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(54) **MODELING FINANCIAL INSTRUMENTS USING BID AND ASK PRICES**

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(52) **U.S. Cl.** ..... **705/37**; 705/35; 705/36 R

(58) **Field of Classification Search** ..... 705/35, 705/36 R, 37

See application file for complete search history.

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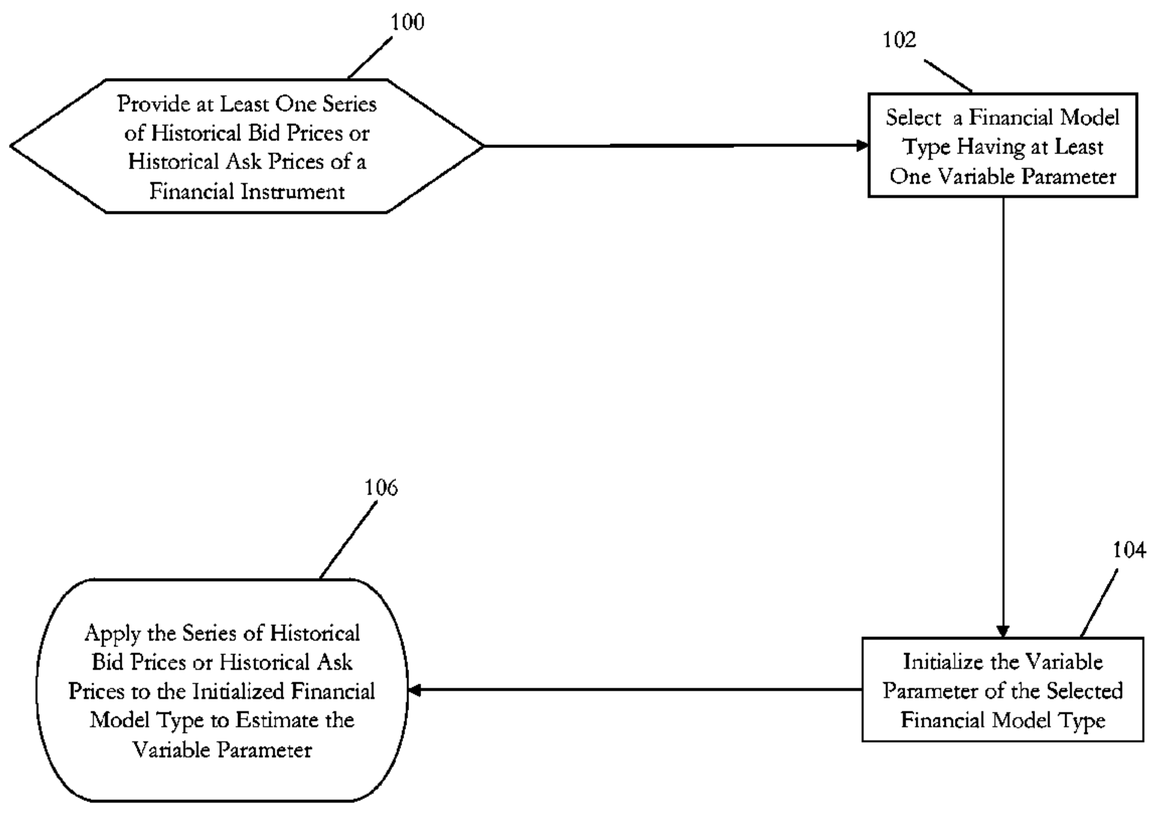
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(57) **ABSTRACT**

A method for modeling an investment significant parameter of a financial instrument, using a computer. At least one series of historical bid prices of the financial instrument or historical ask prices of the financial instrument is provided. A financial model type that has at least one variable parameter is selected. The variable parameter(s) of the selected financial model type is initialized. The series of historical bid prices and/or historical ask prices is applied to the initialized financial model type to estimate the variable parameter(s). The resulting model of the financial instrument may be used to predict future values of the investment significant parameter of the financial instrument. These predicted future values may be used to determine whether to perform automated trades of the financial instrument.

27 Claims, 3 Drawing Sheets



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FIG. 1

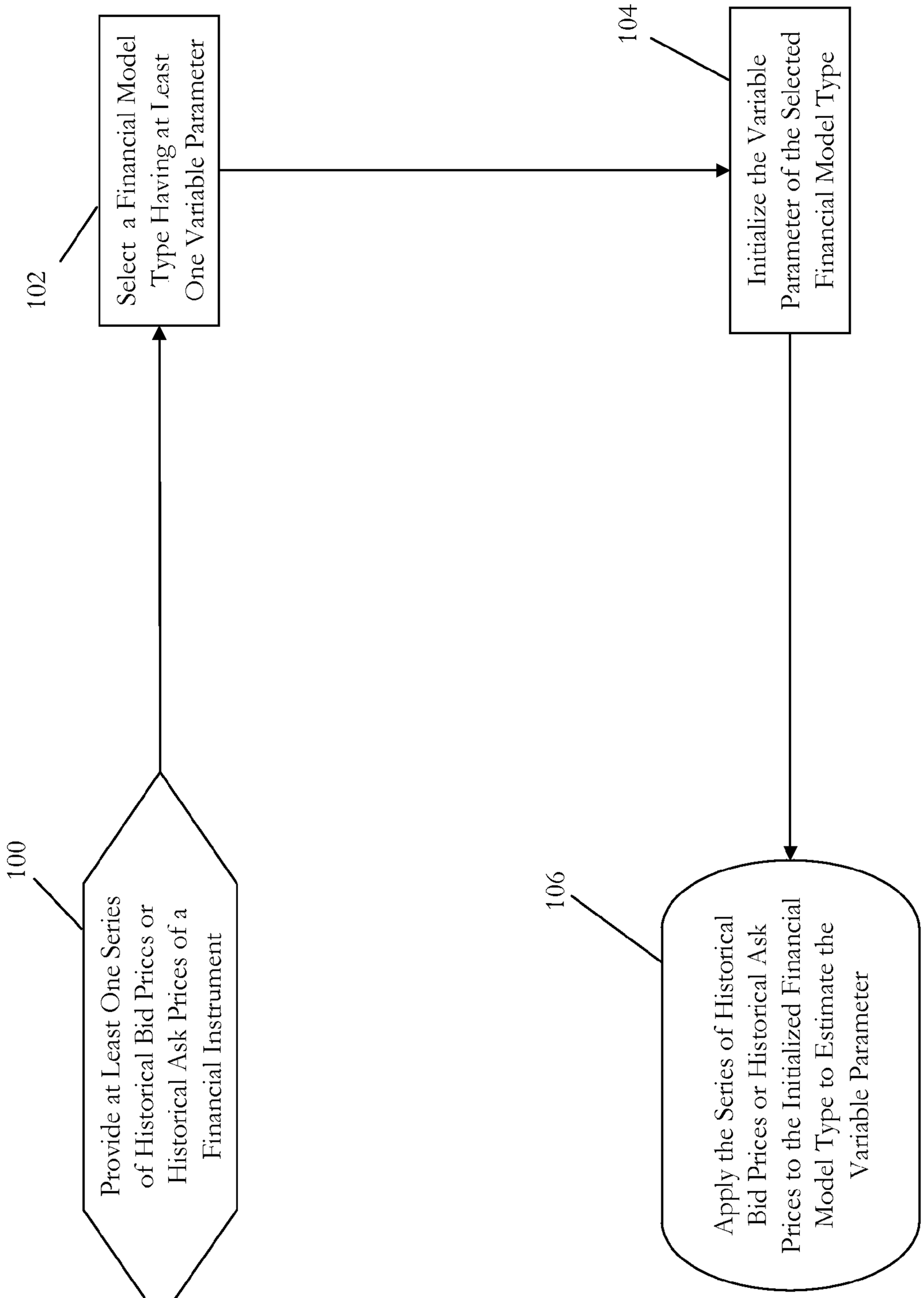
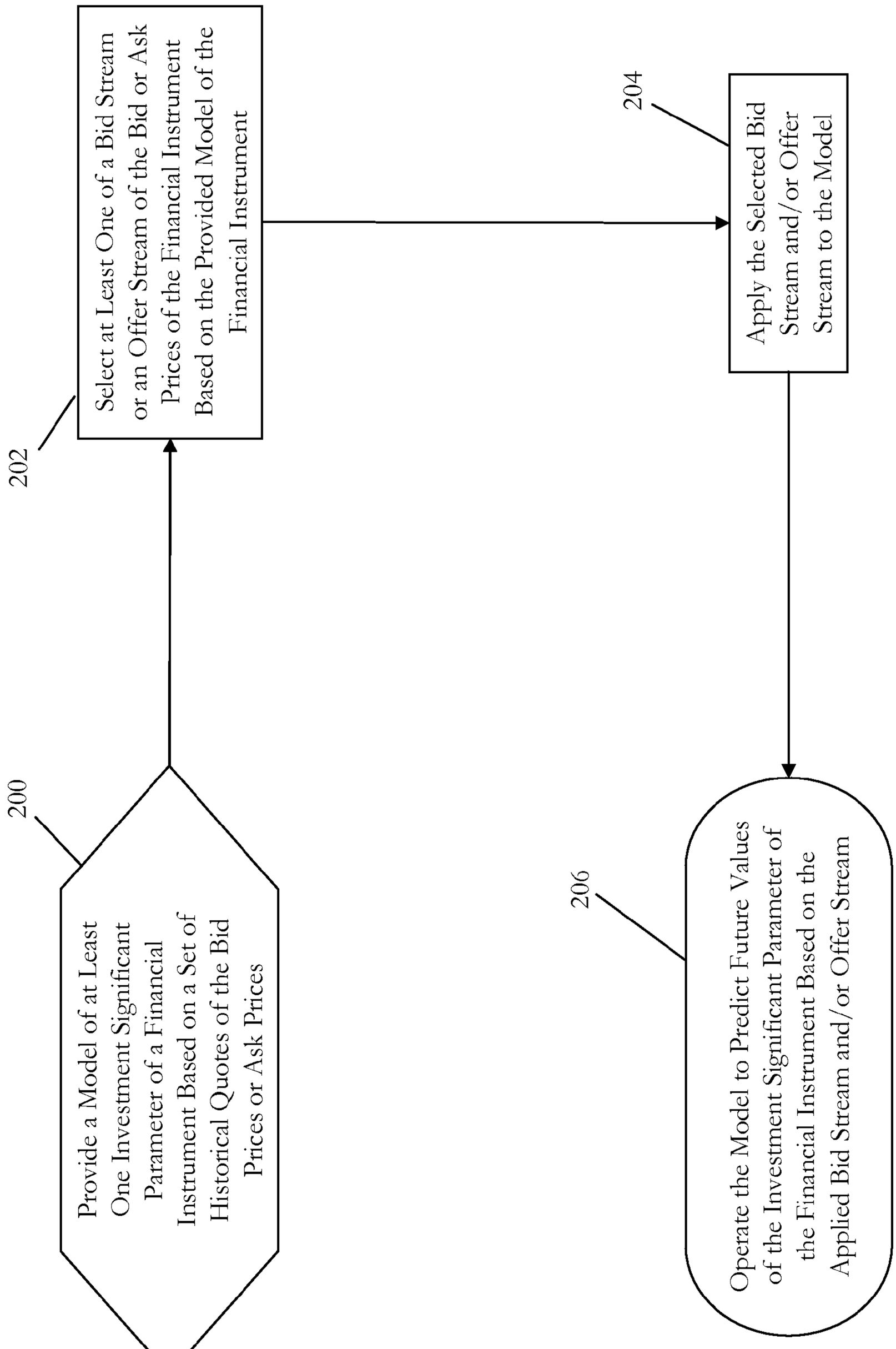

100
Provide at Least One Series of Historical Bid Prices or Historical Ask Prices of a Financial Instrument
102
Select a Financial Model Type Having at Least One Variable Parameter
104
Initialize the Variable Parameter of the Selected Financial Model Type
106
Apply the Series of Historical Bid Prices or Historical Ask Prices to the Initialized Financial Model Type to Estimate the Variable Parameter

FIG. 2


Provide a Model of at Least One Investment Significant Parameter of a Financial Instrument Based on a Set of Historical Quotes of the Bid Prices or Ask Prices
200
Select at Least One of a Bid Stream or an Offer Stream of the Bid or Ask Prices of the Financial Instrument Based on the Provided Model of the Financial Instrument
202
Apply the Selected Bid Stream and/or Offer Stream to the Model
204
Operate the Model to Predict Future Values of the Investment Significant Parameter of the Financial Instrument Based on the Applied Bid Stream and/or Offer Stream
206

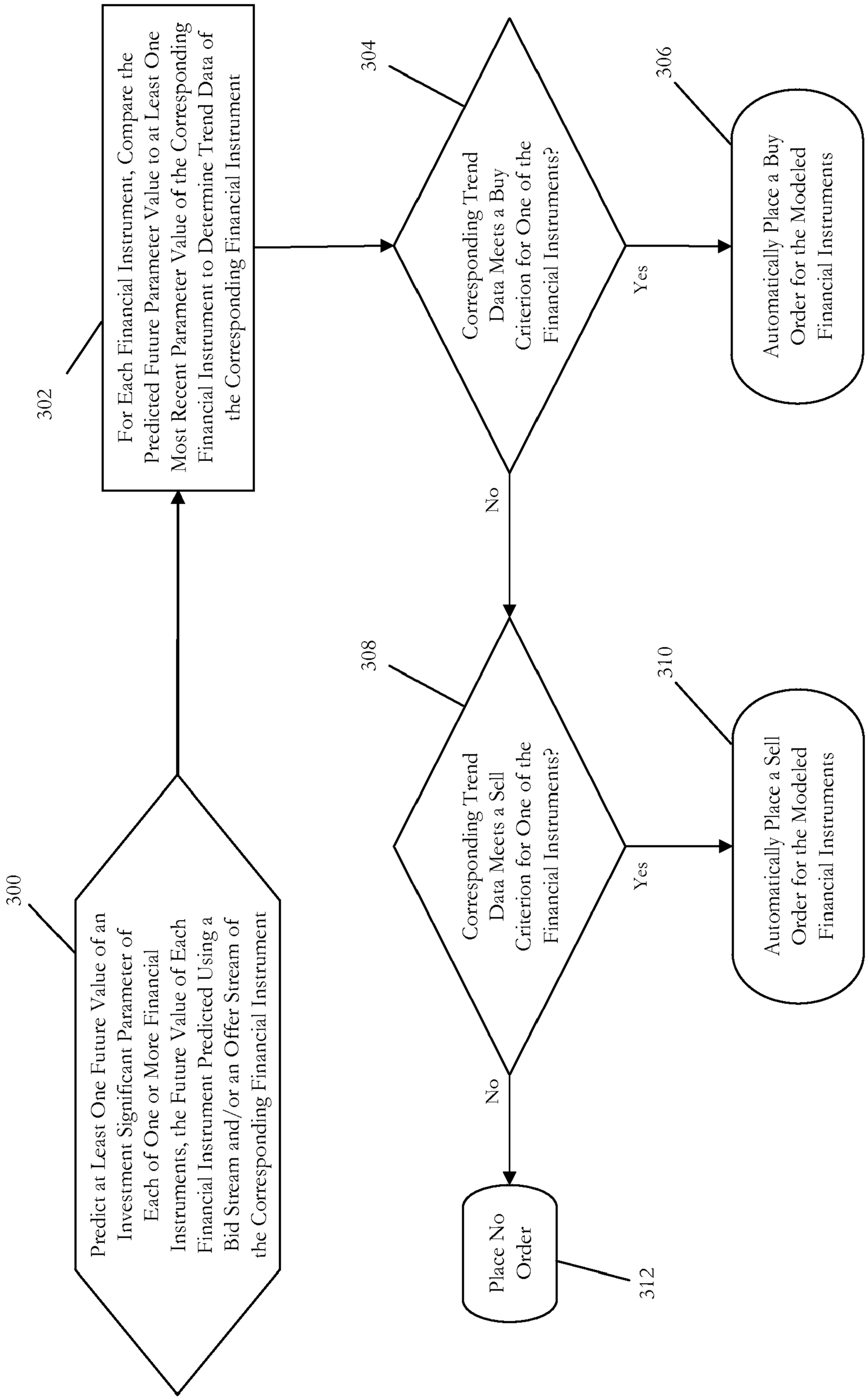

300
Predict at Least One Future Value of an Investment Significant Parameter of Each of One or More Financial Instruments, the Future Value of Each Financial Instrument Predicted Using a Bid Stream and/or an Offer Stream of the Corresponding Financial Instrument
302
For Each Financial Instrument, Compare the Predicted Future Parameter Value to at Least One Most Recent Parameter Value of the Corresponding Financial Instrument to Determine Trend Data of the Corresponding Financial Instrument
304
Corresponding Trend Data Meets a Buy Criterion for One of the Financial Instruments?
Yes
306
Automatically Place a Buy Order for the Modeled Financial Instruments
No
308
Corresponding Trend Data Meets a Sell Criterion for One of the Financial Instruments?
Yes
310
Automatically Place a Sell Order for the Modeled Financial Instruments
No
Place No Order
312

FIG. 3

MODELING FINANCIAL INSTRUMENTS USING BID AND ASK PRICES

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a divisional of U.S. application Ser. No. 11/263,508, filed Oct. 31, 2005. Co-pending U.S. application Ser. No. 12/418,951, filed Apr. 6, 2009, also is a divisional of U.S. application Ser. No. 11/263,508, filed Oct. 31, 2005.

FIELD OF THE INVENTION

The present invention concerns a method and system of modeling financial instruments using bid and ask prices. In particular, this method and system may allow for improved prediction of future bid and ask prices of financial instruments and may be used to provide information to make decisions for automated trading of various financial instruments.

BACKGROUND OF THE INVENTION

A fundamental analysis strategy is the investment in stocks on the basis of the value of the companies represented by the stocks. The company's balance sheet, income statement, etc., are studied to help determine the financial and market position of the company. If the analysis of the company's historic growth and profit patterns shows a steadily growing organization, and the research of the organization and its markets show a company that is competent and sound, a fundamental analysis approach may conclude that the company should continue to grow and prosper.

On the other hand, a technical analysis strategy involves trying to make profits based on the short-term swings of the market, such as, for example, day traders, who try to take advantage of hourly or daily price changes to make a profit. Slightly longer-term technical analysis investors track stock price and trading volume fluctuations over a period of a few days or weeks and trade on the basis of recent trends. As opposed to fundamental analysis where the emphasis is on the strength of the underlying corporation, technical analysis focuses on patterns that appear on the historical price charts of a specific stock and of the stock market in general in order to help predict the future of that stock's price. This strategy is based on the theory that certain patterns of stock prices tend to repeat themselves over time.

The Internet provides a great variety of uses including the buying and selling of financial instruments. The Internet has become a major means by which investors and brokers can both monitor the stock market and buy and sell stocks.

Although an investor does not need to be online to buy stocks, Internet access may be of great value. The Internet offers resources that are unmatched by any single print source. A wired investor can get access to literally thousands of investment services, publications, newsletters, and discussion groups. In this manner an investor can quickly gather a large amount of information about various financial instruments, including information about companies whose stock may be of interest.

The stock market includes a number of features that affect the stock investor. One of these features is the existence of agents to facilitate the functioning of the market. Market makers, specialists and Electronic Communications Networks (ECNs) make market in stocks. Market makers are part of the National Association of Securities Dealers market (NASD), and specialists work on the New York Stock Exchange (NYSE) and other listed exchanges. An ECN is an

electronic board where buy and sell orders may be posted by any investor worldwide. These agents serve a similar function but there are a number of differences between them.

The New York Stock Exchange (NYSE) is the oldest stock exchange in the United States. The NYSE (as well as the Philadelphia, Chicago, Boston, and Pacific Stock Exchanges) uses an agency auction market system that is designed to allow the public to meet the public as much as possible. The majority of trading volume (approximately 90%) occurs with no intervention from the specialist. The responsibility of specialists is to make a fair and orderly market in the issues assigned to them. They must yield to public orders, which means that they may not trade for their own account when there are public bids and asks better than their own. The specialist has an affirmative obligation to eliminate imbalances of supply and demand when they occur. Specialists are required to make a continuous market. The exchange has strict guidelines for trading depth and continuity that must be observed. Specialists are subject to fines and censures if they fail to perform this function. NYSE specialists have large capital requirements and are overseen by Market Surveillance at the NYSE.

A specialist will typically maintain a narrow spread between offers to buy and offers to sell. Generally, the trader will need access to a professional's data feed before the trader can really see the size of the spread.

There are over a thousand NYSE members (i.e., seats), of which approximately a third are specialists. There are over 3000 common and preferred stocks listed on the NYSE. On the average, each specialist handles 6 issues. The very big stocks may have a specialist devoted solely to them.

Every listed stock has one firm assigned to it on the floor. Most stocks are also listed on regional exchanges in San Francisco, Chicago, Philadelphia and Boston. All NYSE trading (approximately 80% of total volume) occurs at that post on the floor of the specialist assigned to it.

The National Association of Securities Dealers Automated Quotation system (NASDAQ) is an interdealer market represented by over 600 securities dealers trading more than 15,000 different issues. These dealers are called market makers. Unlike the NYSE, the NASDAQ market does not operate as an auction market. Instead, market makers are expected to compete against each other by posting the best quotes (best bid, i.e., best offer to buy, and best ask, i.e., best offer to sell).

A NASDAQ Level II quotation system shows all the bid offers, ask offers, size of each offer (the order size), and the market makers making the offers. The order size is simply the number of shares the market maker is prepared to fill at that price. Since about 1985 the average person has had access to Level II quotes.

The Small Order Execution System (SOES) was implemented by NASDAQ following the 1987 market crash. This system is intended to help the small investor have his or her transactions executed without allowing market makers to take advantage of the small investor. The trader may see mention of "SOES Bandits" which is slang for people who day-trade stocks on the NASDAQ using the SOES, scalping profits on the spreads.

A firm can become a market maker on NASDAQ by applying to NASD. The requirements include certain capital requirements, electronic interfaces, and a willingness to make a two-sided market. The trader must be there every day. If the trader doesn't post continuous bids and asks every day the trader can be penalized and not allowed to make a market for a month. Market makers are regulated by the NASD, which is overseen by the SEC.

The brokerage firm can handle customer orders either as a broker or as a dealer/principal. When the firm acts as a broker, it simply arranges the trade between buyer and seller, and charges a commission for its services. When the firm acts as a dealer/principal, it's either buying for or selling from its own account (to or from the customer), or acting as a market maker. The customer is charged either a mark-up or a mark-down, depending on whether they are buying or selling. The firm is disallowed from charging both a mark-up (or mark-down) and a commission. Whether acting as a broker or as a dealer/principal, the brokerage is required to disclose its role in the transaction. However, dealers/principals are not necessarily required to disclose the amount of the mark-up or mark-down, although most do this automatically on the confirmation as a matter of policy. Despite its role in the transaction, the firm must be able to display that it made every effort to obtain the best posted price. Whenever there is a question about the execution price of a trade, it is usually best to ask the firm to produce a Time and Sales report, which allows the customer to compare all execution prices with the actual execution price reported to the customer.

In NASDAQ, the public almost always trades with the dealer as a counterparty instead of another public investor, making it nearly impossible to buy on the bid or sell on the ask. Dealers can buy on the bid even though the public is bidding at the same price. Despite the requirement of making a market, in the case of market makers as opposed to specialists, there is no one firm who has to take responsibility if trading is not fair or orderly, as what seemed to have happened during the crash of 1987. At that time, many NASD firms simply stopped making markets or answering phones until prices were less volatile.

Recently, Electronic Communication Networks (ECN) were established in order to allow investors to trade NASDAQ listed stocks without having to go through market makers, oftentimes resulting in better prices for the investor. An ECN is an electronic system where buy and sell orders may be posted by any investor worldwide, where any investor or dealer may trade against that order. The best bid and best ask orders from the ECN are posted in the NASDAQ system alongside those of market makers.

If a trader wants to buy or sell a financial instrument, such as a stock or other security, in an open market, the trader normally trades via firms who act as agents who specialize in that particular security. These firms stand ready to sell the trader a security at the asking price (the "ask"). Or, if the trader owns the security and would like to sell it, the agent buys the security from the trader at the bid price (the "bid"). The bid and the ask prices remain until a new price is set. The difference between the current bid and the current ask is called the spread. Financial instruments that are heavily traded tend to have very narrow spreads (e.g., a few cents), but financial instruments that are lightly traded may have spreads that are significant, even as high as several dollars.

The width of the spread is indicative of the financial instrument's liquidity. Liquidity basically measures the aggregate quantity investors are willing to buy or sell of the financial instrument at any time. In the stock market, market makers or specialists (depending on the exchange) buy stocks from the public at the bid and sell stocks to the public at the ask (called "making a market in the stock"). At most times (unless the market is crashing, etc.) these people stand ready to make a market in most stocks and often in substantial quantities, thereby maintaining market liquidity. Dealers earn profit by realizing a large part of the spread on each transaction—they normally are not long-term investors.

Two types of online trading available to the public are: Internet trading provided by firms that route a customer's order to a trading desk or to a third party willing to pay for order flow; and dedicated online services provided by firms where customer's orders go directly to the exchange or ECN offering direct execution.

If the online investor uses the first type of online trading discussed above, the customer's order may be gamed by a specialist or market maker handling the order. Unfortunately, if this happens to the customer, they may not be able to recognize that it has happened from the minimal information typically provided in the order confirmation. Typically, this type of customer only has access to what's called Level I data—the best bid, the best ask, the last trade, and the order size of each data respectively.

If the customer uses the second type of online trading discussed above (i.e., the order goes from the firm directly to the exchange), the customer most likely is looking at a NASDAQ Level II screen. This screen shows all the bid offers, ask offers, the recent trades, the size of each offer or trade, and the market makers and ECNs making the offers.

An online trader connected to a web site that has a screen that displays NASDAQ Level II data, may see the following information streaming continuously on the screen: all bid offers, all ask offers, all trades, the size of each offer or trade and the market maker or ECN making the offer. This data may be refreshed as often as ten times per second. Hence, many traders are continuously analyzing the data on their screen all day. Moreover, unless the trader has a prodigious memory and even then the information may arrive too quickly to be fully read, much less utilized by the trader. The more individual financial instruments monitored by the trader, the greater the difficulty in utilizing the flood incoming data. Thus, a lot of important information may escape notice. Additionally, impatience at waiting for the desired trading condition may cause the trader to make a trade at an inopportune moment. Thus, an automated means of analyzing this wealth of information is desirable.

The present invention involves methods of modeling financial markets and automating trades to take advantage of this plethora of bid and ask price data.

SUMMARY OF THE INVENTION

An exemplary embodiment of the present invention is a method and system for modeling an investment significant parameter of a financial instrument, using a computer. At least one series of historical bid prices of the financial instrument or historical ask prices of the financial instrument is provided. A financial model type that has at least one variable parameter is selected. The variable parameter(s) of the selected financial model type is initialized. The series of historical bid prices and/or historical ask prices is applied to the initialized financial model type to estimate the variable parameter(s).

Another exemplary embodiment of the present invention is a method and system for predicting future bid prices and/or future ask prices of a financial instrument, using a computer. A model of at least one of the bid prices or the ask prices of the financial instrument based on a set of historical quotes of the bid prices and/or ask prices is provided. At least one of a bid stream of the bid prices of the financial instrument or an ask stream of the ask prices of the financial instrument is selected based on which of the bid prices and/or ask prices of the financial instrument are modeled by the model. The selected bid stream and/or ask stream is applied to the model. The model is operated to predict at least one future bid price

and/or future ask price of the financial instrument based on the applied bid and/or ask stream.

A further exemplary embodiment of the present invention is a method and system for performing automated trades of at least one financial instrument, using a computer. At least one future bid price or future ask price of each of the financial instruments is predicted. The future bid price and/or future ask price of each financial instrument is predicted using at least one of a bid stream of the bid prices of the corresponding financial instrument or an ask stream of the ask prices of the corresponding financial instrument. For each of the at least one financial instrument, the predicted future bid and/or ask price(s) are compared to at least one most recent bid and/or ask price of the corresponding financial instrument to determine quote trend data of the corresponding financial instrument. If the quote trend data of one of the financial instruments meets a buy criterion for that financial instrument, a buy order is automatically placed for the financial instrument; and if the quote trend data of one of the financial instruments meets a sell criterion for that financial instrument, a sell order is automatically placed for the financial instrument.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is best understood from the following detailed description when read in connection with the accompanying drawings. Included in the drawings are the following figures:

FIG. **1** is a flow chart illustrating an exemplary method and system of modeling an investment significant parameter of a financial instrument according to the present invention.

FIG. **2** is a flow chart illustrating an exemplary method and system of predicting future bid prices and/or future ask prices of a financial instrument according to the present invention.

FIG. **3** is a flow chart illustrating an exemplary method and system of performing automated trades of at least one financial instrument according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Exemplary embodiments of the present invention includes methods and system of modeling financial instruments to predict future prices of these financial instruments as part of exemplary technical analysis investment strategies. These exemplary technical analysis investment strategies may also include the automated placing of buy and sell orders for a portfolio including one or more different financial instruments. These financial instruments may include: stocks, bonds, commodities, currencies, equities, derivatives, and/or futures.

In technical analysis investment strategies, one important consideration is the type of financial model to use. A large number of different types of financial models have been created, such as: expert system models; linear analytic models; non-linear analytic models; chaotic models; neural network models; time delay neural network models; Markov-chain Monte Carlo models; wavelet transformation models; regression models; fractal models; support vector machine models; and Bayesian models. Specific applications of these types of financial models based on trade prices are known to those skilled in the art. For example, Carol Alexander describes a number of specific financial models in chapters 3-13 of MARKET MODELS: A GUIDE TO FINANCIAL DATA ANALYSIS (John Wiley & Sons, Ltd. (2001)).

Each model type includes at least one variable parameter that may be used to match the model to the behavior of the financial instrument. Potential variable parameters may include a numerical value, a string to be optimized, a logical value, a conditional rule, and/or a structural link. For example, in wavelet transformation models, the wavelet transform coefficients are variable parameters, while in expert system models and Bayesian models the variable parameters may include likelihood values and/or decision rules and in neural network models the links between nodes may used as variable parameters.

Additionally, each model type may present a number of advantages and a number of disadvantages when used to model the behavior of a financial instrument. For example, neural network models may take less time to build as compared to many other models, but because these models are essentially black boxes and not causal. Thus, if a neural network model diverges, it may be difficult to identify this divergence quickly as the exact process used to achieve the output is hidden. Still, the ability of neural network models to handle non-linear data make such models attractive for modeling financial instruments.

As another example, chaotic and fractal models may also be attractive for their ability to handle non-linear data, but errors in initial values of these models may lead to exponential divergence over time. Thus, chaotic and fractal models of the financial instrument may require monitoring and occasional re-initialization to maintain their accuracy. This re-initialization procedure typically does not pose a problem in modeling many financial instruments where a stream of new input data may be available to update the initialization almost continuously.

Other considerations for the technical analysis investor include the type of data to apply to the model and the type of data to be determined by the model. Many financial models have been created that utilize historic trade price data as input data.

Trade price data has seemed an obvious choice for the input data of a financial model. This data includes the actual prices paid for the financial instrument previously. Additionally, the amount of data is relatively tractable. As described above, NASDAQ Level II data for a stock may be refreshed as often as ten times a second, but the majority of these updates are due to changes in the bid and ask prices of the stock. Actual trades of the stock occur much less frequently. Thus, new trade prices are posted at a significantly lower rate.

Unfortunately, some trades take place at prices that are much higher or lower than might be expected. These unusual trade prices may be due to trade-specific concerns, such as gaining a controlling share in a company, tax issues, etc., that are not included in the model. If not removed from the input data, these unusual trade prices may significantly affect the accuracy of the financial model, but such outlying trades may be difficult to identify, particularly in a low trade volume financial instrument. Additionally, depending on the financial market, the trade prices may not be posted for period time after the trade occurs. Even in the tightly regulated stock market, there is typically a one to ten second delay before a trade price is posted. Depending on the volatility of the financial instrument, the effect of this delay of the technical analysis investor may range from a minimal issue to an extreme detriment.

In the exemplary embodiments of the present invention, the actual series of bid and/or ask prices of the financial instrument are among the data applied to the model. The bid and ask prices (quotes) provide a number of advantages as input data for a financial model. Unlike trade prices, which represent unique events, bid and ask prices represent a continuous, ongoing record of the market. At any given time, each financial instrument has one, and only one, current best bid price

and one, and only one, current best ask price. These quotes remain valid until replaced by a new quote, at which time the old quote is no longer valid. Thus, because new quotes do not become effective until posted, access to new bid and ask prices is nearly instantaneous. This may allow a financial model based on streams of quotes to operate substantially in real time.

In a low trade volume financial instrument, the time between trades may be days or even longer, potentially leading to large fluctuations between consecutive trade prices and correspondingly large uncertainty for a technical analysis investor. The quotes may move numerous times between trades as potential buyers and sellers seek an appropriate deal, which allows exemplary embodiments of the present invention to more accurately predict investment significant parameters of financial instruments. Investment significant parameters may include any predictions that are desirable to formulate an investment strategy, for example: future trade prices; future bid prices; future ask prices; future spreads; fair market values (FMV) now and/or in the future; expected profit; changes in prices, spreads, FMV's, or profit between two times; rates of change in prices, spreads, FMV's, or profit; winners and losers; and buy/sell instructions. The same advantages may exist for high trade volume financial instruments as well, only on a different time scale.

Additionally, the bid prices and the ask prices of a given financial instrument tend to track one another, thereby maintaining a relatively constant spread for the financial instrument, as described above for stocks. Therefore using both the bid and ask prices in a model may simplify the identification of outlying bid and ask prices. For example, a sudden jump in the ask price which is not followed by a corresponding increase in the bid price to take advantage of the increased price the market is willing to pay is likely to indicate a misquote or other error. However, if the increased ask price is real, the bid price is likely to quickly follow. Thus, exemplary embodiments of the present invention also may allow technical analysis investors to track sudden changes in a financial instrument with greater certainty.

FIG. **1** illustrates an exemplary method for modeling an investment significant parameter of a financial instrument, using a computer, according to the present invention. The financial instrument may desirably be a publicly traded financial instrument, but this is not necessary. It may be any type of financial instrument including: a stock; a bond; a commodity; a currency; an equity; a derivative security, or a future.

At least one series of historical bid prices of the financial instrument or historical ask prices of the financial instrument is provided as training data to the model, step **100**. The provided series of historical bid and/or ask prices of the financial instrument may desirably include corresponding bid or ask sizes, respectively, associated with the quotes. Additionally, the provided series of historical quotes may desirably be provided as time series of the historical bid and/or ask prices including corresponding bid or ask times, respectively. Further a series of historical spreads between the historical bid prices and the historical ask prices of the financial instrument may be provided as well.

It may also be desirable for the historical series of quotes to include at least one complete consecutive series of: historical bid and/or ask prices of the financial instrument spanning a predetermined period of time; or a predetermined number of historical bid and/or ask prices of the starting from a predetermined time.

Outlying quotes may desirably be removed from the provided series of historical quotes, including complete consecutive series, before the series is (are) applied to the model.

An exemplary method of removing outliers from the provided series of historical quotes uses the relative stability of the spread between bid prices and ask price of financial instruments discussed above. Time series of the historical bid prices of the financial instrument, including corresponding bid times, and the historical ask prices of the financial instrument, including corresponding ask times, are provided. A time series of the spread between the historical bid and ask prices is calculated from their historical time series. Outlier bids in the time series of the historical bid prices may be identified using the time series of the spread, as may outlier asks in the time series of the historical ask prices. Quotes that cause the spread to increase, or decrease, beyond certain thresholds that may vary from financial instrument to financial instrument, may indicate potential outliers. If the change in the spread is quickly corrected by a change in the same quote (e.g. an unusually large jump in the bid price is followed by a corresponding drop in the bid price), the quote in question may be identified as an outlier. Conversely, if the change in the spread is corrected by a change in the other quote (e.g. an unusually large jump in the bid price is followed by a corresponding jump in the ask price), the quote in question may indicate the beginning of a trend up or down in the value of the financial instrument. Once identified the outliers bid(s) and/or ask(s) and their corresponding bid or ask times are removed from the time series.

A financial model type is selected, step **102**. As discussed above, numerous financial model types exist, each with its own advantages and disadvantages, depending on the financial instrument to be modeled. One skilled in the art may understand that each financial model type has at least one variable parameter that may be tuned to model the behavior of a particular financial instrument. The variable parameter(s) of the selected financial model type are initialized, step **104**. This initialization may be based on a priori knowledge of the financial instrument and/or the selected financial model type, initial values of the series of historical quotes provided in step **100**, a predetermined initial setting, or a combination of these methods.

The series of historical bid prices and/or historical ask prices are applied to the initialized financial model type as training data to estimate the variable parameter(s), step **106**. In an exemplary embodiment of the present invention, the financial model type selected in step **102** is used to calculate at least one of a predicted bid price or a predicted ask price of the financial instrument. This calculation may be based on a set of historical quotes that includes a predetermined quantity of consecutive historical quotes from the series of historical bid prices and/or historical ask prices provided in step **100**. The calculation may be repeated for each set of historical quotes to calculate a plurality of predicted bid prices and/or a plurality of predicted ask prices. These predicted quotes may then be compared to the series of historical quotes provided in step **100**. The variable parameter of the selected financial model type is varied based on the differences between the predicted quotes and the series of historical quotes. The calculations and comparisons may be repeated until the variable parameter has been estimated and the behavior of the financial model matches the historical behavior of the financial instrument to within a predetermined degree of accuracy, i.e. the predicted quotes substantially correspond to the series of historical quote.

It is noted that the use of the training data provided in step **100** may depend on the type of financial model selected in step **102**. For example, in a non-linear analytic model differences between the output of the model and the series of historical quotes may be used as feedback in an estimation

maximization algorithm or other recursive algorithm to adjust the model parameters. In another example, time series of historical quote prices and corresponding quote times may be used as training data for a time delay neural network model of the financial instrument.

It is noted that other training data which may be provided in step **100**, such as: a time series of the spread between the historical bid prices and the historical ask prices; a series of historical trade prices; and/or extrinsic data, including market indices or related financial instruments, may also be applied to the selected financial model type to improve the estimation of the variable parameter(s).

FIG. **2** illustrates an exemplary method for predicting an investment significant parameter of a financial instrument, using a computer, according to the present invention. A model of the bid prices and/or the ask prices of a financial instrument, based on a set of historical quotes of the bid and/or ask prices, is provided, step **200**. This model may be desirably generated using an exemplary method of FIG. **1** described above.

At least one of a bid stream of the bid prices of the financial instrument or an ask stream of the ask prices of the financial instrument is selected, step **202**. This selection may desirably be based on whether the bid prices, the ask prices, or both of the financial instrument are modeled by the model provided in step **200**. Although not necessary, for many financial instruments, particularly high trade volume financial instruments, it may be desirable for the quote stream(s) selected in step **202** to be a real time bid stream of the bid prices of the financial instrument and/or a real time ask stream of the ask prices of the financial instrument. This may allow for the model to predict, substantially in real time, at least one of future bid prices of the financial instrument or future ask prices of the financial instrument, allowing a technical analysis investor using an exemplary embodiment of the present invention to react substantially faster to changes in the financial market. Such improved reaction time may greatly increase the potential for profits by such an investor.

Desirably, the selected quote stream(s) may include the same variables as the series of historical data used for generating the model provided in step **200**. For example, if a historical time series of the bid prices of the financial instrument, including corresponding bid times is used during generation of the model, then it is desirable for the quote stream selected in step **202** to be a bid stream of the financial instrument, including the bid prices and corresponding bid times. As another example, if a historical series of the ask prices of the financial instrument, including corresponding ask sizes is used during generation of the model, then it is desirable for the quote stream selected in step **202** to be an ask stream of the financial instrument, including the ask prices and corresponding ask sizes. Additionally, if other data is included with the series of historical data used for generating the model provided in step **200**, such as: a time series of the spread between the historical bid prices and the historical ask prices; a series of historical trade prices; and/or extrinsic data, it is desirable for those types of data to be included with the quote stream(s) selected in step **202**.

The selected quote stream(s) is (are) applied to the model, step **204**. As discussed above with reference to the series of historical quotes used in the exemplary method of FIG. **1**, it may be desirable to identify and remove outliers in the selected quote stream(s). If both bid and ask streams of the financial instrument, including corresponding bid and ask times, respectively, are selected in step **202**, then a spread stream may be calculated and used to remove outlying quotes from the bid and ask streams before they are applied to the model. Such an exemplary method of identifying and removing outlying quotes is described above with reference to FIG. **1**.

The model is operated on the selected quote steam(s) to predict at least one investment significant parameter of the financial instrument, step **206**. If the selected quote stream(s) is (are) real time quote stream(s), then the model may desirably be operated to predict, substantially in real time, the desired future quotes, trade prices, FMV, or other stream of investment significant information about the financial instrument.

Whether these predictions are made substantially in real time or not, it may also be desirable for each of the predicted investment significant parameters to include a predicted time, for example future quotes of the financial instrument may desirably include a predicted quote time (i.e. a bid time or an ask time) associated with the predicted future quote. Desirably, the predicted time of each future investment significant parameter prediction may be within a predetermined period of time after prediction. If the predicted time is too close to the time that it is predicted, an investor using the exemplary method may not be able to use the information before it becomes stale, or if the predicted time is too remote, then it may be desirable for the model to hold the prediction until closer to the predicted time, in case new information arrives that may affect the prediction.

It is noted that such time predictions may not be available if the selected quote stream(s) only include(s) sequential quotes of the financial instrument without corresponding quote times. In this situation, the predicted future investment significant parameter(s) of the financial instrument may represent the next anticipated value of the trade, bid, and/or ask price of the financial instrument or a short-term buy/sell instruction, etc. For many technical analysis investors, this information may be adequate and removing the additional temporal variables may significantly simplify the model.

Another feature that may be desirable is a confidence level associated with each of the predicted investment significant parameter. Many financial model types include calculation of such confidence level. Thus, the model may desirably predict one or more future investment significant parameter of the financial instrument that includes a corresponding confidence level.

The model provided in step **200** may also be dynamically updated using the selected quote stream(s) as additional training data. The quotes of the quote streams may be used as additional historic quotes to continually refine the estimate(s) of the variable parameter(s) of the model using the exemplary method of FIG. **1**.

FIG. **3** illustrates an exemplary method for performing automated trades of at least one financial instrument, using a computer, according to the present invention. The financial instrument(s) may be selected from a single type of financial instrument such as publicly traded stocks, for example, or may include a number of financial instruments selected from one or more types of financial instruments, such as stocks, bonds, commodities, currencies, equities, derivatives, and futures.

At least one investment significant parameter of each financial instrument is predicted, step **300**. The predicted investment significant parameter(s) of each financial instrument are predicted using at least one of a bid stream of the bid prices of the corresponding financial instrument or an ask stream of the ask prices of the corresponding financial instrument. Desirably, the predicted investment significant parameter(s) may be determined using one or more of the exemplary methods of FIGS. **1** and **2** as described above. The quote

stream(s) used may include real time quote streams of each financial instrument or may include some quote streams that are not provided in real time. As described above the predictions may utilize additional data, such as: spread streams for one or more of the financial instruments; trade price streams for one or more of the financial instruments; and/or extrinsic data, including market indices or related financial instruments.

Additional prediction information such as predicted times and corresponding confidence levels of each of the one or more corresponding investment significant parameter may be desirably provided as well for one or more of the financial instruments.

If the investment significant parameter(s) predicted in step **300** are numerical values, then, for each of the financial instruments, the predicted investment significant parameter (s) are compared to at least one of the most recent corresponding value(s) of the corresponding financial instrument to determine trend data of the corresponding financial instrument, step **302**. If the predicted investment significant parameter(s) for a financial instrument include corresponding parameter confidence level(s), the trend data determined for the financial instrument may desirably include a corresponding trend confidence level based on the corresponding parameter confidence level. The buy criterion and the sell criterion for a given financial instrument may be varied based on its trend confidence level. Alternatively (or additionally), the trend confidence level(s) of the financial instrument(s) may be tracked to help determine when to place buy and/or sell orders.

If more than one financial instrument is being traded using the exemplary method of FIG. **3**, then an exemplary joint trade strategy approach may be used to determine the trend data corresponding to each of the financial instruments in step **302**. In this exemplary approach, for each of the financial instruments, the predicted investment significant parameter (s) are compared to at least one most recent corresponding value of the corresponding financial instrument to determine a predicted change in the predicted parameter of the corresponding financial instrument. The plurality of predicted changes in the predicted parameters determined may be analyzed to formulate a joint trade strategy for the financial instruments over a predetermined period time to maximize anticipated return. The trend data corresponding to each of the financial instruments may then be set based on the joint trade strategy.

One skilled in the art may understand that various algorithms may be used to analyze the plurality of predicted changes and formulate the joint trade strategy including: expert system models; linear analytic models; non-linear analytic models; chaotic models; neural network models; time delay neural network models; Markov-chain Monte Carlo models; wavelet transformation models; regression models; fractal models; support vector machine models; or Bayesian models.

The corresponding trend data of each financial instrument is compared to the buy criterion of that financial instrument, step **304**. If the corresponding trend data of a financial instrument does not meet the corresponding buy criterion, then the trend data is compared to the sell criterion of that financial instrument, step **308**. As described above the buy and/or sell criteria may be varied based on a trend confidence level of the financial instrument. Alternatively, these criteria may be predetermined, based on a priori knowledge of the financial instrument or financial market, or may be determined by the corresponding model of the financial instrument. Additional factors may also affect these criteria. For example, the amount of cash, or credit, available to purchase financial instruments may affect the buy criteria of the financial instrument and whether any quantity of a given financial instrument is owned may affect the sell criteria of that financial instrument.

It is noted that the order of steps **304** and **308** may be reversed, or these steps may be performed substantially simultaneously without departing from the present invention.

If the buy criterion is met in step **304** for a given financial instrument, then a buy order for that financial instrument is automatically placed, step **306**. Likewise, if the sell criterion is met in step **308** for a given financial instrument, then a buy order for that financial instrument is automatically placed, step **310**. If neither criterion is met, then no order is place for the given financial instrument, step **312**.

When either a buy order is placed in step **306** or a sell order is placed in step **310**, a buy size of the buy order or a sell size of the sell order may desirably be determined. The buy size may be set to a predetermined size, a predetermined total price, or may be based on the amount of cash, credit, and/or other liquid assets available for the purchase. The sell size may be set to a predetermined size, a predetermined total price, or may be based on the quantity of the financial instrument available for sale by the investor. If a corresponding trend confidence level has been determined, then the buy size of the buy order, or the sell size of the sell order, may be determined based on the corresponding trend confidence level.

Alternatively, a buy size and a sell size for each financial instrument may be determined based on a comparison of the trend data and the buy criterion of the financial instrument. A buy order is then automatically placed for each financial instrument for which the buy size is greater than zero and a sell order is automatically placed for each financial instrument for which the sell size is greater than zero.

If the investment significant parameter(s) predicted in step **300** are non-numerical values, e.g. buy/sell instructions and/or winner and loser predictions, then the predicted investment significant parameter(s) may be used directly to determine what trade orders should be placed. If the predicted investment significant parameter(s) for a financial instrument include corresponding parameter confidence level(s), then these parameter confidence level(s) may be used to determine the size of any trade orders that are to be placed. In the case where more than one financial instrument is being traded, the parameter confidence level(s) may be used to develop a joint trade strategy among the financial instruments that may include determining the size of any trade orders to be placed.

It is noted that both numerical and non-numerical investment significant parameters may be predicted by the exemplary model in step **300** of FIG. **3**. In this situation, the investment significant parameters may be used in combination to determine a (joint) trade strategy. In determining a trade strategy in this manner, each investment significant parameter being given a weight in deciding whether to place buy or sell orders. Alternatively, different investment significant parameters may be used for different determinations, e.g. a buy/sell instruction may be used to determine whether to place an order to buy or sell the corresponding financial instrument and the predicted profit of each trade may be used to determine order sizes between several financial instruments.

The various exemplary embodiment of the present invention may be carried out through the use of a general-purpose computer system programmed to perform the steps of the exemplary methods described above with reference to FIGS. **1**, **2**, and **3**. Exemplary general-purpose computer systems may include personal computers, work stations, distributed

processing computer networks, and parallel processing computer systems. Parallel or distributed processing may be desirable for substantially real time applications involving the substantially concurrent prediction of future quotes for a plurality of financial instruments. Dedicated special-purpose computing systems may also be designed for performing exemplary methods of the present invention as well.

Additionally, it is contemplated that the methods previously described may be carried out within a general purpose computer system instructed to perform these functions by means of a computer-readable medium. Such computer-readable media include: integrated circuits, magnetic and optical storage media, as well as audio-frequency, radio frequency, and optical carrier waves.

Although the invention is illustrated and described herein with reference to specific embodiments, the invention is not intended to be limited to the details shown. Rather, various modifications may be made in the details within the scope and range of equivalents of the claims and without departing from the invention.

What is claimed:

1. A method for performing automated trades of at least one financial instrument, using a computer, the method comprising the steps of:

a) predicting by the computer at least one future value of a numerical investment significant parameter of each of the at least one financial instrument, the at least one future value of the numerical investment significant parameter of each financial instrument predicted using at least one of a bid stream of the bid prices of a corresponding financial instrument or an ask stream of the ask prices of the corresponding financial instrument;

b) for each of the at least one financial instrument, using the computer, determining trend data of the corresponding financial instrument by comparing the at least one future value of the numerical investment significant parameter predicted in step (a) to at least one most recent actual value of the numerical investment significant parameter of the corresponding financial instrument;

c) automatically placing a buy order for one of the financial instruments modeled in step (a) if the corresponding trend data determined in step (b) meets a buy criterion for the one of the financial instruments; and

d) automatically placing a sell order for one of the financial instruments modeled in step (a) if the corresponding trend data determined in step (b) meets a sell criterion for the one of the financial instruments.

2. The method according to claim **1**, wherein for each financial instrument, the at least one of the bid stream or the ask stream used in step (a) is at least one of a real time bid stream of the bid prices of the corresponding financial instrument or a real time ask stream of the ask prices of the corresponding financial instrument.

3. The method according to claim **1**, wherein, for each financial instrument, step (a) includes the steps of:

a1) providing with the computer a model of a behavior of the at least one numerical investment significant parameter of the financial instrument based on a set of historical quotes of at least one of bid prices or ask prices of each financial instrument;

a2) selecting at least one of a corresponding real time bid stream or a corresponding real time ask stream based on the at least one of bid prices or ask prices of the financial instrument modeled by the corresponding model;

a3) applying the selected at least one of the corresponding bid stream or the corresponding ask stream to the corresponding model; and

a4) operating the corresponding model to predict the at least one future value of the numerical investment significant parameter of the financial instrument.

4. The method according to claim **3**, wherein, for each of the financial instruments, step (a3) includes the steps of:

a3a) providing the corresponding bid stream of the bid prices of the financial instrument, including corresponding bid times, and the corresponding ask stream of the ask prices of the financial instrument, including corresponding ask times;

a3b) calculating a corresponding spread stream of a spread between the bid prices and the ask prices of the financial instrument from the corresponding bid stream and the corresponding ask stream;

a3c) identifying outlier bids in the corresponding bid stream of the bid prices using the corresponding spread stream;

a3d) removing the identified outliers bids and corresponding bid times from the corresponding bid stream before applying the corresponding bid stream to the corresponding model;

a3e) identifying outlier asks in the corresponding ask stream of the ask prices using the corresponding spread stream; and

a3f) removing the identified outliers asks and corresponding ask times from the corresponding ask stream before applying the corresponding ask stream to the corresponding model.

5. The method according to claim **3**, wherein, for each model corresponding to one of the financial instruments, step (a1) includes the steps of:

a1a) providing the corresponding set of historical quotes of at least one of bid prices or ask prices;

a1b) selecting a corresponding financial model type having at least one variable parameter;

a1c) initializing the at least one variable parameter of the selected financial model type; and

a1d) generating the model of the at least one future value of the numerical investment significant parameter of the corresponding financial instrument by applying the corresponding set of historical quotes to the initialized financial model type and estimating the at least one variable parameter.

6. The method according to claim **5**, wherein, for each model corresponding to one of the financial instruments:

step (a1a) includes providing at least one of:

a corresponding historical time series of the bid prices of the financial instrument, including corresponding bid times; or

a corresponding historical time series of the ask prices of the financial instrument, including corresponding ask times;

step (a1d) includes applying the at least one of the corresponding historical time series of bid prices or the corresponding historical time series of ask prices to the initialized financial model type to estimate the at least one variable parameter;

step (a3) includes the steps of;

a3a) providing the selected at least one of;

the corresponding bid stream of the financial instrument, including the bid prices and corresponding bid times; or

the corresponding ask stream of the financial instrument, including the ask prices and corresponding ask times; and

a3b) applying the selected at least one of the corresponding bid stream or the corresponding ask stream to the model; and

step (a4) includes operating the model to predict one or more corresponding future values of the numerical investment significant parameter of the financial instrument including a predicted time of each of the one or more future values.

7. The method according to claim **6**, wherein, for each model corresponding to one of the financial instruments, the predicted time of each corresponding future value of the numerical investment significant parameter is within a predetermined period of time after its prediction.

8. The method according to claim **5**, wherein, for each model corresponding to one of the financial instruments:

step (a1a) includes the steps of:

a1a1) providing a corresponding historical time series of the bid prices of the financial instrument, including corresponding bid times, and a corresponding historical time series of the ask prices of the financial instrument, including corresponding ask times; and

a1a2) calculating a corresponding historical time series of a spread between the bid prices and the ask prices of the financial instrument from the corresponding historical time series of the bid prices and the corresponding historical time series of the ask prices; and

step (a1d) includes applying the corresponding historical time series of the bid prices, the corresponding historical time series of the ask prices, and the corresponding historical time series of the spread between the bid prices and the ask prices to the initialized financial model type to estimate the at least one variable parameter.

9. The method according to claim **8**, wherein, for each model corresponding to one of the financial instruments, step (a3) includes:

a3a) providing the corresponding bid stream of the bid prices of the financial instrument, including corresponding bid times, and the corresponding ask stream of the ask prices of the financial instrument, including corresponding ask times;

a3b) calculating a corresponding spread stream of a spread between the bid prices and the ask prices of the financial instrument from the corresponding bid stream and the corresponding ask stream; and

a3c) applying the corresponding bid stream, the corresponding ask stream, and the corresponding spread stream to the model.

10. The method according to claim **5**, wherein, for each model corresponding to one of the financial instruments, step (a1b) includes selecting the corresponding financial model type to be one of: an expert system model; a linear analytic model; a non-linear analytic model; a chaotic model; a neural network model; a time delay neural network model; a Markov-chain Monte Carlo model; a wavelet transformation model; a regression model; a fractal model; a support vector machine model; or a Bayesian model.

11. The method according to claim **1**, wherein, for each financial instrument, step (a) includes the steps of:

a1) providing a corresponding model of at least one of bid prices or ask prices of the financial instrument based on a corresponding set of historical quotes of the at least one of bid prices or ask prices of each financial instrument;

a2) selecting at least one of a corresponding real time bid stream or a corresponding real time ask stream based on the at least one of bid prices or ask prices of the financial instrument modeled by the corresponding model;

a3) applying the selected at least one of the corresponding bid stream or the corresponding ask stream to the corresponding model; and

a4) operating the corresponding model to predict at least one of corresponding future bid prices of the financial instrument or corresponding future ask prices of the financial instrument.

12. The method according to claim **11**, wherein, for each model corresponding to one of the financial instruments, step (a1) includes the steps of:

a1a) providing the corresponding set of historical quotes of at least one of bid prices or ask prices;

a1b) selecting a corresponding financial model type having at least one variable parameter;

a1c) initializing the at least one variable parameter of the selected financial model type; and

a1d) generating the model of the at least one of bid prices or ask prices of the corresponding financial instrument by applying the corresponding set of historical quotes to the initialized financial model type and estimating the at least one variable parameter.

13. The method according to claim **12**, wherein, for each model corresponding to one of the financial instruments:

step (a1a) includes providing at least one of:

a corresponding historical time series of the bid prices of the financial instrument, including corresponding bid times; or

a corresponding historical time series of the ask prices of the financial instrument, including corresponding ask times;

step (a1d) includes applying the at least one of the corresponding historical time series of bid prices or the corresponding historical time series of ask prices to the initialized financial model type to estimate the at least one variable parameter;

step (a3) includes the steps of;

a3a) providing the selected at least one of;

the corresponding bid stream of the financial instrument, including the bid prices and corresponding bid times; or

the corresponding ask stream of the financial instrument, including the ask prices and corresponding ask times; and

a3b) applying the selected at least one of the corresponding bid stream or the corresponding ask stream to the model; and

step (a4) includes operating the model to predict at least one of;

one or more corresponding future bid prices of the financial instrument including a predicted bid time of each of the one or more future bid prices; or

one or more corresponding future ask prices of the financial instrument including a predicted ask time of each of the one or more future ask prices.

14. The method according to claim **13**, wherein, for each model corresponding to one of the financial instruments, the predicted bid time of each corresponding future bid price and the predicted ask time of each corresponding future ask price are within a predetermined period of time after their prediction.

15. The method according to claim **1**, wherein the at least one financial instrument is at least one publicly traded financial instrument.

16. The method according to claim **1**, wherein the at least one financial instrument are selected from the group consisting of stocks, bonds, commodities, currencies, equities, derivatives, and futures.

17. The method according to claim **1**, wherein, for each of the financial instruments, step (a) includes predicting one or more corresponding future values of the numerical investment significant parameter of the financial instrument includ-

ing a corresponding parameter confidence level of each of the one or more corresponding future values.

18. The method according to claim **17**, wherein the trend data determined in step (b) for each of the financial instruments includes a corresponding trend confidence level based on at least one of the corresponding parameter confidence level.

19. The method according to claim **18**, wherein the buy criterion and the sell criterion for each of the financial instruments varies based on the corresponding trend confidence level determined in step (b).

20. The method according to claim **18**, wherein:

step (c) includes the steps of:

c1) determining if the corresponding trend data determined in step (b) meets the buy criterion for the one of the financial instruments;

c2) determining a buy size of the buy order based on the corresponding trend confidence level determined in step (b) when the corresponding trend data is determined to meet the buy criterion in step (c1); and

c3) automatically placing the buy order for the one of the financial instruments when the corresponding trend data is determined to meet the buy criterion in step (c1); and

step (d) includes the steps of:

d1) determining if the corresponding trend data determined in step (b) meets the sell criterion for the one of the financial instruments;

d2) determining a sell size of the sell order based on the corresponding trend confidence level determined in step (b) when the corresponding trend data is determined to meet the sell criterion in step (d1); and

d3) automatically placing the sell order for the one of the financial instruments when the corresponding trend data is determined to meet the sell criterion in step (d1).

21. The method according to claim **1**, wherein:

the at least one investment significant parameter of the financial instrument includes at least one of a future bid price or a future ask price; and

for each of the financial instruments, step (a) includes predicting at least one of:

one or more corresponding future bid prices of the financial instrument including a corresponding bid confidence level of each of the one or more corresponding future bid prices; or

one or more corresponding future ask prices of the financial instrument including a corresponding ask confidence level of each of the one or more corresponding future ask prices.

22. The method according to claim **1**, wherein:

the at least one financial instrument is a plurality of financial instruments; and

step (b) includes the steps of:

b1) for each of the at least one financial instrument, comparing the at least one investment significant parameter predicted in step (a) to at least one most recent most recent value of the numerical investment significant parameter of the corresponding financial instrument to determine a predicted change of the corresponding financial instrument;

b2) analyzing the plurality of predicted changes determined in step (b1) to formulate a joint trade strategy for the plurality of financial instruments over a predetermined period time; and

b3) setting the trend data corresponding to each of the financial instruments based on the joint trade strategy.

23. The method according to claim **22**, wherein step (b2) includes analyzing the plurality of predicted changes determined in step (b1) to formulate the joint trade strategy using one of: an expert system model; a linear analytic model; a non-linear analytic model; a chaotic model; a neural network model; a time delay neural network model; a Markov-chain Monte Carlo model; a wavelet transformation model; a regression model; a fractal model; a support vector machine model; or a Bayesian model.

24. The method according to claim **1**, wherein:

the at least one investment significant parameter of the financial instrument includes at least one of a future bid price or a future ask price;

the at least one financial instrument is a plurality of financial instruments; and

step (b) includes the steps of:

b1) for each of the at least one financial instrument, comparing the at least one future bid price or future ask price predicted in step (a) to at least one most recent bid price or at least one most recent ask price of the corresponding financial instrument to determine a predicted quote change of the corresponding financial instrument;

b2) analyzing the plurality of predicted quote changes determined in step (b1) to formulate a joint trade strategy for the plurality of financial instruments over a predetermined period time; and

b3) setting the quote trend data corresponding to each of the financial instruments based on the joint trade strategy.

25. The method according to claim **1**, wherein:

the at least one financial instrument is a plurality of financial instruments;

step (c) includes the steps of:

c1) determining the buy criterion for each of the financial instruments based on at least one trend data determined in step (b) corresponding to another of the financial instruments;

c2) for each financial instrument, determining if the corresponding trend data determined in step (b) meets the corresponding buy criterion determined in step (c1); and

c3) automatically placing the buy order for each financial instrument for which the corresponding trend data is determined to meet the corresponding buy criterion in step (c2); and

step (d) includes the steps of:

d1) determining the sell criterion for each of the financial instruments based on at least one trend data determined in step (b) corresponding to another of the financial instruments;

d2) for each financial instrument, determining if the corresponding trend data determined in step (b) meets the corresponding sell criterion determined in step (d1); and

d3) automatically placing the sell order for each of the financial instruments for which the corresponding trend data is determined to meet the corresponding buy criterion in step (d2).

26. The method according to claim **1**, wherein:

step (c) includes the steps of:

c1) comparing the corresponding trend data determined in step (b) to the buy criterion for the one of the financial instruments;

c2) determining a buy size of the buy order based on the comparison of the corresponding trend data and the buy criterion in step (c1);

c3) automatically placing the buy order for the one of the financial instruments when the buy size determined in step (c2) is greater than zero; and

step (d) includes the steps of:

d1) comparing the corresponding trend data determined in step (b) to the sell criterion for the one of the financial instruments;

d2) determining a sell size of the sell order based on the comparison of the corresponding trend data and the sell criterion in step (d1);

d3) automatically placing the sell order for the one of the financial instruments when the sell size determined in step (d2) is greater than zero.

27. The method according to claim **1**, wherein the investment significant parameter includes at least one of: a future trade price; a future bid price; a future ask price; a future spread; a fair market value (FMV); an expected profit; a change in trade price between two times; a change in bid price between two times; a change in ask price between two times; a change in spread between two times; a change in FMV between two times; a change in profit between two times; a rate of change of trade price; a rate of change of bid price; a rate of change of ask price; a rate of change of spread; a rate of change of FMV; a rate of change of profit; a prediction of winners and losers; or a buy/sell instruction.

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