 5/6 | 8/7-8| 5/5-6| 7/7 | 8/8 | 7/8 | 3/4 | 5/7 | 7/4 | 8/5 | 4/2-3| 6/7 | 2/2 | 4/3 | 3/2 |
| Germany  | 7/7 | 7/7 | 8/7 | 6/5| 6/4 | 5/7-8| 3/5-6| 5/6 | 6/6 | 6/7 | 5/5 | 6/6 | 4/2 | 4/1 | 2/2-3| 2/2 | 3/4 | 6/7 | 8/8 |
Figure 1. The circular motivational continuum of 19 values in the refined value theory
(Source: Cieciuch et al., 2014)