This confirmatory factor analysis model has three correlated factors and assumes each item only has a loading on the concept it aims to measure. To get an idea of the fit of the model we used fit measures, the standardized solution, and computed, for each latent variable, the composite reliability (CR), the average variance extracted (AVE), and the maximum shared variance (MSV) with other latent variables.

To test the validity and reliability we used the following cutoff values:

* CFI > 0.95
* TLI > 0.95
* RMSEA < 0.08
* SRMR < 0.08
* Convergent Validity: AVE > 0.5
* Discriminant Validity: MSV < AVE
* Reliability: CR > 0.7

Fitting the model yields the following results:  

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Chisq | df | p-value | CFI | TLI | RMSEA | SRMR |
| 689.143 | 32 | 0.000 | 0.944 | 0.921 | 0.071 | 0.034 |

|  |  |  |  |
| --- | --- | --- | --- |
| **Factor score** | **AVE** | **MSV** | **CR** |
| **social trust** | 0.4264263 | 0.4732259 | 0.6901061 |
| **trust institutions** | 0.5294827 | 0.6433114 | 0.8160278 |
| **well being** | 0.4873276 | 0.5577240 | 0.7396447 |

Based on the fit measures we can state the following: The chi-square test tells us that the model is significantly different from a perfectly fitted model (chi-square=689.143, df=32, p-value<0.000). However, as this dataset has a large sample size (n=4046) the goodness of fit test can be significantly different even if the difference between the two models is very small. Nonetheless, the other measures indicate that the model cfa1 can probably be improved. Both CFI (0.944) and TLI (0.921) are lower than 0.95 and the RMSEA (0.071) and SRMR (0.034) are higher than 0.08. Furthermore, the validity measurements indicate that there could be improvements: the MSV is not always lower than the AVE, the CR for social trust is not bigger than 0.7, and the AVE is not always above 0.5.

**Question B**: Use modification indices to see how you can obtain a model that meets the criteria of good fit in (in terms of TLI, CFI, RMSEA, SRMR) by including a few well-chosen correlated error terms for pairs of items. Try to justify the correlated error terms from a substantive point of view 

To improve our model, we can use the ‘modificationIndices()’ function to get an idea of which error terms correlation we can add to improve our model.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **lhs** | **op** | **rhs** | **mi** | **epc** | **sepc.lv** | **sepc.all** | **sepc.nox** |
| social\_trust | =~ | trstprl | 16.004 | -0.182 | -0.182 | -0.078 | -0.078 |
| social\_trust | =~ | trstlgl | 11.091 | 0.155 | 0.155 | 0.066 | 0.066 |
| social\_trust | =~ | trstplc | 34.495 | 0.283 | 0.283 | 0.126 | 0.126 |
| social\_trust | =~ | trstplt | 7.946 | -0.119 | -0.119 | -0.055 | -0.055 |
| social\_trust | =~ | fltdpr | 1.150 | 0.013 | 0.013 | 0.019 | 0.019 |
| social\_trust | =~ | fltsd | 7.992 | -0.034 | -0.034 | -0.050 | -0.050 |
| social\_trust | =~ | fltanx | 4.218 | 0.027 | 0.027 | 0.036 | 0.036 |
| trust\_institutions | =~ | ppltrst | 18.110 | 0.228 | 0.228 | 0.106 | 0.106 |
| trust\_institutions | =~ | pplfair | 15.552 | -0.185 | -0.185 | -0.094 | -0.094 |
| trust\_institutions | =~ | pplhlp | 0.168 | -0.020 | -0.020 | -0.010 | -0.010 |
| trust\_institutions | =~ | fltdpr | 0.188 | 0.005 | 0.005 | 0.007 | 0.007 |
| trust\_institutions | =~ | fltsd | 0.723 | -0.009 | -0.009 | -0.013 | -0.013 |
| trust\_institutions | =~ | fltanx | 0.251 | 0.006 | 0.006 | 0.008 | 0.008 |
| well\_being | =~ | ppltrst | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| well\_being | =~ | pplfair | 0.590 | 0.028 | 0.028 | 0.014 | 0.014 |
| well\_being | =~ | pplhlp | 0.594 | -0.029 | -0.029 | -0.014 | -0.014 |
| well\_being | =~ | trstprl | 0.159 | -0.013 | -0.013 | -0.006 | -0.006 |
| well\_being | =~ | trstlgl | 5.796 | 0.083 | 0.083 | 0.035 | 0.035 |
| well\_being | =~ | trstplc | 5.440 | 0.084 | 0.084 | 0.037 | 0.037 |
| well\_being | =~ | trstplt | 9.847 | -0.095 | -0.095 | -0.044 | -0.044 |
| ppltrst | ~~ | pplfair | 0.488 | -0.059 | -0.059 | -0.025 | -0.025 |
| ppltrst | ~~ | pplhlp | 11.715 | -0.296 | -0.296 | -0.116 | -0.116 |
| ppltrst | ~~ | trstprl | 0.702 | 0.041 | 0.041 | 0.018 | 0.018 |
| ppltrst | ~~ | trstlgl | 2.060 | 0.074 | 0.074 | 0.029 | 0.029 |
| ppltrst | ~~ | trstplc | 0.378 | -0.033 | -0.033 | -0.012 | -0.012 |
| ppltrst | ~~ | trstplt | 1.744 | 0.059 | 0.059 | 0.029 | 0.029 |
| ppltrst | ~~ | fltdpr | 0.912 | -0.016 | -0.016 | -0.020 | -0.020 |
| ppltrst | ~~ | fltsd | 1.018 | -0.016 | -0.016 | -0.023 | -0.023 |
| ppltrst | ~~ | fltanx | 4.422 | 0.039 | 0.039 | 0.042 | 0.042 |
| pplfair | ~~ | pplhlp | 16.453 | 0.297 | 0.297 | 0.119 | 0.119 |
| pplfair | ~~ | trstprl | 2.782 | -0.076 | -0.076 | -0.035 | -0.035 |
| pplfair | ~~ | trstlgl | 1.289 | 0.055 | 0.055 | 0.022 | 0.022 |
| pplfair | ~~ | trstplc | 3.774 | 0.099 | 0.099 | 0.036 | 0.036 |
| pplfair | ~~ | trstplt | 12.011 | -0.145 | -0.145 | -0.073 | -0.073 |
| pplfair | ~~ | fltdpr | 6.819 | 0.041 | 0.041 | 0.053 | 0.053 |
| pplfair | ~~ | fltsd | 0.043 | 0.003 | 0.003 | 0.004 | 0.004 |
| pplfair | ~~ | fltanx | 4.821 | -0.038 | -0.038 | -0.043 | -0.043 |
| pplhlp | ~~ | trstprl | 15.802 | -0.192 | -0.192 | -0.082 | -0.082 |
| pplhlp | ~~ | trstlgl | 0.500 | 0.036 | 0.036 | 0.014 | 0.014 |
| pplhlp | ~~ | trstplc | 30.995 | 0.301 | 0.301 | 0.101 | 0.101 |
| pplhlp | ~~ | trstplt | 0.165 | -0.018 | -0.018 | -0.009 | -0.009 |
| pplhlp | ~~ | fltdpr | 0.132 | -0.006 | -0.006 | -0.007 | -0.007 |
| pplhlp | ~~ | fltsd | 6.440 | -0.040 | -0.040 | -0.054 | -0.054 |
| pplhlp | ~~ | fltanx | 7.170 | 0.049 | 0.049 | 0.052 | 0.052 |
| trstprl | ~~ | trstlgl | 51.686 | -0.489 | -0.489 | -0.209 | -0.209 |
| trstprl | ~~ | trstplc | 210.055 | -0.850 | -0.850 | -0.324 | -0.324 |
| Trstprl | ~~ | trstplt | 554.999 | 1.700 | 1.700 | 0.911 | 0.911 |
| Trstprl | ~~ | fltdpr | 0.156 | 0.006 | 0.006 | 0.008 | 0.008 |
| Trstprl | ~~ | fltsd | 2.284 | 0.022 | 0.022 | 0.034 | 0.034 |
| Trstprl | ~~ | fltanx | 3.768 | -0.033 | -0.033 | -0.039 | -0.039 |
| trstlgl | ~~ | trstplc | 479.201 | 1.277 | 1.277 | 0.430 | 0.430 |
| trstlgl | ~~ | trstplt | 169.431 | -0.835 | -0.835 | -0.395 | -0.395 |
| trstlgl | ~~ | fltdpr | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| trstlgl | ~~ | fltsd | 0.645 | 0.012 | 0.012 | 0.017 | 0.017 |
| trstlgl | ~~ | fltanx | 1.307 | 0.021 | 0.021 | 0.022 | 0.022 |
| Trstplc | ~~ | trstplt | 73.607 | -0.470 | -0.470 | -0.198 | -0.198 |
| Trstplc | ~~ | fltdpr | 1.134 | -0.018 | -0.018 | -0.020 | -0.020 |
| Trstplc | ~~ | fltsd | 0.586 | 0.013 | 0.013 | 0.015 | 0.015 |
| Trstplc | ~~ | fltanx | 3.155 | 0.034 | 0.034 | 0.032 | 0.032 |
| Trstplt | ~~ | fltdpr | 0.030 | 0.002 | 0.002 | 0.004 | 0.004 |
| Trstplt | ~~ | fltsd | 4.301 | -0.028 | -0.028 | -0.047 | -0.047 |
| Trstplt | ~~ | fltanx | 0.458 | -0.011 | -0.011 | -0.014 | -0.014 |
| fltdpr | ~~ | fltsd | 3.441 | 0.041 | 0.041 | 0.182 | 0.182 |
| Fltdpr | ~~ | fltanx | 6.709 | -0.049 | -0.049 | -0.167 | -0.167 |
| fltsd | ~~ | fltanx | 1.012 | 0.020 | 0.020 | 0.077 | 0.077 |

Based on the output we included the following every proposal that lowers the chi square by at least 50 which yields the following model:

cfa2 <-' social\_trust =~ NA\*ppltrst + pplfair + pplhlp

         trust\_institutions =~ NA\*trstprl + trstlgl + trstplc + trstplt

         well\_being =~ NA\*fltdpr + fltsd + fltanx

         social\_trust ~~ 1\*social\_trust

         trust\_institutions ~~ 1\*trust\_institutions

         well\_being ~~ 1\*well\_being

         trstprl ~~ trstplc

         trstlgl ~~ trstplc

         trstlgl ~~ trstplt

         trstplc ~~ trstplt

         trstprl ~~ trstplt

        trstprl ~~ trstlgl

      '

Looking at the fit measures we see that the goodness of fit test is still significantly different (chi-square=85.457, df=27, p-value<0.000) but CFI and TLI are both above 0.95 and RMSEA and SRMR have decreased. However, they are still not below the cutoff of 0.08. Overall we can conclude that the model is improved and fits the data better.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Chisq | df | p-value | CFI | TLI | RMSEA | SRMR |
| 85.457 | 26 | 0.000 | 0.995 | 0.991 | 0.024 | 0.014 |

**c.**  Fit a multi-group structural equation model (with country as the group variable) on the matrix of centered variables to investigate how the latent variables “social trust” and “trust in public institutions” affect the latent variable “well-being”. Estimate four versions of the multi-group structural equation model:

1) a configural measurement invariance model with country-specific regression coefficients in the regression equation of the structural model

2) a configural measurement invariance model with regression coefficients that are constrained to be equal across countries

3) a metric measurement invariance model with country-specific regression coefficients in the regression equation of the structural model

4) a metric measurement invariance model with regression coefficients that are constrained to be equal across countries

Compare the fit measures of the four estimated models and/or use model comparison tests to select the best model. Next discuss the results of this final model (e.g., model fit, estimated intercepts, (standardized) regression coefficients, etc.).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | **Chisq** | **Df** | **CFI** | **TLI** | **RMSEA** | **SRMR** | **AIC** |
| **config\_1** | 709.055 | 64 | 0.945 | 0.923 | 0.071 | 0.034 | 139051 |
| **config\_2** | 709.377 | 66 | 0.945 | 0.925 | 0.069 | 0.034 | 139047 |
| **metric\_1** | 775.804 | 74 | 0.94 | 0.927 | 0.068 | 0.043 | 139098 |
| **metric\_2** | 778.457 | 76 | 0.94 | 0.929 | 0.068 | 0.043 | 139096 |