# Package 'AmericanCallOpt'

February 19, 2015

**Type** Package

**Title** This package includes pricing function for selected American call options with underlying assets that generate payouts.

**Version** 0.95

**Date** 2012-03-02

**Author** Paolo Zagaglia

**Maintainer** Paolo Zagaglia <paolo.zagaglia@gmail.com>

**Depends** R (>= 2.0.0)

**Description** This package includes a set of pricing functions for American call options. The following cases are covered: Pricing of an American call using the standard binomial approximation; Hedge parameters for an American call with a standard binomial tree; Binomial pricing of an American call with continuous payout from the underlying asset; Binomial pricing of an American call with an underlying stock that pays proportional dividends in discrete time; Pricing of an American call on futures using a binomial approximation; Pricing of a currency futures American call using a binomial approximation; Pricing of a perpetual American call. The user should kindly notice that this material is for educational purposes only. The codes are not optimized for computational efficiency as they are meant to represent standard cases of analytical and numerical solution.

**License** GPL-3

**Repository** CRAN

**Date/Publication** 2012-03-04 15:32:00

**NeedsCompilation** no

# R topics documented:

---

AmericanCallOpt-package

*Pricing of selected American call options with payoff from the underlying asset*

---

## Description

This package includes pricing function for selected American call options with underlying assets that generate payouts. The functions cover the cases of binomial pricing for American options with continuous payout from the underlying asset or commodity and with an underlying stock that pays proportional dividends in discrete t. There are also functions for American calls on futures using a binomial approximation, for futures currency option using a binomial approximation, and for American perpetual call options. Each type of option is dealt with in a corresponding R function.

## Details

|           |                 |
|-----------|-----------------|
| Package:  | AmericanCallOpt |
| Type:     | Package         |
| Version:  | 0.95            |
| Date:     | 2012-03-02      |
| License:  | GPL-3           |

This package includes a set of pricing functions for American call options. The following cases are covered: (1) Pricing of American call option using the standard binomial approximation; (2) Hedge parameters for an American call option with a standard binomial tree; (3) Binomial pricing of American option with continuous payout from the underlying asset; (4) Binomial pricing of American option with an underlying stock that pays proportional dividends in discrete time; (5) Pricing of American call option on futures using a binomial approximation; (6) Pricing of futures currency option using a binomial approximation; (7) Pricing of American perpetual call option. The user should kindly notice that this material is for educational purposes only. The codes are not optimized for computational efficiency as they are meant to represent standard cases of analytical and numerical solution.

## Author(s)

Paolo Zagaglia

Maintainer: Paolo Zagaglia <paolo.zagaglia@gmail.com>

**References**

John Hull, "Options, Futures and other Derivative Securities", Prentice-Hall, second edition, 1993.

**Examples**

```
#---------------------------------------------------------------------------
#
#  Example program for pricing different American call options using
#  alternative methods
#
#  IMPORTANT:
#  These programs are educational purpose only. The codes are not
#  optimized for computational efficiency as they are meant to
#  represent standard cases of anaytical and numerical solution.
#
#---------------------------------------------------------------------------


rm(list=ls())


#---------------------------------------------------------------------------
# Price of American call option using a binomial approximation
S<-100
K<-100
r<-0.1
sigma<-0.25
t<-1
steps<-100

call_price_am_bin<-am_call_bin(S, K, r, sigma, t, steps)
#---------------------------------------------------------------------------


#---------------------------------------------------------------------------
# Hedge parameters for an American call option using a binomial tree
S<-100
K<-100
r<-0.1
sigma<-0.25
t<-1.0
steps<-100

hedge<-am_call_partials(S, K, r, sigma, t, steps)
#---------------------------------------------------------------------------


#---------------------------------------------------------------------------
# Binomial American option price with continous payout from the
# underlying commodity
S<-100
K<-100
```

```
r<-0.10
y<-0.02
sigma<-0.25
t<-1
steps<-100

call_price_bin_contpay<-am_call_bin_contpay(S, K, r, y, sigma, t, steps)
#-----------------------------------------------------------------------------


#-----------------------------------------------------------------------------
# Binomial price of an American option with an underlying stock that
# pays proportional dividends in discrete t
S<-100
K<-100
r<-0.10
sigma<-0.25
t<-1
steps<-100
dividend_times<-matrix( c(0.25, 0.75) )
dividend_yields<-matrix( c(0.025, 0.025) )

call_price_bin_propdiv<-am_call_bin_propdiv(S, K, r, sigma, t,
steps, dividend_times, dividend_yields)
#-----------------------------------------------------------------------------


#-----------------------------------------------------------------------------
# Pricing an american call option on futures using a binomial approximation
F<-50
K<-45
r<-0.08
sigma<-0.2
t<-0.5
steps<-100

call_price_bin_futures<-am_call_bin_futures(F, K, r, sigma, t, steps)
#-----------------------------------------------------------------------------


#-----------------------------------------------------------------------------
# Pricing a futures currency option using a binomial approximation
S<-50
K<-52
r<-0.08
r_f<-0.05
sigma<-0.2
t<-0.5
steps<-100

call_price_bin_currency<-am_call_bin_currency(S, K, r, r_f, sigma, t, steps)
#-----------------------------------------------------------------------------
```

```
#-------------------------------------------------------------------------
# Price for an American perpetual call option
S<-50.0
K<-40.0
r<-0.05
y<-0.02
sigma<-0.05

call_price_perpetual<-am_call_perpetual(S, K, r, y, sigma)
#-------------------------------------------------------------------------
```

---

am_call_bin                    *Binomial pricing of a standard American call*

---

### Description

Pricing of American call option using a binomial approximation

### Usage

```
am_call_bin(S, K, r, sigma, t, steps)
```

### Arguments

| | |
|---|---|
| S | spot price |
| K | exercise price |
| r | risk-free interest rate |
| sigma | volatility |
| t | time to maturity |
| steps | number of steps in binomial tree |

### Details

The valuation problem of an American option is not trivial because, due to the payoff structure, it may be optimal to use (exercise) the option before the final date. This optimal exercise policy will affect the value of the option. However, the exercise policy is not known. There is therefore no general analytical solution for American options. There are some special cases, though. For American call options on assets that do not have any payouts, the American call price is the same as the European one, since the optimal exercise policy is to not exercise.

Allowing for the possibility of early exercise of American options makes binomial approximations useful from a valuation perspective. At each node we calculate the value of the option as a function of prices in the subsequent periods. At each point in time, we check for the value exercising of exercising the option.

In the application presented in this package, I use a binomial tree. To find the option price, the algorithm rolls backwards starting from the final node. At node t, it calculate the call price as a function of two possible outcomes at time t+1.

## Value

call_price        Option price

## Author(s)

Paolo Zagaglia, paolo.zagaglia@gmail.com

## References

John Hull, "Options, Futures and other Derivative Securities", Prentice-Hall, second edition, 1993.

## Examples

```
rm(list=ls())

S<-100
K<-100
r<-0.1
sigma<-0.25
t<-1
steps<-100

call_price_am_bin<-am_call_bin(S, K, r, sigma, t, steps)
```

---

am_call_bin_contpay        *Binomial option price with continuous payout from the underlying asset*

---

## Description

Pricing of an American call option with continuous payout from the underlying asset using a binomial approximation

## Usage

```
am_call_bin_contpay(S, K, r, y, sigma, t, steps)
```

## Arguments

S                 spot price
K                 exercise price
r                 risk-free interest rate
y                 continuous payout

| sigma | volatility |
|-------|------------|
| t | time to maturity |
| steps | number of steps in binomial tree |

## Details

With this type of option, the underlying asset provides payouts at each period in time. The payoff structure simplifies the computation to a major extent and makes this a case similar to the one of pricing through Black-Scholes.

## Value

| call_price | Option price |
|------------|--------------|

## Author(s)

Paolo Zagaglia, paolo.zagaglia@gmail.com

## References

John Hull, "Options, Futures and other Derivative Securities", Prentice-Hall, second edition, 1993.

## Examples

```
rm(list=ls())

S<-100
K<-100
r<-0.10
y<-0.02
sigma<-0.25
t<-1
steps<-100

call_price_bin_contpay<-am_call_bin_contpay(S, K, r, y, sigma, t, steps)
```

---

am_call_bin_currency    *Binomial pricing of an American call on currency futures*

---

## Description

Pricing of currency futures American option using a binomial approximation

## Usage

```
am_call_bin_currency(S, K, r, r_f, sigma, t, steps)
```

## Arguments

| | |
|---|---|
| S | spot price |
| K | exercice price |
| r | domestic interest rate |
| r_f | foreign interest rate |
| sigma | volatility |
| t | time to maturity |
| steps | number of steps in binomial tree |

## Details

American options written on foreign currencies are priced using a standard binomial tree. The notable point is that early exercise is driven by the difference between national interest rates.

## Value

| | |
|---|---|
| call_price | Option price |

## Author(s)

Paolo Zagaglia, paolo.zagaglia@gmail.com

## References

John Hull, "Options, Futures and other Derivative Securities", Prentice-Hall, second edition, 1993.

## Examples

```
rm(list=ls())

S<-50
K<-52
r<-0.08
r_f<-0.05
sigma<-0.2
t<-0.5
steps<-100

call_price_bin_currency<-am_call_bin_currency(S, K, r, r_f, sigma, t, steps)
```

---

am_call_bin_futures      *Binomial pricing of a futures American call*

---

## Description

Pricing of American call option on futures using a binomial approximation

## Usage

```
am_call_bin_futures(F, K, r, sigma, t, steps)
```

## Arguments

| | |
|---|---|
| F | price of futures contract |
| K | exercise price |
| r | risk-free interest rate |
| sigma | volatility |
| t | time to maturity |
| steps | number of steps in binomial tree |

## Value

| | |
|---|---|
| call_price | Option price |

## Author(s)

Paolo Zagaglia, paolo.zagaglia@gmail.com

## References

John Hull, "Options, Futures and other Derivative Securities", Prentice-Hall, second edition, 1993.

## Examples

```
rm(list=ls())

F<-50
K<-45
r<-0.08
sigma<-0.2
t<-0.5
steps<-100

call_price_bin_futures<-am_call_bin_futures(F, K, r, sigma, t, steps)
```

---

| am_call_bin_propdiv | *Binomial price of an American call with an underlying stock that pays proportional dividends* |

---

### Description

Pricing of an American call stock option that pays proportional dividends

### Usage

```
am_call_bin_propdiv(S, K, r, sigma, t, steps,
                    dividend_times, dividend_yields)
```

### Arguments

| | |
|---|---|
| S | spot price |
| K | exercice price |
| r | interest rate |
| sigma | volatility |
| t | time to maturity |
| steps | number of steps in binomial tree |
| dividend_times | periods when dividend is paid out |
| dividend_yields | |
| | dividend yields in each period |

### Details

If the underlying asset is a stock paying dividends during the maturity of the option, the terms of the option are not adjusted to reflect this cash payment, which means that the option value will reflect the dividend payments. In the binomial model, the adjustment for dividends depends on whether the dividends are discrete or proportional. In this R package, we deal with the second case. To address this issue, we multiply the stock prices at the ex-dividend date by an adjustment term. Since the structure of the adjusted payoffs along the binomial tree is standard, we can again compute option price backward starting from the final states.

### Value

| | |
|---|---|
| call_price | Option price |

### Author(s)

Paolo Zagaglia, paolo.zagaglia@gmail.com

### References

John Hull, "Options, Futures and other Derivative Securities", Prentice-Hall, second edition, 1993.

## Examples

```
rm(list=ls())

S<-100
K<-100
r<-0.10
sigma<-0.25
t<-1
steps<-100
dividend_times<-matrix(c(0.25, 0.75))
dividend_yields<-matrix(c(0.025, 0.025))

call_price_bin_propdiv<-am_call_bin_propdiv(S, K, r, sigma, t, steps,
 dividend_times, dividend_yields)
```

---

am_call_partials            *Hedge parameters of a standard American call option using a bino-mial tree*

---

## Description

Partials of an American call option using a binomial approximation

## Usage

```
am_call_partials(S, K, r, sigma, t, steps)
```

## Arguments

| | |
|---|---|
| S | spot price |
| K | exercise price |
| r | risk-free interest rate |
| sigma | volatility |
| t | time to maturity |
| steps | number of steps in binomial tree |

## Details

The binomial method provides for techniques to approximate the partials of a derivative instrument. The computation of the partials for the binomial tree used in this package is discussed by Hull (2006).

## Value

| | |
|---|---|
| `hedge$delta` | partial with respect to S |
| `hedge$gamma` | second partial with respect to S |
| `hedge$theta` | partial with respect to time |
| `hedge$vega` | partial with respect to sigma |
| `hedge$rho` | partial with respect to r |

## Author(s)

Paolo Zagaglia, paolo.zagaglia@gmail.com

## References

John Hull, "Options, Futures and Other Derivatives", Prentice-Hall, Sixth Edition, 2006.

## Examples

```
rm(list=ls())

S<-100
K<-100
r<-0.1
sigma<-0.25
t<-1.0
steps<-100

hedge<-am_call_partials(S, K, r, sigma, t, steps)
```

---

| am_call_perpetual | *Analytical pricing of an American perpetual call* |
|---|---|

---

## Description

Pricing of an American perpetual call option using an analytical formula

## Usage

```
am_call_perpetual(S, K, r, y, sigma)
```

## Arguments

| | |
|---|---|
| S | spot price |
| K | exercise price |
| r | risk-free interest rate |
| y | dividend yield from underlying asset |
| sigma | volatility |

## Details

A perpetual option is one with no maturity date. This obviously applies only to the case of American-style options. Analytical formulas are available in this case both for call and put options.

## Value

`call_price`      Option price

## Author(s)

Paolo Zagaglia, paolo.zagaglia@gmail.com

## References

John Hull, "Options, Futures and other Derivative Securities", Prentice-Hall, second edition, 1993.

## Examples

```
rm(list=ls())

S<-50.0
K<-40.0
r<-0.05
y<-0.02
sigma<-0.05

call_price_perpetual<-am_call_perpetual(S, K, r, y, sigma)
```

# Index