Sensitivty analaysis in moment condition models

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Introduction

The package `GMMSensitivity` implements estimators and confidence interval for sensitivity analsysis in moment condition models considered in Armstrong and Kolesár (2018). In this vignette, we demonstrate the implementation of these confidence intervals using the demand model for automobiles from Berry, Levinsohn, and Pakes (1995).

The package includes the dataset `blp`, which contains estimates of the Berry, Levinsohn, and Pakes (1995) model, as implemented by Andrews, Gentzkow, and Shapiro (2017). A description of the dataset can be obtained using the `help` function:

```
library("GMMSensitivity")
help("blp", type = "text")
#> Using development documentation for blp
```

Usage

The package implements estimators, confidence intervals, and efficiency calculations for the model (in the notation of Armstrong and Kolesár (2018))

$$g(\theta_0) = c, \quad c = B\gamma, \quad \|\gamma\|_p \leq K.$$

For example, suppose that all excluded instruments may be invalid with $K = \sqrt{\#I}$, where $\#I$ is the numer of invalid instruments (using the scaling descibed in the paper). Then the confidence interval can be constructed as follows:

```
## Construct estimate of initial sensitivity
blp$k_init <- -drop(blp$H %*% solve(crossprod(blp$G, blp$W %*%
    blp$G), crossprod(blp$G, blp$W)))
eo <- list(H = blp$H, G = blp$G, Sig = blp$Sig, n = blp$n,
    g_init = blp$g_init, k_init = blp$k_init, h_init = blp$h_init)
## Rows corresponding to invalid instruments
I <- vector(mode = "logical", length = nrow(eo$G))
I[c(6:13, 20:31)] <- TRUE
## Matrix B, scaled as described in the paper
B <- (abs(blp$perturb) * blp$OmZZ)[, I, drop = FALSE]
```

```r
## Value of K
K0 <- sqrt(sum(I))
OptEstimator(eo, B, K = K0, p = 2, alpha = 0.05, opt.criterion = "FLCI")
#>
#>
#> Estimate   Max. bias   SE          CI
#> ---------  ----------  ----------  ---------------------
#> 0.37963    0.0426027   0.0241137   (0.297363, 0.461896)
```

The efficiency κ^* for this confidence interval can be computed using the `EffBounds` function (which can also be used to compute efficiency of one-sided confidence intervals):

```r
EffBounds(eo, B, K = K0, p = 2)$twosided
#> [1] 0.967071
```

For comparison, using the initial estimator yields the confidence interval:

```r
OptEstimator(eo, B, K = K0, p = 2, alpha = 0.05, opt.criterion = "Valid")
#>
#>
#> Estimate   Max. bias   SE          CI
#> ---------  ----------  ----------  ----------------------
#> 0.327179   0.291766    0.0181566   (0.00554775, 0.64881)
```

Finally a specification test for whether the value $K = K0$ is too low, that is a test of the hypothesis $H_0 : : K \leq K0$:

```r
Jtest(eo, B, K = K0, p = 2, alpha = 0.05)
#> $J
#> [1] 404.676
#>
#> $p0
#> [1] 0
#>
#> $pC
#> [1] 1
#>
#> $Kmin
#> [1] 2.461
```

Here `J` is the J-statistic, `p0` is the p-value of the usual J-test (that assumes $K = 0$ under the null), `pC` is the p-value of the test, and `Kmin` is the smallest value of K that is not rejected.

References

Andrews, Isaiah, Matthew Gentzkow, and Jesse M. Shapiro. 2017. "Measuring the Sensitivity of Parameter Estimates to Sample Statistics." *Quarterly Journal of Economics* 132 (4): 1553–92.

Armstrong, Tim, and Michal Kolesár. 2018. "Sensitivity Analysis Using Approximate Moment Condition Models."

Berry, Steven T., James Levinsohn, and Ariel Pakes. 1995. "Automobile Prices in Market Equilibrium." *Econometrica* 63 (4): 841–90.