Package ‘jrvFinance’

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Title Basic Finance; NPV/IRR/Annuities/Bond-Pricing; Black Scholes

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Description Implements the basic financial analysis functions similar to (but not identical to) what is available in most spreadsheet software. This includes finding the IRR and NPV of regularly spaced cash flows and annuities. Bond pricing and YTM calculations are included. In addition, Black Scholes option pricing and Greeks are also provided.

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Description

This package implements the basic financial analysis functions similar to (but not identical to) what is available in most spreadsheet software. This includes finding the IRR, NPV and duration of possibly irregularly spaced cash flows and annuities. Bond pricing, YTM and duration calculations are included. Black Scholes option pricing, Greeks and implied volatility are also provided.

Details

Important functions include:

```
npv, irr, duration, annuity_pv, bond_price, bond_yield, GenBS, GenBSImplied
```

For more details, see the vignette

Author(s)

Prof. Jayanth R. Varma <jrvarma@iima.ac.in>

References

The 30/360 day count was converted from C++ code in the QuantLib library. The Newton Raphson solver was converted from C++ code in the Boost library
Description

Functions to compute present value and future value of annuities, to find instalment given the present value or future value. Can also find the rate or the number of periods given other parameters.

Usage

annuity.pv(rate, n.periods = Inf, instalment = 1,
             terminal.payment = 0, immediate.start = FALSE, cf.freq = 1,
             comp.freq = 1)

annuity.fv(rate, n.periods = Inf, instalment = 1,
             terminal.payment = 0, immediate.start = FALSE, cf.freq = 1,
             comp.freq = 1)

annuity.instalment(rate, n.periods = Inf, pv = if (missing(fv)) 1 else 0,
                   fv = 0, terminal.payment = 0, immediate.start = FALSE,
                   cf.freq = 1, comp.freq = 1)

annuity.periods(rate, instalment = 1, pv = if (missing(fv)) 1 else 0,
                 fv = 0, terminal.payment = 0, immediate.start = FALSE,
                 cf.freq = 1, comp.freq = 1, round2int.digits = 3)

annuity.rate(n.periods = Inf, instalment = 1, pv = if (missing(fv)) 1
             else 0, fv = 0, terminal.payment = 0, immediate.start = FALSE,
             cf.freq = 1, comp.freq = 1)

annuity.instalment.breakup(rate, n.periods = Inf, pv = 1,
                           immediate.start = FALSE, cf.freq = 1, comp.freq = 1,
                           period.no = 1)

Arguments

rate The interest rate in decimal (0.10 or 10e-2 for 10%)
n.periods The number of periods in the annuity.
instalment The instalment (cash flow) per period.
terminal.payment Any cash flow at the end of the annuity. For example, a bullet repayment at maturity of the unamortized principal.
immediate.start Logical variable which is TRUE for immediate annuities (the first instalment is due immediately) and FALSE for deferred annuities (the first instalment is due at the end of the first period).
annuity

**cf.freq**
Frequency of annuity payments: 1 for annual, 2 for semi-annual, 12 for monthly.

**comp.freq**
Frequency of compounding of interest rates: 1 for annual, 2 for semi-annual, 12 for monthly, Inf for continuous compounding.

**pv**
The present value of all the cash flows including the terminal payment.

**fv**
The future value (at the end of the annuity) of all the cash flows including the terminal payment.

**round2int.digits**
Used only in `annuity.periods`. If the computed number of periods is an integer when rounded to `round2int.digits`, then the rounded integer value is returned. With the default value of 3, 9.9996 is returned as 10, but 9.9994 and 9.39999999 are returned without any rounding.

**period.no**
Used only in `annuity.instalment.breakup`. This is the period for which the instalment needs to be broken up into principal and interest parts.

### Details

These functions are based on the Present Value relationship:

\[ pv = fv \cdot df = terminal.payment \cdot df + \frac{instalment(1 - df)}{r} \]

where \( df = (1 + r)^{-n.periods} \) is the \( n.periods \) discount factor and \( r \) is the per period interest rate computed using rate, cf.freq and comp.freq.

It is intended that only one of \( pv \) or \( fv \) is used in any function call, but internally the functions use \( pv + fv \cdot df \) as the LHS of the present value relationship under the assumption that only of the two is non zero.

The function `annuity.instalment.breakup` regards the annuity as a repayment of a loan equal to \( pv \) plus the present value of `terminal.payment`. The instalment paid in period `period.no` is broken up into the principal repayment (amortization) and interest components.

### Value

For most functions, the return value is one of the arguments described above. For example `annuity.pv` returns \( pv \). The only exception is `annuity.instalment.breakup`. This returns a list with the following components:

- **opening.principal**
  The principal balance at the beginning of the period

- **closing.principal**
  The principal balance at the end of the period

- **interest.part**
  The portion of the instalment which represents interest

- **principal.part**
  The portion of the instalment which represents principal repayment

### Author(s)

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bisection.root  Find zero of a function by bracketing the zero and then using bisection.

Description
Tries to find the zero of a function by using the bisection method (\text{\texttt{uniroot}}). To call \text{\texttt{uniroot}}, the zero must be bracketed by finding two points at which the function value has opposite signs. The main code in this function is a grid search to find such a pair of points. A geometric grid of points between lower and guess and also between guess and upper. This grid is searched for two neighbouring points across which the function changes sign. This brackets the root, and then we try to locate the root by calling \text{\texttt{uniroot}}.

Usage

\begin{verbatim}
\texttt{bisection.root(f, guess, lower, upper, nstep = 100, toler = 1e-06)}
\end{verbatim}

Arguments
\begin{itemize}
\item \texttt{f} The function whose zero is to be found. An R function object that takes one numeric argument and returns a numeric value. In an IRR application, this will be the NPV function. In an implied volatility application, the value will be the option price.
\item \texttt{guess} The starting value (guess) from which the solver starts searching for the root. Must be positive.
\item \texttt{lower} The lower end of the interval within which to search for the root. Must be positive.
\item \texttt{upper} The upper end of the interval within which to search for the root. Must be positive.
\item \texttt{nstep} The number of steps in the grid search to bracket the zero. See details.
\item \texttt{toler} The criterion to determine whether a zero has been found. This is passed on to \text{\texttt{uniroot}}.
\end{itemize}

Value
The root (or NA if the method fails)

Author(s)
Prof. Jayanth R. Varma
Description

bond.price computes the price given the yield to maturity bond.duration computes the duration given the yield to maturity bond.yield computes the yield to maturity given the price, bond.duration and bond.yield are wrapper functions that use mapply to vectorize bond.price, bond.duration and bond.yield All arguments to bond.prices, bond.durations and bond.yields can be vectors. On the other hand, bond.price, bond.duration and bond.yield do not allow vectors Standard compounding and day count conventions are supported for all functions.

Usage

bond.price(settle, mature, coupon, freq = 2, yield,
            convention = c("30/360", "ACT/ACT", "ACT/360", "30/360E"),
            comp.freq = freq, redemption_value = 100)

bond.yield(settle, mature, coupon, freq = 2, price,
           convention = c("30/360", "ACT/ACT", "ACT/360", "30/360E"),
           comp.freq = freq, redemption_value = 100)

bond.duration(settle, mature, coupon, freq = 2, yield,
              convention = c("30/360", "ACT/ACT", "ACT/360", "30/360E"),
              modified = FALSE, comp.freq = freq, redemption_value = 100)

bond.TCF(settle, mature, coupon, freq = 2, convention = c("30/360", "ACT/ACT", "ACT/360", "30/360E"),
         redemption_value = 100)

bond.prices(settle, mature, coupon, freq = 2, yield,
            convention = c("30/360", "ACT/ACT", "ACT/360", "30/360E"),
            comp.freq = freq, redemption_value = 100)

bond.yields(settle, mature, coupon, freq = 2, price,
           convention = c("30/360", "ACT/ACT", "ACT/360", "30/360E"),
           comp.freq = freq, redemption_value = 100)

bond.durations(settle, mature, coupon, freq = 2, yield,
               convention = c("30/360", "ACT/ACT", "ACT/360", "30/360E"),
               modified = FALSE, comp.freq = freq, redemption_value = 100)

Arguments

- settle: The settlement date for which the bond is traded. Can be a character string or any object that can be converted into date using as.Date.
- mature: The maturity date of the bond. Can be a character string or any object that can be converted into date using as.Date.
coupons

**coupons**

- **coupon**  The coupon rate in decimal (0.10 or 10e-2 for 10%)
- **freq**  The frequency of coupon payments: 1 for annual, 2 for semi-annual, 12 for monthly.
- **yield**  The yield to maturity of the bond
- **convention**  The daycount convention
- **comp.freq**  The frequency of compounding of the bond yield: 1 for annual, 2 for semi-annual, 12 for monthly. Usually same as freq.
- **redemption_value**  The principal amount that the bond will pay on maturity or call. Typically necessary when the bond is expected to be called at premium to par.
- **price**  The clean price of the bond.
- **modified**  A logical value used in duration. TRUE to return Modified Duration, FALSE otherwise

**Value**

bond.TCF returns a list of three components

- **t**  A vector of cash flow dates in number of years
- **cf**  A vector of cash flows
- **accrued**  The accrued interest

**Author(s)**

Prof. Jayanth R. Varma <jrvarma@iima.ac.in>

---

**Description**

Convenience functions for finding coupon dates and number of coupons of a bond.

**Usage**

- `coupons.dates(settle, mature, freq = 2)`
- `coupons.n(settle, mature, freq = 2)`
- `coupons.next(settle, mature, freq = 2)`
- `coupons.prev(settle, mature, freq = 2)`
Arguments

**settle** The settlement date for which the bond is traded. Can be a character string or any object that can be converted into date using `as.Date`.

**mature** The maturity date of the bond. Can be a character string or any object that can be converted into date using `as.Date`.

**freq** The frequency of coupon payments: 1 for annual, 2 for semi-annual, 12 for monthly.

Author(s)

Prof. Jayanth R. Varma <jrvarma@iima.ac.in>

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**daycount**  
*Day count and year fraction for bond pricing*

Description

Implements 30/360, ACT/360, ACT/360 and 30/360E day count conventions.

Usage

```r
yearFraction(d1, d2, r1, r2, freq = 2, convention = c("30/360", "ACT/ACT", "ACT/360", "30/360E"))

daycount.actual(d1, d2, variant = c("bond"))

daycount.30.360(d1, d2, variant = c("US", "EU", "IT"))
```

Arguments

- **d1** The starting date of period for day counts
- **d2** The ending date of period for day counts
- **r1** The starting date of reference period for ACT/ACT day counts
- **r2** The ending date of reference period for ACT/ACT day counts
- **freq** The frequency of coupon payments: 1 for annual, 2 for semi-annual, 12 for monthly.
- **convention** The daycount convention
- **variant** Three variants of the 30/360 convention are implemented, but only one variant of ACT/ACT is currently implemented

Author(s)

Prof. Jayanth R. Varma <jrvarma@iima.ac.in>

References

The 30/360 day count was converted from C++ code in the QuantLib library.
duration

**Description**
Computes Duration and Modified Duration for cash flows with different cash flow and compounding conventions. Cash flows need not be evenly spaced.

**Usage**
duration(cf, rate, cf.freq = 1, comp.freq = 1, cf.t = seq(from = 
  ifelse(immediate.start, 0, 1/cf.freq), by = 1/cf.freq, along.with = cf),
  immediate.start = FALSE, modified = FALSE)

**Arguments**
- **cf** Vector of cash flows
- **rate** The interest rate in decimal (0.10 or 10e-2 for 10%)
- **cf.freq** Frequency of annuity payments: 1 for annual, 2 for semi-annual, 12 for monthly.
- **comp.freq** Frequency of compounding of interest rates: 1 for annual, 2 for semi-annual, 12 for monthly, Inf for continuous compounding.
- **cf.t** Optional vector of timing (in years) of cash flows. If omitted regular sequence of years is assumed.
- **immediate.start** Logical variable which is TRUE when the first cash flows is at the beginning of the first period (for example, immediate annuities) and FALSE when the first cash flows is at the end of the first period (for example, deferred annuities)
- **modified** in function duration, TRUE if modified duration is desired. FALSE otherwise.

edate

**Description**
Convenience function for finding the same date in different months. Used for example to find coupon dates of bonds given the maturity date. See coupons

**Usage**
edate(from, months = 1)

**Arguments**
- **from** starting date - a character string or any object that can be converted into date using as.Date.
- **months** Number of months (can be negative)
equiv.rate  

**Equivalent Rates under different Compounding Conventions**

**Description**

Converts an interest rate from one compounding convention to another (for example from semi-annual to monthly compounding or from annual to continuous compounding)

**Usage**

equiv.rate(rate, from.freq = 1, to.freq = 1)

**Arguments**

- **rate**: The interest rate in decimal (0.10 or 10e-2 for 10%)
- **from.freq**: Frequency of compounding of the given interest rate: 1 for annual, 2 for semi-annual, 12 for monthly, Inf for continuous compounding.
- **to.freq**: Frequency of compounding to which the given interest rate is to be converted: 1 for annual, 2 for semi-annual, 12 for monthly, Inf for continuous compounding.

GenBS  

**Generalized Black Scholes model for pricing vanilla European options**

**Description**

Compute values of call and put options as well as the Greeks - the sensitivities of the option price to various input arguments using the Generalized Black Scholes model. "Generalized" means that the asset can have a continuous dividend yield.

**Usage**

GenBS(s, X, r, Sigma, t, div_yield = 0)

**Arguments**

- **s**: the spot price of the asset (the stock price for options on stocks)
- **X**: the exercise or strike price of the option
- **r**: the continuously compounded rate of interest in decimal (0.10 or 10e-2 for 10%) (use equiv.rate to convert to a continuously compounded rate)
- **Sigma**: the volatility of the asset price in decimal (0.20 or 20e-2 for 20%)
- **t**: the maturity of the option in years
- **div_yield**: the continuously compounded dividend yield (0.05 or 5e-2 for 5%) (use equiv.rate to convert to a continuously compounded rate)
Details

The Generalized Black Scholes formula for call options is

\[ e^{-rt}(s e^{gt} \ N(d1) - X \ N(d2)) \]

where

\[ g = r - \text{div} \text{ yield} \]
\[ N(d1) = N(d1) \text{ and } N(d2) = N(d2) \]
\[ d1 = \frac{\log(s/X) + (g + \Sigma^2/2)t}{\Sigma \sqrt{t}} \]
\[ d2 = d1 - \Sigma \sqrt{t} \]

\( N \) denotes the normal CDF (\texttt{pnorm})

For put options, the formula is

\[ e^{-rt}(-s e^{gt} \ Nminus(d1) + X \ Nminus(d2)) \]

where

\[ Nminus(d1) = N(-d1) \text{ and } Nminus(d2) = N(-d2) \]

Value

A list of the following elements

call the value of a call option
put the value of a put option
Greeks a list of the following elements
GreeksdcallDelta the delta of a call option - the sensitivity to the spot price of the asset
GreeksdputDelta the delta of a put option - the sensitivity to the spot price of the asset
GreeksdcallTheta the theta of a call option - the time decay of the option value with passage of time. Note that time is measured in years. To find a daily theta divided by 365.
GreeksdputTheta the theta of a put option
GreeksdGamma the gamma of a call or put option - the second derivative with respect to the spot price or the sensitivity of delta to the spot price
GreeksdVega the vega of a call or put option - the sensitivity to the volatility
GreeksdcallRho the rho of a call option - the sensitivity to the interest rate
GreeksdputRho the rho of a put option - the sensitivity to the interest rate
extra a list of the following elements
extra$d1 the d1 of the Generalized Black Scholes formula
extra$d2 the d2 of the Generalized Black Scholes formula
extra$Nd1 is \texttt{pnorm(d1)}
extra$Nd2 is \texttt{pnorm(d2)}
extra$Nminusd1 is \texttt{pnorm(-d1)}
extra$Nminusd2 is \texttt{pnorm(-d2)}
extra$callProb the (risk neutral) probability that the call will be exercised = \texttt{Nd2}
extra$putProb the (risk neutral) probability that the put will be exercised = \texttt{Nminusd2}
GenBSImplied  

Generalized Black Scholes model implied volatility

Description

Find implied volatility given the option price using the generalized Black Scholes model. "Generalized" means that the asset can have a continuous dividend yield.

Usage

GenBSImplied(s, X, r, price, t, div_yield, PutOpt = FALSE,
      toler = 1e-06, max.iter = 100, convergence = 1e-08)

Arguments

s  the spot price of the asset (the stock price for options on stocks)
X  the exercise or strike price of the option
r  the continuously compounded rate of interest in decimal (0.10 or 10e-2 for 10%)
    (use equiv.rate to convert to a continuously compounded rate)
price  the price of the option
t  the maturity of the option in years
div_yield  the continuously compounded dividend yield (0.05 or 5e-2 for 5%) (use equiv.rate
    to convert to a continuously compounded rate)
PutOpt  TRUE for put options, FALSE for call options
toler  passed on to newton.raphson.root The implied volatility is regarded as cor-
      rect if the solver is able to match the option price to within less than toler.
      Otherwise the function returns NA
max.iter  passed on to newton.raphson.root
convergence  passed on to newton.raphson.root

Details

GenBSImplied calls newton.raphson.root and if that fails uniroot
**irr**

**Internal Rate of Return**

**Description**

Computes IRR (Internal Rate of Return) for cash flows with different cash flow and compounding conventions. Cash flows need not be evenly spaced.

**Usage**

```r
irr(cf, interval = NULL, cf.freq = 1, comp.freq = 1,
    cf.t = seq(from = 0, by = 1/cf.freq, along.with = cf),
    r.guess = NULL, toler = 1e-06, convergence = 1e-08,
    max.iter = 100, method = c("default", "newton", "bisection"))
```

**Arguments**

- `cf`: Vector of cash flows
- `interval`: the interval (lower, upper) within which to search for the IRR
- `cf.freq`: Frequency of annuity payments: 1 for annual, 2 for semi-annual, 12 for monthly.
- `comp.freq`: Frequency of compounding of interest rates: 1 for annual, 2 for semi-annual, 12 for monthly, Inf for continuous compounding.
- `cf.t`: Optional vector of timing (in years) of cash flows. If omitted regular sequence of years is assumed.
- `r.guess`: the starting value (guess) from which the solver starts searching for the IRR
- `toler`: the argument toler for `irr.solve`. The IRR is regarded as correct if abs(NPV) is less than toler. Otherwise the `irr` function returns NA
- `convergence`: the argument convergence for `irr.solve`
- `max.iter`: the argument max.iter for `irr.solve`
- `method`: The root finding method to be used. The default is to try Newton-Raphson method (`newton.raphson.root`) and if that fails to try bisection (`bisection.root`). The other two choices (newton and bisection force only one of the methods to be tried.

**irr.solve**

*Solve for IRR (internal rate of return) or YTM (yield to maturity)*

**Description**

This function computes the internal rate of return at which the net present value equals zero. It requires as input a function that computes the net present value of a series of cash flows for a given interest rate as well as the derivative of the NPV with respect to the interest rate (10,000 times this derivative is the PVBP or DV01). In this package, `irr.solve` is primarily intended to be called by the `irr` and `bond.yield` functions. It is made available for those who want to find IRR of more complex instruments.
Usage

irr.solve(f, interval = NULL, r.guess = NULL, toler = 1e-06, convergence = 1e-08, max.iter = 100, method = c("default", "newton", "bisection"))

Arguments

f
The function whose zero is to be found. An R function object that takes one
numeric argument and returns a list of two components (value and gradient). In
the IRR applications, these two components will be the NPV and its derivative
interval
The interval c(lower, upper) within which to search for the IRR
r.guess
The starting value (guess) from which the solver starts searching for the IRR
toler
The argument toler to newton.raphson.root. The IRR is regarded as correct
if abs(NPV) is less than toler. Otherwise the irr.solve returns NA
convergence
The argument convergence to newton.raphson.root.
max.iter
The maximum number of iterations of the Newton-Raphson procedure
method
The root finding method to be used. The default is to try Newton-Raphson
method (newton.raphson.root) and if that fails to try bisection (bisection.root).
The other two choices (newton and bisection force only one of the methods
to be tried.

Details

The function irr.solve is basically an interface to the general root finder newton.raphson.root. However, if newton.raphson.root fails, irr.solve makes an attempt to find the root using uniroot from the R stats package. Uniroot uses bisection and it requires the root to be bracketed (the function must be of opposite sign at the two end points - lower and upper).

Value

The function irr.solve returns NA if the IRR/YTM could not be found. Otherwise it returns the IRR/YTM. When NA is returned, a warning message is printed

Author(s)

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newton.raphson.root
A Newton Raphson root finder: finds x such that f(x) = 0

Description

The function newton.raphson.root is a general root finder which can find the zero of any function whose derivative is available. In this package, it is called by irr.solve and by GenBSImplied. It can be used in other situations as well - see the examples below.
Usage

newton.raphson.root(f, guess = 0, lower = -Inf, upper = Inf, 
max.iter = 100, toler = 1e-06, convergence = 1e-08)

Arguments

f The function whose zero is to be found. An R function object that takes one numeric argument and returns a list of two components (value and gradient). In an IRR application, these two components will be the NPV and the DV01/10000. In an implied volatility application, the components will be the option price and the vega. See also the examples below

guess The starting value (guess) from which the solver starts searching for the IRR

lower The lower end of the interval within which to search for the root

upper The upper end of the interval within which to search for the root

max.iter The maximum number of iterations of the Newton-Raphson procedure

toler The criterion to determine whether a zero has been found. If the value of the function exceeds toler in absolute value, then NA is returned with a warning

convergence The relative tolerance threshold used to determine whether the Newton-Raphson procedure has converged. The procedure terminates when the last step is less than convergence times the current estimate of the root. Convergence can take place to a non zero local minimum. This is checked using the toler criterion below

Value

The function returns NA under either of two conditions: (a) the procedure did not converge after max.iter iterations, or (b) the procedure converged but the function value is not zero within the limits of toler at this point. The second condition usually implies that the procedure has converged to a non zero local minimum from which there is no downhill gradient.

If the iterations converge to a genuine root (within the limits of toler), then it returns the root that was found.

References

The Newton Raphson solver was converted from C++ code in the Boost library

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npv  Net Present Value

Description

Computes NPV (Net Present Value) for cash flows with different cash flow and compounding conventions. Cash flows need not be evenly spaced.
Usage

```r
npv(cf, rate, cf.freq = 1, comp.freq = 1, cf.t = seq(from = if (immediate.start) 0 else 1/cf.freq, by = 1/cf.freq, along.with = cf), immediate.start = FALSE)
```

Arguments

- **cf**: Vector of cash flows
- **rate**: The interest rate in decimal (0.10 or 10e-2 for 10%)
- **cf.freq**: Frequency of annuity payments: 1 for annual, 2 for semi-annual, 12 for monthly.
- **comp.freq**: Frequency of compounding of interest rates: 1 for annual, 2 for semi-annual, 12 for monthly, Inf for continuous compounding.
- **cf.t**: Optional vector of timing (in years) of cash flows. If omitted regular sequence of years is assumed.
- **immediate.start**: Logical variable which is TRUE when the first cash flows is at the beginning of the first period (for example, immediate annuities) and FALSE when the first cash flows is at the end of the first period (for example, deferred annuities)
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