How to classify existing exotic options and design new ones?

Jian Wu, Wei Yu*

ABSTRACT

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Keywords: Options; traditional options; exotic options; classification of exotic options; basic exotic options; complicated exotic options.

Journal of Economic Literature Classification: G19.

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How to Classify Existing Exotic Options and Design New Ones?

ABSTRACT

Numerous exotic options have been tailor-made over the last twenty years to meet investors' specific needs. This article aims to propose an intelligible method for classifying the most commonly used exotic options. In fact, the proposed classification method is based on five conditions. Each of these conditions is met by traditional options, but not always by exotic ones. Options for which the same conditions are not met can be regrouped within the same class. In this way, all options, either traditional or exotic, can be assigned into one and only one of the thirty-two option classes. The proposed method has the advantage to enable 72 existing exotic options to be classified. It can also help to facilitate the design of new exotic instruments that are hitherto unexplored.

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1. INTRODUCTION

Options can be classified in different ways. Depending on whether the option gives the holder the right to buy or sell the underlying asset, "call options" are distinguished from "put options". According to whether this right is valid only at the maturity date, during only a part of the life period of the option, or during the whole life period of the option, "European options" (which can be exercised only at the maturity date) are distinguished from "Bermudan options" (which can be exercised at some times before the maturity date), or "American options" (which can be exercised at any date before the maturity date). Depending on whether the option is traded on an exchange or over the counter, "listed options" are distinguished from "OTC or private options". According to the nature of the underlying asset, "stock options" are distinguished from "index options", "interest-rate options", "currency options", "commodity options", "credit options", "insurance options", "climate options", and "electricity options". Finally, according to the mechanism of the option, "traditional or plain-vanilla options" are distinguished from "exotic options".

Tailor-made to fit investors' specific needs, most exotic options have appeared since the 1980s. Originally, the term "exotic" was used to describe "Asian options" first appearing in Tokyo, as Japan is perceived as a somewhat "exotic" country by the Western world. In 1991, Marc Rubinstein used the term "exotic options" in a working paper published at Berkeley (Rubinstein (1991a)). Since then, this expression has been used to describe all non-traditional options. Today, some exotic options are actively exchanged on the over-the-counter markets (which is the case of average options, barrier options, basket options, binary options, and multiple underlying assets options) or listed markets (which is the case of CAPs exchanged on the Chicago Board Options Exchange, spread options on the New York Mercantile Exchange, and quanto options on the American Stock Exchange), while others are added to firms' stock or bond issues to render these issues more attractive (for applications the framework of executive stock options, see Johnson& Tian (2000a)). The development of exotic options should not stop at its present stage, but rather should be driven forward, thanks chiefly to investors' different needs and the seemingly unlimited imagination of financial engineers.

Research on exotic options has been very active since the beginning of the 1990s. In spite of abundant literature devoted to this topic (Lyden (1996), Nelken (1996), Haug (1997), Zhang (1998), Lipton (2003)), as far as we know, there exists no definition for exotic options that is commonly accepted by professionals and/or researchers. As no definition exists, there is no widely accepted classification method. In fact, most authors writing books and/or articles on exotic options just present the existing products without giving a precise definition or trying to classify them, which is the case with Rubinstein (1991a). As a result, a certain number of confusions or misunderstandings exist. For example, many, including some specialists in this area, take wrongly American and Bermudan style options, having either traditional or non-traditional mechanisms, for exotic options.

Our objective here is not to propose a sophisticated model to price a certain type of exotic options, as do most specialists in this field. This article aims rather to propose a classification method covering most existing non-traditional options on the one hand, and facilitating the creation of new instruments on the other. In Section 2, we explain the motivation for developing a new classification method. In Section 3, we propose a definition for exotic options according to their specificities compared to traditional ones, and on this basis a classification method is put forward. The fifth and last section summarizes the main results obtained in this article.

2. THE NEED FOR A NEW CLASSIFICATION METHOD

Only very few classification methods exist. For example, according to Ong (1996), exotic options can be categorized into seven families, namely 1) "path-dependent options" including barrier options, lookback options, and average options, 2) "singular-payoff options" including contingent premium options and digital options, 3) "time-dependent options" including American options, Bermudan options, chooser options, forward-starting options, and ratchet options, 4) "multi-variant options" including multi-asset options and multi-currency options, 5) "compounded-payoff options" including chooser options, compound options, captions, and floptions, 6) "leveraged-payoff options" including nonlinear payoff options, and 7) "embedded options" including options that are embedded explicitly or implicitly in different structures. According to Zhang (1998), exotic options can be grouped into three families, namely 1) "path-dependent options" including barrier options, lookback options, average options, and forward-starting options; 2) "correlation options" including multi-asset options, multi-currency options, and digital options; and 3) "other options" including all options which are neither path-dependent options nor correlation options, such as nonlinear options, compound options, chooser options, contingent premium options, and hybrid products.

However, the existing methods suffer from a certain number of weaknesses. Firstly, many options, especially the "complicated" exotic options, cannot be classified by these methods. For example, it is impossible to classify a multi-asset path-dependent option, which has the characteristics of both path-dependent options and multi-asset options. Secondly, according to these methods, some options can be assigned into two or more option classes. For example, according to Ong's method (1996), chooser options can be considered as both time-dependent options and compounded-payoff options. Finally, these methods are sometimes ambiguous. For example, according to Zhang's method (1998), hybrid products are considered to be exotic options and digital options are seen as correlation options. However, hybrid products should rather be considered to be linear combinations of traditional options, while plain-vanilla digital options, having only one underlying asset, should not be considered as correlation options. According to Ong's method (1996), American and Bermudan style options are considered as exotic options. However, as is the case for European style options, American and Bermudan style options should be considered as traditional options if they have a traditional mechanism, while they should be considered as exotic ones if they have a non-traditional mechanism. In such a context, it will be useful to propose a new classification method, one that is able to overcome the aforementioned weaknesses.

3. PROPOSAL FOR A NEW CLASSIFICATION METHOD

Before trying to classify exotic options, we should have a good understanding about their characteristics compared with the traditional ones. Upon examination, we find that five conditions are met by traditional options, but not always by the exotic ones. These five conditions, henceforth to be called "traditional conditions", are as follows:

- Condition 1 (or C1): The option is unconditionally activated throughout the life period of the contract, and cannot be cancelled before reaching maturity;
- C2: The maturity of the option can be neither reduced, nor extended;
- C3: The premium, paid by the buyer to the seller at the beginning of the life period of the option is obligatory and cannot be reimbursed;
- C4: All the variables of the option contract, namely the underlying asset price, the strike price, and the option price, are written in the same currency;
- C5: The option has only one underlying asset that is a basic risky asset, with a standard payoff, namely the positive or negative part of the difference between the

spot price of the underlying asset and the pre-determined strike price.

An option is deemed "traditional" if and only if all of these traditional conditions are met. As soon as one of these conditions is no longer respected, and the option cannot be decomposed into traditional ones, the option becomes non-traditional or exotic. On this basis, the "exotic degree" of an option can be defined as the number of traditional conditions that are not met by the option. The higher its exotic degree, the more the option is "exotic": for example, the exotic degree of traditional options is zero, while that of the most exotic options is five. Moreover, we distinguish "basic exotic options", whose exotic degree is one, from "complicated exotic options", whose exotic degree is strictly superior to one (cf. Table 1).

Insert Table 1 Here

Within this framework, options with an exotic degree of i, where $i \in \{1, 2, 3, 4, 5\}$, can be gathered together into the same category, entitled "option category with an exotic degree of i". Within each of these categories, options for which the same i conditions are not met can be grouped into the same class, entitled "option class for which traditional conditions $n_1, n_2, \ldots,$ and n_i are not met", where $n_j \in \{1, 2, 3, 4, 5\}$ for $j \in \{1, 2, \ldots, i\}$ and $n_1 < n_2 < \ldots < n_i$. The number of such option classes is C_5^i, namely the number of possible combinations of i elements among 5 elements, with $C_5^i = \dfrac{5!}{i! \times (5-i)!}$, where $i! = i \times (i-1) \times \ldots \times 2 \times 1$. As we have $C_5^0 = 1$, $C_5^1 = 5$, $C_5^2 = C_5^3 = 10$, $C_5^4 = 5$, and $C_5^5 = 1$, options with an exotic degree of 0 can be grouped into a single class (i.e., the class for traditional options), options with an exotic degree of 1 can be assigned into 5 classes (i.e., non-C1, non-C2, non-C3, non-C4, and non-C5), options with an exotic degree of 2 can be assigned into 10 classes (i.e., non-C12, non-C13, non-C14, non-C15, non-C23, non-C24, non-C25, non-C34, non-C35, non-C45), options with an exotic degree of 3 can be assigned into 10 classes (i.e., non-C123, non-C124, non-C125, non-C134, non-C135, non-C145, non-C234, non-C235, non-C245, non-C345), options with an exotic degree of 4 can be assigned into 5 classes (i.e., non-C1234, non-C1235, non-C1245, non-C1345, non-C2345), and options with an exotic degree of 5 can be grouped into a single class (i.e., non-C12345, the class for the most exotic options). Definitively, all options, traditional or exotic, can be assigned into one and only one of these 32 classes (cf. Figure 1).

Insert Figure 1 Here

To reach a better understanding about this classification method, we can compare each option class to a vector of dimension 5, designated $v = (x_1, x_2, x_3, x_4, x_5)$, with $x_j = 0$ if the traditional condition j is met, and $x_j = 1$ if not, for $j \in \{1, 2, 3, 4, 5\}$. The 5 basic vectors, namely $e_1 = (1, 0, 0, 0, 0)$, $e_2 = (0, 1, 0, 0, 0)$, $e_3 = (0, 0, 1, 0, 0)$, $e_4 = (0, 0, 0, 1, 0)$, and $e_5 = (0, 0, 0, 0, 1)$, represent respectively the five basic exotic option classes. All vectors written as $\sum_{j=1}^{5} x_j e_j$, with $x_j = 0$ or 1 for $j \in \{1, 2, 3, 4, 5\}$, can be generated by these five basic vectors with a coefficient 0 or 1. More precisely, when $\sum_{j=1}^{5} x_j = 0$, the vector is a null vector (0, 0, 0, 0, 0) and represents the traditional option class; when $\sum_{j=1}^{5} x_j = 1$, the vector is a basic vector and represents one of the five basic exotic option classes; when $\sum_{j=1}^{5} x_j \in \{2, 3, 4, 5\}$, the vector is a "general vector" and represents one of the 26 complicated exotic option classes.

4. USING THE PROPOSED CLASSIFICATION METHOD

In this section, we will show that the proposed classification method not only allows the classification of almost all existing (basic or complicated) exotic options, but also facilitates the design of new exotic instruments. It should be made explicit that "existing products" are those that have been examined in other articles, while "new instruments" are those that are defined for the first time in this paper.

4.1. Classification of Existing Exotic Options

4.1.1. Classification of existing basic exotic options

There are 5 classes for options whose exotic degree is one. As shown in Table 2, these 5 classes permit the classification of the 64 most commonly used existing exotic options. For each of these classes, after having specified which traditional condition is not met, we will present all the existing products that we know before displaying their main characteristics compared with traditional ones. At the end of this subsection, we will also analyze some linear combinations of these basic exotic options.

Insert Table 2 Here

4.1.1.1 Options within the contingent activation option class

When condition C1 is not met, the activation of the option is no longer unconditional. For example, it can depend on the fluctuation of the underlying asset price during the life period of the option. Such an option can be assigned into the class represented by [e_1] and entitled "Contingent activation option class", or "basic exotic 1". Products in this option class are numerous. "Average barrier options" (Zhang (1998)), "Barrier options" (Merton (1973), Reiner & Rubinstein (1991a), Rich (1994)), "Capped options" (Trippi & Chance (1993), Chance (1994), Broadie & Detemple (1995)), "Double barrier options" (Ikeda & Kunitomo (1992), Geman & Yor (1996)), "Floating barrier options" (Heynen & Kat (1996b)), "Forward-start barrier options", "Parisian options" (Chesney *et al.* (1997)), "Partial-time barrier options" (Heynen & Kat (1994a)), "Flexible barrier options" (Hart & Ross (1994)), and "Touch options" are some examples. Compared with traditional options, contingent activation options are made for users having a finer perception of the evolution of the underlying asset price during the life period of the option. They also permit a reduction of the option's premium. Such options are embedded in convertible bonds that can be repurchased or reimbursed in advance when the underlying stock price reaches a certain ceiling level.

4.1.1.2 Options within the contingent maturity option class

When condition C2 is not met, the maturity of the option is no longer fixed. For example, the initial maturity can be extended for a given period according to the fluctuation of the underlying asset price within a certain period. Such an option can be assigned into the class represented by [e_2], entitled "Contingent maturity option class", or "basic exotic 2". The extension of the option can either be automatic in the event of non-exercise of the option, which is the case with "Writer-extendible options", or decided by the option holder, as with "Holder-extendible options" (Longstaff (1990)). Compared with traditional options, contingent maturity options give their holders a second chance to exercise their right if these options are not exercised at the initial maturity date. Applications for such options can be found in many financial contracts, such as real estate options, extendible bonds, and corporate warrants, as shown by Longstaff (1990).

4.1.1.3 Options within the contingent premium option class

When condition C3 is not fulfilled, the payment of the option's premium is no longer obligatory. For example, it can depend on the movement of the underlying asset price during the life period of the option. Such an option can be assigned to the class represented by [e_3] and entitled "Contingent premium option class", or "basic exotic 3". The premium can be paid at the beginning of the life period of the option as for traditional options, but the option holder has the possibility to reclaim this premium at the maturity date when certain conditions are met, which is the case with "Money-back options". However, the premium payment can also be postponed until the maturity date and will be effective only when certain predetermined conditions are met, as with "Pay-later options" (Gastineau (1994), Kat (1994)). Compared with traditional options, such options permit both the holder and the writer to reinforce their forecasts on the movement of the underlying market. The characteristics of contingent premium options are embedded in corporate warrants that can be reimbursed in the case of non-exercise.

4.1.1.4 Options within the multi-currency option class

When condition C4 is not met, all variables of the option contract, namely the underlying asset price, the strike price, and the option price, are no longer written in the same currency, but in two or more currencies. Such an option can be assigned to the class represented by [e_4] and entitled "Multi-currency option class", or "basic exotic 4". "Beach options" (Reiner (1992), Wei (1992)), "Compo options" (Reiner (1992)), "Dual options", "Equity-linked foreign exchange options", "Flexo options", and "Quanto options" (Reiner (1992), Dravid *et al.* (1993)) are some of the most known examples. Compared with traditional options, multi-currency options give possibilities to manage, with one contract, at least two risks of different natures: one risk is related to the underlying asset price (such as a stock, an index, an interest-rate instrument, or a commodity), while the other is related to the exchange rate between two currencies. Fund managers quite often use such options in their investment on foreign markets.

4.1.1.5 Options within the exotic-payoff option class

When condition C5 is not fulfilled, the option's payoff ceases to be "traditional" or no longer defined as the positive or negative part of the difference between the spot price of the only underlying asset of the option and the pre-determined strike price. Such an option can be assigned to the class represented by [e_5] and entitled "Exotic-payoff option class", or "basic exotic 5". This option class is made up of two categories. In the first category, options are based on one basic underlying asset, but their payoff does not have the traditional form. These options are called "Mono-asset exotic payoff options". In the second category, options are based on two or more basic underlying assets, and are called "Multi-asset exotic payoff options".

4.1.1.5a) Options within the sub-class of mono-asset exotic payoff options

Among mono-asset exotic payoff options, some have a predetermined strike price in advance, while others have a strike price that evolves with the underlying asset price, or even have no strike price as defined for traditional options. Compared with traditional options, such options permit each user's specific forecast to be taken into account. Applications for these options are manifold. For example, average options are often embedded in corporate warrants, while characteristics of binary options are incorporated in a number of structured bonds.

Products in this sub-class of options are extremely abundant. Firstly, as examples of options with a predetermined strike price, we cite "Captions", "Compound options" (Geske (1977 & 1979), Geske & Johnson (1984), Omberg (1987), Hodges & Selby (1987), Rubinstein (1991d)), "Exponential options", "Fixed-strike average options" (Kemna & Vorst (1990), Turnbull & Wakeman (1991), Curran (1992 & 1994), Levy & Turnbull (1992), Geman & Yor (1993), Haykov (1993), Bouaziz *et al.* (1994)), "Fixed-strike flexible average options" (Zhang (1994 & 1995a)), "Fixed-strike ladder options", "Fixed-strike lookback options" (Conze & Viswanathan (1991a)), "Fixed-strike shout options" (Thomas (1993)), "Fixed-strike step-lock ladder options" (Street (1992)), "Floptions", "Installment options", "Log options", "One-clique options", "Partial-time fixed-strike average options", "Partial-time fixed-strike lookback options” (Heynen & Kat (1994c)), “Polynomial options” (Neuberger (1994)), and “Swaptions”.

Secondly, as examples of options with a floating strike price, we offer “Chooser options” (Rubinstein (1991c), Nelken, (1993)), “Extreme spread options” (Zhang (1998)), “Floating-strike average options” (Conze & Viswanathan (1991b)), “Floating-strike flexible average options” (Zhang (1994 & 1995a)), “Floating-strike ladder options”, “Floating-strike lookback options” (Goldman *et al.* (1979), Garman (1989)), “Floating-strike shout options”, “Forward-start options” (Rubinstein (1991b)), “Partial-time floating-strike average options”, and “Partial-time floating-strike lookback options” (Heynen & Kat (1994c)).

Finally, as examples of options for which the strike price is meaningless, we cite “Binary options” (Reiner & Rubinstein (1991), Turnbull (1995)), and “Symmetric power options”.

4.1.1.5b) Options within the sub-class of multi-asset exotic payoff options

In the payoff of a multi-asset exotic payoff option, the prices of at least two basic underlying assets are taken into account. Compared with traditional options, such options give the possibility of taking forecasts on two or more underlying markets by means of only one option contract. These options are often incorporated in flexible investment projects and currency option bonds.

As examples, we cite “Alternative options”, “Basket options” (Huynh (1994)), “Double lookback options” (He *et al.* (1998)), “Exchange options” (Margrabe (1978), Bjerksund & Stensland (1993), Johnson & Tian (2000b), Wu & Yu (2003)), “Exchange options on an exchange option” (Carr (1988)), “External binary options” (Zhang (1995b), Heynen & Kat (1996a)), “Madonna options” (Ong (1996)), “Multi-strike options” (Rubinstein (1991a)), “Options on the maximum or the minimum of several assets” (Stulz

(1982), Johnson (1987), Boyle *et al.* (1989), Boyle & Tse (1990), Rubinstein (1991e), Rich & Chance (1993)), "Product options", "Pyramid options", "Quotient options", "Rolling options", "Spread options" (Boyle (1988), Ravindran (1993), Bjerksund & Stensland (1994), Rubinstein (1994), Shimko (1994), Pearson (1995)), and "Two-asset correlation options" (Heynen & Kat (1996a)).

4.1.1.6 Some examples of linear combinations of the existing basic exotic options

Some exotic options that appear complicated can be transformed into linear combinations of basic exotic options. For example, "Gap options" (Reiner & Rubinstein (1991b)) and "Supershare options" (Hakansson (1976)) can be transformed into combinations of binary options, "Repriceable options" can be transformed into combinations of barrier options (Brenner *et al.* (2000), Chance *et al.* (2000)), "Ratchet options" (Haug (1997)) can be transformed into combinations of forward-start options, and "Time-switch options" (Pechtl (1995)) can be rendered as combinations of double barrier options.

4.1.2. Classification of existing complicated exotic options

Compared with the basic exotic options, complicated exotic options are less well known and more rarely used. As far as we know, such existing products are limited to options with an exotic degree of two. For example, we cite the "Money-back barrier option" (Kat (1994)) in the option class represented by $[e_1 + e_3]$ and seven options in the option class represented by $[e_1 + e_5]$, namely the "Binary barrier options" (Reiner & Rubinstein (1991b)), the "External barrier option" (Heynen & Kat (1994b)), as well as the "Average barrier options", the "External binary barrier options", the "Look-barrier options", the "One-touch digital options", and the "Partial-time external barrier options" as analyzed by Zhang (1998).

4.2. Creation of New Exotic Options

We will show, with the help of the proposed classification method, that it becomes quite easy to create new exotic products. For each option class whose exotic degree is superior or equal to two, after having specified all the traditional conditions not being met by the options in this class, we will show a new option product as an example. In total, 26 new complicated exotic options will be designed as shown in Table 3.

Insert Table 3 Here

Before we analyze these new products, a recap of the five traditional conditions might be worthwhile:

C1: Unconditional activation;

C2: Fixed maturity;

C3: Unconditional premium payment;

C4: All variables written in the same currency;

C5: Traditional option payoff.

4.2.1. Options with an exotic degree of two

There are 10 classes for options whose exotic degree is two. When conditions C1 and C2 are not met, options can be assigned into the class represented by $[e_1 + e_2]$. As an example, we introduce a new type of option, called the "Extendible barrier option". This option is similar to a "Barrier option" insofar as its activation depends on the evolution of the underlying asset price. Once the option is activated, the maturity is extended for a given period if the intrinsic value of the option is zero at the initial maturity date.

When conditions C1 and C3 are not met, options can be assigned into the class represented by $[e_1 + e_3]$. For example, the "Money-back double barrier option" is similar to a "Double barrier option", except that the premium paid to the option writer is reimbursed to the option holder if the option is activated, but is valueless at the maturity date.

When conditions C1 and C4 are not met, options can be assigned to the class represented by [$e_1 + e_4$]. As an example, we introduce a new type of option, called the "Barrier quanto option", which is similar to a "Quanto option", except that its activation depends on the evolution of the underlying asset price.

When conditions C1 and C5 are not met, options can be assigned into the class represented by [$e_1 + e_5$]. For example, the "External double barrier option" is similar to a "Double barrier option", except that the activation of the option is not related to the price of the underlying asset determining the intrinsic value of the option, but to the price of a second underlying asset.

When conditions C2 and C3 are not met, options can be assigned into the class represented by [$e_2 + e_3$]. For example, we introduce a new type of option, called the "Money-back extendible option". Such an option is similar to a traditional "Extendible option", except that its premium is paid back to the option holder if the option is extended at the initial maturity date and expires valueless at the extended maturity date.

When conditions C2 and C4 are not fulfilled, options can be assigned into the class represented by [$e_2 + e_4$]. For example, we introduce a new type of option, called the "Extendible quanto option". Such an option is similar to a traditional "Quanto option", except that the maturity is extended for a given period if the intrinsic value of the option is zero at the initial maturity date.

When conditions C2 and C5 are not met, options can be assigned into the class represented by [$e_2 + e_5$]. As an example, we introduce a new type of option, called the "External extendible option". Such an option is similar to a traditional "Extendible option", except that the option is written on the price of a second underlying asset during the extended period.

When conditions C3 and C4 are not met, options can be assigned into the class represented by [$e_3 + e_4$]. For example, we introduce a new type of option, called the "Money-back quanto option", which is similar to a traditional "Quanto option", except that its premium is reimbursed to the option holder if the option expires valueless.

When conditions C3 and C5 are not fulfilled, options can be assigned to the class represented by [$e_3 + e_5$]. For example, we introduce a new type of option, called the "Money-back fixed-strike average option". This option is similar to a "Fixed-strike average option", except that its premium is reimbursed to the option holder if the option expires valueless.

When conditions C4 and C5 are not met, options can be assigned into the class represented by [$e_4 + e_5$]. As an example, we introduce a new type of option, called the "Fixed-strike average quanto option". Similar to a quanto option, the difference here is that the payoff is based on a certain average price of the underlying asset during the lifetime of the option rather than its spot price.

4.2.2. Options with an exotic degree of three

There are 10 classes for options whose exotic degree is three. When conditions C1, C2, and C3 are not met, options can be assigned into the class represented by [$e_1 + e_2 + e_3$]. As an example, we introduce the "Money-back extendible barrier option", which is similar to an "Extendible barrier option", except that the premium is reimbursed to the option holder if the option expires valueless at the extended maturity date.

When conditions C1, C2, and C4 are not met, options can be assigned into the class represented by [$e_1 + e_2 + e_4$]. We introduce here the "Extendible barrier quanto option", which is similar to a "Barrier quanto option", except that the maturity is extendible.

When conditions C1, C2, and C5 are not met, options can be assigned to the class represented by [$e_1 + e_2 + e_5$]. As an example, we introduce the "External extendible barrier option", which is similar to an "External barrier option", except that its maturity is extended for a given period if the option is activated, but expires valueless at the initial maturity date.

When conditions C1, C3, and C4 are not met, options can be assigned into the class represented by $[e_1 + e_3 + e_4]$. As an example, we introduce the "Money-back barrier quanto option", which is similar to a "Barrier quanto option", except that its premium is reimbursed to the option holder if the option is activated, but expires valueless.

When conditions C1, C3, and C5 are not met, options can be assigned to the class represented by $[e_1 + e_3 + e_5]$. For example, we introduce the "Money-back external barrier option", which is similar to an "External barrier option", except that the premium is reimbursed to the option holder if the option is activated and expires valueless.

When conditions C1, C4, and C5 are not met, options can be assigned into the class represented by $[e_1 + e_4 + e_5]$. As an example of this, we introduce the "External barrier quanto option", which is similar to a "Barrier quanto option", except that its activation depends on the evolution of the price of a second underlying asset.

When conditions C2, C3, and C4 are not met, options can be assigned to the class represented by $[e_2 + e_3 + e_4]$. As an example, we introduce the "Money-back extendible quanto option", which is similar to an "Extendible quanto option", except that its premium is paid back to the option holder if the option expires valueless at the extended maturity date.

When conditions C2, C3, and C5 are not fulfilled, options can be assigned into the class represented by $[e_2 + e_3 + e_5]$. For example, we introduce the "Money-back external extendible option", which is similar to an "External extendible option", except that, the premium is reimbursed to the option holder if the option expires valueless at the extended maturity date.

When conditions C2, C4, and C5 are not met, options can be grouped into the class represented by $[e_2 + e_4 + e_5]$. For example, we introduce the "External extendible quanto option", which is similar to an "Extendible quanto option", except that the payoff of the option is based on the price of a second underlying asset during the extended period.

When conditions C3, C4, and C5 are not met, options can be assigned into the class represented by [$e_3 + e_4 + e_5$]. As an example, we introduce the "Money-back fixed-strike average quanto option", which is similar to a "Fixed-strike average quanto option", except that the option holder has the possibility of recouping the prepaid premium.

4.2.3. Options with an exotic degree of four

There are 5 classes for options whose exotic degree is four. When conditions C1, C2, C3, and C4 are not met, options can be assigned into the class represented by [$e_1 + e_2 + e_3 + e_4$]. As an example, we introduce the "Money-back extendible barrier quanto option". Such an option is similar to an "Extendible barrier quanto option", except that the premium is refundable.

When conditions C1, C2, C3, and C5 are not met, options can be placed into the class represented by [$e_1 + e_2 + e_3 + e_5$]. As an example, we introduce the "Money-back external extendible barrier option". Such an option is similar to an "External extendible barrier option", except that the premium is reimbursed to the option holder if the option expires valueless at the extended maturity date.

When conditions C1, C2, C4, and C5 are not met, options can be assigned to the class represented by [$e_1 + e_2 + e_4 + e_5$]. For example, we introduce the "External extendible barrier quanto option". Such an option is similar to an "External barrier quanto option", except that the maturity is extended for a given period if the option is activated and expires valueless at the initial maturity date.

When conditions C1, C3, C4, and C5 are not met, options can be assigned into the class represented by [$e_1 + e_3 + e_4 + e_5$]. As an example, we introduce the "Money-back external barrier quanto option". This option is similar to an "External barrier quanto option", except that the premium is paid back to the option holder if the option is activated, but expires valueless.

When conditions C2, C3, C4, and C5 are not met, options can be assigned into the class represented by [$e_2 + e_3 + e_4 + e_5$]. For example, we introduce the "Money-back external extendible quanto option". This option is similar to an "External extendible quanto option", except that the premium is paid back to the option holder if the option expires valueless at the extended maturity date.

4.2.4. Options with an exotic degree of five

Only one class exists for options whose exotic degree is five. In fact, when none of the five traditional conditions C1, C2, C3, C4, and C5 are met, options can be assigned into the class represented by [$e_1 + e_2 + e_3 + e_4 + e_5$], whose exotic degree reaches the maximum. As an example, we introduce the "Money-back external extendible barrier quanto option". Such an option is similar to an "External extendible barrier quanto option", except that the premium is paid back to the option holder if the option expires valueless at the extended maturity date.

5. DISCUSSION

Specially designed to fit users' specific purposes, exotic options are more effective than traditional options in risk transferring. The innovation process in creating exotic options is ongoing. In fact, not only does the design of new instruments continue, but also basic exotic instruments can be combined to constitute new products. As it is nearly impossible to list all exotic options, it is important to propose a method that allows them to be classified.

In this article, exotic options are defined as those for which at least one of the five characteristics of traditional options is not met. If we group all the options for which the same traditional conditions are not met within the same class, all options, including traditional and exotic ones, can be assigned into one and only one of the 32 classes, namely 1 class with an exotic degree of zero, 5 with an exotic degree of one, 10 with an exotic degree of two, 10 with an exotic degree of three, 5 with an exotic degree of four, and 1 with an exotic degree of five. The proposed classification method has two main advantages. Firstly, it enables 72 existing exotic options (of which 64 are basic exotic options and 8 are complicated ones) to be classified. Secondly, it helps to design new instruments. In this article, 26 new complicated exotic options, including 10 with an exotic degree of two, 10 with an exotic degree of three, 5 with an exotic degree of four, and 1 with an exotic degree of five, seem almost to have evolved naturally.

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Table 1: Some examples of basic and complicated exotic options

Traditional conditions	Traditional class	Basic exotic 1	Basic exotic 2	Basic exotic 3	Basic exotic 4	Basic exotic 5	Exotic degree of 2	Exotic degree of 3	Exotic degree of 4	Exotic degree of 5
C1: The activation of the option is unconditional.	✓	✗	✓	✓	✓	✓	✗	✗	✗	✗
C2: The maturity date cannot be changed.	✓	✓	✗	✓	✓	✓	✗	✗	✗	✗
C3: The premium paid by the buyer cannot be reimbursed.	✓	✓	✓	✗	✓	✓	✓	✗	✗	✗
C4: All the variables of the option are written in the same currency.	✓	✓	✓	✓	✗	✓	✓	✓	✗	✗
C5: The option has only one basic underlying asset, and the payoff is the positive or negative of the difference between the spot price of the underlying asset and the predetermined strike price.	✓	✓	✓	✓	✓	✗	✓	✓	✓	✗
Example	Traditional options	Barrier options	Extendible options	Money-back options	Quanto options	Exchange options	Extendible barrier options	Money-back extendible barrier options	Money-back extendible barrier quanto options	Money-back external extendible barrier quanto options

Figure 1: Classifying traditional and exotic options into 32 classes

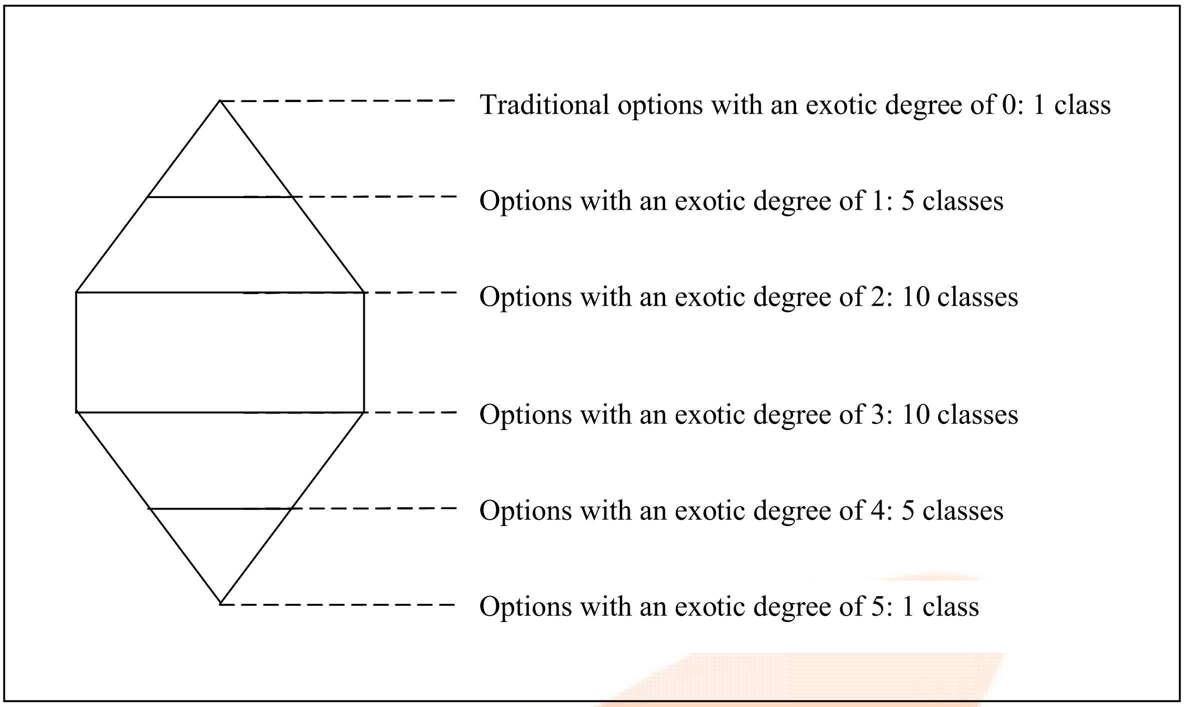

Table 2: Classifying 64 existing basic exotic options into 5 classes

Basic classic 1 Vector (1, 0, 0, 0, 0)	Basic classic 2 Vector (0, 1, 0, 0, 0)	Basic classic 3 Vector (0, 0, 1, 0, 0)	Basic classic 4 Vector (0, 0, 0, 1, 0)	Basic classic 5 Vector (0, 0, 0, 0, 1)		
Contingent activation options	Contingent maturity options	Contingent premium options	Multi-currency options	Mono-asset options		Multi-asset options
				Fixed-strike price	Floating-strike price or strike price meaningless	
Average barrier options Barrier options - Down-and-in - Down-and-out - Up-and-in - Up-and-out Capped options Double barrier options - Down-and-up in - Down-and-up out - Down-in and up-out - Down-out and up-in Flexible barrier options Floating barrier options Forward-start barrier options Parisian options Partial-time barrier options Touch options	Holder-extendible options Writer-extendible options	Money-back options - Money-back if-in-the-money - Money-back if-out-of-the-money Pay-later options - Pay-later if-in-the-money - Pay-later if-out-of-the-money	Beach options Compo options Dual options Equity-linked foreign exchange options Flexo options Quanto options	Caption Compound options - Options on call - Options on put Exponential options Fixed-strike average options Fixed-strike flexible average options Fixed-strike ladder options Fixed-strike lookback options Fixed-strike shout options Fixed-strike step lock options Floption Installment options Log options One-clique options Partial-time fixed-strike average options Partial-time fixed-strike lookback options Polynomial options Swaption	Binary options - Asset-or-nothing - Cash-or-nothing Chooser options - Simple chooser options - Complex chooser options Extreme spread options Floating-strike average options Floating-strike flexible average options Floating-rate ladder options Floating-strike lookback options Floating-strike shout options Forward-start options - FS in-the-money - FS at-the-money - FS out-of-the-money Partial-time floating-strike average options Partial-time floating-strike lookback options Symmetric power options	Alternative options Basket options Double lookback options Exchange options Exchange options on an exchange option External binary options - External asset-or-nothing options - External cash-or-nothing options Madonna options Multi-strike options Options on the maximum or the minimum of several assets Product options Pyramid options Quotient options Rolling options Spread options Two-asset correlation options
10 options	2 options	2 options	6 options	17 options	12 options	15 options
Total: 64 options						

Table 3: Some examples of the design of new complicated exotic options

Name of the complicated option designed	Exotic degree	Vector
Extendible barrier options	2	(1, 1, 0, 0, 0)
Money-back double barrier options	2	(1, 0, 1, 0, 0)
Barrier quanto options	2	(1, 0, 0, 1, 0)
External double barrier options	2	(1, 0, 0, 0, 1)
Money-back extendible options	2	(0, 1, 1, 0, 0)
Extendible quanto options	2	(0, 1, 0, 1, 0)
External extendible options	2	(0, 1, 0, 0, 1)
Money-back quanto options	2	(0, 0, 1, 1, 0)
Money-back fixed-strike average options	2	(0, 0, 1, 0, 1)
Fixed-strike average quanto options	2	(0, 0, 0, 1, 1)
Money-back extendible barrier options	3	(1, 1, 1, 0, 0)
Extendible barrier quanto options	3	(1, 1, 0, 1, 0)
External extendible barrier options	3	(1, 1, 0, 0, 1)
Money-back barrier quanto options	3	(1, 0, 1, 1, 0)
Money-back external barrier options	3	(1, 0, 1, 0, 1)
External barrier quanto options	3	(1, 0, 0, 1, 1)
Money-back extendible quanto options	3	(0, 1, 1, 1, 0)
Money-back external extendible options	3	(0, 1, 1, 0, 1)
External extendible quanto options	3	(0, 1, 0, 1, 1)
Money-back fixed-strike average quanto options	3	(0, 0, 1, 1, 1)
Money-back extendible barrier quanto options	4	(1, 1, 1, 1, 0)
Money-back external extendible barrier options	4	(1, 1, 1, 0, 1)
External extendible barrier quanto options	4	(1, 1, 0, 1, 1)
Money-back external barrier quanto options	4	(1, 0, 1, 1, 1)
Money-back external extendible quanto options	4	(0, 1, 1, 1, 1)
Money-back external extendible barrier quanto options	5	(1, 1, 1, 1, 1)
Total number of these new options: 26		