SIMULATION OF BARRIER OPTIONS

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В статье рассматривается модель барьерного опциона, созданная из стандартных блоков пакета Simulink с использованием заданной платежной функции инновационного финансового инструмента

There are so-called exotic non-standard options that are traded on the financial market. Exotic options always include additional conditions unlike standard options. These conditions usually involve prehistory of prices and affect the premium.

The most popular options are the barrier options which differ in three main features: purchase options or sale options (*call/put*); options have the upper or lower position of the barrier relative to the initial price (*upper/down*); options are turned on or off when reaching the barrier (*in/out*). Since each attribute can take two values the result is eight goals.

For option *up-in-call* buyer is entitled to buy the underlying asset at the time of execution T at a price K if the price of it exceeded the level U up to this in this case point. This level is always higher than the initial price. Payoff function has the form in this case: $b\ (S_T - K)^+$ where b – binary variable which takes the value 1 if max $S_t > U$ и 0 if this condition is not fulfilled.

For option *up-out-call* the buyer has the right at the moment T to buy the underlying asset at a price K If up to this point the price of it does not exceed the level U. Payoff function has the same form in this case and a binary variable b assumes the value 1 if $max\ S_t < U$ and 0 if this condition is not fulfilled. Likewise payoff functions determined for other types of barrier options which are given in table 1 where the lower boundary is shown by the letter D.

Table 1 – Payoff functions of barrier options

Option type	Payoff functions (*units Add and max*)	Condition (*unit Relational operator*)
Up-in-call	$b\ (S_T - K)^+$	$Max\ S_t > U$
Up-out-call	$b\ (S_T - K)^+$	$Max\ S_t < U$
Up-in-put	$b\ (K - S_T)^+$	$Max\ S_t > U$
Up-out-put	$b\ (K - S_T)^+$	$Max\ S_t < U$
Down-in-call	$b\ (S_T - K)^+$	$Min\ S_t < D$
Down-out-call	$b\ (S_T - K)^+$	$Min\ S_t > D$
Down-in-put	$b\ (K - S_T)^+$	$Min\ S_t < D$
Down-out-put	$b\ (K - S_T)^+$	$Min\ S_t > D$

If the option ceases to exist its owner depending on the terms of the contract or receives nothing or receives a fixed amount in the form of compensation.

Payoff function for a standard option *call* is $(S_T - K)^+$ and for the option *put* it is respectively $(K - S_T)^+$ where S_T – the market price of the asset at the date of execution; K – the exercise price. Superscript (+) means a positive value and is used instead of the formulas $max\ [(S_T - K), 0]$ or $max\ [(K - S_T), 0]$.

Behavior of a random process with respect to a given scope is determined by the properties of the process under consideration and is characterized by parameters that are the subject of the theory of random processes emissions [3]. Practical results obtained mainly for stationary processes that can be roughly classified many real processes. However the typical stock market processes are non-stationary and the lack of correlation between the levels of the time series does useless any methods to predict future values. The best share of coincidences for such processes is based on the assumption that tomorrow will be like yesterday. This paradox can be tested experimentally using the exponential smoothing method for predicting the dynamics of any stock market index. Therefore the theory of these processes is not sufficiently developed in terms of practical implementation.

Known formulas for the calculation of the cost of exotic options are cause despondency because each occupies almost half of the page but it works only within a certain range depending on the ratio of the barrier level and the exercise price. The practical application of these relationships can't be out of the question because even entering formulas in spreadsheets turns into a problem. In addition when creating innovations can't be in principle analytical relationships. Therefore we developed a model that allows instantly to getting the value of any option of eight options and this model allows creating many other kinds of options (*Figure 1*).

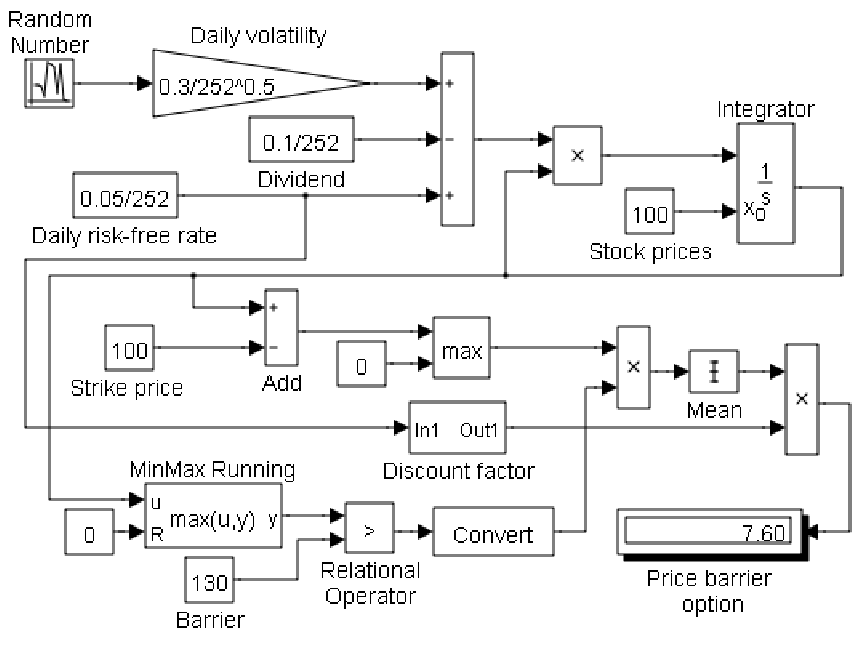

Figure 1 – Universal model of barrier options

Three units are used for manual control: adder *Add*, unit for calculating the extreme values of the trajectories implementations prices *MinMax Running*, calculation unit operation relations *Relational Operator* that compares the current values of the input variables. First operand in relational operators is the signal applied to the first (top) input block and the second operand is the signal applied to the second (bottom) input. The output signal of the block is *1* if the result of calculating the relationship is "*TRUE*" and *0* if the result is "*FALSE*". Each block has two practically realizable conditions therefore a combination of switching provides eight options barrier options (*Table 1*).

Input data for the model are given in conditional monetary units: market rate – *100*, exercise price – *100*, risk-free rate – *5%*, dividend rate – *10%*, annual volatility – *30%*, time prior to the option exercise – one year (*252* days). The display of *Figure 2* shows the value of the option *up-in-call* if the upper bound is *130* and the simulation time is one year. Under the scheme is easy to understand why the sum of the value of options type *in* and *out* is always equal to the value of the corresponding standard option. Unit *Convert* is designed only for data type conversion. Module outline Discount factor that is designed to reduce the size of the model is given in *Figure 2* where a given risk-free rate from the block Daily risk-free rate enters at the input *1*.

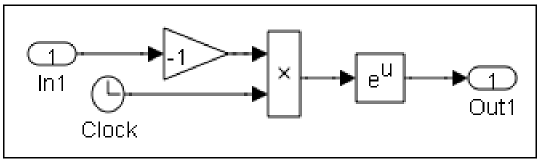

Figure 2 – Module of discounting factor

New options based on the above model can be created for example the simultaneous use of both borders that provided by the two units MinMax Running associated with one of the logical blocks *AND, OR*. Another way is to specify the functional dependence for one or both barriers in the form of speed, periodic, power or any other function of a set of building blocks library *Simulink.*

References

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