1 TSFA Guide

This guide illustrates the steps for estimating a factor model using as an example the data and process which led to results reported in Gilbert and Meijer (2006). The background theory is reported in Gilbert and Meijer (2005).

Plots and some output from the examples below are omitted to save paper. The graphics parameter setting for margins have been adjusted for new versions of tfplot() and are not those used in the original paper. (Original settings no longer give the same result.)

The functions in the tsfa package are made available with

```r
> library("tsfa")
```

The code from the vignette that generates this guide can be loaded into an editor with `edit(vignette("Guide", package="tsfa"))`. This uses the default editor, which can be changed using `options()`. In some examples the code may run into the margins and is truncated in the pdf. If in doubt about the code, please edit the vignette as above or consult its source, which is distributed in the package.

The data is converted to real per capita data as follows

```r
> data("CanadianMoneyData.asof.28Jan2005", package="CDNmoney")
> data("CanadianCreditData.asof.28Jan2005", package="CDNmoney")
> cpi <- 100 * M1total / M1real
> seriesNames(cpi) <- "CPI"
> popm <- M1total / M1PerCapita
> seriesNames(popm) <- "Population of Canada"
> z <- tbind(MB2001,
MB456 + MB459 + MB453,
NonbankCheq,
MB472 + MB473 + MB487p,
MB475,
NonbankNonCheq + MB454 + NonbankTerm + MB2046 + MB2047 + MB2048 +
MB2057 + MB2058 + MB482),
names=c("currency", "personal cheq.", "NonbankCheq", "N-P demand & notice", "N-P term", "Investment")
)
> TotalMoney <- tfwindow(rowSums(z), tframe(z))
> z <- tbind (z, ConsumerCredit, ResidentialMortgage,
ShortTermBusinessCredit, OtherBusinessCredit)
```

Investment series goes back only to November 1981 and some of the data ends in November 2004, so the data is truncated to that time window.

```r
> z <- tfwindow(z, start=c(1981,11), end=c(2004,11))
> scale <- tfwindow(1e8 /(popm * cpi), tf=tfframe(z))
> MBandCredit <- sweep(z, 1, scale, "+")
```
Multiplying by 1e8 gives real dollars per person. (Credit aggregates, B and MB numbers are in millions, CPI is in percentage points, popm is in units.) Plots to check the data can be generated with

\[ \texttt{tfplot(MBandCredit, graphs.per.page=3)} \]

\[ \texttt{tfplot(diff(MBandCredit), graphs.per.page=3)} \]
Various sample statistics are checked with

```r
> start(MBandCredit)
> end(MBandCredit)
> Tobs(MBandCredit)
[1] 277
> DX <- diff(MBandCredit, lag=1)
```

The number of observations is

```r
> Tobs(MBandCredit)
[1] 277
```

The number of series is

```r
> nseries(MBandCredit)
```
The means of differenced series are

\[
> \text{colMeans}(DX)
\]

\[
\begin{array}{ll}
\text{currency} & \text{personal cheq.} \\
1.398385 & 2.880048 \\
\text{NonbankCheq} & \text{N-P demand \\& notice} \\
3.157783 & 9.156883 \\
\text{N-P term} & \text{Investment} \\
4.926683 & 48.744141 \\
\text{Consumer Credit} & \text{Residential Mortgage} \\
12.703423 & 29.878367 \\
\text{Short Term Business Credit} & \text{Other Business Credit} \\
-8.066348 & 37.283246
\end{array}
\]

The standard deviations of differenced series are

\[
> \text{sqrt(diag(cov(DX)))}
\]

\[
\begin{array}{ll}
\text{currency} & \text{personal cheq.} \\
13.46788 & 42.94902 \\
\text{NonbankCheq} & \text{N-P demand \\& notice} \\
10.74835 & 46.04252 \\
\text{N-P term} & \text{Investment} \\
71.93040 & 116.98518 \\
\text{Consumer Credit} & \text{Residential Mortgage} \\
30.00178 & 50.32996 \\
\text{Short Term Business Credit} & \text{Other Business Credit} \\
71.83893 & 56.30949
\end{array}
\]

2 Checking for the number of factors

Eigenvalues for the scree plot are

\[
> \text{zz <- eigen(cor(diff(MBandCredit, lag=1)), symmetric=TRUE)[["values"]]} \\
> \text{print(zz)}
\]

\[
[1] 3.2659246 \ 1.6498244 \ 1.0754761 \ 0.8689273 \ 0.8380089 \ 0.8668101 \ 0.8380089 \ 0.8668101 \ 0.8380089 \ 0.8668101 \ 0.8380089 \ 0.8668101
\]

The scree plot (Figure 1) is generated by

\[
> \text{par(omi=c(0.1,0.1,0.1,0.1),mar=c(4.1,4.1,0.6,0.1))} \\
> \text{plot(zz, ylab="Value", xlab="Eigenvalue Number", pch=20:20,cex=1,type="o")}
\]
FAfitStats is used to calculate the fit statistics for different numbers of factors (Table 1).

```r
> z <- FAfitStats(MBandCredit)
> print(z, digits=3)
```

<table>
<thead>
<tr>
<th>Eigenvalue Number</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td>4</td>
<td>1.0</td>
</tr>
<tr>
<td>6</td>
<td>1.5</td>
</tr>
<tr>
<td>8</td>
<td>2.0</td>
</tr>
<tr>
<td>10</td>
<td>2.5</td>
</tr>
<tr>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td>4</td>
<td>1.0</td>
</tr>
<tr>
<td>6</td>
<td>1.5</td>
</tr>
<tr>
<td>8</td>
<td>2.0</td>
</tr>
<tr>
<td>10</td>
<td>2.5</td>
</tr>
</tbody>
</table>

FAfitStats is used to calculate the fit statistics for different numbers of factors (Table 1).

```r
> z <- FAfitStats(MBandCredit)
> print(z, digits=3)
```

<table>
<thead>
<tr>
<th>$fitStats</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6 saturated</th>
</tr>
</thead>
<tbody>
<tr>
<td>chisq</td>
<td>7.22e+02</td>
<td>2.52e+02</td>
<td>1.26e+02</td>
<td>3.79e+01</td>
<td>17.8435</td>
<td>8.5095</td>
<td>1.217</td>
</tr>
<tr>
<td>df</td>
<td>4.50e+01</td>
<td>3.50e+01</td>
<td>2.60e+01</td>
<td>1.80e+01</td>
<td>11.0000</td>
<td>5.0000</td>
<td>0.000</td>
</tr>
<tr>
<td>pval</td>
<td>8.88e-123</td>
<td>1.38e-34</td>
<td>3.93e-15</td>
<td>4.01e-03</td>
<td>0.0853</td>
<td>0.1303</td>
<td>0.000</td>
</tr>
<tr>
<td>delta</td>
<td>6.77e+02</td>
<td>2.17e+02</td>
<td>1.00e+02</td>
<td>1.99e+01</td>
<td>6.8435</td>
<td>3.5095</td>
<td>1.217</td>
</tr>
<tr>
<td>RMSEA</td>
<td>2.33e-01</td>
<td>1.50e-01</td>
<td>1.18e-01</td>
<td>6.33e-02</td>
<td>0.0475</td>
<td>0.0504</td>
<td>Inf</td>
</tr>
<tr>
<td>RNI</td>
<td>0.00e+00</td>
<td>6.80e-01</td>
<td>8.52e-01</td>
<td>9.71e-01</td>
<td>0.9899</td>
<td>0.9948</td>
<td>0.998</td>
</tr>
<tr>
<td>CFI</td>
<td>0.00e+00</td>
<td>6.80e-01</td>
<td>8.52e-01</td>
<td>9.71e-01</td>
<td>0.9899</td>
<td>0.9948</td>
<td>0.998</td>
</tr>
<tr>
<td>MCI</td>
<td>2.94e-01</td>
<td>6.75e-01</td>
<td>8.34e-01</td>
<td>9.65e-01</td>
<td>0.9877</td>
<td>0.9937</td>
<td>0.998</td>
</tr>
<tr>
<td>GFI</td>
<td>5.84e-01</td>
<td>8.33e-01</td>
<td>9.13e-01</td>
<td>9.75e-01</td>
<td>0.9881</td>
<td>0.9941</td>
<td>0.999</td>
</tr>
<tr>
<td>AGFI</td>
<td>4.91e-01</td>
<td>7.37e-01</td>
<td>8.16e-01</td>
<td>9.22e-01</td>
<td>0.9406</td>
<td>0.9347</td>
<td>-Inf</td>
</tr>
<tr>
<td>AIC</td>
<td>6.32e+02</td>
<td>1.82e+02</td>
<td>7.43e+01</td>
<td>1.89e+00</td>
<td>-4.1565</td>
<td>-1.4905</td>
<td>1.217</td>
</tr>
<tr>
<td>CAIC</td>
<td>7.88e+02</td>
<td>3.84e+02</td>
<td>3.18e+02</td>
<td>2.83e+02</td>
<td>309.1411</td>
<td>339.5296</td>
<td>365.339</td>
</tr>
<tr>
<td>SIC</td>
<td>7.78e+02</td>
<td>3.64e+02</td>
<td>2.89e+02</td>
<td>2.46e+02</td>
<td>265.1411</td>
<td>289.5296</td>
<td>310.339</td>
</tr>
<tr>
<td>CKA</td>
<td>2.69e+00</td>
<td>1.06e+00</td>
<td>6.68e-01</td>
<td>4.05e-01</td>
<td>0.3835</td>
<td>0.3932</td>
<td>0.403</td>
</tr>
<tr>
<td>CK</td>
<td>2.69e+00</td>
<td>1.06e+00</td>
<td>6.76e-01</td>
<td>4.17e-01</td>
<td>0.3967</td>
<td>0.4082</td>
<td>0.420</td>
</tr>
</tbody>
</table>
The sign and order of factors is arbitrary. For simulation and estimation comparisons it is useful to put them in the same order when different results are compared. This is done by specifying the \textit{BpermuteTarget} argument in \textit{estTSF.ML}. Other than the sign, this does not affect the estimated values, it only rearranges their order. Here they are arranged so 1=transactions, 2=long term, 3=potential spending, 4=consumer credit , 5=N-P term (which is the order they appear as factors are added). The \textit{BpermuteTarget}, \textit{z} below was determined by an initial run.

\begin{verbatim}
> z <- matrix(0,10,3)
> z[matrix(c( 1,6,2,1:3),3,2)] <- c(10, 56, 41)
> c3withML <- estTSF.ML(MBandCredit, 3, BpermuteTarget=z)
> z <- matrix(0,10,4)
> z[matrix(c( 1,6,2,7,1:4),4,2)] <- c(13, 54, 37, 24)
> c4withML <- estTSF.ML(MBandCredit, 4, BpermuteTarget=z)
> z <- matrix(0,10,5)
> z[matrix(c( 1,6,2,7,5,1:5),5,2)] <- c(13, 67, 30, 72)
> c5withML <- estTSF.ML(MBandCredit, 5, BpermuteTarget=z)
\end{verbatim}

The standardized loadings for the four factor model (Table 2) are

\begin{verbatim}
> print(DstandardizedLoadings(c4withML) )
\end{verbatim}

\begin{verbatim}
Factor 1 Factor 2 Factor 3 Factor 4
currency 1.01983211 0.09441862 -0.09386876 -0.08001695
personal cheq. -0.02898840 0.20319639 0.87632955 -0.07894600
NonbankCheq 0.20214387 -0.13884613 0.36792951 0.11966332
N-P demand & notice 0.55851463 -0.00326414 0.20169780 0.24090075
N-P term 0.02120284 0.10107575 -0.23481508 0.33307726
Investment 0.15013102 0.45888993 -0.23944032 0.06862474
Consumer Credit 0.01841197 0.10508972 0.10142580 0.79551987
Residential Mortgage 0.21597515 0.49350633 0.22622020 0.14854196
Short Term Business Credit -0.09041731 0.23970572 -0.01376311 0.09703765
Other Business Credit 0.09632589 0.66331904 0.23994908 0.04224045
\end{verbatim}

The estimated $\Phi$ matrix is

\begin{verbatim}
> print(c4withML$Phi, digits=3)
\end{verbatim}
Factor1 Factor2 Factor3 Factor4
Factor1  1.000  0.1783  0.3003  0.3400
Factor2  0.178  1.0000 -0.0245  0.5685
Factor3  0.300 -0.0245  1.0000  0.0124
Factor4  0.340  0.5685  0.0124  1.0000

Communalities for the 4 factor model are

\[
\text{currency} \quad \text{personal cheq.} \\
0.97758543 \quad 0.77183960 \\
\text{NonbankCheq} \quad \text{N-P demand \& notice} \\
0.24563691 \quad 0.56949887 \\
\text{N-P term} \quad \text{Investment} \\
0.21682570 \quad 0.34592814 \\
\text{Consumer Credit} \quad \text{Residential Mortgage} \\
0.76283210 \quad 0.53132528 \\
\text{Short Term Business Credit} \quad \text{Other Business Credit} \\
0.08886927 \quad 0.57238659
\]

Communalities for other models are given by the following, but output is omitted here.

\[
\text{currency} \quad \text{personal cheq.} \\
\text{NonbankCheq} \quad \text{N-P demand \& notice} \\
\text{N-P term} \quad \text{Investment} \\
\text{Consumer Credit} \quad \text{Residential Mortgage} \\
\text{Short Term Business Credit} \quad \text{Other Business Credit}
\]

Loadings for 4 factor model (Table 3) are

\[
\text{currency} \quad \text{personal cheq.} \\
13.7349771 \quad 1.2716188 \quad -1.2642133 \quad -1.077659 \\
\text{NonbankCheq} \quad \text{N-P demand \& notice} \\
-1.2450233 \quad 8.7270851 \quad 37.6374926 \quad -3.390653 \\
\text{N-P term} \quad \text{Investment} \\
2.1727138 \quad -1.4923673 \quad 3.9546366 \quad 1.286184 \\
\text{Consumer Credit} \quad \text{Residential Mortgage} \\
25.7154238 \quad -0.1502893 \quad 9.2866761 \quad 11.091679 \\
\text{N-P term} \quad \text{Investment} \\
1.5251290 \quad 7.2704190 \quad -16.8903434 \quad 23.958381 \\
\text{Consumer Credit} \quad \text{Residential Mortgage} \\
0.5523918 \quad 3.1528783 \quad 3.0429543 \quad 23.867010 \\
\text{Residential Mortgage} \quad \text{Investment} \\
10.8700198 \quad 24.8381514 \quad 11.3865626 \quad 7.476110 \\
\text{Short Term Business Credit} \quad \text{Other Business Credit} \\
-6.4954824 \quad 17.2202022 \quad -0.9887271 \quad 6.971081 \\
\text{Other Business Credit} \quad \text{Residential Mortgage} \\
5.4240616 \quad 37.3511568 \quad 13.5114103 \quad 2.378538
\]

Figure 2 is generated by

\[
\text{tfplot(ytoypc(factors(c4withML)),}
\]

Title= "Factors from 4 factor model (year-to-year growth rate)"
Factors from 4 factor model (year-to-year growth rate)

Figure 3 is generated by

```r
> tfplot(factors(c4withML),
      Title="Factors from 4 factor model",
      lty=c("solid"),
      col=c("black"),
      xlab="",ylab=c("factor 1","factor 2","factor 3","factor 4"),
      par=list(mar=c(2.1, 4.1, 1.1, 0.1)),
      reset.screen=TRUE)
```
Some points are close to zero and cause problems in growth rate graphics. One solution is to set them to NA, but truncating the graphic works better.

Figure 4 is generated by

```R
z <- explained(c4withML)
tfplot(ytoypc(MBandCredit), ytoypc(z), series=1:5, graphs.per.page=5,
     lty=c("solid", "dashed"),
     col=c("black", "red"),
     ylab=c("currency", "personal cheq.", "NonbankCheq",
            "N-P demand & notice", "N-P term"),
     ylim=list(NULL,NULL,c(-100,100),NULL,NULL),
     Title="Explained money indicator 1-5 (year-to-year growth rate) using 4 factors",
     par=list(mar=c(2.1, 4.1, 1.1, 0.1)),
     reset.screen=TRUE)
```
Figure 5 is generated by

```r
> tfplot(ytoypc(MBandCredit), ytoypc(explained(c4withML)), series=6:10,
    graphs.per.page=5,
    lty=c("solid", "dashed"),
    col=c("black", "red"),
    ylab=c("", "", "", "", "Investment", "Consumer Credit", "Residential Mortgage",
        "Short Term Business Credit", "Other Business Credit"),
    Title="Explained money indicator 6-10 (year-to-year growth rate) using 4 factors",
    par=list(mar=c(2.1, 4.1, 1.1, 0.1)),
    reset.screen=TRUE)
```
Figure 6 is generated by

```r
> tfplot( MBandCredit, explained(c4withML), series=1:5, graphs.per.page=5,
       lty=c("solid", "dashed"),
       col=c("black", "red"),
       Title= "Explained money indicators 1-5 using 4 factors",
       par=list(mar=c(2.1, 4.1, 1.1, 0.1)),
       reset.screen=TRUE)
```
### Table 7.1

<table>
<thead>
<tr>
<th>Year</th>
<th>Personal Cheq.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td></td>
</tr>
<tr>
<td>1983</td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td></td>
</tr>
<tr>
<td>1987</td>
<td></td>
</tr>
<tr>
<td>1989</td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td></td>
</tr>
</tbody>
</table>

### Graph 7.1

Figure 7.1 is generated by

```r
> tfplot( MBandCredit, explained(c4withML), series=6:10, graphs.per.page=5,
        lty=c("solid", "dashed"),
        col=c("black", "red"),
        Title= "Explained money indicator 6-10 using 4 factors",
        par=list(mar=c(2.1, 4.1, 1.1, 0.1)),
        reset.screen=TRUE)
```
The differenced version of the above is not in the paper, but is given by

```r
> tfplot( diff(MBandCredit), diff(explained(c4withML)), graphs.per.page=3)
```
Summary information about the model is calculated with

> summary(MBandCredit)

3 Two, three and five factors models

Tables of standardized loadings for differenced models, and the estimated Φ are given by the following (output is omitted).

> D standardizedLoadings(c2withML)
> print(c2withML$Phi, digits=3)
> D standardizedLoadings(c3withML)
> print(c3withML$Phi, digits=3)
> print(D standardizedLoadings(c5withML), digits=3)
> print(c5withML$Phi, digits=3)
> D standardizedLoadings(c4withML)
> print(c2withML$Phi, digits=3)

Figure 8 part 1 is generated by

> tfplot(ytoypc(factors(c4withML)), ytoypc(factors(c2withML)),
         ytoypc(factors(c3withML)),
         ytoypc(factors(c5withML)), series=1:2,
Figure 8 part 2 is generated by

```r
> tfplot(ytoypc(factors(c4withML)),
         ytoypc(factors(c3withML)),
         ytoypc(factors(c5withML)), series=3,
         xlab=c(""), ylab=c("","","factor 3"),
         col=c("black","red","blue"),
         Title=paste("Factor near ",
                   "(year-to-year growth rate) using 3, 4 and 5 factor models", sep=""),
         par=list(mar=c(2.1, 4.1, 1.1, 0.1)),
         reset.screen=TRUE)
```

4 Rotation method sensitivity

`BpermuteTarget` just helps put the factors in the same order, and with the same signs as `c4withML`. It does not otherwise affect the estimation or rotation. The oblimin rotation with $\gamma = 0.5$ is given by

```r
> c4withMLg0.5 <- estTSF.ML(MBandCredit, 4, BpermuteTarget=loadings(c4withML),
                           rotation="oblimin", rotationArgs=list(gam=0.5))
> loadings(c4withMLg0.5)

<table>
<thead>
<tr>
<th></th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
<th>Factor 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>currency</td>
<td>17.204376</td>
<td>-0.2993325</td>
<td>-2.9221503</td>
<td>-4.161355</td>
</tr>
<tr>
<td>personal cheq.</td>
<td>-5.888054</td>
<td>11.849892</td>
<td>40.8218129</td>
<td>-9.350992</td>
</tr>
<tr>
<td>NonbankCheq</td>
<td>2.306075</td>
<td>-3.1917702</td>
<td>3.5808888</td>
<td>2.094587</td>
</tr>
<tr>
<td>N-P term</td>
<td>-2.519688</td>
<td>1.6858628</td>
<td>-21.7335744</td>
<td>-30.5725683</td>
</tr>
<tr>
<td>Investment</td>
<td>14.121979</td>
<td>70.4973501</td>
<td>-30.5725683</td>
<td>-12.535677</td>
</tr>
<tr>
<td>Consumer Credit</td>
<td>-4.945051</td>
<td>-4.9008176</td>
<td>-0.7956332</td>
<td>33.697057</td>
</tr>
<tr>
<td>Residential Mortgage</td>
<td>6.854980</td>
<td>29.4305518</td>
<td>10.4874854</td>
<td>-1.255816</td>
</tr>
<tr>
<td>Short Term Business Credit</td>
<td>-12.201107</td>
<td>22.7939544</td>
<td>-0.5132386</td>
<td>4.095379</td>
</tr>
<tr>
<td>Other Business Credit</td>
<td>-1.130633</td>
<td>49.8454385</td>
<td>14.9460409</td>
<td>-13.213999</td>
</tr>
</tbody>
</table>

> DstandardizedLoadings(c4withMLg0.5)

<table>
<thead>
<tr>
<th></th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
<th>Factor 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>currency</td>
<td>1.2774374</td>
<td>-0.02222566</td>
<td>-0.216971802</td>
<td>-0.30898366</td>
</tr>
</tbody>
</table>
personal cheq.  -0.13709404  0.27588499  0.95047141  -0.21772307
NonbankCheq   0.21455145  -0.29695432  0.33315694  0.19487511
N-P demand & notice  0.62678638  -0.21052354  0.09634667  0.26717270
N-P term    -0.03502953  0.02343742  -0.30214727  0.45107975
Investment  0.12071597  0.60261780  -0.26133711  -0.10715611
Consumer Credit   -0.16482527  -0.16335091  -0.02651954  1.12316872
Residential Mortgage  0.13620079  0.58475219  0.20837462  -0.02495165
Short Term Business Credit  -0.16983977  0.31729252  -0.00714429  0.05700780
Other Business Credit  -0.02007891  0.88520494  0.26542668  -0.23466735

> DstandardizedLoadings(c4withMLg0.5) - DstandardizedLoadings(c4withML)

<table>
<thead>
<tr>
<th></th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
<th>Factor 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>currency</td>
<td>0.25760538</td>
<td>-0.11664428</td>
<td>-0.12310304</td>
<td>-0.22896671</td>
</tr>
<tr>
<td>personal cheq.</td>
<td>-0.10810564</td>
<td>0.07268860</td>
<td>0.07414186</td>
<td>-0.13877707</td>
</tr>
<tr>
<td>NonbankCheq</td>
<td>0.01240759</td>
<td>-0.15810820</td>
<td>-0.03477256</td>
<td>0.07521179</td>
</tr>
<tr>
<td>N-P demand &amp; notice</td>
<td>0.06827175</td>
<td>-0.20725940</td>
<td>-0.10535113</td>
<td>0.02627196</td>
</tr>
<tr>
<td>N-P term</td>
<td>-0.05623237</td>
<td>-0.07763833</td>
<td>-0.06732182</td>
<td>0.11800249</td>
</tr>
<tr>
<td>Investment</td>
<td>-0.02941505</td>
<td>0.14372787</td>
<td>-0.02189679</td>
<td>-0.17578085</td>
</tr>
<tr>
<td>Consumer Credit</td>
<td>-0.18323724</td>
<td>-0.26844063</td>
<td>-0.12794533</td>
<td>0.32768864</td>
</tr>
<tr>
<td>Residential Mortgage</td>
<td>-0.07977436</td>
<td>0.09124587</td>
<td>-0.01784567</td>
<td>-0.17349361</td>
</tr>
<tr>
<td>Short Term Business Credit</td>
<td>-0.07942246</td>
<td>0.07758680</td>
<td>0.00661881</td>
<td>-0.04002985</td>
</tr>
<tr>
<td>Other Business Credit</td>
<td>-0.11640480</td>
<td>0.22188590</td>
<td>0.02547760</td>
<td>-0.27690780</td>
</tr>
</tbody>
</table>

Other rotation results are produced by the following, but outputs are omitted.

> c4withMLgneg0.5 <- estTSF.ML(MBandCredit, 4, BpermuteTarget=loadings(c4withML),
rotation="oblimin", rotationArgs=list(gam=-0.5))
> loadings(c4withMLgneg0.5)
> DstandardizedLoadings(c4withMLgneg0.5)
> DstandardizedLoadings(c4withMLgneg0.5) - DstandardizedLoadings(c4withML)
> summary(c4withMLgneg0.5)
> c4withMLgneg1.0 <- estTSF.ML(MBandCredit, 4, BpermuteTarget=loadings(c4withML),
rotation="oblimin", rotationArgs=list(gam=-1.0))
> loadings(c4withMLgneg1.0)
> DstandardizedLoadings(c4withMLgneg1.0)
> DstandardizedLoadings(c4withMLgneg1.0) - DstandardizedLoadings(c4withML)
> summary(c4withMLgneg1.0)
> c4withMLbQ <- estTSF.ML(MBandCredit, 4, rotation="bentlerQ",
BpermuteTarget=loadings(c4withML))
> loadings(c4withMLbQ)
> DstandardizedLoadings(c4withMLbQ)
> DstandardizedLoadings(c4withMLbQ) - DstandardizedLoadings(c4withML)
> summary(c4withMLbQ)
Figure 9 is generated by

```r
> tfplot(ytoypc(factors(c4withML)), ytoypc(factors(c4withMLg0.5)), ytoypc(factors(c4withMlneg0.5)), ytoypc(factors(c4withMLgneg1.0)), ytoypc(factors(c4withMLbQ)),
  xlab=c(""),ylab=c("factor 1","factor 2","factor 3","factor 4"),
  lty=c("solid","dashed","dotted","dotdash","longdash"),
  col=c("black","red","blue","green","pink"),
  Title= paste(
    "Factors from various 4 factor models (year-to-year growth rate)",
    "\n and oblimin with gam=0 (solid)"),
  par=list(mar=c(2.1, 4.1, 1.1, 0.1)),
  reset.screen=TRUE)
```

Geomin factors 2 and 3 each have one modestly different loading. Factor 2 has personal chequing mixed in with investment and credit. Factor 3 explains on currency, personal chequing, and investment, so the separation is not so interesting. Output is omitted from these.

```r
> c4withMLgm <- estTSF.ML(MBandCredit, 4, rotation="geominQ", BpermuteTarget=loadings(c4withML))
> loadings(c4withMLgm)
> DstandardizedLoadings(c4withMLgm)

The difference between the estimates can be checked with (output omitted)

```r
> DstandardizedLoadings(c4withMLgm) - DstandardizedLoadings(c4withML)
```

The summary of the 4 factor geomin estimate is given by

```r
> summary(c4withMLgm)
```

Figure 10 is generated by

```r
> tfplot(ytoypc(factors(c4withML)), ytoypc(factors(c4withMLgm)),
  xlab=c(""),ylab=c("factor 1","factor 2","factor 3","factor 4"),
  lty=c("solid","dashed"),
  col=c("black","red"),
  Title= paste(
    "Factors from geomin (dashed) 4 factor model (year-to-year growth rate)",
    "\n and oblimin with gam=0 (solid)"),
  par=list(mar=c(2.1, 4.1, 1.1, 0.1)),
  reset.screen=TRUE)
> c4withMLnotNorm <- estTSF.ML(MBandCredit, 4, normalize=FALSE, BpermuteTarget=loadings(c4withML))
> 
```

There is only a qualitative statement about the next in the paper (outputs omitted).
DstandardizedLoadings(c4withML)
DstandardizedLoadings(c4withMLnotNorm)
DstandardizedLoadings(c4withML) - DstandardizedLoadings(c4withMLnotNorm)

5 Sensitivity to sample period

BpermuteTarget=loadings(c4withML) is not good enough in some cases. There are difficulties interpreting factors 2 and 3 in here.

> z <- matrix(0,10,4)
z[matrix(c( 1,6,2,7,1:4),4,2)] <- c(11, 104, 20, 13)
c4withMLbefore90 <- estTSF.ML(tfwindow(MBandCredit, end=c(1989,12)), 4, BpermuteTarget=z)
c4withMLafter95 <- estTSF.ML(tfwindow(MBandCredit, start=c(1995,1)), 4, BpermuteTarget=loadings(c4withML))
z <- matrix(0,10,4)
z[matrix(c( 1,6,2,7,1:4),4,2)] <- c(11, 104, 20, 13)
c4withMLbefore95 <- estTSF.ML(tfwindow(MBandCredit, end=c(1994,12)), 4, BpermuteTarget=z)
c4withMLafter00 <- estTSF.ML(tfwindow(MBandCredit, start=c(2000,1)), 4, BpermuteTarget=loadings(c4withML))
c4withML90to00 <- estTSF.ML(tfwindow(MBandCredit, start=c(1990,1), end=c(2000,1)), 4, BpermuteTarget=loadings(c4withML))

Figure 11 is generated by

> tfplot(ytoypc(factors(c4withML)), ytoypc(factors(c4withMLbefore90)), ytoypc(factors(c4withMLbefore95)), ytoypc(factors(c4withMLafter95)), ytoypc(factors(c4withMLafter00)), ytoypc(factors(c4withML90to00)), xlab=c(""),ylab=c("factor 1","factor 2","factor 3","factor 4"), ylim=list(NULL,c(-20,20),c(-25,40),NULL), graphs.per.page=4, lty=c("dashed","dotted","dotdash","longdash","dotted","twodash"), col=c("red","blue","green","pink","violet","brown"), Title= paste( "Factors (year to year growth) using full sample and sub-samples\n", "ML estimation with quartimin rotation objective", sep=""), par=list(mar=c(2.1, 4.1, 1.1, 0.1)), reset.screen=TRUE)

Figure 12 is generated by

> tfplot(ytoypc(MBandCredit), ytoypc(explained(c4withML)), ytoypc(explained(c4withMLbefore90)), ytoypc(explained(c4withMLbefore95)), ytoypc(explained(c4withMLafter95)), ytoypc(explained(c4withMLafter00)), 18
ytoypc(explained(c4withML90to00)), series=1:5, graphs.per.page=5,
ylab=c("currency", "personal cheq.", "NonbankCheq",
"N-P demand & notice", "N-P term"),
ylim=list(NULL,NULL,c(-70,70),NULL,c(-70,70)),
lty=c("solid", "dashed", "dotted", "dotdash", "longdash", "dotted",
"twodash"),
col=c("black", "red", "blue", "green", "pink", "violet", "brown"),
Title= paste("Explained money indicators 1-5 (year to year growth)\
using 4 factors, full sample and sub-samples", sep=""),
par=list(mar=c(2.1, 4.1, 1.1, 0.1)),
reset.screen=TRUE)

Figure 13 is generated by

```r
tfplot(ytoypc(MBandCredit), ytoypc(explained(c4withML)),
ytoypc(explained(c4withMLbefore90)), ytoypc(explained(c4withMLbefore95)),
ytoypc(explained(c4withMLafter95)), ytoypc(explained(c4withMLafter00)),
ytoypc(explained(c4withML90to00)), series=6:10, graphs.per.page=5,
ylab=c("", "", "", "", "Investment", "Consumer Credit", "Residential Mortgage",
"Short Term Business Credit", "Other Business Credit"),
lty=c("solid", "dashed", "dotted", "dotdash", "longdash", "dotted",
"twodash"),
col=c("black", "red", "blue", "green", "pink", "violet", "brown"),
Title= paste("Explained money indicators 6-10 (year to year growth)\
using 4 factors, full sample and sub-samples", sep=""),
par=list(mar=c(2.1, 4.1, 1.1, 0.1)),
reset.screen=TRUE)
```

6 Comparison with Aggregates

Compute aggregates M1+ and M2++

```r
M1 <- tfwindow(M1total, start=c(1981,11), end=c(2004,11)) * scale
seriesNames(M1) <- "Real per Capita M1"

z <- tframed(MB2001 + MB486 + MB487p + MB452 + MB452adj + MB472 + NonbankCheq)
M1p <- tfwindow(z, start=c(1981,11), end=c(2004,11)) * scale
seriesNames(M1p) <- "Real per Capita M1+

M2pp <- tfwindow(M1total
  + MB472 + MB473 + MB452 + MB453 + MB454
  + NonbankCheq + NonbankNonCheq + NonbankTerm
  + MB2046 + MB2047 + MB2048
  + MB2057 + MB2058, start=c(1981,11), end=c(2004,11))* scale
seriesNames(M2pp) <- "Real per Capita M2++"
```

and put factors on the same scale.
> f <- tframed(factors(c4withML)[,1:2], tf=tframe(factors(c4withML)))
> mnF <- colMeans(f)
> mnM <- colMeans(cbind(M1p, M2pp))
> f <- sweep(f, 2, mnM/mnF, "*")

Now compare the transaction factor with M1+ and the long term factor with M2++. Figure 14 is generated by

```r
> tfplot(ytoypc(f), ytoypc(cbind(M1, M2pp)), graphs.per.page=2,
> lty=c("dashed", "solid"),
> col=c("red","black"),
> Title=  
> paste("(year to year growth) M1+ and M2++ (solid) and scaled Bartlett Predictors\n", 
> "computed using ordinary ML parameters (dashed)", sep=""),
> ylab=c("M1+ vs. factor 1", "M2++ vs. factor 2" ),
> par=list(mar=c(2.1, 4.1, 1.1, 0.1)),
> reset.screen=TRUE)
```

7 References
