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| **Headquarter:** **Switzerland** | **Company:** **Elite Bank** | **Date:** **18th July 2017** |
| **Banking / Finance:** **Banks** | **Departmental Function(s):** **Technology and Operations** | **Nature:** **Solution Proposal** |

**REVEALING THE PROMISED LAND**: **Synergy for Achieving Financial Excellence**

**A Glimpse of Price Discrepancy in Derivative Trading**

Price discrepancy has two layers of meaning. Firstly, it is the difference of price quotes amidst different external data source. For instance, the stock price of HSBC shown at one particular time on Bloomberg Terminal is $58 whereas from Thomson Reuters is $58.2. Secondly, it is the discrepancy between the real spot price and the wrongly captured spot price. In addition, the daily generated P/L is based on the difference between the spot price and the strike price.

**(a) – Unreliable External Data Sources**

MarketBox is a warehouse which stores market movement data, and oftentimes such data is captured by external data sources. For instance, Thomson Reuters is the subscribed database for Elite Bank. There is a possibility for reporting errors to occur in Reuters, and relying on only one source is therefore unwise. Thus, multisource reference checking is recommended **[1]**. Prior to the recording of spot price, a cross-check is conducted to detect any price discrepancy (e.g. between Bloomberg Terminal and Thomson Reuters) **[2]**.

**(b) – Wrong Capturing of Spot Price**

MoneyClip is where price discrepancy can occur due to the inconsistent treatment of how spot price should be taken, together with inappropriate instructions for departmental surveillance. Corrective actions can be taken by first understanding thoroughly the guidelines of determining spot price **[3]**. Consequently, regular instruction checks of MoneyClip should be adopted. For instance, currency is traded in a decentralized market, and it is essential to determine how the unrealized profit is calculated. This implies it is necessary to consider which exchange is referred to when unrealized profit is detected **[4]**.

**ELITE BANK FOR THE WINNING EDGE**: **Smarter Solution Made Simple**

|  |
| --- |
| **References:**  Goldman Sachs FinTech Forecasts,  Blackrock Investment Commentary |

**|Page 1**

**[01].** Goldman Sachs. (2017). Securities Division: Electronic Trading SIGMA X MTFTM Participant Manual.

**[02].** Accenture. (2016). Bridging the technology gap in financial services boardrooms.

**[03].** Ernst and Young. (2016). Capital Markets: Building the Investment Bank of the Future.

**[04].** Boston Consulting Group. (2017). Global Capital Markets 2017: Mastering the Value Migration.

**INTRINSICALLY MOTIVATED, TECHNICALLY DRIVEN: Problems Identification**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Problem(s)** | | | **Suggested Perspective(s)** | **Solution(s)** | **Mitigation**  **Ability** |
| **Technological** | 1 | Unreliable External Data Sources | Front-to-Back Trading  Cycle Improvement | Multisource Referencing  & Alert System | **87%** |
| 2 | Wrong Capturing of Spot Price | Improvement of Timeliness  & Efficiency | EM Algorithm & Exchange Linkage | **91%** |
| **Operational** | 3 | High Maintenance Manpower Cost | Operational Risk  Controls | Chatbot for  Inhouse Support | **80%** |
| 4 | In-house System Incompetence | Cost Reduction via  Offshoring & Outsourcing | FinTech Venture  Capital Investment | **83%** |

**[Problem 1: Unreliable External Data Sources]:** The authenticity of data available on external data sources (e.g. Thomson Reuters) and the reliability of using only one data source **[5]**.

**[Problem 2: Wrong Capturing of Spot Price]:** Functional components in the trade system (e.g. MoneyClip) fails to capture the closing price as spot price due to unanticipated errors **[6]**.

**[Problem 3: High Maintenance Manpower Cost]:** Inconvenience caused when system supporters are off-duty and the low operational efficiency in addressing general inquiries **[7]**.

**[Problem 4: In-house System Incompetence]:** Obsolescence of existing system infrastructure in pursuit of operational efficiency enhancement and accuracy in reporting **[8]**.

**SYNERGIZING TALENTS FOR A GREATER VISION: User Case Analysis Overview**

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Technically speaking, price discrepancy is highly correlated to errors of external data sources (MarketBox) and the wrong capturing of spot price (MoneyClip). Therefore, a desirable solution proposal should jostle to negotiate a course of action that best serves the interests of different stakeholders. Furthermore, the trading desk demands the accurate price quotes, while the data integrity team is expected to provide timely support when emergencies happen.

**|Page 2**

**[05].** Morgan Stanley. (2016). Blockchain in Banking: Disruptive Threat or Tool?.

**[06].** Hong Kong Monetary Authority. (2016). Whitepaper on Distributed Ledger Technology.

**[07].** Ernst and Young. (2016). Global Banking Outlook: Transforming Talent - The Banker of the Future.

**[08].** World Economic Forum. (2015). The Future of Financial Services Yearly Report.

**TRADE SYSTEM SOLUTIONS ON DEMAND: Technology & Operations Area**

**[1] Multisource Reference Checking and Alert System**

Price discrepancy risk is not mitigated if Elite Bank continues to lean on single data source for compiling daily profit and loss. To capture a more accurate market price, it is advisable to have at least one more market data source for comparison purpose. For instance, Bloomberg is a renowned financial data vendor with the provision of data terminal services. Cross-checking between the market data from Reuters and Bloomberg is necessary to confirm the data accuracy, especially during the market-close period. Whenever there is a price discrepancy, the alert system will be triggered and corrective actions must be taken. Below are the two layers of the defense mechanism.

**[1.1] EM Algorithm for Stock Price Forecasting**

Expectation-Maximization (EM) algorithm is an iterative algorithm for parameter estimation by maximum likelihood when random variables involved in a time series are not served (i.e. missing stock prices in certain time stamps). Missing data points can be estimated through multiple layers of simulations, the trendline of a certain stock can therefore be generalized **[9]**.

**Simplified Data Log-Likelihood (Rubin 1976):**

*F*(θ|Yobservation) = *f*1(θ|Y) – log[ *f*2(Ymissing|Yobservation ;θ) ]

Elite bank recognizes the quotes provided by exchanges should be the most reliable data. However, the deployment of EM algorithmic machine learning system can be utilized as preliminary parameters for alert trigger, in accordance with the mean squared errors of deviant data points **[10]**. Despite accessible information can be provided by exchanges directly, it is still essential to rely on Blomberg and Reuters for real-time market data feeding, especially for financial instruments traded outside the exchange.

**EM Algorithmic Simulation**

|  |  |
| --- | --- |
| Suppose the red dot indicates a missing data point, whereas the blue squares are subsets of the time series plot. The value of red dot is computed by simulating the expected value through observing the whole dataset **[11]**. A prototype has been created to simulate the estimation of missing stock quotes by using SAS and Excel, entitled **“EM-Algorithm (0005HK\_Missing Value Estimation).xlsx”**. |  |

**|Page 3**

**[09].** G. Andrew Karolyi. (2015). Cracking the Emerging Markets Enigma.

**[10].** J.P. Morgan. (2016). Local Markets Guide: Emerging Market Research.

**[11].** Doz, C., Giannone, D., & Reichlin, L. (2012). A quasi–maximum likelihood approach for large, aapproximate dynamic factor models.

**[1.2] System Linkage with Exchange**

In case the emergency alert is triggered due to the inconsistency of market data from Bloomberg and Reuters, the data from the exchange determines the closing price of the securities. For securities traded on the exchange, data from the exchange must be reliable. For example, the closing price of HSBC (HKG:0005) can be found on HKEx whereas the closing price of The Coca-Cola Co (NYSE: KO) can be identified on New York Stock Exchange.

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| With a sharp focus on the equity desk, Elite Bank can purchase stock price data from HKEx and other exchanges directly. All essential stock information, such as high, low, closing price and turnover can be obtained in CSV format. Since a broad range of products such as options and futures are being traded by the equity desk on a daily basis, the costs of price data subscription (e.g. from HKEx) are therefore reasonable expenses. | |  |  | | --- | --- | | **HKEx Subscription** | | | **($ in HKD)** | | | Entry Level Package  (Morning & market close) | **500** | | One Cross Connect | **1500** | | Daily Market Reports  **–** Futures & Options | **600** | | **Monthly Recurrent Fee ($)** | **2600** | |

**Scenario Analysis: Real Time Data Feeding**

**Step 1** – Input Bloomberg data and Reuters data into the internal warehouse, let the automated system conduct the logical comparison.

**(“Elite Bank Multisource Reference Checking.xlsx”)**

**Step 2** – If the data matches, it passes “true” to EM system such that Bloomberg market data is adopted to compute the real-time P/L.

**Step 3** – If the data doesn’t match, it passes “false” to EM system, triggering the EM algorithmic function to approximate the “should-be” value. The figures generated by EM algorithm is then used to compute the real-time P/L for error estimation.

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| --- | --- | --- | --- | --- | --- | --- | --- |
| **References:**  J.P. Morgan Investor Services – eXecute & KPMG Global Analysis | |  |  | | --- | --- | | **Industrial News** | | | **new york times square logo的圖片搜尋結果** | **Monday’s Plunge in the Yuan Freaked Out China Watchers** | | In December 2016, professional traders using Bloomberg terminals observed the yuan spot prices from a dozen banks all hovering around the actual price of 6.86/$1. Then there was ICAP’s ask price at 7.48 to $1. Reasons for capturing erroneous yuan exchange rate were still unclear. | | |

**|Page 4**

**[12].** Thomson Reuters. (2016). Accessing Rates via Bloomberg - Thomson Reuters.

**[13].** HKEx. (2017). HKEx Market Data Services: Real-time Securities Market Data.

**[14].** Bank of America Merrill Lynch (2016). Impact Investing: The Performance Realities.

**[15].** U.S. Securities and Exchange Commission. (2014). Deutsche Bank Securities Complaints.

**[2] Chatbot for In-house Support**

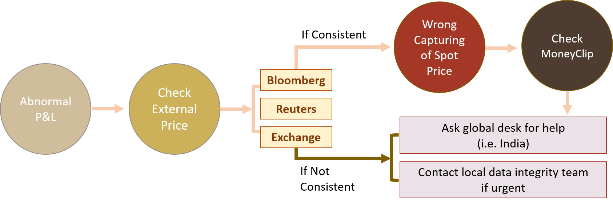
P&L corrections were unable to be completed after office hours due to the lack of workforce in the Data Integrity Team. With the help of Chatbots or conventional robotic advisors, instant feedback can be generated with preset computerized program designated to simulate an intelligent conversation with one or multiple human users, in natural language via auditory or textual methods. Preinstalled solution manual can be immediately delivered with 90% of relevance and is available 24/7 **[16]**. The application of Chatbots is a time-saving and cost-efficient process, which eases the burden of system supporters. Below are two scenarios of how Elite Bank can utilize Chatbot to enhance its operational efficiency.

**Scenario Analysis 1: Learning to Become Familiarized with the Trading System**

New employees in Elite Bank may not be familiar with the current system architecture for Equity Trading Desk. Hence, approaching Chatbot for instant assistance provides information on the trade system description (e.g. functions of MoneyClip) and the linkages between various systems (e.g. MarketBox and StatBox) **[17]**.

**Scenario Analysis 2: Solving Price Discrepancy Problem**

In this scenario, there are two different layers of suggestions. Firstly, when a trader finds out there exists abnormal P&L after working hours which Data Integrity team is off duty, he/she can ask Chatbot on the potential error leading to this problem **[18]**. After identifying the root causes, Chatbot will then advise trader with different approaches to mitigate price discrepancy. If it is due to inaccurate external data sources, contacting global desk for correcting the internal price quotes is highly recommended. For instance, India office (GMT+5.5) is still in normal working hours to provide technical support for core business locations, like Hong Kong, Singapore, Japan and Australia. Calling local Data Integrity Team for help is also understandable for emergencies. If it is due to wrong capturing of spot price, Chatbot will propose the user to conduct instruction checks of MoneyClip in the first place **[19]**, and the remaining procedures are similar to the above instructions. **(“** <http://56e5a1c8.ngrok.io/>**”)**



**|Page 5**

**[16].** Boston Consulting Group. (2017). Global Risk 2017: Staying the Course in Banking.

**[17].** Deloitte. (2016). How chatbots can answer questions for both customers and employees.

**[18].** Accenture. (2017). Embracing the Disruptive Power of Chatbots.

**[19].** Forbes. (2016). UBS And Amazon Team Up For 'Ask UBS' Chatbot.

**[3] FinTech Venture Capital Investment**

System upgrades, starting from detecting price discrepancy to automatedly generating daily P&L, are essential to keep pace with the continuous growth and expansion of financial markets. Investing in firms which promote the use of automation and even artificial intelligence can be a potential alternative **[20]**.

Outsourcing system maintenance duties to the India Office (GMT+5.5) might be one of the many options available in the long run. However, time differences between India and Hong Kong might result in a less fully-covered support for the provision of system maintenance services. To abide by the regulatory requirements and internal requirements of accurate P/L generation, fully-covered support is in no doubt the foundation. Granting the aforementioned reasons, it is important to start considering investments in technology firms, which supports the automation of the whole P/L reporting service in the technical support centre (e.g. India).

**APAC FinTech Investment Volume and Value 2011-2015 (USD Millions) [21]**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Global financial institutions** | **FinTech Venture Capital funds** | **Fund Size**  **(USD mm)** | **Country of Fund** | **Year of Origin** | | **Goldman Sachs** | Goldman Sachs Strategic Investments | Undisclosed | U.S. | Since 2009 | | **Citigroup** | Citi Ventures | Undisclosed | U.S. | Jan 2010 | | **HSBC** | HSBC Fund | 100 | U.K. | May 2014 | | **AXA** | AXA Strategic Ventures | 220 | U.S. | Feb 2015 | | **NAB** | NAB Ventures | 50 | Australia | July 2015 | |  |

The new investment initiatives share the following benefits. First, the technology firm invested can generate long-term income source. The firm is not only providing integrated service to Elite Bank, but it can also provide one-stop service to other financial institutions. Thus, a wider revenue source is given. Second, the commitment to technological investment is considered as a stepping stone to the advancement of technology, maintaining the competitive edges of Elite Bank in the long run **[22]**. The first step taken by Elite Bank to automate the whole P/L reporting service can promote future use of technology, such as applying artificial intelligence in generating trading algorithms and execution of trades **[23]**.

**[20].** Barclays. (2016). Venture Capital in the UK: Its Vital Role in Driving Growth.

**[21].** Deloitte. (2016). Development, Prospect and Regulatory Environment of Fintech.

**[22].** Deutsche Bank. (2017). FinTech 2.0: Creating New Opportunities Through Strategic Alliance.

**[23].** KPMG. (2017). The Pulse of Fintech Q1 2017: Global Analysis of Investment in Fintech.

**|Page 6**

**BEYOND THE BORDERS**: **Risk Oversight and Mitigation**

**References:** PwC. (2016). Blurred Lines: How Fintech is Shaping Financial Services – Global Fintech Report.

There are several areas where risk factors are obstructing the application of FinTech in the banking industry. These areas include financial investments, differences in operational processes and the collision of business models.

**(1) Long Term Financial Burden:** Outsourcing and offshoring are continuous cost items for Elite Bank as the reliance on supportive infrastructure will grow when the scalability of technology deployment is accelerating in the future **[24]**.

**(2) Differences in Operational Processes:** Given thatdifferent financial institutions hold their respective operational processes **[25]**, which implies that establishing joint ventures is indeed a tougher road for FinTech innovation.

**(3) Collision of Business Models:** As investment banking department heavily relies on financial modeling and marketing materials whereas smooth transaction and P/L generation are the key elements for sales and trading department, the perquisite of bringing quality technological solutions is to thoroughly understand the needs of Elite Bank promptly **[26]**.

|  |  |
| --- | --- |
|  | **[Remark]**: As Elite Bank projects that investing in technological firms can provide tailored solutions to our financial institution, venture capital investment **[27]** thus contributes to a sustainable and profitable business model in the long-run. |

**|Page 7**

**[24].** Oracle. (2015). The Benefits of Risk Assessment for Projects, Portfolios, and Businesses.

**[25].** Citibank. (2017). Digital Disruption: How FinTech is Forcing Banking to a Tipping Point.

**[26].** Nomura. (2016). Why FinTech is hot and how it will change financial services.

**[27].** The Institute of Risk Management. (2014). Risk Culture in the Microscope Guidance for Boards

**PRIMING ELITE BANK FOR SUCCESS**: **Three-Year Implementation Timeline [28]**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| **Intrinsically Motivated. Technically Driven.** | | **2017** | | **2018** | | | | **2019** | | | | **2020** | |
| **Q3** | **Q4** | **Q1** | **Q2** | **Q3** | **Q4** | **Q1** | **Q2** | **Q3** | **Q4** | **Q1** | **Q2** |
| **Short Term** | **[1.1] EM Algorithm for Stock Price Forecasting** | | | | | | | | | | | | |
| Assumptions & Algorithmic Setup |  |  |  |  |  |  |  |  |  |  |  |  |
| Implementation Action planning |  |  |  |  |  |  |  |  |  |  |  |  |
| System Architecture Development |  |  |  |  |  |  |  |  |  |  |  |  |
| Ongoing System Maintenance |  |  |  |  |  |  |  |  |  |  |  |  |
| **[1.2] Multi-Source Reference Checking & System Linkage with Exchange** | | | | | | | | | | | | |
| Subscription of Bloomberg Terminal  & Stock Exchange Data Feed |  |  |  |  |  |  |  |  |  |  |  |  |
| Development of Cross-Checking Alert |  |  |  |  |  |  |  |  |  |  |  |  |
| Ongoing System Maintenance |  |  |  |  |  |  |  |  |  |  |  |  |
| **[2] Chatbot for In-house Support** | | | | | | | | | | | | |
| Data Analytics and Robotics Setup **[29]** |  |  |  |  |  |  |  |  |  |  |  |  |
| Continuous Feedback Receival  & UI Modification |  |  |  |  |  |  |  |  |  |  |  |  |
| **Long Term** | **[3] FinTech Venture Capital Investment** | | | | | | | | | | | | |
| Business Negotiation  and Due Diligence |  |  |  |  |  |  |  |  |  |  |  |  |
| Strategic Partnership Confirmation |  |  |  |  |  |  |  |  |  |  |  |  |

Nowadays, FinTech offerings come on stream and new opportunities exist from front office to back office throughout the whole investment bank. As for examples of innovation in post-trade operations, Robotic Process Automation (RPA) can be used to reduce costs associated with repetitive manual process, meanwhile, increasing speed and improving quality and consistency. Therefore, part of this solution proposal advocates the significance of robotics chatbot for system support and emergency alert. Currently, RPA are being adopted across a wide range of operational functions, including remediation activities. The cost savings from automating suboptimal process can be reinvested in longer-term strategic initiatives, such as the application of Blockchain and Smart Contracts to clearing, settlement and reporting **[30]**.

The investment bank of the future is taking shape today. For capital market firms, now is the time to evolve, or risk facing a struggle to catch up in the years to come **[31]**. Therefore, a clear message on FinTech development is stated at the start of this page:

**|Page 8**

**“Game-changing innovation in investment banking is no longer optional, but imperative.”**

**[28].** McKinsey & Company. (2015). Cutting Through the FinTech Noise: Markers of Success, Imperatives for Banks.

**[29].** CFA Institute. (2017). FinTech disruption in the financial Industry and its impact on banks

**[30].** Accenture. (2016). Strategic workforce planning finally gets strategic.

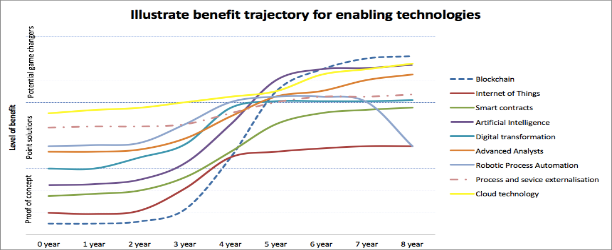
**[31].** Deloitte. (2016). Investment Banking current and future challenges and changes.

**LOOKING AHEAD**: **Financial Budgeting and Forecasting**

|  |  |  |  |
| --- | --- | --- | --- |
| **Developmental Cost Break-Down** | **Year 1** | **Year 2** | **Year 3** |
| **[1.1] EM Algorithm for Stock Price Forecasting** | | | |
| **Development** | <Inhouse design> | / | / |
| **Maintenance & Modification** | <Inhouse design> | <Inhouse design> | <Inhouse design> |
| **[1.2] Multi-Source Reference Checking & System Linkage with Exchange** | | | |
| **Subscription Fee (HKEx) [17]** | $1500 per month | $1500 per month | $1500 per month |
| **Subscription Fee (Bloomberg) [32]** | $20,000 per year | $20,000 per year | $20,000 per year |
| **Development** | <Inhouse design> | / | / |
| **Maintenance & Modification** | <Inhouse design> | <Inhouse design> | <Inhouse design> |
| **[2] Chatbot for In-house Support** | | | |
| **Development [33]** | <Inhouse design> | / | / |
| **Maintenance & Modification** | <Inhouse design> | <Inhouse design> | <Inhouse design> |

**FinTech Venture Capital Investment by Financial Institutions ($USD Millions) [34]**

|  |  |  |
| --- | --- | --- |
| Fund | Invested FinTech Company | Amount |
| AXA Strategic Ventures | One, Inc. | $20M / Series B (Lead) |
| AXA Strategic Ventures | Particeep | $0.92M / Venture |
| Citi Ventures | Kinetica | $50M / Series A |
| Citi Ventures | Trading Ticket | $2.5M / Seed |
| Goldman Sachs Principal  Strategic Investments | DiffBlue | $19.63M / Series A (Lead) |
| Goldman Sachs Principal  Strategic Investments | Dyadic Security | $12M / Series B (Lead) |
| NAB Ventures | Veem | $24M / Series B (Lead) |
| NAB Ventures | Data Republic | $10.5M / Series A (Lead) |



**|Page 9**

**[32].** Bloomberg. (2017). Bloomberg Professional Services | Bloomberg Finance LP.

**[33].** The Economist. (2017). Artificial intelligence in the Real World.

**[34].** CB Insights. (2017). The Boom in Global Fintech Investment**.**

**AMBITION AND IDENTITY OF THE ELITE**: **To Inspire, Be Inspired**

|  |  |
| --- | --- |
|  | The changes and evolution of the financial services landscape that the banking industry has witnessed nowadays are just the beginning of an ever-developing banking eco-system **[35]**. Technology forces changes in the new financial industry, and it is crucial to deploy innovative and more efficient strategies when combating new disruptions **[36]**. |

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| --- | --- | --- | --- | --- | --- |
| **43%** | Rabobank的圖片搜尋結果 | BBVA的圖片搜尋結果 | ABN AMRO的圖片搜尋結果 | 相關圖片 | lloyds banking group的圖片搜尋結果 |
| Barclays的圖片搜尋結果 | bank of ireland的圖片搜尋結果 | unicredit group的圖片搜尋結果 | commerzbank的圖片搜尋結果 | state street的圖片搜尋結果 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **20%** | hsbc的圖片搜尋結果 | citibank的圖片搜尋結果 | 相關圖片 | santander的圖片搜尋結果 |

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| **20%** | hsbc的圖片搜尋結果 | TD bank的圖片搜尋結果 | metro bank的圖片搜尋結果 | santander的圖片搜尋結果 |

**References:**

CurrencyCloud. (2016).

Banks and the FinTech Challenge

|  |  |  |  |
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| **10%** | Barclays的圖片搜尋結果 | citibank的圖片搜尋結果 | BBVA的圖片搜尋結果 |

|  |  |  |
| --- | --- | --- |
| **7%** | ABN AMRO的圖片搜尋結果 | Egon logo的圖片搜尋結果 |

In order to keep pace with other competitors, Elite Bank should be open to digital and FinTech solutions to mitigate enterprise-wide risks and lower operational expenses **[37]**. This Bank holds the firm belief that smarter solution could be made simple, and the intrinsic motivation to alleviate the bank’s operation should be complemented with technological tools. Understanding, regulating and maximizing the benefit of FinTech is set to be a critical means of not only success, but also the survival in the future investment banking landscape **[38]**.

**Contacts**

For further information or to request a full copy of the report, please contact

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  | | --- | --- | |  | **Michelle MA**  **Vice President**  Equity Sales and Trading | | |  |  | | --- | --- | |  | **Charles WONG**  **Senior Manager**  Technology and Operations | | |  |  | | --- | --- | |  | **Ken CHEUNG**  **Senior Manager**  IT Infrastructure | |

**|Page 10**

**[35].** BBVA. (2017). Ebook CIBBVA Fintech Revolution - Centro de Innovación BBVA.

**[36].** Ernst and Young. (2017). Banking in emerging markets - GCC FinTech play 2017.

**[37].** Goldman Sachs**.** (2017).Fintech Developer as Robo-Advisers in The Works**.**

**[38].** Fidelity. (2016). Fintech: The next disruptive frontier.

**[APPENDIX 1]: EM Algorithm for Stock Price Forecasting**

Please refer to **“EM-Algorithm (0005HK\_Missing Value Estimation).xlsx”**

**Estimating Missing Values Using Likelihood Approach**

The expectation–maximization (EM) algorithm is a very general iterative algorithm for parameter estimation by maximum likelihood when some of the random variables involved are not observed, (i.e., considered missing or incomplete.) It formalizes an intuitive idea for obtaining parameter estimates when some of the data are missing **[39]**:

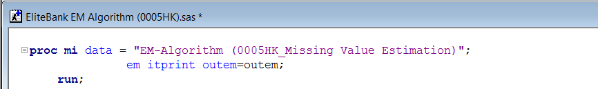
**(1). Replace missing values by estimated values**

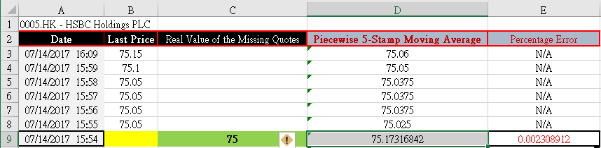
**(2). Estimate parameters**

**(3). Repeat** Step 1 using estimated parameter values as true values, and

Step 2 using estimated values as “observed” values, iterating until convergence.

**SAS Programming Code (PROC MI statement in SAS Software System)**

****



|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | =Missing Value |  | = Estimated Value Using  Maximum Likelihood Simulation |  | = Real Minute Quote  from Bloomberg |

**Remark:** The Maximum Likelihood Simulation was satisfactory in simulating 0005.HK missing quote at 15:54 on 14th July 2017. The estimated value is approximated to 75.173 while the percentage error is less than 0.0025, indicating that the data set fits well in the user-defined partition **[40]**.

**|Page 11**

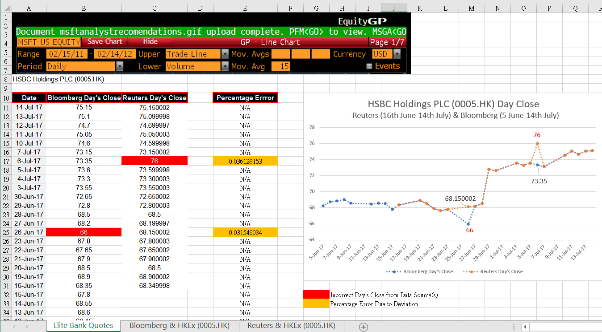
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**[40].** Xu, L., & Jordan, M. I. (1996). On convergence properties of the EM algorithm for Gaussian mixtures.

**[APPENDIX 2]: System Linkage with Exchange**

Please refer to **“Elite Bank Multisource Reference Checking and Alert System (0005HK).xlsx”**

Under the multisource reference checking and alert system, the occurrence of price discrepancy indicates that quote prices of Bloomberg and Reuters do not converge. Suppose there were two errors occurred on 06/07/2017 and 26/06/2017) and the alert was triggered.



**Utilizing Exchange Data as the Second Line of Defense**

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After matching the separated data sources with HKEx Day’s Close (0005.HK), it was detected that error on 6/7/2017 belongs to Reuters’ incompetency, whereas error on 26/06/2017 belongs to Bloomberg’s incompetency.

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**[41].** Mazzucato, M., & Penna, C. C. (2016). Beyond market failures: The market creating and shaping roles of state investment banks.

**[42].** Berger, A. N., Imbierowicz, B., & Rauch, C. (2016). The roles of corporate governance in bank failures during the recent financial crisis.

**[APPENDIX 3]: ChatBot for In-House Support**

**Guideline of Using the ChatBot:**

**Step 1:** Please access the following link: “<http://56e5a1c8.ngrok.io/>”

**Step 2:** You can then start your conversation with ChatBot. However, if you cannot access the above link, please contact us by [michelle03211997@gmail.com](mailto:michelle03211997@gmail.com). The problem might occur as the server of the link is held by us. In case our server is not connected to the Internet, the link cannot be accessed. However, we endeavor to ensure that the server is connected to the Internet at all times, in order to provide a smooth ChatBot experience.

**Step 3:** You might want to read the following scenarios to understand how ChatBot can support the operations team.

**Scenario 1**  
**(a)** Greet ChatBot by typing “Hello, I need support”, then a message of “How may I help you?” pops out. ChatBot then provides you the phone number of the production team, application development team, and Data Integrity team, respectively.

**(b)** If you are not familiar with the functions of segments within the trade systems (e.g. TradeCather, TradeLife etc), ChatBot can provide you these descriptions. Suppose you do not understand the function of “TradeCatcher”, you might ask “Can you tell me the function of TradeCatcher?”. Then, a detailed explanation is given. Occasionally, you might forget the exact name of the parts of the trading system, you can simply type the keywords listed below.

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|  |  |
| --- | --- |
| **Trading System Components** | **Key Words** |
| TradeCatcher | Tradecatcher/execute/book |
| TradeLife | operations/Tradelife/products |
| RMS | Risk/ RMS/ Risk Management/database |
| MoneyClip | MoneyClip/profit/loss |
| StatBox | Data storage/ StatBox/ independent/ instruments |
| WorldDating | date/ WorldDating/calendar |
| MarketBox | movement/ MarketBox/dynamic/market |

  
  
**Scenario 2**  
**(a)** If you are confused with the seemingly abnormal P&L figures, you can input some keywords that you come up with (i.e. discrepancy, mistake, quote and etc.) to find out the causes. Normally, there are two main situations.

1. **Case One: Unreliable External Data Source**  
   It is possible to have reporting errors occurred in Bloomberg or Reuters. Consequently, multisource reference checking is recommended. In addition, when there is price discrepancy between these two sources, double check with the Exchange and take the price quotes from it as the final reference.
2. **Case Two: Wrong Capturing of Spot Price**

If you find that there is no price discrepancy between the three external data sources (i.e. Reuters, Bloomberg and the Exchange), the occurrence of abnormal P&L generation might be attributed to inappropriate instructions set in MoneyClip.

**(b)** ChatBot will ask the user to identify the above two scenarios first, and ask him/her to type in “caseone” or “casetwo”.

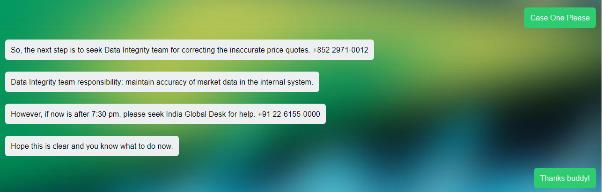
**(c)** ChatBot will suggest users two main solutions based on the time of the dialogue.

1. Before 7:30 p.m. HKT (During DI team’s normal working hours), contact local DI team to input the accurate market price data into the internal system.

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1. After 7:30 p.m. HKT (After DI team’s normal working hours), seek help from global support desk. For example, India(GMT+5.5), which is 2-4 hours behind other APAC core financial center, is available to provide real-time assistance for Hong Kong Teams.

**(d)** If you finish your consultation with ChatBot, say thanks or goodbye to ChatBot. ChatBot is looking forward to serving you again.

**Below are some more keywords that might facilitate your interaction with ChatBot**

|  |  |
| --- | --- |
| **Support** | support/help/people/urgent |
| **P&L** | price/discrepancy/ P&L/ report/ abnormal/ mistake / calculation/ quote/ quoting/ external/ capture/ inhouse |
| **Case 1** | Caseone/one |
| **Case 2** | Casetwo/ two |
| **Closing** | thanks/ NO/ thank you/ bye/ goodbye |

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