

Changes to the Japanese Equity Market as Visualised by NEEDS-TickVision

A look at how the launch of TSE Arrowhead has changed equity trading in Tokyo

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Background to the implementation of Arrowhead in the Tokyo Stock Exchange

The Tokyo stock exchange (TSE) launched its next generation trading system Arrowhead on 4th January 2010. What has this new trading system done to the Japanese equity market?

Over the next six pages, we will look at the changes taking place in the market following the introduction of Arrowhead and the new directions the trading environment is taking using NEEDS-TickVision - a new tick data service from Nikkei Digital Media Inc.

Background to System Innovation

As I reported in a previous article published through the Nikkei NEEDS website, there was a good case for upgrading the trading system at the TSE following a series of system malfunctions which occurred between late 2005 and early 2006. This time I would like to start by looking at a timeline of trends in financial engineering. The reason for this is that the TSE was moving in the direction of a system overhaul before the problems hit the old system.

World history and financial engineering innovation

Financial engineering has advanced not only through the evolution of computer power but also in response to the demands of financial trends as seen in the timeline below.

The timeline shows various global events and their corresponding changes in the financial world and to computer technologies. (The relationship between the financial engineering and computer technology is outside the remit of this report.) Below the timeline are the names of three different scholars who have won the Nobel Prize for Economics. They were researchers covering the most important economic trends of their time.

Harry Markowitz presented a solution to portfolio selection and the type of assets to be held in an age of uncertainty during the postwar period. Myron S. Scholes (If Fisher Black had been alive, he would certainly have shared the Nobel prize as well.) introduced the methodology to evaluate fluctuations in asset value – providing the formulas for hedging assets against wild price fluctuations caused by the oil crisis and the Nixon shock. And finally Robert Engle established a descriptive grammar on time series data to link price fluctuations with forecasts in a time of high volatility and frequent sudden rises and falls in the market following the Plaza Accord and Black Monday.

What is the next trend in financial services?

The previous timeline shows not only financial engineering technology of the past but also the direction of development in the future. It will be new technologies that will address the issues of the current financial system and

market structure that have arisen with the credit crunch – or the Lehman shock - which started in the U.S.A. with the default of subprime loans in 2007 and culminated in the bankruptcy of Lehman Brothers in 2008.

The Lehman shock was a crisis in which financial derivatives were securitized leading to a huge bubble economy that nobody had anticipated and warped normal market behaviour throughout the entire financial system. Although they made full use of existing financial technologies in applied risk management, a danger grew due to time lags in the financial clearing system. In this case, what kind of financial technology is required to tackle a similar crisis in the future? Is current technology enough?

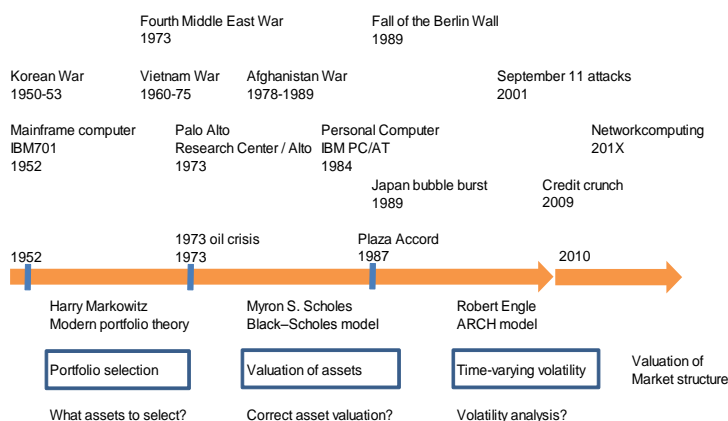
One answer to this issue can be found in the engineering used in natural science research or the manufacturing industry. It is a technique called “simulation” which is used for analyzing complex processes such as the stability of atmospheric weather patterns or inspecting the durability of an object.

Existing simulation technology and TSE Arrowhead

Used in current risk management technology, a stress test assesses potential risk quantitatively by applying scenarios of probability or changing patterns of price fluctuations using simulation technology. This simulation technology is very useful in evaluating various kinds of risk scenarios. However the analysis result is limited to a static snap shot of tables and charts, ie they do not change in real-time. In fact, this type of limited analysis applies to all other types of financial engineering, not only stress tests, which are merely calculation technology using a process for outputting a result.

The problem is that market participants are urged to carry out risk management in constantly changing financial markets. In other words they are using static information of risk value as a preparation tool while managing the risk in constantly changing markets. And most financial

World History and Innovations in Financial Technology



*Financial Technology is developed according to the needs and trend of the time period



Screenshot(1) NEEDS TickVision

institutes have left risk management to their traders' analysis of the market environment. Unfortunately TSE Arrowhead has overturned traders' sense of their trading environment because the 10 millisecond response time has become far too fast for humans to keep up with.

Simulation of changes

Nikkei Digital Media Inc. launched a new tick data analysis service in April 2010 called NEEDS-TickVision, which provides basic analysis functions to replay market movements in animation mode. NEEDS-TickVision has replaced market movements which have grown too fast to be spotted into a simulation which can then be analyzed tick by tick. It enables market participants to see price movement patterns which are now no longer visible.

The first step for financial analysis is to recognise market movements and then afterwards produce ideas for further analysis.

The screenshot (1) above is a sample of the daily movements in an order book which is available in NEEDS-TickVision. In this screen, daily movements in the order book can be replayed as an animation. This animation enables us to see changes to prices in the order book, not only as a final result but giving a feeling of reality to the trading environment as prices suddenly rise in the order book. This feeling of reality supports the view I proposed in my previous report, "A Look at Tick Data Analysis and Algorithmic Trading using NEEDS Tick Data" in which I stated that computer resources have never been more important in stock trading. The main change that Arrowhead has caused is that it has converted the market into a place where we cannot follow daily price movements without computer assistance. NEEDS-TickVision provides a new analysis environment which helps us to recognise and understand these price movements.

Tick Analysis following the launch of TSE Arrowhead

When TSE Arrowhead was first launched, it changed the order matching (trading) speed from once in every three seconds to every few milliseconds - several hundred times faster than before. What happens when trading speeds up? Let's look at an actual example to see how the stock market changed because of TSE Arrowhead.

History of the stock market computerization

The Tokyo Stock Exchange (TSE) started to use computers for trading in 1982. Computerization began in the TSE second section trading and then expanded into part of the first section (off-floor trading). Computerization was completed

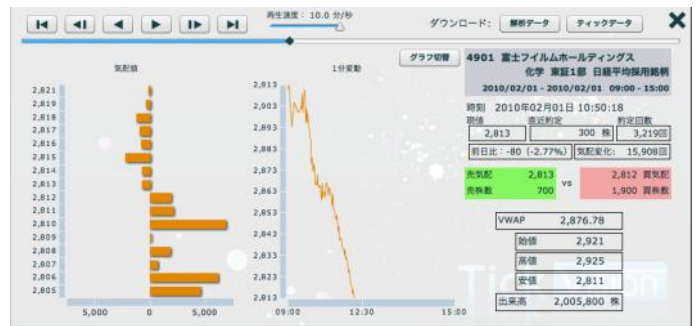
Graph(1) Inter-day trading for Dai-Ichi Life Insurance 02/04/2010



Graph(2) Dai-Ichi Order Book at 09:02:44 on 02/04/2010



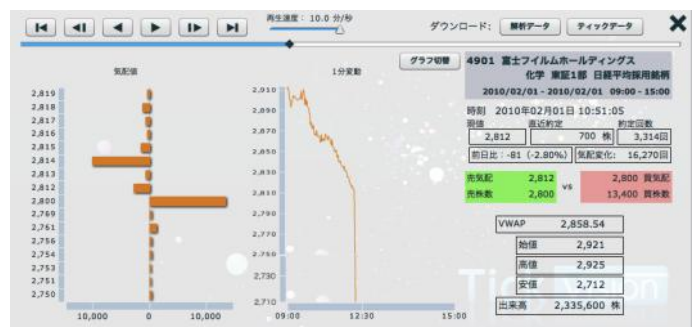
Graph(3) Order Book for Fuji Film Corp at 10:50:18 on 02/04/2010



Graph(4) Order Book for Fuji Film Corp at 10:50:52 on 02/04/2010



Graph(5) Order Book for Fuji Film Corp at 10:51:05 on 02/04/2010



for all trading sections on 01/05/1999.

Computerization allows vast amounts of data to be handled many times faster than a human could possibly cope with.

As information infrastructures such as the Internet have developed, market data has become widely accessible and equity trading is now more familiar to the general public. Looking back at the history of the computerization of the stock market, it has contributed a lot to the promotion of the stock market to the public.

TSE Computerization History	
1982	Second section
1985	First section (off-floor trading)
1991	Floor trading computerization started
1992	Computerization complete

How quickly does the TSE Arrowhead process trading?

TSE Arrowhead has expanded the capacity of trading and enabled large volume trading (not only in the quantity of trading, but also number of times of the trading), but it is doubtful whether or not it has made equity trading more convenient. This is because recognizing the changes to the order book has now exceeded the response capability of humans.

It is thought that humans need 0.5 seconds (500 milliseconds) to identify new movement. (For details please refer to "Mind time" by Shinsuke Shimojo and Iwanami Shoten). TSE Arrowhead processes and matches trades within two milliseconds (one millisecond is one-thousandth second). With this in mind, how many potential market movements can occur in one second?

Using the NEEDS-TickVision you can calculate how quickly market data changes. Let's have a look at the inter-day trading of Dai-ichi Life Insurance Company Limited (8750), listed on the first section of the TSE on 2nd April this year. (On the listing day, it closed limit-up and only one trade existed, so we will look at the second day of listing)

In Graph(1) you can see the highest frequency in trading in one minute on the day was 994 times in one minute at 09:06 am, as marked in the red box. The left hand chart shows there were between 500 to 1,000 time trades every minute during the 10 minute period after 09:00 am (market opening time). Therefore during the first 10 minutes there existed 10 trades every second on average. It means on average one trade every 0.1 seconds.

Check it in the order book

How many times did the order book change during that period? Using the download function of NEEDS-TickVision you can extract pin-point data during the first 10 minutes. This data (the data has time stamp in second level) shows that there were 55 time changes in the order book in one second at 09:02:44. You can confirm it in a distribution diagram in an inter-day analysis function of the NEEDS-TickVision. Graph (2) shows the order book situation of

09:02:44 on 02/04/2010. (Normally the order book information is in table format, but NEEDS-TickVision visualises the data into a bar chart to make it easier for users to interpret.) The left hand bars of the chart shows bid orders and the right hand bars shows ask orders.

It shows the order book changed 55 times in one second and trades were made 28 times during that period with a trading volume of 578 in total. It is obvious that it is impossible for a human to trade by acting on changes to the order book. Even though humans cannot keep track of the order book, this case does not present much of a problem because prices didn't fluctuate very much. However the next case will highlight the problem.

As shown in Graph (3) the stock price of Fuji Film Corp. (4901) kept falling from its opening, hitting a low of 2,811 yen at 10:49:07 am then showed the order book layout in the left hand chart at 10:50:18 am, when the price was 2,813 yen. However, just 0.5 seconds after this time, the price dropped from 2,813 yen to 2,714 yen (judging from the number of orders). Following the dramatic fall, the order book of the Fuji Film Corp. (4901) became a sequential trade quote (*), a new rule implemented by the TSE with Arrowhead. The sequential trade quote displays a suspended price for one minute when the price change exceeds double the bid/ask change margin (for this case 50 yen). The suspended price was 2,713 yen which was 100 yen less than 2,813 yen with 121,500 stocks for the ask quote. Fuji Film Corp was traded at 2,713 yen after 34 seconds from the start of the one minute suspension. In other words it means that bid orders reached the new price level after 34 seconds. Graph (4) shows the order book situation at 10:50:52 am.

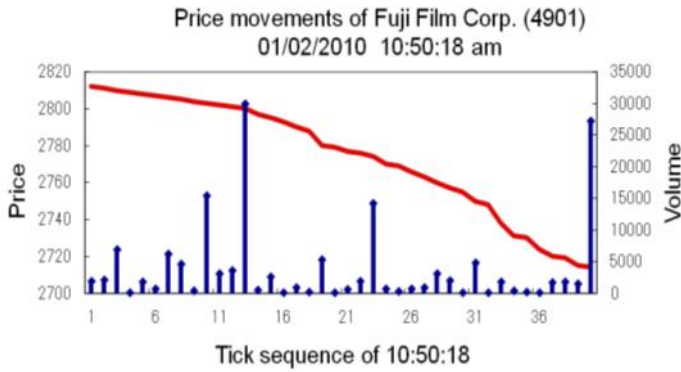
After the price fall, a very interesting event occurred. Although the price dropped 100 yen (3.55%) from the order book level at 10:50:18 am (showed in the graph (3)), it rose back to 2,812 yen in the next 13 seconds after the fall at 10:51:05 am as shown in Graph (5). Therefore it dropped 100 yen and rose 99 yen in the space of 47 seconds from 10:50:18 am which resulted in a 1 yen fall overall. During the fall, the number of traded stocks was 278,100 (in 40 trades) and the VWAP was 2,746.54 yen. During the rise, the number of traded stocks was 51,700 and VWAP was 2,753.20 yen.

We have talked about the second level here but we need to talk about the millisecond level for TSE Arrowhead.

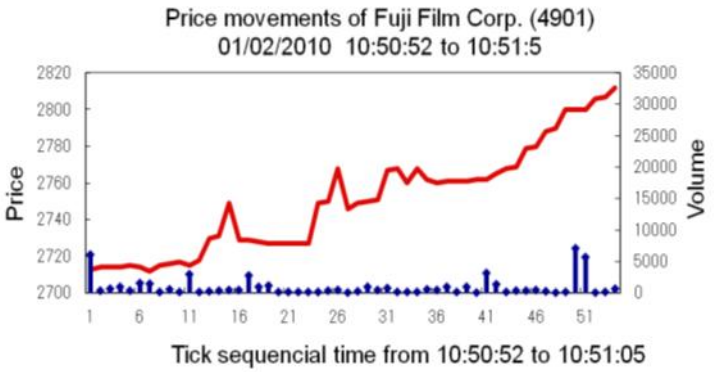
Analyzing Tick base movements

Graphs (6) and (7) over the page show the details of the price drop and the price rise. (Graph (7) shows price movements in 13 seconds. Note that the time scales for the graphs are different). Comparing Graph (6) with Graph (7), the price fell steadily in Graph (6) but rose in a zigzag in Graph (7). This is because the price fell in just 0.5 second, indicating that the fall was a market sell order, executed very quickly. Therefore there were no buy orders in response to the price fall and the price fell steadily. This is to be expected with large market sell orders.

On the other hand the price rose due to limited buy orders and in total there were 54 trades during the period. There were just three market buy orders and just two market sell



Graph(6) Source: Nikkei NEEDS



Graph(7) Source: Nikkei NEEDS

orders in the 54 trades.

Let's see the price movements from another angle. Graph (8) and (9) represent the frequency of trades based on the number of shares traded during the period of price falls and price rises respectively. As the minimum number of shares per trade for Fuji Film Corp. is 100 shares, the probability of trades of greater than or equal to 100 shares is 100%. Graphs (8) and (9) show the probability of trades over 100 shares is 100%. If so, what percentage do trades of more than 1,000 stocks occupy in the price fall? Graph (8) shows that 56% of trades were in volumes greater than 1,000 shares during the period of price falls but according to Graph (9) is only about 22% during the price rise. (The fitted curve shows 22% but the actual probability was 28%, mid values are out slightly due to rounding).

The data sample is not significant enough, but comparing Graph (8) with Graph (9), the frequency of occurrence of the number of traded stocks does show a different pattern during the price fall and price rise periods. It means that the content of the trades during the falling price period and the rising price period was different. Therefore price movements traded by market sell orders only have different statistical features from periods of multiple limit buy orders, and it is possible to discriminate between the order types.

Conclusion

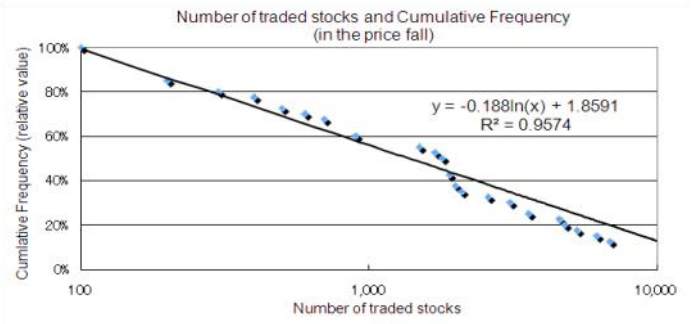
In this chapter I explained the price movement of individual issues to see what effect TSE Arrowhead has had on changes in inter-day prices using NEEDS-TickVision. You may recognise that we can no longer see the high speed movement of the market. The most important point is not to catch up with the speed but to grasp the price movements correctly. Any statistic model without an understanding of price movements will not allow you to take effective countermeasures and correct investment decisions.

Portfolio Analysis using NEEDS - Tick VISION

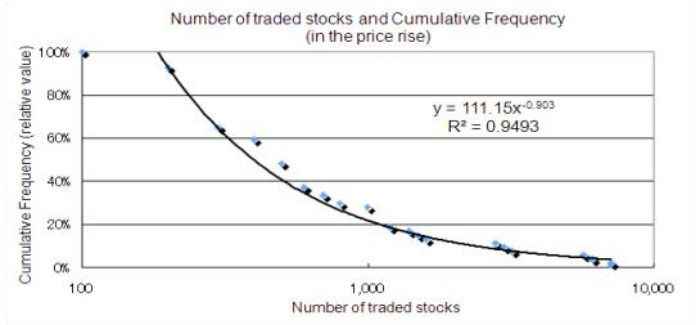
Portfolio theory – the theory that a diversified portfolio of investments gives a better performance in terms of risk-return than investing in a single asset - is common knowledge in the investment world and is widely used by investors. In this last chapter I will introduce portfolio analysis from a tick by tick perspective using NEEDS-TickVision and then conclude by reviewing my points and discuss the direction the stock market is taking

What is Portfolio Theory?

Portfolio theory - a basic tenet in financial business - teaches the risk/return balance to hold financial positions



Graph(8) Source: Nikkei NEEDS



Graph(9) Source: Nikkei NEEDS

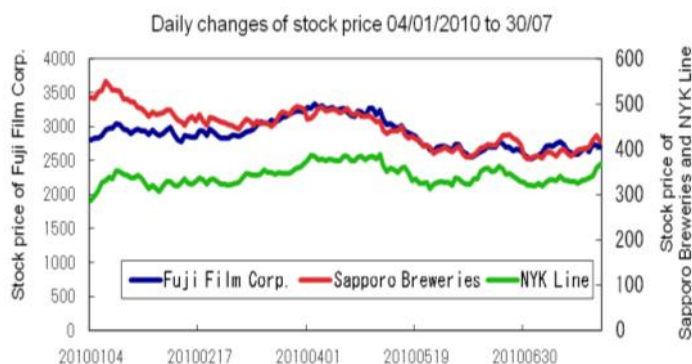
effectively. Currently the risk in the financial industry is assessed by volatility, usually the standard deviation of a time series of returns from an asset. Thus equity which fluctuates wildly is considered a high risk asset class. In general the volatility value decreases when holding multiple assets in a portfolio rather than holding a single asset.

Portfolio theory states that the best asset allocation is when investors hold multiple assets. Let's verify this through NEEDS-TickVision.

Graph (9) shows the daily changes of three stocks chosen at random between 04/01/2010 and 30/07/2010. The table below shows the volatility (annually converted) of the same stocks.

Fuji Film Corp.	Sapporo Breweries Ltd.	NYK Line
26.30%	30.00%	34.90%

If we hold each stock at the minimum trade unit (Fuji Film is 100, Sapporo Breweries 1,000 and NYK Line 1,000), the volatility of this portfolio becomes 24.8%. This value is



Graph (9) Source: Nikkei NEEDS

and intrPmR). amOR is the average return on the opening in the morning, intrR is the inter-day return, pmOR is return after the opening in the afternoon (The TSE closes for lunch), intrAmR is the inter-day return during the morning session and intrPmR is the inter-day return during the afternoon session. dayR is total of amOR and intrR giving the average return for the period.

There are buttons titled “解析データ” (analysis data) and “ティックデータ” (tick data) in the right corner of the screen. Clicking these buttons gives you the csv files of the portfolio for the period in closing price base.

Using this time series data on portfolio value gives a volatility calculation of 24.8%. This example shows how NEEDS-TickVision outputs portfolio data as a single stock.



Graph (10) Source: Nikkei NEEDS

For portfolio management

When we consider the executions of trades for a portfolio, we should not manage each constituent separately but think of the portfolio as a whole. Because the main essence of a portfolio is to lower the overall risk using the correlation between constituents (an increase in return should be for a given risk), it makes sense to consider the portfolio as one when trading for the portfolio. Managing each individual constituent separately for each execution is a different form of risk management, separate from Portfolio risk management. (This execution style does not take the portfolio as a whole but we do not consider it here.)



Graph (11) Source: Nikkei NEEDS

To add constituents while thinking of the portfolio as an individual entity, the portfolio is ‘sliced’ and the parts managed separately. But the portfolio differs from other market participants and the slices of the original portfolio - which we can call “child portfolios” for convenience - may have a different composition ratio of constituents from the other slices, making it impossible to place the perfect order for the portfolio (it is impractical that each execution is judged and analysed by the fund manager to form the perfect portfolio immediately before execution.) If order book analysis improves, this may be possible in the future.

lower than any of the three stocks individually. This shows that holding a position in a portfolio lowers the overall volatility. (Note that holding in a portfolio does not always make the volatility lower than each constituent - It depends on the ratio of number of holding and correlation between constituents).

This volatility of 24.8% can be calculated using the correlation values of the three issues, but it can be calculated much easier in NEEDS-TickVision. NEEDS-TickVision has a portfolio management function which enables a portfolio to be managed as if it was a single stock

Graph (10) is a screenshot of the daily analysis screen of a portfolio managed in NEEDS-TickVision and is similar to the analysis screen of a single issue which we looked at earlier. The centre chart of graph (10) shows the daily changes to the portfolio from 04/01/2010 to 30/07/2010 (over the same period as graph (9), portfolio management operation and screen have to be omitted here).

The bar chart to the left summarizes the daily changes and shows that the price rose on opening (the bars labeled amOR and pmOR) and dropped during the day (intrAmR

So NEEDS-TickVision provides a portfolio order book by summing up the order books of each constituent to display the portfolio as an individual issue.

Graph (11) shows the portfolio order book as of 30/07/2010 13:39:00 for the previously-mentioned three issues. The order volume of this portfolio is the sum of the number of bid/ask shares adjusted to the minimum trade unit.

This graph shows that the ask quotation has a larger volume than the bid quotation at 13:39:00. You can review and evaluate trading for a portfolio to see whether your bid/ask was liquid enough by replaying the order book as an animation in NEEDS-TickVision. You can also review the inter-day bid/ask spread (the gap between the ask quotation and bid quotation) of the portfolio which is shown in graph (12) over the page. “Bid-Ask平均” is the bid-ask-spread of 30/07/2010 15:00:00 and value of 5,500 yen (51.8bp of total portfolio value: 1bp is 0.01%) which can be seen to the right of the graphs in (12).

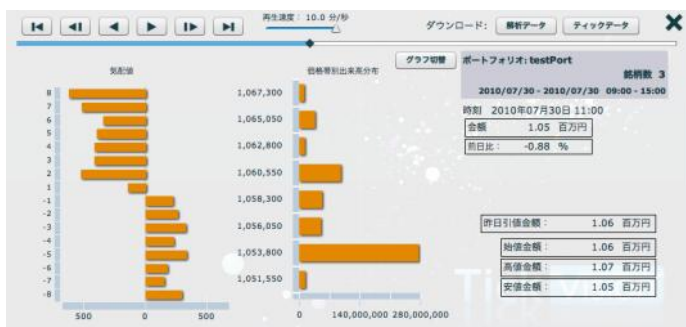
In NEEDS-TickVision, the bid-ask-spread of every minute



Graph(12) Source: Nikkei NEEDS



Graph(13) Volume Chart - Sapporo Breweries 30/07/2010 11:00



Graph(14) Volume Chart - Price zones for portfolio

can be checked, allowing you to analyze the spread at your time of trading.

Volume Distribution of portfolio

I want to now introduce one final feature of NEEDS TickVision. Market participants always check the stock price before they buy or sell, however a more careful trader may look at the volume of each price level, indicating the relation between the price and the volume. This suggests that the price level with the highest volume – the price at which the largest number of market participants have placed an order - indicates the cost of the asset at that time and comes to the attention of other traders. There is a toggle button in the right top corner of the centre chart which switches the chart from inter-day price movements to a volume chart of each price level.

Graph (13) shows the volume chart for each price level for Sapporo Brewery Ltd. (2501) at the close of the morning session on 30/07/2010. Using NEEDS-TickVision you can replay this volume chart to visualize the changes over the morning. This volume chart can be seen in other analysis tools provided by securities companies or data vendors. However volume charts of inter-day price movements are quite rare.

Moreover NEEDS-TickVision provides a volume map of a portfolio, shown in graph (14) above.

The volume chart for each price level of your portfolio shows you which price level (value zone for a portfolio) was the most actively traded for your portfolio. This information enables you to review the market situation from a trading perspective, not only looking at the traded price but also judging from the trading volume, if you traded your portfolio at an active or inactive time. (This cannot be clear by analyzing each constituent of the portfolio separately.) As I mentioned at the beginning of this chapter, by treating a portfolio of assets as a single issue, NEEDS-TickVision provides intuitive and visual information.

How has Arrowhead changed the stock market?

So far I have focused on analysis of the markets after the introduction of TSE Arrowhead. It is clear that we will never return to an era of slow processing now that we have changed to a low latency system.

It will make financial professionals compete to create faster and faster systems. But unfortunately not all market participants will win in a HFT (High Frequency Trading) world. This situation will divide participants into two groups, the group skillful at HFT and the other who doesn't need HFT.

The most important thing is to grasp what is happening to the stock market and to carry out portfolio management based upon your judgment of the situation. (Traders know that the market is not a place to compete on speed but to compete on profit.)

As I mentioned in the previous series and the first chapter of this series, No human can deal effectively in the markets without computers now that the trading speed has increased beyond human reaction times. But the assistance we need from computers is not an algorithm which makes a profit automatically but a tool to execute orders effectively according to the market situation which can be analyzed. A risk taker is a market participant who trades in response to every situation.

Conclusion

I would like to conclude by evaluating the opinions of researchers analyzing the current stock market.

When analyzing recent stock market trends, it becomes clear that risk concepts and risk analysis of global financial instruments is starting to diverge from what it should be. For example, risk from a financial engineering perspective is measured as volatility. When you are holding a position, I certainly think that volatility plays a key role but when looking at one sided volume or sudden changes during inter-day trading, risk cannot be expressed as a volatility calculation. And then consider the Lehman shock. Even by making full use of financial technology at the time or technical expressions it was clear that we do not fully understand the risks involved. It is important to follow existing technology, but we may be able to find something new from original market data. (Since we can handle the data easily in NEEDS-TickVision.)

We are facing a new period when new financial technology will be developed including new concepts of risk. ■

Quick Start Tutorial : NEEDS - TickVision

Tick Data Analysis and Download from Nikkei Digital Media.

NEEDS TickVision is Nikkei's online tick data download service, providing over 15 years of individual stock tick data, futures and options tick data, JGB data and stock index tick data all from one convenient source. Nikkei has built an unrivalled reputation for quality financial market data in the Japanese sector and over 95% of Japan based financial institutions use Nikkei NEEDS data.

TickVision provides brokers, risk analysts, portfolio managers and algorithmic trading professionals with access to level 2 order book data downloads and analysis tools to accurately measure VWAP, bid/ask spreads, beta coefficients to generate original financial analysis systems and research.

Data Analysis Page

Here we provide an example of order book analysis and tick data download in NEEDS TickVision for Sony Corp (6758)

Time and date of data analysis - in Japanese format YYYY/MM/DD



The Order book situation for Sony at 12:46. Bid is in Green, Ask is in red.

1 minute inter-day price chart for Sony up to 12:46.



1. Stock Selection

After the Stock Analysis (市場分析) screen loads, the above screen is displayed allowing you to enter the stock code and dates for analysis. You can perform analysis on individual security codes or on a portfolio as a whole. In this example, we are looking at Sony Corp(6758), which is entered into the box marked in Yellow. The name of the company in Japanese appears in the box next to the code. It is also possible to enter codes for other securities such as Futures and Options, stock indices, bonds etc, which can be altered through the option in the red box.

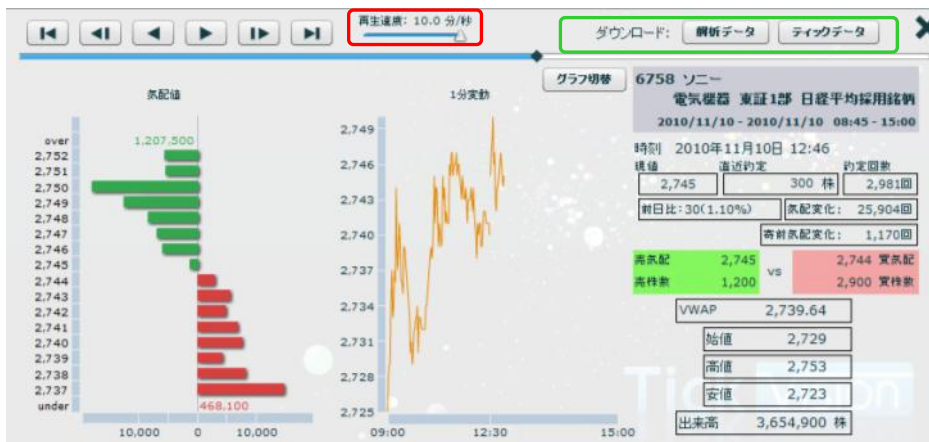
The date and time can be entered into the box above to alter the timing of the analysis.



2. Analysis Selection

After selecting the security and timing for the analysis, it is time to select the type of analysis we wish to perform. Using the graphs on the side, click the analysis action you wish to perform. The main graph and user controls displayed in the screenshot above will appear.

The first graph in the list 日中板変動 displays the full inter day order book, 気配分析 displays indicator analysis and the bid ask spread as basis points; 変動パターン分析 displays statistical pattern analysis on price direction based on probability; 分布分析 displays number of trades analysis and 相関変動分析 displays Nikkei beta coefficient and R2 analysis.



3. Summary Data

Summary data is provided along with the graphical representation of the data, detailing the VWAP, the bid ask spread, the volume of the bids and asks, the total traded volume, number of changes to the order book, number of shares at the best bid and ask etc.

4. Playback and Download

Using the control buttons and the timeline, it is possible to replay, pause and rewind the daily changes to see how tick by tick decisions affect the prices of the security. The box in red allows you to replay the video at different speeds and is in default mode at 10 minutes per second of replay. The box in green allows you to download the data in csv format for further analysis or integration with your own bespoke systems.

By clicking the data download ティックデータ button, TickVision opens the download portal, allowing you to download the data as a zip file in csv format.

Downloads include the entire order book data, including *Itayose* pre-trading data. Tick Vision also gives you the option of downloading the analysis data as well, enabling you to download summary items such as VWAP, number of trades, volume of the bid and ask, price levels etc.

Tick Vision provides the tools necessary to understand the Japanese Securities Market - it is an essential tool for algorithmic trading researchers, brokers and risk management professionals to produce accurate and original insights into TSE Arrowhead.

Please contact a Nikkei Representative for a trial or demonstration.

President YOON Hiwon, CMD Laboratories Inc

Dr Hiwon Yoon is the author of the main article and President of CMD Laboratories in Tokyo, providing research and analysis services to the financial, medical and agricultural sectors. For more information www.cmdlab.co.jp

Nikkei NEEDS

Nikkei is not only the world's largest economic newspaper and publisher of the Nikkei 225 benchmark index for Japan, we are also the premier source of Japanese corporate financial and securities data. The Nikkei Economic Electronic Databank Service (NEEDS) provides over 40 years of corporate financial data, securities data, macroeconomic and consumer statistics.

Nikkei NEEDS data has an unrivalled reputation for quality and is used by more than 95% of investment companies in Japan. We have a global support network in place to ensure that our clients receive timely support while using our service, with international offices in Tokyo, London, Hong Kong and New York.

We offer a range of different access options to suit the needs of our clients: NEEDS SPOT is for bespoke one time data sets designed to fill gaps in investment company databases and for academic researchers; NEEDS BULK provides daily updated clones of the Nikkei master databases for banks and investment companies; NEEDS FinancialQUEST provides a subscription based online data download service, ideal for fund managers and company analysts.

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