Estimating knots in BLSGMs w/o(w) TICs in the framework of individual measurement occasions

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OS, R version and OpenMx Version

```
OpenMx::mxVersion()
```

```
## OpenMx version: 2.14.11 [GIT v2.14.11]
## R version: R version 3.6.1 (2019-07-05)
## Platform: x86_64-apple-darwin15.6.0
## MacOS: 10.15
## Default optimizer: CSOLNP
## NPSOL-enabled?: No
## OpenMP-enabled?: Yes
```

Require package would be used

```
library(tidyr)
library(ggplot2)
```

Read in dataset for analyses (wide-format data)

```
dat <- read.csv(file = "example_data.csv")
```

Summarize data

```
summary(dat)
```

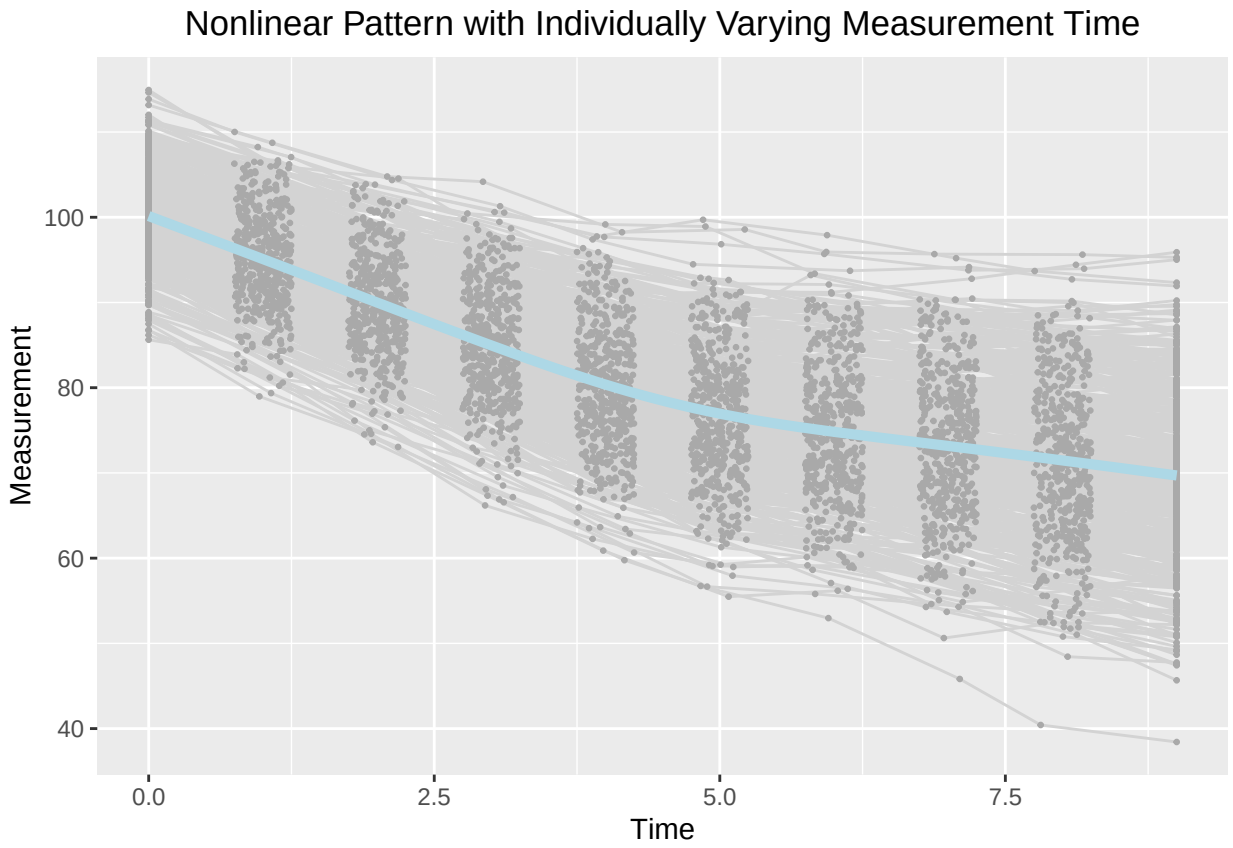
```
##        id              Y1               Y2               Y3
##  Min.   :  1.0   Min.   : 85.62   Min.   : 78.98   Min.   : 73.05
##  1st Qu.:125.8   1st Qu.: 96.84   1st Qu.: 91.31   1st Qu.: 86.10
##  Median :250.5   Median : 99.95   Median : 94.95   Median : 89.68
##  Mean   :250.5   Mean   :100.14   Mean   : 95.10   Mean   : 90.04
##  3rd Qu.:375.2   3rd Qu.:103.42   3rd Qu.: 98.75   3rd Qu.: 94.24
##  Max.   :500.0   Max.   :114.93   Max.   :110.01   Max.   :104.79
##        Y4               Y5               Y6               Y7
##  Min.   : 66.18   Min.   :59.76   Min.   :55.48   Min.   :52.96
##  1st Qu.: 80.69   1st Qu.:75.04   1st Qu.:71.45   1st Qu.:69.43
##  Median : 84.89   Median :79.78   Median :76.59   Median :74.64
##  Mean   : 85.13   Mean   :80.06   Mean   :76.73   Mean   :75.03
##  3rd Qu.: 89.97   3rd Qu.:84.97   3rd Qu.:82.02   3rd Qu.:80.35
##  Max.   :104.17   Max.   :99.16   Max.   :99.71   Max.   :97.90
##        Y8               Y9              Y10               T1
```

```
##  Min.   :45.82   Min.   :40.42   Min.   :38.43   Min.   :0
##  1st Qu.:67.01   1st Qu.:64.77   1st Qu.:62.87   1st Qu.:0
##  Median :73.03   Median :71.75   Median :69.77   Median :0
##  Mean   :73.29   Mean   :71.39   Mean   :69.72   Mean   :0
##  3rd Qu.:79.15   3rd Qu.:77.86   3rd Qu.:76.72   3rd Qu.:0
##  Max.   :95.68   Max.   :95.62   Max.   :95.90   Max.   :0
##        T2              T3              T4              T5
##  Min.   :0.7504   Min.   :1.751   Min.   :2.750   Min.   :3.750
##  1st Qu.:0.8691   1st Qu.:1.886   1st Qu.:2.885   1st Qu.:3.891
##  Median :1.0158   Median :2.007   Median :2.998   Median :4.008
##  Mean   :1.0056   Mean   :2.002   Mean   :3.002   Mean   :4.007
##  3rd Qu.:1.1279   3rd Qu.:2.117   3rd Qu.:3.119   3rd Qu.:4.137
##  Max.   :1.2493   Max.   :2.250   Max.   :3.250   Max.   :4.250
##        T6              T7              T8              T9
##  Min.   :4.751   Min.   :5.751   Min.   :6.751   Min.   :7.750
##  1st Qu.:4.867   1st Qu.:5.855   1st Qu.:6.869   1st Qu.:7.891
##  Median :4.990   Median :5.999   Median :6.995   Median :8.034
##  Mean   :4.993   Mean   :5.990   Mean   :6.996   Mean   :8.015
##  3rd Qu.:5.123   3rd Qu.:6.116   3rd Qu.:7.125   3rd Qu.:8.141
##  Max.   :5.248   Max.   :6.250   Max.   :7.249   Max.   :8.250
##       T10          x1                x2
##  Min.   :9   Min.   :-2.75128   Min.   :-3.42053
##  1st Qu.:9   1st Qu.:-0.62326   1st Qu.:-0.59155
##  Median :9   Median : 0.03191   Median : 0.05391
##  Mean   :9   Mean   : 0.04213   Mean   : 0.03263
##  3rd Qu.:9   3rd Qu.: 0.68883   3rd Qu.: 0.73213
##  Max.   :9   Max.   : 2.61251   Max.   : 2.38615
```

Visualize data

```
long_dat_T <- gather(dat, var.T, time, T1:T10)
long_dat_Y <- gather(dat, var.Y, measures, Y1:Y10)
long_dat <- data.frame(id = long_dat_T[, 1], time = long_dat_T[, 15],
                       measures = long_dat_Y[, 15])
ggplot(aes(x = time, y = measures), data = long_dat) +
  geom_line(aes(group = id), color = "lightgrey") +
  geom_point(aes(group = id), color = "darkgrey", size = 0.5) +
  geom_smooth(aes(group = 1), size = 1.8, col = "lightblue", se = F) +
  labs(title = "Nonlinear Pattern with Individually Varying Measurement Time",
       x ="Time", y = "Measurement") +
  theme(plot.title = element_text(hjust = 0.5))
```

```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```



Bilinear Spline Growth Model with an Unknown Fixed Knot

```
source("BLSGM_fixed.R")
```

```
out
```

```
##      Name    Estimate         SE  true
## 1  mueta0 100.1293951 0.23173856 100.0
## 2  mueta1  -5.0073851 0.04598703  -5.0
## 3  mueta2  -1.7595549 0.04740934  -1.8
## 4     mug   4.4901431 0.01715137   4.5
## 5   psi00  26.2243744 1.69479350  25.0
## 8   psi11   0.9564998 0.06466096   1.0
## 10  psi22   1.0235949 0.06899424   1.0
```

Bilinear Spline Growth Model with an Unknown Random Knot

```
source("BLSGM_random.R")
```

```
out
```

```
##      Name     Estimate         SE   true
## 1  mueta0 100.13152651 0.22990749 100.00
## 2  mueta1  -5.00905590 0.04678654  -5.00
## 3  mueta2  -1.76048653 0.04849613  -1.80
## 4     mug   4.48745916 0.02127763   4.50
```

```
## 5   psi00  25.83578186 1.67147353  25.00
## 9   psi11   0.99605274 0.06931469   1.00
## 12  psi22   1.07807623 0.07439831   1.00
## 14  psigg   0.07265726 0.01506776   0.09
```

Bilinear Spline Growth Model-TICs with an Unknown Fixed Knot

```
source("BLSGM_TICs_fixed.R")
```

```
out
```

```
##      Name    Estimate         SE        true
## 1  mueta0 100.0541640 0.22034754 100.0000000
## 2  mueta1  -5.0196910 0.04460125  -5.0000000
## 3  mueta2  -1.7733599 0.04566146  -1.8000000
## 4     mug   4.4904224 0.01715195   4.5000000
## 5   psi00  23.5852888 1.52831616  21.7500000
## 8   psi11   0.8910039 0.06066808   0.8700000
## 10  psi22   0.9397712 0.06366320   0.8700000
## 11 beta10   0.6407171 0.23776040   0.8849477
## 12 beta11   0.1314015 0.04728437   0.1769895
## 13 beta12   0.1412063 0.04838719   0.1769895
## 14 beta20   1.4744591 0.24116733   1.3274219
## 15 beta21   0.2113152 0.04798255   0.2654843
## 16 beta22   0.2450017 0.04915263   0.2654843
```

Bilinear Spline Growth Model-TICs with an Unknown Random Knot

```
source("BLSGM_TICs_random.R")
```

```
out
```

```
##      Name     Estimate         SE         true
## 1  mueta0 100.05946813 0.21919764 100.00000000
## 2  mueta1  -5.02406736 0.04482681  -5.00000000
## 3  mueta2  -1.77713794 0.04614374  -1.80000000
## 4     mug   4.48208176 0.02081631   4.50000000
## 5   psi00  23.36764153 1.51553677  21.75000000
## 9   psi11   0.90360398 0.06346954   0.87000000
## 12  psi22   0.96393471 0.06716172   0.87000000
## 14  psigg   0.06219010 0.01440652   0.07830000
## 15 beta10   0.59683600 0.23642860   0.88494767
## 16 beta11   0.16863219 0.04835258   0.17698953
## 17 beta12   0.17883578 0.04973972   0.17698953
## 18 beta1r   0.07641219 0.02246162   0.05309687
## 19 beta20   1.43909941 0.24014651   1.32742186
## 20 beta21   0.24121752 0.04910246   0.26548430
## 21 beta22   0.27576944 0.05053915   0.26548430
## 22 beta2r   0.06190593 0.02283298   0.07964533
```