Package 'mfbvar'

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Type Package

Title Mixed-Frequency Bayesian VAR Models

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Description Functions and tools for estimation of mixed-frequency Bayesian vector autoregressive (VAR) models. The package implements a state space-based VAR model that handles mixed frequencies of the data as proposed by Schorfheide and Song (2015) <doi:10.1080/07350015.2014.954707>, and extensions thereof developed by Ankargren, Unosson and Yang (2020) <doi:10.1515/jtse-2018-0034>, Ankargren and Joneus (2019) <arXiv:1912.02231>, and Ankargren and Joneus (2020) <doi:10.1016/j.ecosta.2020.05.007>. The models are estimated using Markov Chain Monte Carlo to numerically approximate the posterior distribution. Prior distributions that can be used include normal-inverse Wishart and normal-diffuse priors as well as steady-state priors. Stochastic volatility can be handled by common or factor stochastic volatility models.

License GPL-3

LazyData TRUE

URL https://github.com/ankargren/mfbvar

BugReports https://github.com/ankargren/mfbvar/issues

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`estimate_mfbvar` *Mixed-frequency Bayesian VAR*

Description

The main function for estimating a mixed-frequency BVAR.

Usage

```
estimate_mfbvar(mfbvar_prior = NULL, prior, variance = "iw", ...)
```

Arguments

mfbvar_prior	a mfbvar_prior object
prior	either "ss" (steady-state prior), "ssng" (hierarchical steady-state prior with normal-gamma shrinkage) or "minn" (Minnesota prior)
variance	form of the error variance-covariance matrix: "iw" for the inverse Wishart prior, "diffuse" for a diffuse prior, "csv" for common stochastic volatility or "fsv" for factor stochastic volatility
...	additional arguments to update_prior (if mfbvar_prior is NULL, the arguments are passed on to set_prior)

Value

An object of class mfbvar, mfbvar_<prior> and mfbvar_<prior>_<variance> containing posterior quantities as well as the prior object. For all choices of prior and variance, the returned object contains:

Pi	Array of dynamic coefficient matrices; Pi[,,r] is the rth draw
Z	Array of monthly processes; Z[,,r] is the rth draw
Z_fcst	Array of monthly forecasts; Z_fcst[,,r] is the rth forecast. The first n_lags rows are taken from the data to offer a bridge between observations and forecasts and for computing nowcasts (i.e. with ragged edges).

Steady-state priors: If prior = "ss", it also includes:

psi Matrix of steady-state parameter vectors; psi[r,] is the rth draw

roots The maximum eigenvalue of the lag polynomial (if check_roots = TRUE)

If prior = "ssng", it also includes:

psi Matrix of steady-state parameter vectors; psi[r,] is the rth draw

roots The maximum eigenvalue of the lag polynomial (if check_roots = TRUE)

lambda_psi Vector of draws of the global hyperparameter in the normal-Gamma prior

phi_psi Vector of draws of the auxiliary hyperparameter in the normal-Gamma prior

omega_psi Matrix of draws of the prior variances of psi; omega_psi[r,] is the rth draw, where diag(omega_psi[r,]) is used as the prior covariance matrix for psi

Constant error covariances: If variance = "iw" or variance = "diffuse", it also includes:

Sigma Array of error covariance matrices; Sigma[,,r] is the rth draw

Time-varying error covariances: If variance = "csv", it also includes:

Sigma Array of error covariance matrices; Sigma[,,r] is the rth draw

phi Vector of AR(1) parameters for the log-volatility regression; phi[r] is the rth draw

sigma Vector of error standard deviations for the log-volatility regression; sigma[r] is the rth draw

f Matrix of log-volatilities; f[r,] is the rth draw

If variance = "fsv", it also includes:

facload Array of factor loadings; facload[,,r] is the rth draw

`latent` Array of latent log-volatilities; `latent[,,r]` is the `r`th draw

`mu` Matrix of means of the log-volatilities; `mu[,r]` is the `r`th draw

`phi` Matrix of AR(1) parameters for the log-volatilities; `phi[,r]` is the `r`th draw

`sigma` Matrix of innovation variances for the log-volatilities; `sigma[,r]` is the `r`th draw

References

Ankargren, S., Unosson, M., & Yang, Y. (2020) A Flexible Mixed-Frequency Bayesian Vector Autoregression with a Steady-State Prior. *Journal of Time Series Econometrics*, 12(2), doi: 10.1515/jtse20180034.

Ankargren, S., & Jonéus, P. (2020) Simulation Smoothing for Nowcasting with Large Mixed-Frequency VARs. *Econometrics and Statistics*, doi: 10.1016/j.ecosta.2020.05.007.

Ankargren, S., & Jonéus, P. (2019) Estimating Large Mixed-Frequency Bayesian VAR Models. arXiv:1912.02231, https://arxiv.org/abs/1912.02231.

Kastner, G., & Huber, F. (2020) Sparse Bayesian Vector Autoregressions in Huge Dimensions. *Journal of Forecasting*, 39, 1142–1165. doi: 10.1002/for.2680.

Schorfheide, F., & Song, D. (2015) Real-Time Forecasting With a Mixed-Frequency VAR. *Journal of Business & Economic Statistics*, 33(3), 366–380. doi: 10.1080/07350015.2014.954707

See Also

`set_prior`, `update_prior`, `predict.mfbvar`, `plot.mfbvar_minn`, `plot.mfbvar_ss`, `varplot`, `summary.mfbvar`

Examples

```
prior_obj <- set_prior(Y = mf_usa, n_lags = 4, n_reps = 20)
mod_minn <- estimate_mfbvar(prior_obj, prior = "minn")
```

`interval_to_moments` *Interval to moments*

Description

Convert a matrix of `100*(1-alpha)` % prior probability intervals for the steady states to prior moments.

Usage

```
interval_to_moments(prior_psi_int, alpha = 0.05)
```

Arguments

`prior_psi_int`	Matrix of size `(n_determ*n_vars) * 2` with the prior 95 % prior probability intervals.
`alpha`	`100*(1-alpha)` is the prior probability of the interval

Value

A list with two components:

`prior_psi_mean` The prior mean of psi

`prior_psi_Omega`
The prior covariance matrix of psi

Examples

```
prior_intervals <- matrix(c(0.1, 0.2,
                            0.4, 0.6), ncol = 2, byrow = TRUE)
psi_moments <- interval_to_moments(prior_intervals)
```

---

mdd *Marginal data density estimation*

Description

mdd estimates the (log) marginal data density.

Usage

```
mdd(x, ...)
```

Arguments

x	argument to dispatch on (of class mfbvar_ss or mfbvar_minn)
...	additional named arguments passed on to the methods

Details

This is a generic function. See the methods for more information.

The marginal data density is also known as the marginal likelihood.

Value

The logarithm of the marginal data density.

See Also

mdd.mfbvar_ss_iw, mdd.mfbvar_minn_iw

`mdd.mfbvar_minn_iw` *Marginal data density method for class* `mfbvar_minn`

Description

Estimate the marginal data density for the model with a Minnesota prior.

Usage

```
## S3 method for class 'mfbvar_minn_iw'
mdd(x, ...)
```

Arguments

`x`	object of class `mfbvar_minn`
`...`	additional arguments (currently only `p_trunc` for the degree of truncation is available)

Details

The method used for estimating the marginal data density is the proposal made by Schorfheide and Song (2015).

Value

The logarithm of the marginal data density.

References

Schorfheide, F., & Song, D. (2015) Real-Time Forecasting With a Mixed-Frequency VAR. *Journal of Business & Economic Statistics*, 33(3), 366–380. doi: 10.1080/07350015.2014.954707

See Also

`mdd`, `mdd.mfbvar_ss_iw`

`mdd.mfbvar_ss_iw` *Marginal data density method for class* `mfbvar_ss`

Description

Estimate the marginal data density for the model with a steady-state prior.

Usage

```
## S3 method for class 'mfbvar_ss_iw'
mdd(x, method = 1, ...)
```

Arguments

`x`	object of class `mfbvar_ss`
`method`	option for which method to choose for computing the mdd (1 or 2)
`...`	additional arguments (currently only `p_trunc` for the degree of truncation for method 2 is available)

Details

Two methods for estimating the marginal data density are implemented. Method 1 and 2 correspond to the two methods proposed by Fuentes-Albero and Melosi (2013) and Ankargren, Unosson and Yang (2018).

Value

The logarithm of the marginal data density.

References

Fuentes-Albero, C. and Melosi, L. (2013) Methods for Computing Marginal Data Densities from the Gibbs Output. *Journal of Econometrics*, 175(2), 132-141, doi: 10.1016/j.jeconom.2013.03.002
Ankargren, S., Unosson, M., & Yang, Y. (2018) A Mixed-Frequency Bayesian Vector Autoregression with a Steady-State Prior. Working Paper, Department of Statistics, Uppsala University No. 2018:3.

See Also

`mdd`, `mdd.mfbvar_minn_iw`

mfbvar *mfbvar: A package for mixed-frequency Bayesian vector autoregressive (VAR) models.*

Description

The mfbvar package makes estimation of Bayesian VARs with a mix of monthly and quarterly data simple. The prior for the regression parameters is normal with Minnesota-style prior moments. The package supports either an inverse Wishart prior for the error covariance matrix, yielding a standard normal-inverse Wishart prior, or a time-varying error covariance matrix by means of a factor stochastic volatility model through the `factorstochvol-package` package.

Specifying the prior

The prior of the VAR model is specified using the function `set_prior`. The function creates a prior object, which can be further updated using `update_prior`. The model can be estimated using the steady-state prior, which requires the prior moments of the steady-state parameters. The function `interval_to_moments` is a helper function for obtaining these from prior intervals.

Estimating the model

The model is estimated using the function `estimate_mfbvar`. The error covariance matrix is given an inverse Wishart prior or modeled using factor stochastic volatility. If the former is used, `mdd` can be used to estimate to the marginal data density (marginal likelihood).

Processing the output

Plots of the output can be obtained from calling the generic function `plot` (see `plot-mfbvar`). If factor stochastic volatility is used, the time-varying standard deviations can be plotted using `varplot`. Predictions can be obtained from `predict.mfbvar`.

mf_sweden *Real-time data set for Sweden.*

Description

A dataset containing real-time data for mixed and quarterly frequencies.

Usage

```
mf_sweden
```

Format

A mixed-frequency data set of five Swedish macroeconomic variables.

unemp harmonized unemployment rate (source: OECD)

infl inflation rate (source: OECD)

ip industrial production (source: OECD)

eti economic tendency indicator (source: National Institute of Economic Research)

gdp GDP growth (source: Statistics Sweden)

References

OECD (2016) MEI Archive: Revisions Analysis Dataset.
Billstam, M., Fr\"and\'en, J., Samuelsson, J., \"Osterholm, P. (2016) Quasi-Real-Time Data of the Economic Tendency Survey. Working Paper No. 143, National Institute of Economic Research.
Statistics Sweden (2016) Revisions, expenditure approach and hours worked at each release.

`mf_usa` *US Macroeconomic Data Set*

Description

A dataset containing mixed-frequency data from FRED for three US macroeconomic variables.

Usage

```
mf_usa
```

Format

A list with components:

CPIAUCSL inflation rate

UNRATE unemployment rate

GDPC1 GDP growth rate

plot-mfbvar *Plotting methods for posterior mfbvar objects*

Description

Methods for plotting posterior mfbvar objects.

Usage

```
## S3 method for class 'mfbvar_ss'
plot(
  x,
  aggregate_fcst = TRUE,
  plot_start = NULL,
  pred_bands = 0.8,
  nrow_facet = NULL,
  ss_bands = 0.95,
  ...
)

## S3 method for class 'mfbvar_ssng'
plot(
  x,
  aggregate_fcst = TRUE,
  plot_start = NULL,
  pred_bands = 0.8,
  nrow_facet = NULL,
  ss_bands = 0.95,
  ...
)

## S3 method for class 'mfbvar_minn'
plot(
  x,
  aggregate_fcst = TRUE,
  plot_start = NULL,
  pred_bands = 0.8,
  nrow_facet = NULL,
  ...
)

varplot(x, variables = colnames(x$Y), var_bands = 0.95, nrow_facet = NULL, ...)
```

Arguments

x	object of class `mfbvar_minn` or `mfbvar_ss`

aggregate_fcst	Boolean indicating whether forecasts of the latent monthly series should be aggregated to the quarterly frequency.
plot_start	Time period (date or number) to start plotting from. Default is to to use 5*n_fcst time periods if n_fcst exists, otherwise the entire sample.
pred_bands	Single number (between 0.0 and 1.0) giving the coverage level of forecast intervals.
nrow_facet	an integer giving the number of rows to use in the facet
ss_bands	(Steady-state prior only) Single number (between 0.0 and 1.0) giving the coverage level of posterior steady-state intervals.
...	Currently not in use.
variables	Vector of names or positions of variables to include in the plot of variances
var_bands	(varplot only) Single number (between 0.0 and 1.0) giving the coverage level of posterior intervals for the error standard deviations.

Value

A ggplot.

Examples

```
prior_obj <- set_prior(Y = mf_usa, d = "intercept",
                       n_lags = 4, n_reps = 20,
                       n_fcst = 4, n_fac = 1)

prior_intervals <- matrix(c(1, 3,
                            4, 8,
                            1, 3), ncol = 2, byrow = TRUE)
psi_moments <- interval_to_moments(prior_intervals)
prior_psi_mean <- psi_moments$prior_psi_mean
prior_psi_Omega <- psi_moments$prior_psi_Omega
prior_obj <- update_prior(prior_obj,
                          prior_psi_mean = prior_psi_mean,
                          prior_psi_Omega = prior_psi_Omega)

mod_ss <- estimate_mfbvar(prior_obj, prior = "ss", variance = "fsv")
plot(mod_ss)
varplot(mod_ss)
```

---

plot.mfbvar_prior *Plot method for class* mfbvar_prior

Description

Method for plotting mfbvar_prior objects.

Usage

```
## S3 method for class 'mfbvar_prior'
plot(x, nrow_facet = NULL, ...)
```

Arguments

x	object of class mfbvar_prior
nrow_facet	number of rows in facet
...	Currently not in use.

Details

The function plots the data. If the prior moments for the steady-state parameters are available in x, these are included.

Value

A ggplot.

Examples

```
prior_obj <- set_prior(Y = mf_usa, n_lags = 4, n_reps = 20, n_fcst = 4)
plot(prior_obj)
```

---

predict.mfbvar *Predict method for class* mfbvar

Description

Method for predicting mfbvar objects.

Usage

```
## S3 method for class 'mfbvar'
predict(object, aggregate_fcst = TRUE, pred_bands = 0.8, ...)
```

Arguments

object	object of class mfbvar
aggregate_fcst	If forecasts of quarterly variables should be aggregated back to the quarterly frequency.
pred_bands	The level of the probability bands for the forecasts.
...	Currently not in use.

Details

Note that this requires that forecasts were made in the original mfbvar call.

Value

A tibble with columns:

`variable` Name of variable

`time` Time index

`fcst_date` Date of forecast

If the argument `pred_bands` is given as a numeric value between 0 and 1, the returned tibble also includes columns:

`lower` The `(1-pred_bands)/2` lower quantiles of the predictive distributions

`median` The medians of the predictive distributions

`upper` The `(1+pred_bands)/2` upper quantiles of the predictive distributions

If `pred_bands` `NULL` or `NA`, the returned tibble also includes the columns:

`fcst` MCMC samples from the predictive distributions

`iter` Iteration indexes for the MCMC samples

Examples

```
prior_obj <- set_prior(Y = mf_usa, n_lags = 4, n_reps = 20, n_fcst = 4)
mod_minn <- estimate_mfbvar(prior_obj, prior = "minn")
predict(mod_minn)
```

---

print.mfbvar *Printing method for class mfbvar*

Description

Method for printing `mfbvar` objects.

Usage

```
## S3 method for class 'mfbvar'
print(x, ...)
```

Arguments

`x`	object of class `mfbvar`
`...`	Currently not in use.

Value

No return value, called for side effects.

Examples

```
prior_obj <- set_prior(Y = mf_usa, n_lags = 4, n_reps = 20)
mod_minn <- estimate_mfbvar(prior_obj, prior = "minn")
mod_minn
```

`print.mfbvar_prior` *Print method for mfbvar_prior*

Description

Printing method for object of class mfbvar_prior, checking if information in the prior is sufficient for estimating models.

Usage

```
## S3 method for class 'mfbvar_prior'
print(x, ...)
```

Arguments

`x`	prior object (class `mfbvar_prior`)
`...`	additional arguments (currently unused)

Details

The print method checks whether the steady-state and Minnesota priors can be used with the current specification. This check is minimal in the sense that it checks only prior elements with no defaults, and it only checks for estimation and not forecasting (for which the steady-state prior requires additional information).

Value

No return value, called for side effects.

See Also

`set_prior`, `update_prior`, `estimate_mfbvar`, `summary.mfbvar_prior`

Examples

```
prior_obj <- set_prior(Y = mf_usa, n_lags = 4, n_reps = 100)
print(prior_obj)
```

set_prior *Set priors for mfbvar*

Description

The function creates an object storing all information needed for estimating a mixed-frequency BVAR. The object includes data as well as details for the model and its priors.

Usage

```
set_prior(
  Y,
  aggregation = "average",
  prior_Pi_AR1 = 0,
  lambda1 = 0.2,
  lambda2 = 0.5,
  lambda3 = 1,
  lambda4 = 10000,
  block_exo = NULL,
  n_lags,
  n_fcst = 0,
  n_thin = 1,
  n_reps,
  n_burnin = n_reps,
  freq = NULL,
  d = NULL,
  d_fcst = NULL,
  prior_psi_mean = NULL,
  prior_psi_Omega = NULL,
  check_roots = FALSE,
  s = -1000,
  prior_ng = c(0.01, 0.01),
  prior_phi = c(0.9, 0.1),
  prior_sigma2 = c(0.01, 4),
  n_fac = NULL,
  n_cores = 1,
  verbose = FALSE,
  ...
)

update_prior(prior_obj, ...)
```

Arguments

Y	data input. For monthly-quarterly data, should be a list with components containing regularly spaced time series (that inherit from `ts` or `zooreg`). If a component contains a single time series, the component itself must be named. If

	a component contains multiple time series, each time series must be named. Monthly variables can only contain missing values at the end of the sample, and should precede quarterly variables in the list. Matrices in which quarterly variables are padded with NA and observations stored at the end of each quarter are also accepted, but then the frequency of each variable must be given in the argument freq. Weekly-monthly mixes can be provided using the matrix way, see examples.
aggregation	the aggregation scheme used for relating latent high-frequency series to their low-frequency observations. The default is "average" for averaging within each low-frequency period (e.g., quarterly observations are averages of the constituent monthly observations). The alternative "triangular" can be used for monthly-quarterly mixes, and uses the Mariano-Murasawa triangular set of weights. See details for more information.
prior_Pi_AR1	The prior means for the AR(1) coefficients.
lambda1	The overall tightness.
lambda2	(Only if variance is one of c("diffuse","fsv") The cross-variable tightness
lambda3	The tightness of the intercept prior variance.
lambda4	(Minnesota only) Prior variance of the intercept.
block_exo	(Only if variance is one of c("diffuse","fsv")) Vector of indexes/names of variables to be treated as block exogenous
n_lags	The number of lags.
n_fcst	The number of periods to forecast.
n_thin	Store every n_thinth draw
n_reps	The number of replications.
n_burnin	The number of burn-in replications.
freq	(Only used if Y is a matrix) Character vector with elements 'm' (monthly) or 'q' (quarterly) for sampling frequency. Monthly variables must precede all quarterly variables.
d	(Steady state only) Either a matrix with same number of rows as Y and n_determ number of columns containing the deterministic terms or a string "intercept" for requesting an intercept as the only deterministic term.
d_fcst	(Steady state only) The deterministic terms for the forecasting period (not used if d = "intercept").
prior_psi_mean	(Steady state only) Vector of length n_determ*n_vars with the prior means of the steady-state parameters.
prior_psi_Omega	(Steady state only) Matrix of size (n_determ*n_vars) * (n_determ*n_vars) with the prior covariance of the steady-state parameters.#'
check_roots	Logical, if roots of the companion matrix are to be checked to ensure stationarity.
s	(Hierarchical steady state only) scalar giving the tuning parameter for the Metropolis-Hastings proposal for the kurtosis parameter. If s < 0, then adaptive Metropolis-Hastings targeting an acceptance rate of 0.44 is used, where the scaling factor is restricted to the interval [-abs(s),abs(s)]

prior_ng	(Hierarchical steady state only) vector with two elements giving the parameters c(c0,c1) of the hyperprior for the global shrinkage parameter
prior_phi	(Only used with common stochastic volatility) Vector with two elements c(mean,variance) for the AR(1) parameter in the log-volatility regression
prior_sigma2	(Only used with common stochastic volatility) Vector with two elements c(mean,df) for the innovation variance of the log-volatility regression
n_fac	(Only used with factor stochastic volatility) Number of factors to use for the factor stochastic volatility model
n_cores	(Only used with factor stochastic volatility) Number of cores to use for drawing regression parameters in parallel
verbose	Logical, if progress should be printed to the console.
...	(Only used with factor stochastic volatility) Arguments to pass along to fsvsample. See details.
prior_obj	an object of class mfbvar_prior

Details

Some support is provided for single-frequency data sets, where Y contains variables sampled with the same frequency.

The aggregation weights that can be used for aggregation are intra-quarterly averages (aggregation = "average"), where the quarterly observations $y_{q,t}$ are assumed to relate to the underlying monthly series $z_{q,,t}$ through:

$$y_{q,t} = \frac{1}{3}(z_{q,,t} + z_{q,,t-1} + z_{q,,t-2})$$

If aggregation = "triangular", then instead

$$y_{q,t} = \frac{1}{9}(z_{q,,t} + 2z_{q,,t-1} + 3z_{q,,t-2}) + 2z_{q,,t-3}) + z_{q,,t-4})$$

The latter is typically used when modeling growth rates, and the former when working with log-levels.

If the steady-state prior is to be used, the deterministic matrix needs to be supplied, or a string indicating that the intercept should be the only deterministic term (d = "intercept"). If the latter, d_fcst is automatically set to be intercept only. Otherwise, if forecasts are requested (n_fcst > 0) also d_fcst must be provided. Finally, the prior means of the steady-state parameters must (at the very minimum) also be provided in prior_psi_mean. The steady-state prior involves inverting the lag polynomial. For this reason, draws in which the largest eigenvalue (in absolute value) of the lag polynomial is greater than 1 are discarded and new draws are made if check_roots = TRUE. The maximum number of attempts is 1,000.

For modeling stochastic volatility by the factor stochastic volatility model, the number of factors to use must be supplied. Further arguments can be passed along, but are not included as formal arguments. If the default settings are not overriden, the defaults used are as follows (see fsvsample for descriptions):

- priormu = c(0,10)
- priorphiidi = c(10,3)

- priorphifac = c(10,3)
- priorsigmaidi = 1
- priorsigmafac = 1
- priorfacload = 1
- restrict = "none"

The function update_prior can be used to update an existing prior object. See the examples.

Value

An object of class mfbvar_prior that is used as input to estimate_mfbvar.

See Also

estimate_mfbvar, update_prior, interval_to_moments, print.mfbvar_prior, summary.mfbvar_prior, fsvsample

Examples

```
# Standard list-based way
prior_obj <- set_prior(Y = mf_usa, n_lags = 4, n_reps = 100)
prior_obj <- update_prior(prior_obj, n_fcst = 4)

# Weekly-monthly mix of data, four weeks per month
Y <- matrix(rnorm(400), 100, 4)
Y[setdiff(1:100,seq(4, 100, by = 4)), 4] <- NA
prior_obj <- set_prior(Y = Y, freq = c(rep("w", 3), "m"),
                       n_lags = 4, n_reps = 10)
```

---

summary.mfbvar *Summary method for class mfbvar*

Description

Method for summarizing mfbvar objects.

Usage

```
## S3 method for class 'mfbvar'
summary(object, ...)
```

Arguments

object	object of class mfbvar
...	Currently not in use.

Examples

```
prior_obj <- set_prior(Y = mf_usa, n_lags = 4, n_reps = 20)
mod_minn <- estimate_mfbvar(prior_obj, prior = "minn")
summary(mod_minn)
```

`summary.mfbvar_prior` *Summary method for mfbvar_prior*

Description

summary method for object of class mfbvar_prior, showing some basic information regarding the contents of the prior.

Usage

```
## S3 method for class 'mfbvar_prior'
summary(object, ...)
```

Arguments

`object`	prior object (class `mfbvar_prior`)
`...`	additional arguments (currently unused)

See Also

`set_prior`, `update_prior`, `estimate_mfbvar`, `print.mfbvar_prior`

Examples

```
prior_obj <- set_prior(Y = mf_usa, n_lags = 4, n_reps = 100)
summary(prior_obj)
```

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