BNP Paribas: Enterprise Architecture – Phase II

A Major Qualifying Project Report

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by

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Abstract

The primary goal of this project, sponsored by the Global Equities and Commodity Derivatives (GECD) at BNP Paribas NY, was to adapt and scale the Enterprise Architecture (EA) – Prototype for production used by the GECD IT Application Support Team and the GECD Transversal BA Team. At the end of the project, BNP Paribas NY IT operations and support was fully reflected in flows and infrastructure/data available in the EA toolset. The visualizations available within the EA application served as a common hub for illustrating the current state of IT applications and underlying infrastructure in discussions, documentation and planning for BNP Paribas GECD NY.

The secondary goal was to work with GECD Business Management to review and update their requirements and translate these into a proposed Design Specification for Phase III of the project being proposed in BNP Paribas NY for 2013.

Acknowledgement

There were many people involved with the Enterprise Architecture project both from BNP Paribas and Worcester Polytechnic Institute. Foremost we would like to thank Mr. Dhaval Oza and Mr. Tom Keyes, our sponsors, who oversaw the project from the BNP Paribas side. Also Mr. Arjun Kohli, the project manager, who managed the day-to-day operations of the project. We want to extend our gratitude towards Professor Arthur Gerstenfeld, director of the Wall Street Project Center, for creating such an energizing experience. Along with Professor Gerstenfeld, we want to thank Professors Micha Hofri and Professor Jon Abraham, our faculty advisors, for their continued support and advice and assistance in our final report and presentation. Finally we thank everyone in the GECD division of BNP Paribas who lent their advice, support and opinions concerning the eventual destination of the project. Thank you.

Authorship

The academic work of this project consists of 3/3 unit of work in B-Term 2012 (October 2012 – December 2012) and an additional 1/3 unit of work in C-Term 2013 (January 2013 – March 2013). Yanxin Zhou and Yuchen Zhang took credit of the work done in B-Term 2012. Later since Yanxin Zhou and Yuchen Zhang are both double major, they partnered with Jian Mao and finished the rest 1/3 unit of work related to this project in C-Term 2013.

For the work done in B Term 2012, all sections were created and edited as a team, with equal contributions between Yanxin Zhou and Yuchen Zhang.

The work done in C Term 2013 was reported as Appendix IV – Report of C Term 2013. This section was created and edited by Jian Mao, Yanxin Zhou and Yuchen Zhang, with equal contributions.

Executive Summary

BNP Paribas' Global Equities and Commodity Derivatives (GECD) division offers a variety of industry leading financial products. To keep its businesses operating smoothly, the division relies on various internal applications and hardware that conduct and support many business operations to function correctly and efficiently. As a result, maintaining good health of these applications and hardware is crucial within the context of different business flows. Whenever a performance problem happens, IT managers and infrastructure team should be informed right away.

For years, however, managers have been keeping track of business flows and performed capacity planning manually. It was extremely costly and inefficient.

To increase efficiency and achieve automation in this area, IT managers at BNP Paribas want to visualize their entire enterprise architecture. Meanwhile, Human Resources managers and Business managers were also looking for a better application to display visualization of organization. Their existing database level of presentation of the data could not meet their need.

With this said, this project aimed to help BNP Paribas to visualize and maintain their enterprise architecture. The goal of the project was to adapt and scale the Enterprise Architecture (EA) – Prototype for production used by the GECD IT Application Support Team and the GECD Transversal BA Team. There are three primary components of the implementation. The first one is to automatically extract data from the database and feed it into a data management interface. The second component is to visualize the flow. The last component is about graph interactivity.

This project was a continuation of Enterprise Architecture – Phase I. This project concentrated on the core development of Enterprise Architecture. It involved two parts: front end user interface development and back end database development. Based on the proof of concept done in Phase I, Oracle Application Express (ApEx) was used to develop the front end user interface. It provided handy methods to interact with back end Oracle database. For the back end database

development, information about each diagram was stored in corresponding tables in the database. The database also contained various functions that can be applied to diagrams. Moreover, on rendering a diagram, the database would trigger the Graphviz render engines through a pre-defined Oracle database job scheduler. Graphviz was the visualization tool that passed the feasibility test in Phase I.

Some further researches on the Graphviz tool were finished during the project. Graphviz has its strength in positioning optimization and it is rich in graphical attribute options. Furthermore, Graphviz offers different layout engines, each of which has some unique features. Moreover, all engines provided by Graphviz can use the same input, making it easier to switch between different layout engines. These were all crucial merits that contribute to the development of the final application.

By the end of this project, a well-integrated browser-based data visualization and management application was built. The application has the following features: Visualization based on User Selection, Graph Interactivity, Table Interactivity, Interactions between Graphs and Tables, and Data management. It also has other functionalities including Export to Diagrams, and Graphical Attribute Management.

The application is an excellent blend of various technologies. Three major tools, four programming languages, and other technical concept were deployed. SQL Developer as the programming environment, Graphviz as graphing tool, and ApEx as application interface developer, were heavily used and well integrated to function as a unit. Towards the end of the project, real data were plugged into the application for testing. After a week of testing, the first version of the application was finally released to the Business Analyst team for real life testing.

There are many business uses of Enterprise Architecture. In general, the visualizations available within the Enterprise Architecture application would serve as a common hub for illustrating the current state of IT applications and underlying infrastructure in discussions, documentation and planning for GECD New York.

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1. Introduction

BNP Paribas Global Equities & Commodity Derivatives (GECD) is a worldwide leading provider of financial products and services. GECD combines three complementary business lines, including structured equity, flow and financing covers products and services, and commodity derivatives. All these leading edge technologies and processes are developed and maintained by over 1,500 middle-office, back-office and IT professionals, together with the support of various internal applications, systems and hardware. On the other hand, IT managers also have to monitor the health of these internal applications and hardware within the context of different business flows, where the monitor data can reflect any system performance problems and help IT professionals to understand the impact of over-capacity server on any particular flow.

In the times of automated and high frequency trading, it is vital to make sure the machines won't trigger mistaken orders. On August 2nd, 2012, the Knight Capital Group announced that it lost $440 million when it sold all the stocks it accidently bought on August 1st, 2012 because of a computer glitch. The loss was nearly four times the company's 2011 profit, crippled the firm and brought it to the edge of bankruptcy. The disaster was eventually concluded as a result of a bug occurred in the company's trading algorithm. The company might not be able to detect and fix the bug before it happened; however, if the company could discover the ill system performance in time through monitoring and shut down the algorithm immediately, the loss would be much less than $440 million.

From the appalling "2010 Flash Crash" event, which caused the Dow Jones Industrial Average plunged 998.5 points in a few minutes only to recover its losses several minutes later, to the catastrophe of the Knight Capital Group, and till now, errors made by computer glitches in marketplace happened occasionally. In order to protect the financial industry from program bugs, we either need perfectly healthy programs, which is extremely hard to achieve, or reliable applications that can discover problems before they go big.

As a result, BNP Paribas NY developed a new application GECD Enterprise Architecture (EA) application that provides the unique capability of visualizing and managing an organization's live data in a contextual and inter-related manner. EA's key benefits include process visualization & management, operational capacity & performance management, data management and impact analysis. EA - prototype has already been created in the project led by Arjun Kohli in the fourth quarter 2011, with WPI students Zhen He and Joe Servi. The scope of the initial project in 2011 was a proof of concept to demonstrate that enterprise data management of application and server inventory could be represented and managed visually off a referential database/inventory system. With this visualization in place, business process flows can be tracked for metrics related to underlying application performance and alert statuses.

With EA – prototype in practice, the primary goal was to adapt and scale the Enterprise Architecture (EA) – Prototype for production used by the GECD IT Application Support Team and the GECD Transversal BA Team. At the end of the project, BNP Paribas NY IT operations and support was fully reflected in flows and infrastructure/data available in the EA toolset. The visualizations available within the EA application served as a common hub for illustrating the current state of IT applications and underlying infrastructure in discussions, documentation and planning for BNP Paribas GECD NY.

The secondary goal was to work with GECD Business Management to review and update their requirements and translate these into a proposed Design Specification for Phase III of the project being proposed in BNP Paribas NY for 2013.

2. Background

In this background chapter, we will briefly talk about the idea of Enterprise Architecture (EA), the project that has been done in 2011 and the development plan for deploying EA to IT Application Support, Business Analysts and Business Management of BNP Paribas Global Equities & Commodity Derivatives (GECD).

2.1 What is EA

Briefly speaking, EA is a data management toolset that can provide the unique capability of visualizing and managing an organization's live data in a contextual and inter-related manner. It will have the following detailed functionalities:

- It is a web application;
- It can graph and diagram a large number of elements with complex relationships, where the information comes from a live database and is not static data;
- It integrates existing organizational data, including application, hardware, organization unit, people and process;
- The graph / diagram it generates can scale to potentially thousands of on-screen elements;
- It manages and enriches the data and relationships between data elements;
- It provides on screen interactivity to build and display the diagram elements;
- It charts live data to make the diagram a living representation of system flows;
- It has dashboard capabilities that list performance statistics on certain capacity attributes;
- It has data entry and modification forms;

- It does not use static / stale data; all the data are directly retrieved from referential sources and EA database;
- It provides bi-direction data synchronization – via on screen interaction with data, and via database refresh;
- It provides the visualization of real time health through metrics, key performance indicators (KPI's) and capacity utilization, which are layered on top of relationship diagrams;
- It has powerful data integration capabilities and open API for downstream applications;
- It records interactions to trigger downstream actions for organization or process changes;
- It provides tailor made representation of individual or group's perimeter of responsibilities.

The EA application can be conceptualized as a tool, which aggregates existing data assets in its own data access/integration, and then transforms these into a model where they can be interrelated (see Figure 1 and Figure 2 below). The Ontologies layer is exposed to the user via the web user interface (UI) hosted using the Application Express (ApEx) platform. It selects data elements based on user criteria in the Query panel to draw the elements and their inter-relationships or links to draw a representative diagram using the Graphviz engine.

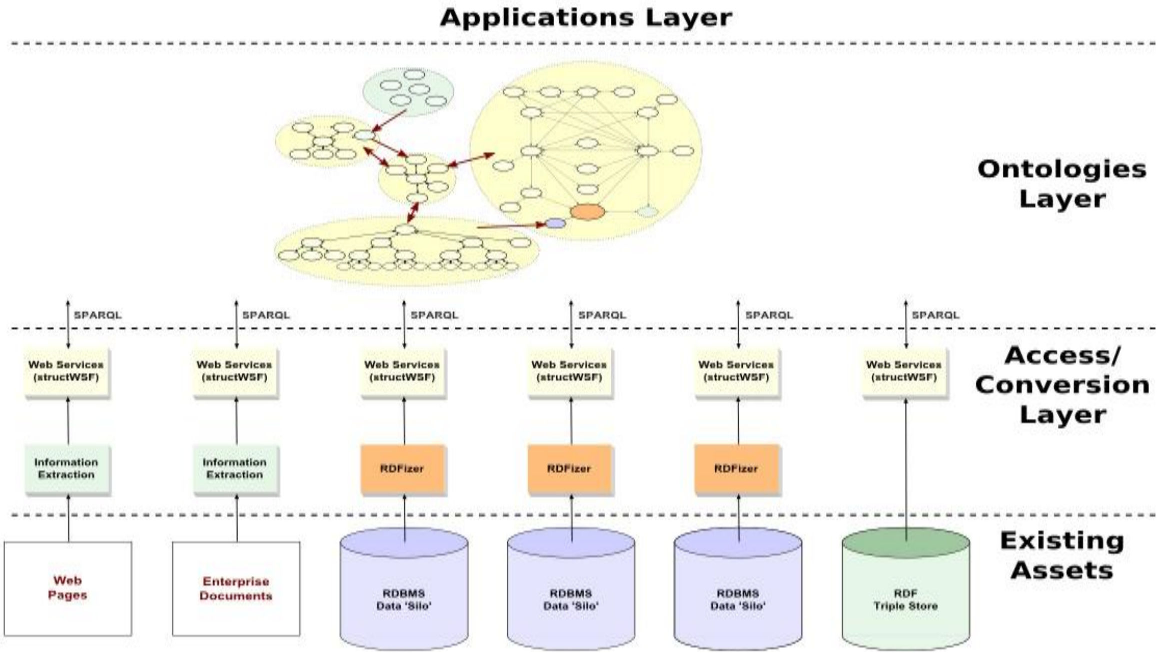


Figure 1 EA Logical Architecture

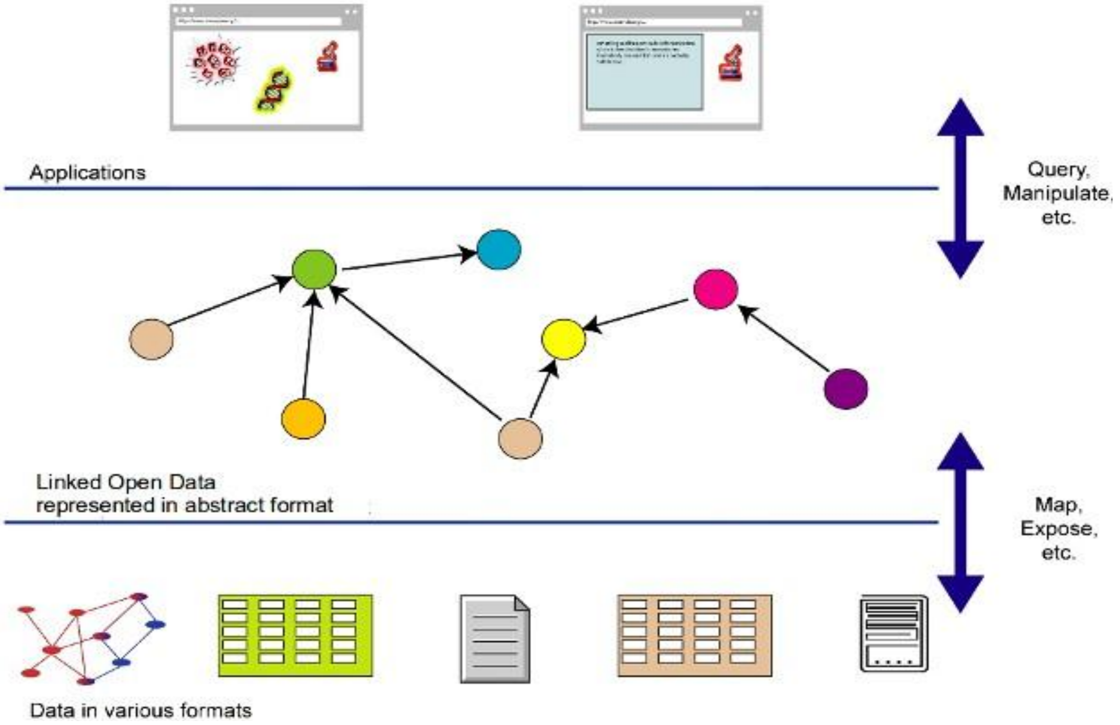


Figure 2 Layers of Aggregation and Enrichment

Relationships may be created in EA for the application and business layers to create Business Processes or Flows, which themselves become key elements of the overall Enterprise Architecture.

2.2 EA – Current Implementation

Some major functionalities and capabilities of EA have been implemented in the 2011 project. They include:

Database Visualization based on User Selection: Within the context of a saved diagram, users can select/deselect through checkboxes the entities they want to include/exclude in their visualization. They can further indicate if the entity is expanded downward to include child entities or collapsed as a single node. The visualization of the selected entities is then displayed.

Graph Interactivity: Users can expand and collapse nodes and branches or add and remove nodes and links using the on screen UI methods. In addition, the attributes of each element may be edited by clicking the edit method that exposes a screen for data management of that element and its relationships. Users can also choose to see their data in a summary view, which collapses all the physical instances of an entity into one single node, or a detailed view, which in contrast, rolls down to show every instance of an entity.

KPI's, Metrics and Notification: These may be defined with thresholds at multiple levels, including infrastructure, application and process. The metrics are a time-based series of performance statistics measured against certain attributes (e.g. latency, memory). Alerts are logged and may be propagated via downstream API's. These alerts can be defined at a process or individual component (e.g. application instance, server) level.

More details of the previous implementation can be found in Appendix II – Enterprise Architecture Application – Phase I Implementation.

2.3 Technology Review

A variety of technologies contributed to the development of the project. Below is a literature review of each of them.

2.3.1 Applications

Oracle APEX

Oracle Application Express, usually known as Oracle APEX, is a handy web application development tool that sits on top of Oracle Databases. It is a pure browser-based Rapid Application Development (RAD) software, which offers conversions from and to spreadsheet and MS Access databases. It can be used to build applications that will be accessed by thousands of users at the same time with high speed because its framework adds very little load to each request.

Oracle SQL Developer

Oracle SQL Developer is a free integrated development environment that simplifies the development and management of Oracle Database. SQL Developer offers complete end-to-end development of PL/SQL applications, a worksheet for running queries and scripts, a Database Administration console for managing the database, a reports interface, a complete data modeling solution, and a migration platform for moving your 3rd party databases to Oracle. This software is used to create Oracle database and set up connection to Oracle database server from client machines.

Graphviz

Graphviz, short for Graph Visualization Software is a package of open-source tools initiated by AT&T Labs Research for drawing graphs specified in DOT language scripts. This software takes description of a graph, which is written in a simple text language called DOT, as input, which can be later rendered into a variety of formats including JPEG and SVG with different layout options such as radial and circular layout. In the market, Graphviz is known as industry-standard graph visualization software. It has many important applications in networking, bioinformatics, software engineering, database and other technical areas.

2.3.2 Programming Languages

PL/SQL

Procedural Language/ Structural Query Language (PL/SQL) is Oracle Corporation's procedural extension language for SQL and Oracle relational Database. It is designed specifically for the seamless processing of SQL commands. Server-side PL/SQL is stored and compiled in Oracle Database and runs within the Oracle executable. As one of the three key languages embedded in the Oracle Database, it automatically inherits the robustness, security, and portability of Oracle Database.

DOT Language

DOT is a plain text graph description language. It is a way to describe graphs. The files in DOT language usually have extensions like *.gv* or *.dot*. Many programs can process DOT files, including *dot, neato, fdp,* and *circo*. Most of the programs are part of the Graphviz package.

HTML

HTML, short for Hyper Text Markup Language, is a markup language that uses tags to describe web pages. HTML documents are equivalent to web pages. Web browsers read these documents, interpret the content by HTML tags, and display them as web pages.

JavaScript

JavaScript is a prototype-based scripting language that supports object-oriented, imperative and functional programming styles. It is primarily used in the client side, implemented as part of a web browser to provide enhanced user interfaces and dynamic websites. Besides web pages, it has other applications such as PDF document.

3. EA Phase II Requirements

This phase envisions upgrading the EA Prototype to Production ready deployment to the specifications of GECD Transversal BA team and GECD IT Application Support team. The requirements of this project come from 2 major areas.

3.1 Front End Enhancement

This requirement is to improve the current user interface, implemented in Phase I, to visualize flows, architecture and monitoring of capacity and alert status at different levels of the architecture. Users will be able to manipulate nodes in a graph as well as collapse, expand sub-graphs on the web page in a more user friendly way. Also, in this phase, the current user interface needs to be improved so that, without loss of generality and information amount, users can easily navigate through different part of graphs and perform different actions to the graphs, including but not limited to displaying and updating general information of every node. Furthermore, user can modify graph structure by simply dragging and dropping nodes to each other to modify the connection between them. It is expected to have more detailed enhancements as the application will be deployed and bring into daily use to both teams when the user interface design is finished and database server is set up for use.

Figure 3 is an example of layout of an organization chart, where users can define relationship between different nodes using dragging and dropping functions. Also, users can edit details of node from the buttons on each node. The goal of this phase is to make these functions work properly and user-friendly, so that users can start with EA by working on the graph they request. With EA, users can have a better picture of how each part in the company connects and collaborates with others. And EA makes it easier to audit trail changes in the databases, which will in return enhance the security level of the complete database.

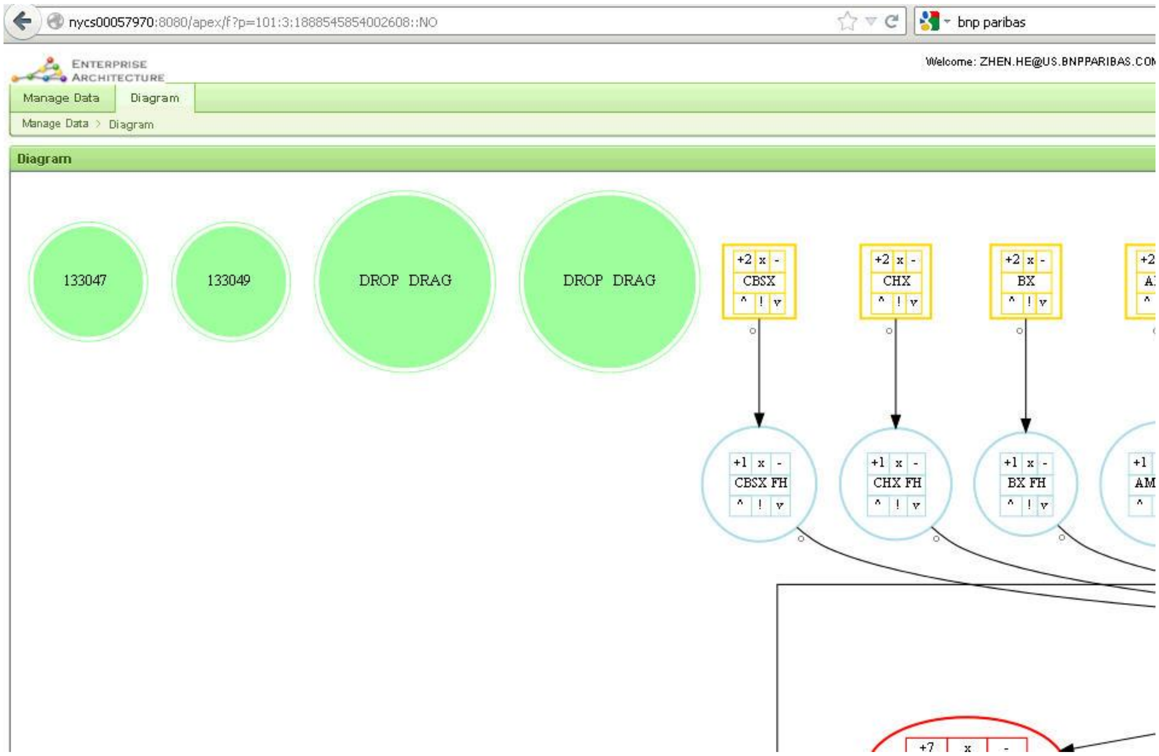


Figure 3 EA Phase I Sample Diagram

3.2 Back End Enhancement

This requirement is to improve data entry and enrichment, using existing Oracle ApEx forms integrated to Oracle and SQL Server referential databases for application and server inventory. The database design needs to be improved so that data will be processed in a more efficient way. This is the base step of rendering a graph because all the data in the graph come from databases. Then needed data are retrieved to create a temporary table, according to which the graph description is constructed and passed to Graphviz.

4. Front End Development

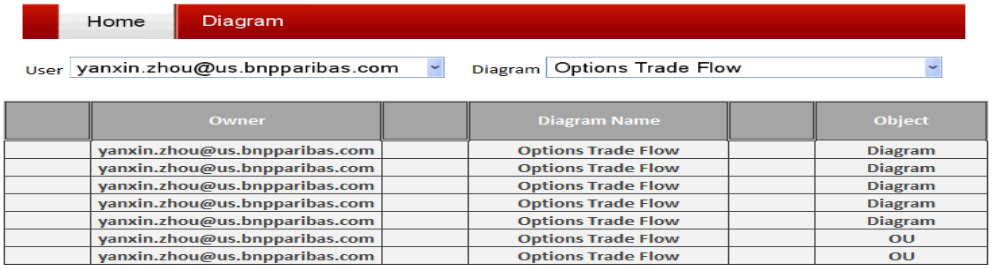
The front-end development involved three major improvements: table interactivity, graph interactivity, and interactions between graphs and tables. This chapter explains design and methodology used in developing these three aspects.

4.1 Table Interactivity

According to the requirement, we want it to be easier to navigate between different tables and forms. Users should find all the table contents meaningful and could easily look up or make changes to the data through the web user interface.

4.1.1. Design

Home Page:



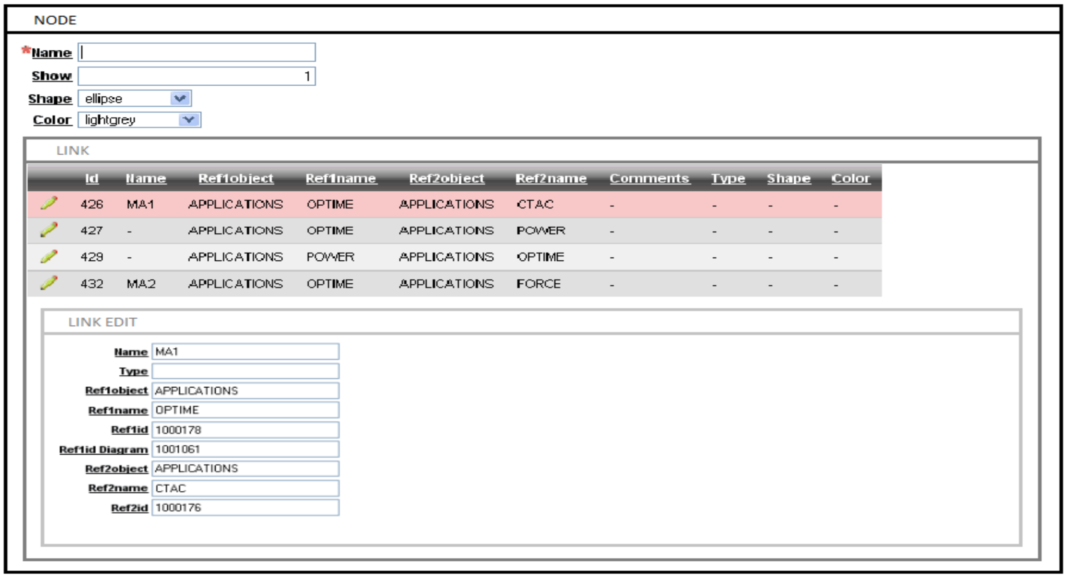
User yanxin.zhou@us.bnpparibas.com

Diagram Options Trade Flow

	Owner		Diagram Name		Object
	yanxin.zhou@us.bnpparibas.com		Options Trade Flow		Diagram
	yanxin.zhou@us.bnpparibas.com		Options Trade Flow		Diagram
	yanxin.zhou@us.bnpparibas.com		Options Trade Flow		Diagram
	yanxin.zhou@us.bnpparibas.com		Options Trade Flow		Diagram
	yanxin.zhou@us.bnpparibas.com		Options Trade Flow		Diagram
	yanxin.zhou@us.bnpparibas.com		Options Trade Flow		OU
	yanxin.zhou@us.bnpparibas.com		Options Trade Flow		OU

Figure 4 Home Page Design

Edit Page:



NODE

*Name	
Show	1
Shape	ellipse
Color	lightgrey

LINK

	Id	Name	Ref1object	Ref1name	Ref2object	Ref2name	Comments	Type	Shape	Color
✎	426	MA1	APPLICATIONS	OPTIME	APPLICATIONS	CTAC	-	-	-	-
✎	427	-	APPLICATIONS	OPTIME	APPLICATIONS	POWER	-	-	-	-
✎	429	-	APPLICATIONS	POWER	APPLICATIONS	OPTIME	-	-	-	-
✎	432	MA2	APPLICATIONS	OPTIME	APPLICATIONS	FORCE	-	-	-	-

LINK EDIT

Name	MA1
Type	
Ref1object	APPLICATIONS
Ref1name	OPTIME
Ref1id	1000178
Ref1id Diagram	1001061
Ref2object	APPLICATIONS
Ref2name	CTAC
Ref2id	1000176

Figure 5 Node-Edit Page Design

4.1.2. Methodology

This section explains how we implemented the most important features mentioned in the design section.

Auto Filtering

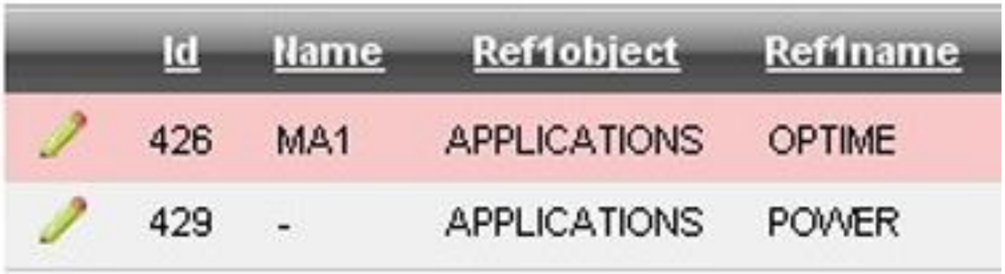
Since Oracle ApEx has already provided filters for tables, we only needed to integrate the filters to the select lists on the Home page. Two of the select lists on the Home page are User and Diagram. Values in the User select list are the same as values in the Owner column of the table on the Home page, and values in the Diagram select list are the same as the Diagram Name column. As users changed value of User select list, we made a call to the ApEx table filter on the Owner column; when users changed the Diagram select list, we applied the ApEx table filter on the Diagram Name column. As a result, actions of filtering were automatically done by GUI and it saves time for looking up specific entries in the table.

3-Level Edit Form

According to the database design, there are 2 kinds of edit form in this application. One is to edit master level data, while the other is to modify diagram level data. Both kinds of forms use the 3-level design.

For master object data pages, the first level is a search region for all objects of the same kind as the selected object. In other words, from the perspective of database design, it is a collection of all data from the table, which the selected object comes from, where the selected object is filtered out automatically. It lists all the fields related to this object. Users can check all the fields about this object to see if they want to make any changes. Furthermore, this search region makes it easier for users to switch between objects of the same kind as well as to modify multiple objects at a time. By clicking on modify button (pencil icon in Figure 6) on the page, the fields of the second level, which is the edit region for a specific entry from the first level, will get filled automatically based on the values of each fields from the database. Users can either make changes to the object or even delete an object from these pages. Changes made here will be saved directly to the database once the

"Apply Change" button is clicked. And the third level is a list of instances where the object is used as a node in diagrams. From this report, users can go to edit page for any of the instances directly.



	Id	Name	Ref1object	Ref1name
✎	426	MA1	APPLICATIONS	OPTIME
✎	429	-	APPLICATIONS	POWER

Figure 6 Link Table Pencil Icon (Edit Button)

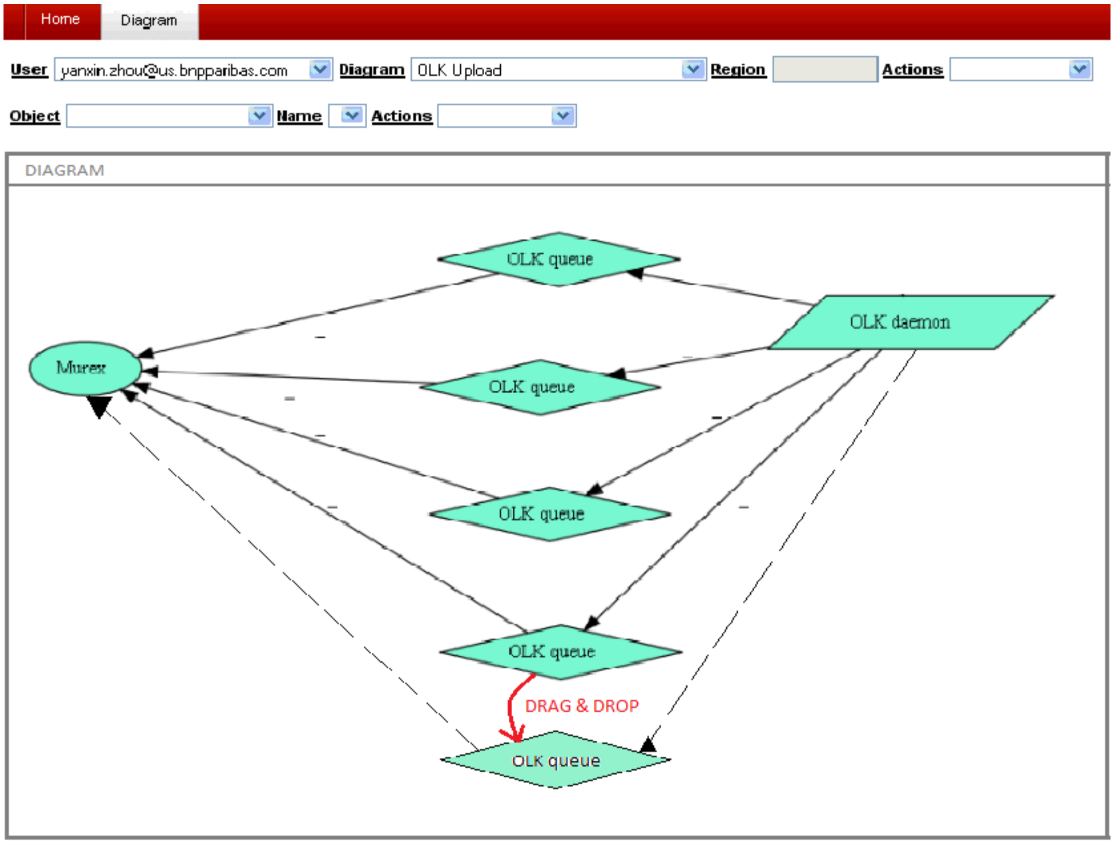
For instance object data pages, the 3 levels are slightly different. The first level is the same as the second level of the master one, where users can modify the instance object. All the fields will be automatically populated based on the values of the selected object from the database. The second level is an interactive report where all the links in and out of this node are listed. All the details about the links are displayed in the report and by clicking on the modify button (pencil icon in Figure 6) in the first column of the interactive report, the third level, which is an edit region for links, will get automatically filled in. Under this design, users can edit both the node itself and any links coming in or going out of it at the same time.

4.2 Graph Interactivity

The previous version of EA has had some level of graph interactions, however, the customization of graphs is not sufficient. In this development phase, we introduced more features, which guarantee that users can have their own preferences shown in the graph and hence, improving the interactions between users and graphs.

4.2.1. Design

Diagram Page:



User yanxin.zhou@us.bnpparibas.com Diagram OLK Upload Region Actions

Object Name Actions

Figure 7 Diagram Page Design

4.2.2. Methodology

This section described major improvements we made for the graph interactivity.

The implementation of Exact Placement

This is one of the main improvements in this phase of development. Exact placement is a concept which users can specify where they want to place a node on a diagram. When a diagram is displayed on the screen, there is a canvas to the back of the diagram. Each node has its own x and y coordinates on the canvas. These coordinates are stored as an attribute of nodes in the instance tables.

Every time a diagram is about to be drawn, the program will check if there are coordinates specified for each node. If there are coordinates for every node, the program will use Neato engine to place each node at exactly their coordinates. Otherwise, the program will use Dot engine to draw the diagram in an most optimized and compact way. Because nodes in a diagram are set to be not overlapping with each other, there might be slight difference between the real position of the node in the diagram and the coordinates in the database. The engine will take care of this and try to locate the nodes at the nearest available spot. Based on the generated files, the program will collect updated coordinates in the current diagram and update corresponding columns in the database.

On the screen, when users send request of updating coordinates, the program will detect the position of mouse cursor using JavaScript API. Then the program will calculate the real coordinates in the diagram by finding its relative position towards the origin on the diagram, where the effect of both horizontal and vertical scroll bars as well as the effect of current scale of the diagram is taking into account.

This implementation is one of the major improvements from Phase I of this project last year, because it makes drag and drop to place a node feasible in our application; therefore our application is now comparable with other 2 dimensional graph drawing software, like Visio and OmniGraffle where users have the freedom of placing nodes at positions they specify.

Improvement of Diagram Interactivity

We improved the interactivity of node, link and diagram from the previous version of development. Formerly, all the available actions were listed around the node in a table, which made the diagram much too messy because it provided the users a great deal of redundant information and also resulted in the fact that the diagram was too small to see on a single screen. In our implementation, we improved these interactions by introducing a drop-down list on the screen named Action, where all the available actions are listed. By default, none of the actions are available because there is not a node selected. All available actions are listed in Table 1 and Table 2.

Table 1 Actions Related To Single Node

Objects Actions	Diagram Node	Common Node
Remove	Will remove this diagram, including all the nodes and sub-diagrams in it and all the links within, in and out of it	Will remove this node and all the links in and out of it
Next Level	Will show the hidden nodes which this node connects to	
Drag and Drop to Move	Will move the diagram node of this diagram to the new position where users release the mouse and move the rest of the diagram relatively to the diagram node	Will move this node to the new position where users release the mouse
Show	Will show all nodes within this diagram and all links in and out of the diagram	N/A
Hide	Will collapse this diagram to a single diagram node	Will hide this node and all the links in and out of it

Table 2 Other Actions

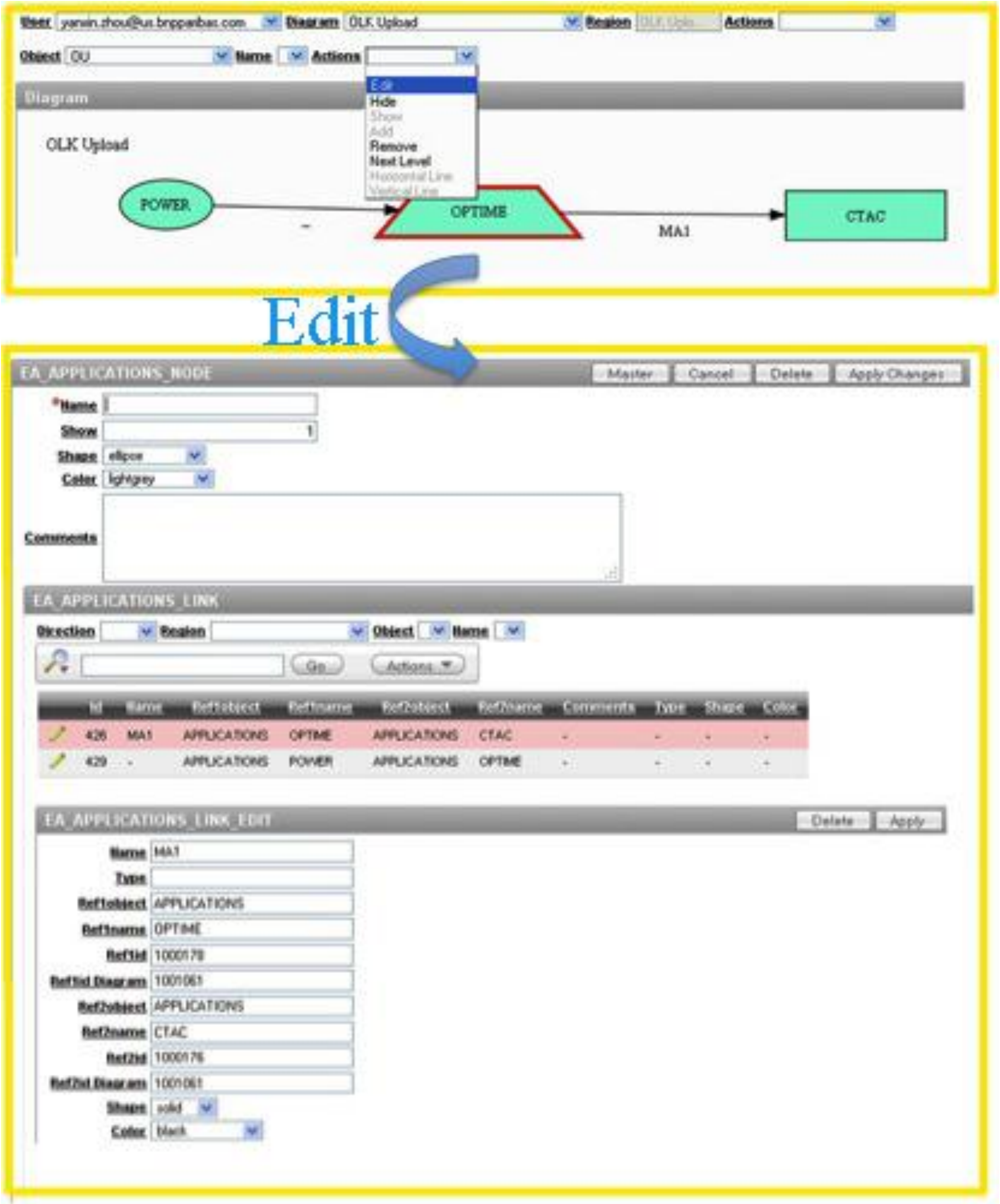
Actions	Usage
Create Links	Dragging a node and dropping it on another will create a link from the previous one to the latter one.
Clone Diagram	Will create a copy of the current diagram under the current user’s account

Actions	Usage
Add An Element	Will add the selected element to the place user specifies
Horizontal Line	Clicking 2 places on the diagram region will create a horizontal line between the 2 points.
Vertical Line	Clicking 2 places on the diagram region will create a vertical line between the 2 points.
Auto Layout	Users have the option to use different layout engines from Graphviz. Each engine has some unique features. • Dot engine: Default engine from Graphviz. It layouts the diagram in the most compact way. • Neato engine: Users can specify the scale of the diagram and the position of each node on the diagram. • Fdp engine: Users can specify the position of each node on the diagram, but have no control over the scale of the diagram. • Twopi engine: It layouts the diagram on concentric circles depending their distance from a given root node • Circo engine: It layouts the whole diagram on a circle.
Click & Click To Move	By clicking on single or multiple node(s), then clicking on a white space, all the selected nodes will be moved in a way where the first selected node gets moved to the exact place which users specify, while the rest move to the relative position with the first node.

By clicking on a node or link, the border of the node or the link itself will become red, indicating that it is selected. Then some of the actions will become available in the drop-down list, according to the item selected.

4.3 Interactions Between Graphs and Tables

4.3.1. Design



User yanxin.zhou@us.bnpparibas.com Diagram OLK Upload Region OLK Uplo Actions

Object OU Name Actions

EA_APPLICATIONS_NODE

*Name	
Show	1
Shape	ellipse
Color	lightgrey
Comments	

EA_APPLICATIONS_LINK

Direction Region Object Name

Id	Name	Ref1object	Ref1name	Ref2object	Ref2name	Comments	Type	Shape	Color
426	MA1	APPLICATIONS	OPTIME	APPLICATIONS	CTAC	-	-	-	-
429	-	APPLICATIONS	POWER	APPLICATIONS	OPTIME	-	-	-	-

EA_APPLICATIONS_LINK_EDIT

Name	MA1
Type	
Ref1object	APPLICATIONS
Ref1name	OPTIME
Ref1id	1000178
Ref1id Diagram	1001061
Ref2object	APPLICATIONS
Ref2name	CTAC
Ref2id	1000176
Ref2id Diagram	1001061
Shape	solid
Color	black

Figure 8 Diagram Link to Node-Edit Page

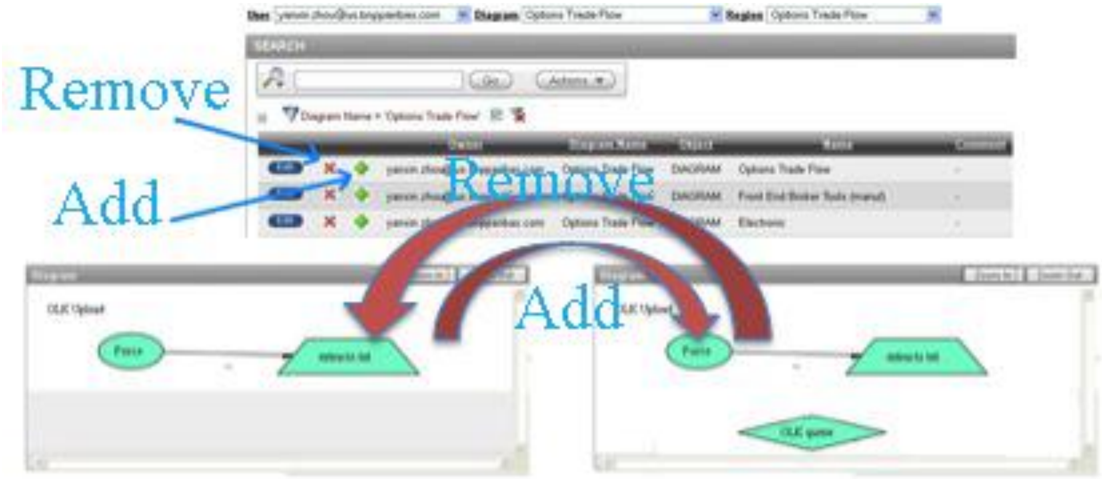


Figure 9 Add/Remove Nodes from Home Page

4.3.2. Method

This section contains two major implementations we made for improving interactions between graphs and tables.

Add/Delete Nodes on Diagram from Table

In the previous version, users could select/deselect the entities they want to include in the diagram through checkboxes in the table on the Home page. They could also indicate if the entity is expanded downward to include child entities or collapse as a single node. In this project, we added two Home page actions on entities that would change their visualizations in the Diagram page: add entities and delete entities.

Users should first use select lists and table filters to find out entities they want to add or delete. When users chose to add the entity, we decided which graph and which region of the graph the entity should be added to by evaluating values of User, Diagram and Region select lists. The add action would not be approved if any of the three values are not specified. The delete action was designed in the same way as add action. While an entity is added or deleted, its data in the database is updated as well.

Enter Node Edit Page from Diagram

In this version, users can navigate to the node-edit page not only by clicking the edit button in the table on the Home page, but also by selecting a node on the Diagram page and then choose "edit" in the Action select list. This improvement gives users a direct viewing of which node needs editing. In the node-edit page, users could change all the editable attributes of the node, including links connect to or from it. When users got back to the Diagram page after the modification, all the changes done in the node-edit page were shown on the diagram visually. The corresponding data of the node was also updated.

When users navigate to the node-edit page, all the current values of the node's attributes were filled in corresponding text fields or select lists. This auto fill was accomplished by using the function "htmldb_Get". When users clicked on a node, hyperlink embedded in this node launched some JavaScript functions to fill hidden fields that stored the node's information on the Diagram page. When users chose "edit", we passed the node's information in the hidden fields as parameters to the function htmldb_Get, and then this function called the corresponding function in database with those parameters so that database could return correct values of the node's current attributes.

Users could also link to the node-edit page by selecting a link in the Diagram page and then chose "edit". The difference is that in the second-level form on the node-edit page, except the selected link on the Diagram page, all the other links are filtered out. The auto filtering was implemented in the same way as the auto filtering on the Home page, since we could get the link's id through htmldb_Get and then filtered the link table by id.

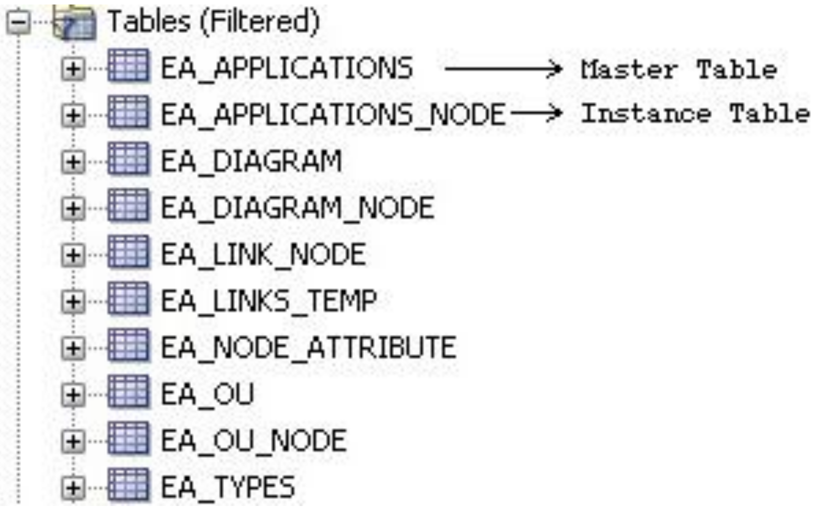
5. Back End Development

In this phase of development, we built up the database with new structure and design. This decision was made for the reason that the new design increases the flexibility and changeability of the database as we implemented more functions.

Database

5.1 Database Design

We introduced a master-and-instance design for the database in this project. Each type of enterprise entity was recorded in two tables, as is shown in Figure 10. One, called master table, kept the basic information about each entry of this entity, while the other one, called instance table, and kept how this entry is displayed in diagrams. Each instance had an ID_PARENT field to indicate which piece of master data it was referring to.



```
Tables (Filtered)
  EA_APPLICATIONS ——→ Master Table
  EA_APPLICATIONS_NODE→ Instance Table
  EA_DIAGRAM
  EA_DIAGRAM_NODE
  EA_LINK_NODE
  EA_LINKS_TEMP
  EA_NODE_ATTRIBUTE
  EA_OU
  EA_OU_NODE
  EA_TYPES
```

Figure 10 Master and Instance Design

Master-and-instance was a very important design decision made in the project. It keeps the original data from the company untouched and manages the diagram data in a systematic and organized way.

5.2 Database Structure

There are 17 different types of enterprise entities in the visualization, each of which is consisted of a series of master data. They come directly from 17 tables in the company's currently database. All of them can become nodes in diagrams. How to store these 17 types of entities as well as their relationships between each other in the database becomes especially significant. We designed a database management system where we keep those 17 types of entities and their properties as it is in 17 tables. Because different entities can have totally different properties, it is hard to accommodate all the needs for different entities in one table. Then, 17 corresponding instance level tables are created to store attributes about how each piece of master data is displayed in different diagrams, including shape and color as well as placement. Every time users want to add a node to a diagram, it must come from a piece of the master level data and then an instance of this master will be created and stored in the corresponding instance level data table.

Besides these 34 tables, there are still several more tables to store diagram information. For general diagram data, we have a master data table, EA_DIAGRAM, where basic information like name and owner of diagram is stored, and an instance data table, EA_DIAGRAM_NODE, where users can keep different versions of the same diagram. Also, there is a table to store all the links information, where links are defined as source-to-destination 2-dimensional records to specify relationships among these 17 types of entities. Lastly, there is a table to store all available customizable attributes of nodes or links and their possible values.

For simplicity of retrieving data from the database, several views are defined. EA_MASTER_VIEW is a generalization of all master level data, while EA_NODE_VIEW is a generalization of all instance level data. EA_LINK_VIEW collects information about all the relationships between entities in diagrams in the whole system. And EA_SEARCH_VIEW is a generalization of the other 3 views.

5.3 Methodology

This section illustrates the implementation of most critical functions in the database.

5.3.1. The Implementation of User Preferences

In this phase of development, we introduce a very important idea that every node in every diagram is an instance of the master data. Under this design, we can offer great freedom to users, where they can customize a great many details for each node, including name, shape, color and etc. Considering user experience, if users do not want to spend much time on customizing these details, by default, the node will always inherit these settings from the master data they come from. For example, in cases where users want to have multiple versions of the same diagram, they can simply make copies of the original diagram and all of them will have the same master; therefore, all these diagrams have the same default settings. Users can then make changes to different copies for different uses. Also this design is useful for data maintenance, where diagram data are separated from master ones; hence by changing attributes at diagram level will not affect the same nodes in any other diagrams, while by changing attributes at master level will make changes to all the diagrams where the piece of data is displayed. Last but not least, this design can be easily re-apply to any database system, because what needs to be done are simply building up the diagram level database structure and creating one-to-many relationships from the master data to diagram data. Then the database is ready to be used for diagram constructing.

5.3.2. Embedment of Diagrams

We inherited the idea of embedded diagrams from last year, where each diagram can have multi-level embedded diagrams within it and each sub-diagram will be surrounded by a square, indicating that it is a sub-diagram. When rendering a diagram, always the most inner ones will be drawn first and then moving outside level by level until the outer most diagram is finished.

This functionality adds more flexibility to the diagram; however, it is implemented in a distinct way in our design, where each diagram created has a field called ID_DIAGRAM to denote the ID of its parent level diagram. If the diagram itself is of the highest level, then its ID_DIAGRAM will show the same as its own ID.

5.3.3. Interaction with Front End User Interface

A lot of functions mentioned in Section 4.3.2 would send request to the back end through the function "htmldb_Get". This generally involves look-ups or updates to the data.

Rendering Diagrams

Every time users asked to display a diagram on the screen, it actually sent request to database. A function defined in the database would retrieve information of every element, including sub-diagrams, nodes, and links, within the diagram and transfer them into Graphviz format. Then the database would call Oracle Job Scheduler to render the diagram.

Diagram Interactions

Every diagram interaction would make some changes to the diagram. The application would record the changes by modifying some values in the database. Generally speaking, all attributes about each node, each diagram and each link were stored in the database. Users requested changes on the diagram would result in value changes in the database. Then the application would re-render the diagram with those changes in effect.

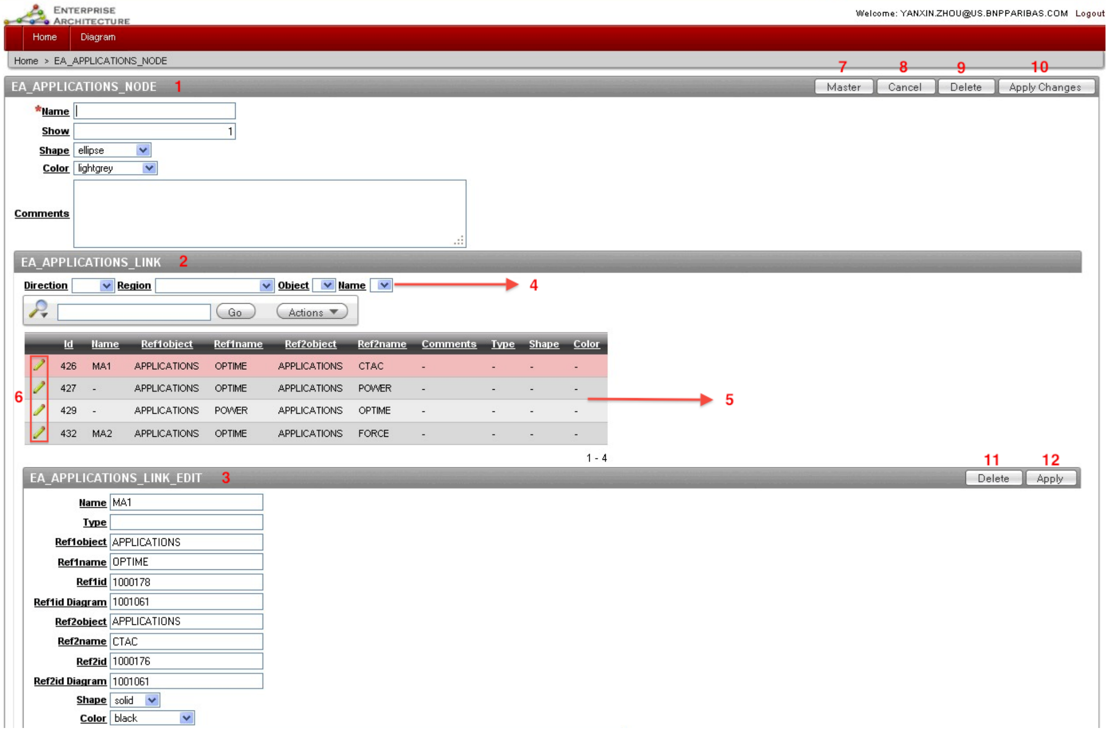
6. Results

At the end of the project, a well-integrated visualization and data management application was built. This chapter is a full presentation of the final product.

6.1 Applications Pages Overview

This section shows the most important pages in Enterprise Architecture. They were implemented closely following the application design.

6.1.1. Instance Node-Edit Page



*Name	
Show	1
Shape	ellipse
Color	lightgrey
Comments	

Id	Name	Ref1object	Ref1name	Ref2object	Ref2name	Comments	Type	Shape	Color
426	MA1	APPLICATIONS	OPTIME	APPLICATIONS	CTAC	-	-	-	-
427	-	APPLICATIONS	OPTIME	APPLICATIONS	POWER	-	-	-	-
429	-	APPLICATIONS	POWER	APPLICATIONS	OPTIME	-	-	-	-
432	MA2	APPLICATIONS	OPTIME	APPLICATIONS	FORCE	-	-	-	-

1 - 4

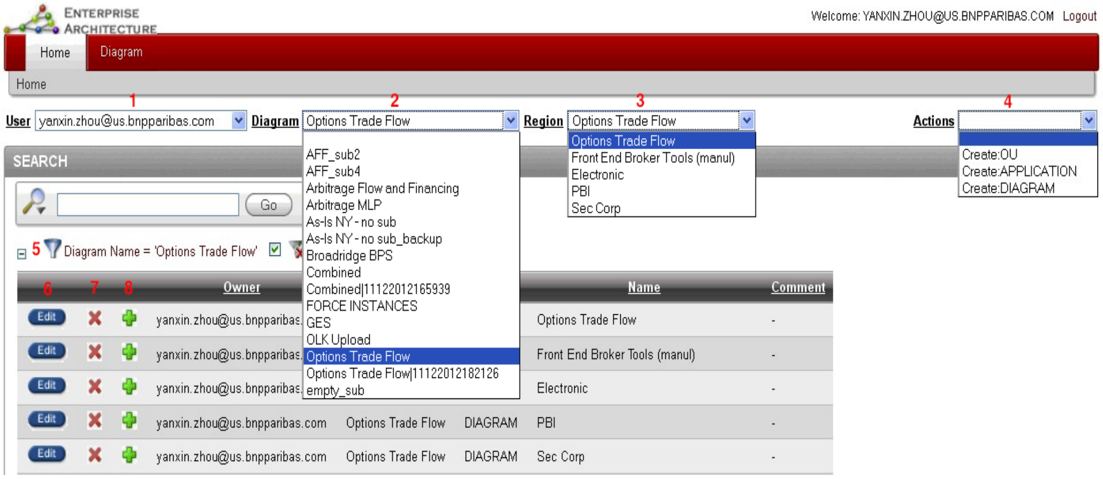
Name	MA1
Type	
Ref1object	APPLICATIONS
Ref1name	OPTIME
Ref1id	1000178
Ref1id Diagram	1001061
Ref2object	APPLICATIONS
Ref2name	CTAC
Ref2id	1000176
Ref2id Diagram	1001061
Shape	solid
Color	black

Figure 11 Node Edit Page

Table 3 Instructions of Node-Edit Page

Number	Item	Description
1	Level-1 Form	It contains information of the instance node. Users can modify the instance object here.
2	Level-2 Form	It contains an interactive report where all the links in and out of this node are listed.
3	Level-3 Form	It is an edit region for links.
4	Create Link	After the 4 select lists have values, a "Create Link" button will appear at the end of this line. The newly created link will then be shown in the link table below.
5	Link Table	It displays all the links in and out of this node.
6	Edit Link Button	The pencil icon is the "Edit Link" button. By clicking it, the third level form will get automatically filled in.
7	Master Button	It links to the master node-edit page of this instance node.
8	Cancel Button	It cancels the current edit without saving.
9	Delete Button[1]	It deletes the instance node.
10	Apply Changes Button	It saves current changes to this instance node.
11	Delete Button[2]	It deletes the link of the instance node.
12	Apply Button	It saves current changes to the link of the instance node.

6.1.2. Home Page



Welcome: YANXIN.ZHOU@US.BNPPARIBAS.COM

User yanxin.zhou@us.bnpparibas.com
Diagram Options Trade Flow
Region Options Trade Flow
Actions

Diagram Name = 'Options Trade Flow' ☑

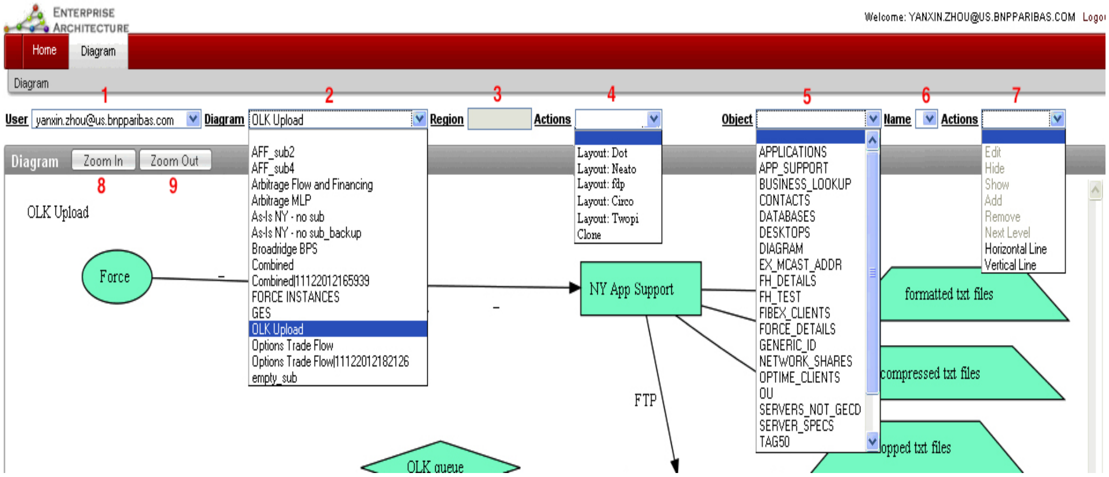
6	7	8	Owner			Name	Comment
Edit	✕	✚	yanxin.zhou@us.bnpparibas			Options Trade Flow	-
Edit	✕	✚	yanxin.zhou@us.bnpparibas			Front End Broker Tools (manul)	-
Edit	✕	✚	yanxin.zhou@us.bnpparibas			Electronic	-
Edit	✕	✚	yanxin.zhou@us.bnpparibas.com	Options Trade Flow	DIAGRAM	PBI	-
Edit	✕	✚	yanxin.zhou@us.bnpparibas.com	Options Trade Flow	DIAGRAM	Sec Corp	-

Figure 12 Home Page

Table 4 Instruction of Home Page

Number	Item	Description
1	User Select List	It shows all the user accounts of this application.
2	Diagram Select List	It shows all the graphs' names under the selected user account.
3	Region Select List	It shows all the sub-graphs' names under the selected graph.
4	Actions Select List	It shows all available actions on this page.
5	Table Filters	Automatically, the table will be filtered to show elements in the selected diagram only. However, users can still filter the table by adding more criteria.
6	Edit Node Button	Clicking it will get redirected to the edit page of that object.
7	Delete Node Button	Clicking it will delete that node from the diagram or delete that entry in the database.
8	Add Node Button	Clicking it will add that object to the current diagram.

6.1.3. Diagram Page



Welcome: YANXIN.ZHOU@US.BNPPARIBAS.COM

User yanxin.zhou@us.bnpparibas.com

Diagram OLK Upload

Figure 13 Diagram Page

Table 5 Instructions of Diagram Page

Number	Item	Description
1	User Select List	It shows all the user accounts of this application.
2	Diagram Select List	It shows all the graphs' names under the selected user account.
3	Region Display	It displays the name of the region the selected object is in.
4	Actions Select List[1]	It shows all available actions on the diagram.
5	Object Select List	It shows all objects in the system that can be inserted to the current diagram.
6	Name Select List	It shows names of one kind of object, which is specified in (5).
7	Actions Select List[2]	It shows all available actions on the nodes and links.
8	Zoom In	Clicking it will zoom in the whole diagram.
9	Zoom Out	Clicking it will zoom out the whole diagram.

6.2 Specific Features Overview

This section displays some specific features on the application user interface. They greatly improve user experience.

6.2.1. Auto Filter on Actions List

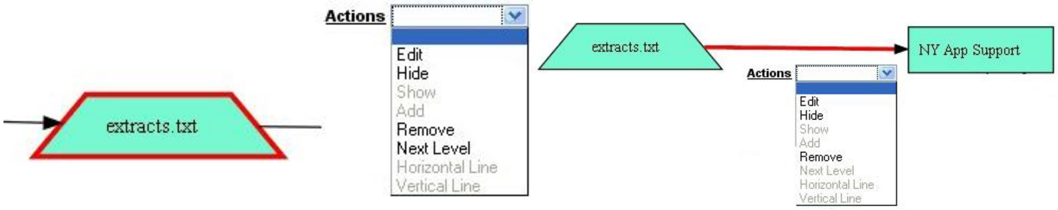


Figure 14 Auto Filter on Actions List

Actions list will show different available actions as users select different kind of objects. Some actions in the list are not applicable to nodes, while some are not applicable to links.

6.2.2. Multi Selection of Nodes

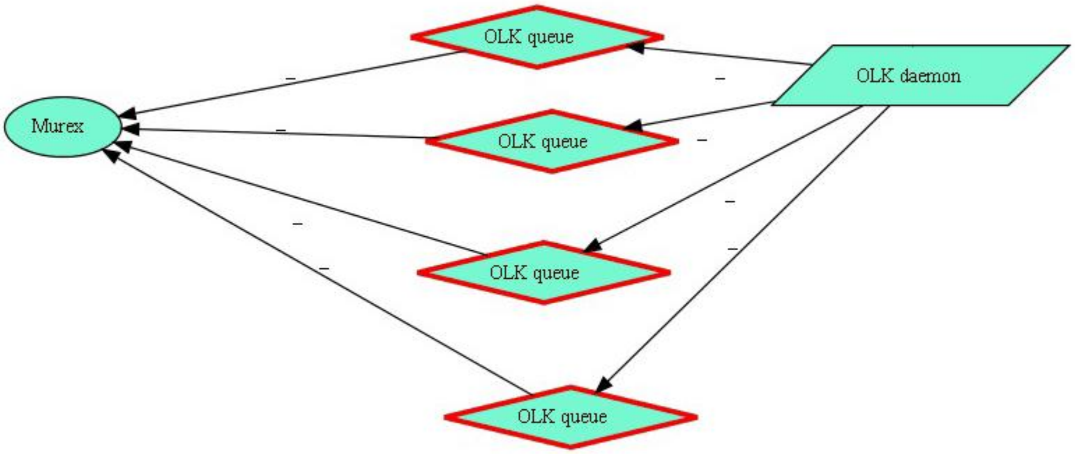


Figure 15 Multi Selection of Nodes

Multi selection of nodes allows users to select multiple nodes at a time and move them as a group. This will make the first selected object move to the exact place the users specify, while the rest of the group moves relatively to the first one.

7. Conclusions and Recommendations

In this project, we adapted and scaled the Enterprise Architecture prototype to a well-integrated browser-based data visualization and management tool. The application prototype underwent extensive developments and improvements in aspects of table interactivity, graph interactivity, interactions between tables and graphs, database reconstruction and data management. All these improvements greatly enhanced the ability of customizing visualizations of data. Summarized descriptions of each aspect of development are as follows:

Table Interactivity:

- Introduced the 3-level edit form, which provides users great convenience to make changes to master nodes, instance nodes and links in the same page.
- Introduced auto filtering while changing values of select lists. It saves users' time for looking up specific entries in the table.

Graph Interactivity:

- Introduced exact placement of nodes. This makes our application now comparable with other 2 dimensional graph drawing software, like Visio and OmniGraffle, where users have the freedom of placing nodes at positions they specify.
- Introduced 5 actions on single node and 7 actions on diagrams and links. Greatly improved the ability of user customization.

Interactions between Graphs and Tables:

- Introduced add/delete functions in the table on the Home page. It avoids the long graph-rendering time after each add/delete action on nodes on the Diagram page.
- Introduced the link between graphs and node-edit page. This improvement gives users a direct viewing of which node needs editing.

Database Reconstruction:

- Introduced user preference functions. It provides full control over the attributes of diagrams to the users.
- Introduced master and instance object design. It encapsulates the original database from the company, while building up diagrams in instance tables.
- Introduced the interaction between back end and front end. It makes it feasible for users to direct modify diagrams on the user interface.

The Enterprise Architecture still remains some limitations at the end of development phase II, and we summarized them into two major development objectives for teams that will work further on this application:

Actions on nodes, links and graphs need capabilities of "undo" and "redo":

Without undo and redo, it can sometimes cause catastrophes to the whole database because a simple click could mess up the data and the whole database, where the only way to make up for this is to roll back the complete database which will for sure result in inestimable loss to the company.

For further developments, teams should consider to have backup database, which at least stores one previous state of the whole system. This may involve extensive design of how to switch between two states fast and accurately.

Multi-user processing needs to be implemented:

In current development, Oracle database will raise concurrency error when two or more users try to modify the same diagram at the same time. This decreases the usability of the application to some extent. In real life, it is very likely that two users work on the same diagram concurrently. However, Oracle database banned these multi-user processes.

For further developments, teams should consider to have a request list, where all requests from different users are kept in a list and will be finished one by one in a time-efficient manner.

Besides the above two major objectives, future teams should also consider to optimize data processing algorithms used in this system. Since Enterprise

Architecture Phase I and II were mainly focused on proofs of feasibilities and implementations of major features that can bring this product to live as soon as possible, algorithms used in the system did not go through extensive designs and tests. Optimizing these algorithms will incredibly improve the system behavior.

Appendix I – BNP Paribas and GECD

BNP Paribas is a leader in banking and financial services in Europe. The Group is present in 80 countries. Headquartered in New York, BNP Paribas North America has locations in all of the major corporate and financial centers of the United States and Canada. The bank serves a world-class client base of multinational corporates and mid-capitalization companies, as well as major issuers and institutional buyers. BNP Paribas North America relies on strong, established franchises in order to provide a full-service institutional corporate and investment banking approach, and to offer a broad range of advisory services and corporate finance capabilities to key industry sectors. BNP Paribas Global Equities & Commodity Derivatives, a branch of BNP Paribas Corporate and Investment Banking, offers derivatives on equities and commodities, as well as financing solutions and integrated equity brokerage platform. It is organized into 3 lines of business: Structured Equity, Flow & Financing and Commodity Derivatives.

Structured Equity

It provides structured solutions to a broad variety of business customers, banking networks, insurance companies and pension funds. It provides customized or exchange-traded structured products to meet their needs in capital protection, yield and diversification.

Flow and Financing

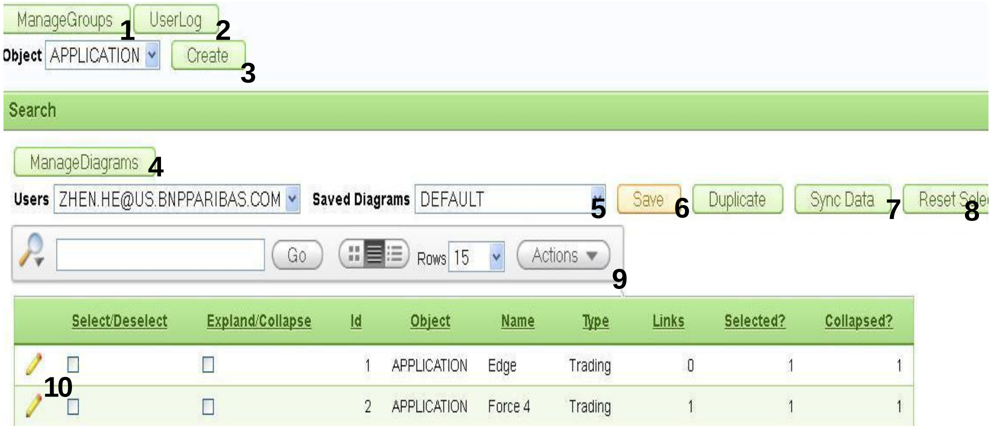
It caters to the needs of institutional investors and hedge funds. It designs appropriate and innovative investment and hedging strategies in equity market and provides its clients with a rapidly developing integrated equity brokerage platform.

Commodity Derivatives

It provides a range of risk hedging solutions to corporate clients and access to commodities through various investment strategies and structured solutions to investors.

Appendix II – Enterprise Architecture Application – Phase I Implementation

Summary of functions



Object APPLICATION

Users ZHEN.HE@US.BNPPARIBAS.COM Saved Diagrams DEFAULT

Rows 15

	Select/Deselect	Expland/Collapse	Id	Object	Name	Type	Links	Selected?	Collapsed?
✎	□	□	1	APPLICATION	Edge	Trading	0	1	1
✎	□	□	2	APPLICATION	Force 4	Trading	1	1	1

Figure 16 Summary of Functions

1. Manage the graphical attributes of an entity or a relationship in the graph. Users can assign colors, shapes, and styles to a node or link.

2. Keep a log of user actions made to the data. The actions include insert, delete, and update and can be sorted by date.

3. Create an entity of type Application, Hardware, OU, People, or Process.

4. Create a new diagram or edit an existing one. A diagram is a copy of the master database with a specific set of user preferences. It is equivalent to a graph in its database format.

5. Go back to any saved diagram under the current selected user.

6. Save any user preferences modification made to the current diagram.

7. Synchronize the current user copy with the master database. The mismatch between the two comes from create/edit/delete an entity or a relationship. The synchronization has nothing to do with user preferences.

8. Reset user preference.

9. Search for any particular record(s).

10. Edit an existing entity. Relationships that involve that entity can be edited from the editing page for that entity.

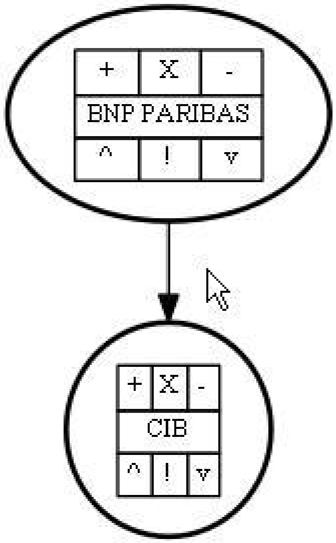


Figure 17 EA Phase I Graph Interactivity

+: Expand a node so that children of that node are shown in the graph.

-: Collapse a node so that children of that node are hid.

X: Hide the current node.

[Node Name]: Prompt the user to the editing page for the node.

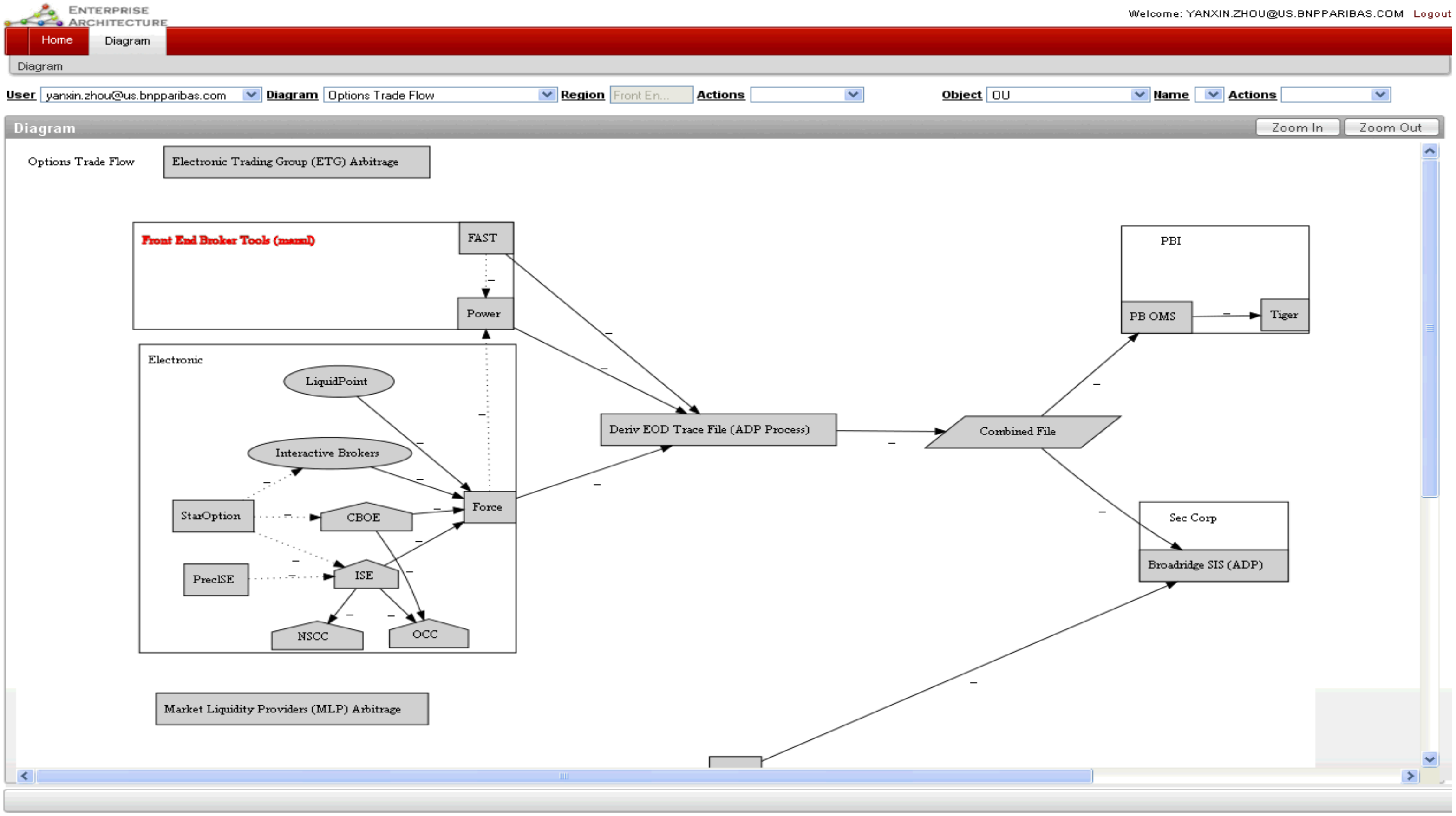
^: Roll up the graph so it displays a summary view.

v: Roll down the graph so it displays a detailed view.

!: Prompt the user to the performance metrics page for the node. This section is color-coded according to the health of the entity.

Appendix III – A Complete Business Flow Diagram

Figure 18 is a complete business flow diagram built by Enterprise Architecture Phase II.



Welcome: YANXIN.ZHOU@US.BNPPARIBAS.COM Logout

User yanxin.zhou@us.bnpparibas.com Diagram Options Trade Flow Region Front En... Actions Object OU Name Actions

Figure 18 EA Phase II Production Diagram

Appendix IV – Report of C Term 2013

Introduction

Under the pressures of globalization, competitions from non-banking financial industries and the volatile market dynamics (Soteriou & Zenios, 1997), commercial banks have to constantly modify operating strategies, in order to maintain their stabilities in the financial world. The study carried out by Abul Shamsuddin and Dong Xiang has shown that the operating efficiency of banks determines the stability of the banking system. They observed that during the Asian financial crisis and the subprime mortgage crisis, the Australian banks were resilient to external shocks, which suggested the fact that "an economically efficient bank can withstand financial market turmoil better than its inefficient counterpart and can contribute more to the efficient allocation of capital and the stability of the financial system" (Shamsuddin & Xiang, 2012).

In order to know whether world's top banks perform in a cost-effective manner or not, and which of them are doing better than their competitors, we evaluated the operating efficiency of the world's top banks in this project. To attain this goal, we selected the world's top 20 banks (ranking based on the annual total revenue in 2011 - 2012) and completed the following objectives:

- Create an inventory of information of target banks;
- Conduct data analysis and calculate the operating efficiency of these selected banks.

To fulfill these objectives, we collected the data from the 2007 – 2011 annual reports of each bank. We then used the Data Envelopment Analysis (DEA) method to analyze the efficiency of these banks. Data Envelopment Analysis is a method to assess the efficiency and performance of each unit. The calculation requires the same input and output factors for each unit. After determining the input factors and output factors, we used two DEA models in the analysis, including 1) CCR Model and 2) BCC Model. In addition, we used the averages and standard deviations of the results from previous analysis to determine the average efficiency and stability of each bank.

Lastly, we identified banks that have fully consistent high operating efficiency and banks that need improvements. We also provided recommendations to enhance our evaluation process.

Background

Operating Efficiency

Operating Efficiency has been defined as:

"What occurs when the right combination of people, process, and technology come together to enhance the productivity and value of any business operation, while driving down the cost of routine operations to a desired level. The end result is that resources previously needed to manage operational tasks can be redirected to new, high-value initiatives that bring additional capabilities to the organization. (Schawk, Inc., 2008)"

In other words, operating efficiency is the indicator of an enterprise's capability to sell products and services for high revenues at low costs. It is usually calculated as the ratio between the input to produce products and services and the output gained by the enterprise.

It is important to monitor operating efficiency since it reflects the enterprise's stability in the financial market. It helps managers to predict potential risks the enterprise may come into and adjust future operational strategies. It is also an indicator that determines whether an enterprise performs in a cost-effective manner.

Operating Efficiency Model

There are two major approaches for evaluating operating efficiency, a production approach and an intermediation approach (Soteriou & Zenios, 1997). In the production approach, the enterprise is considered as a "factory" that it provides products and services to its customers in the form of transactions. Operating efficiency in this approach examines how well the enterprise uses its resources, such as personnel, computers and space, to produce the largest possible number of transactions. While in the intermediation approach, the enterprise's resources are various types of costs, and those are combined to produce the largest possible revenues.

Data Envelopment Analysis

The above two model approaches are both established based on the Data Envelopment Analysis (DEA) technique. DEA is developed by Charnes, Cooper and Rhodes (1978) to evaluate the relative efficiency of public sectors. Now it has widespread applications in measuring the operating efficiency of banks, hospitals, schools, and so on.

DEA is commonly used to evaluate the efficiency of a number of producers using a linear programming procedure (Trick, 1998). Each producer has a set of inputs and a set of outputs. Through DEA, producers will be mapped on to a plane of outputs versus inputs. Then linear programming formulations are used to define the envelopment surface (Soteriou & Zenios, 1997). Efficient units will always be on the envelopment surface, but we can also project inefficient units onto the efficient frontier as virtual units. This could be done by decreasing inputs, known as the *input minimization* model, or by increasing outputs, which is called the *output maximization* model.

Figure 19 illustrated the mapping plane of DEA.

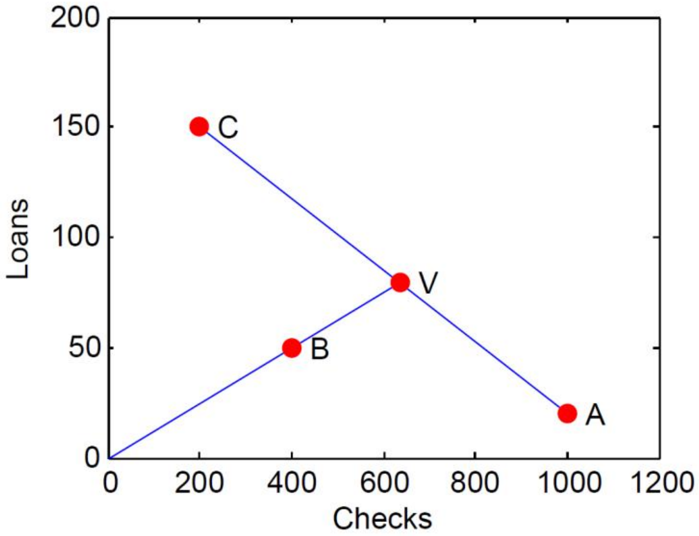


Figure 19. Mapping plane of DEA

Point A and point C represent the two banks that are efficient. Point B is not on the envelopment surface, so this bank is not efficient. However, we can map point B to point V, which is the virtual image of point B.

Methodology

The goal of our project was to evaluate the operating efficiency of top banks from FY2007 – FY 2011. We selected the world's top 20 banks (ranking based on the annual total revenue in 2011 - 2012) and completed the following objectives to fulfill this goal:

1. Create an inventory of information of target banks;
2. Conduct data analysis and calculate the operating efficiencies of these selected banks.

Data Collection

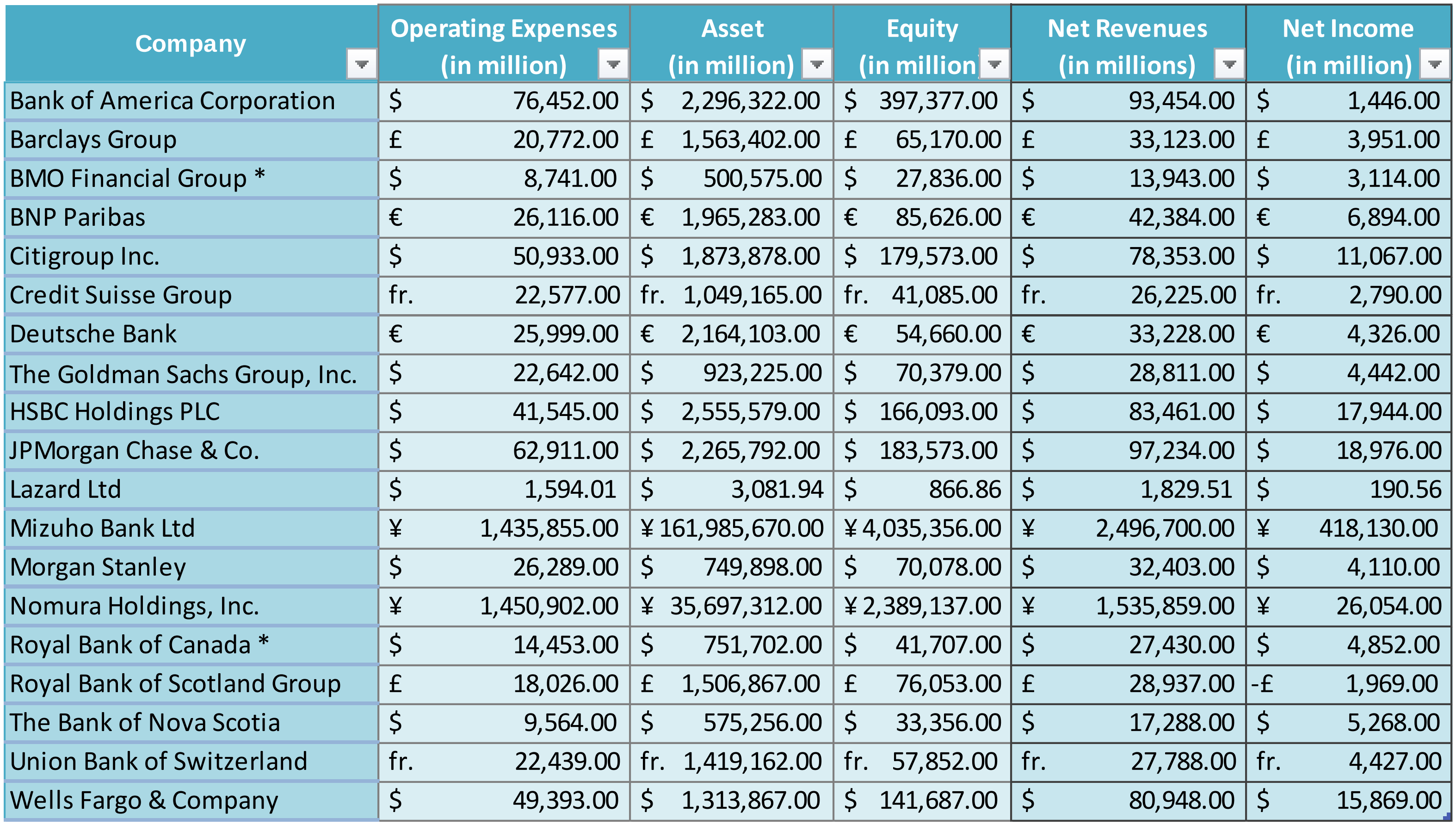
Input and output factors play a decisive role in data envelopment analysis model. The three key factors in this project include selection of banks, financial input, and financial output.

Based on the Global IB Revenue Ranking from dialogic (Dealogic, 2012), we selected top 20 banks in the world. The input factors consist of operating expenses, asset, and equity for FY 2007 – FY 2011. Compensations to employees, research and development costs, and administrative expenses belong to operating expenses (Investopedia US, 2013). Asset, equity, and liabilities are the other three important indexes indicating the bank's financial situation. However, since asset equals the sum of equity and liabilities, taking these any two of them into consideration is sufficient for the model.

As for the output, we decided to use yearly net incomes and revenues of each bank. These two numbers explicitly indicate the income and profit of each bank. If a bank could use limited resources and expenses yet achieve large amount of turnover, it means that the bank holds a good operating efficiency.

All data were collected from annual reports of each bank. Due to insufficient financial data from Jefferies & Company, we eliminated the list to 19 top banks. Table 6 shows the input and output data for FY 2011.

Table 6. Input and output data for FY2011



Company	Operating Expenses (in million)	Asset (in million)	Equity (in million	Net Revenues (in millions)	Net Income (in million)
Bank of America Corporation	$ 76,452.00	$ 2,296,322.00	$ 397,377.00	$ 93,454.00	$ 1,446.00
Barclays Group	£ 20,772.00	£ 1,563,402.00	£ 65,170.00	£ 33,123.00	£ 3,951.00
BMO Financial Group *	$ 8,741.00	$ 500,575.00	$ 27,836.00	$ 13,943.00	$ 3,114.00
BNP Paribas	€ 26,116.00	€ 1,965,283.00	€ 85,626.00	€ 42,384.00	€ 6,894.00
Citigroup Inc.	$ 50,933.00	$ 1,873,878.00	$ 179,573.00	$ 78,353.00	$ 11,067.00
Credit Suisse Group	fr. 22,577.00	fr. 1,049,165.00	fr. 41,085.00	fr. 26,225.00	fr. 2,790.00
Deutsche Bank	€ 25,999.00	€ 2,164,103.00	€ 54,660.00	€ 33,228.00	€ 4,326.00
The Goldman Sachs Group, Inc.	$ 22,642.00	$ 923,225.00	$ 70,379.00	$ 28,811.00	$ 4,442.00
HSBC Holdings PLC	$ 41,545.00	$ 2,555,579.00	$ 166,093.00	$ 83,461.00	$ 17,944.00
JPMorgan Chase & Co.	$ 62,911.00	$ 2,265,792.00	$ 183,573.00	$ 97,234.00	$ 18,976.00
Lazard Ltd	$ 1,594.01	$ 3,081.94	$ 866.86	$ 1,829.51	$ 190.56
Mizuho Bank Ltd	¥ 1,435,855.00	¥ 161,985,670.00	¥ 4,035,356.00	¥ 2,496,700.00	¥ 418,130.00
Morgan Stanley	$ 26,289.00	$ 749,898.00	$ 70,078.00	$ 32,403.00	$ 4,110.00
Nomura Holdings, Inc.	¥ 1,450,902.00	¥ 35,697,312.00	¥ 2,389,137.00	¥ 1,535,859.00	¥ 26,054.00
Royal Bank of Canada *	$ 14,453.00	$ 751,702.00	$ 41,707.00	$ 27,430.00	$ 4,852.00
Royal Bank of Scotland Group	£ 18,026.00	£ 1,506,867.00	£ 76,053.00	£ 28,937.00	-£ 1,969.00
The Bank of Nova Scotia	$ 9,564.00	$ 575,256.00	$ 33,356.00	$ 17,288.00	$ 5,268.00
Union Bank of Switzerland	fr. 22,439.00	fr. 1,419,162.00	fr. 57,852.00	fr. 27,788.00	fr. 4,427.00
Wells Fargo & Company	$ 49,393.00	$ 1,313,867.00	$ 141,687.00	$ 80,948.00	$ 15,869.00

[1]

To view more data for FY 2007 to FY 2011, please see Appendix A.

[1] Note: BMO Financial Group and Royal Bank of Canada using Canadian dollars.

As we can see from Table 6, banks are using different currencies for their financial reporting. To make them consistent, we convert them into dollars by using the average conversion rate for each year (IRS, 2012). Table 7 presents the currency rates we used for currency conversion.

Table 7. Currency conversion rate for 2007 - 2011

Currency	2011	2010	2009	2008	2007
Dollar	1	1	1	1	1
Canadian Dollar	1.029	1.072	1.187	1.109	1.117
Euro	0.748	0.785	0.748	0.711	0.76
Franc	0.923	1.085	1.129	1.126	1.248
Pound	0.649	0.673	0.667	0.567	0.52
Yen	82.931	91.342	97.361	107.605	122.527

Data Analysis

Both CCR Model and BCC Model, named after Banker, Charnes, and Cooper, are frequently used DEA Models. The CCR Model spans its production frontier with a linear combination of every Decision Making Unit (DMU, which refers to each bank in this project), while the BCC Model spans its production frontier with a convex hull of every DMU (Cooper, Selford, & Tone, 2005). A convex hull of a set of points *S* is defined as the intersection of all convex sets containing *S* (Wolfram MathWorld, 2013). Thus, the frontiers of the CCR Model have linear characteristics, while those of the BCC Model have piece-wise

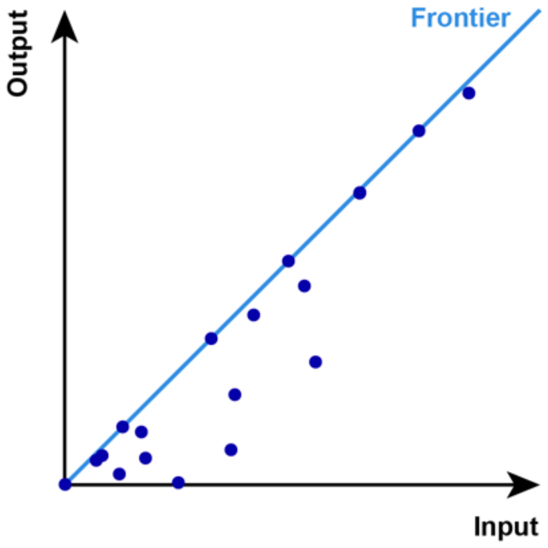


Figure 21 CCR Model Frontier

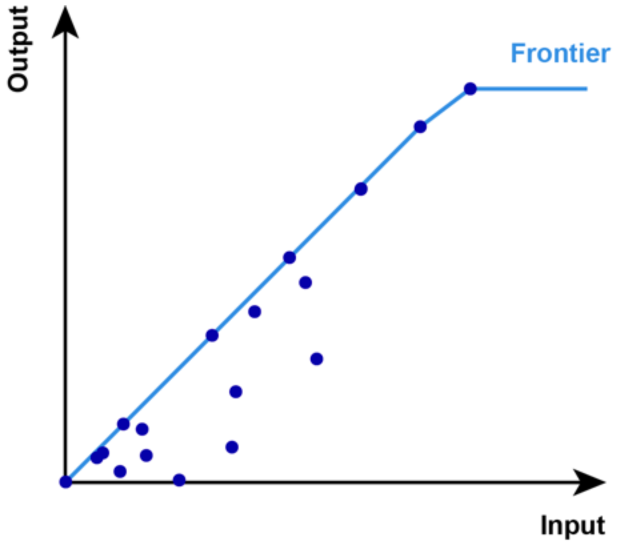


Figure 20 BCC Model Frontier

linear and concave characteristics, as shown in Figure 20 and Figure 21 (Lertworasirikul, Fang, Nuttle, & Joines, 2003).

As we can see from these two figures, points below the frontier are able to approach the frontier line by keeping the input value unchanged and increasing the output. Similarly, they can approach the frontier by keeping the output value unchanged and decreasing the input. It means that the efficiency of these points can be improved by either increasing the output or decreasing the input. The relative efficiency of a DMU, which defines as the ratio of the weighted sum of its outputs to the weighted sum of its inputs, falls in the interval of (0,1]. This ratio can be expressed as below:

$$Operating\ Efficiency\ Rate = \frac{weighted\ sum\ of\ outputs}{weighted\ sum\ of\ inputs}$$

CCR Model

CCR Model is the primary model for Data Envelopment Analysis. Assume that there are m inputs and n outputs for each DMU. We can write the input matrix X and output matrix Y as below:

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \qquad Y = \begin{bmatrix} y_{11} & \cdots & y_{1n} \\ \vdots & \ddots & \vdots \\ y_{s1} & \cdots & y_{sn} \end{bmatrix}$$

Then, the operating efficiency θ_q of DMU$_q$ can be interpreted as

$$\theta_q = \frac{weighted\ sum\ of\ outputs}{weighted\ sum\ of\ inputs} = \frac{\sum_{i=1}^{s} u_i y_{iq}}{\sum_{j=1}^{m} v_j x_{jq}}$$

Where:

v_j, j = 1, 2, …, m, are weights assigned to j-th input,

u_i, i = 1, 2, …, s, are weights assigned to i-th output.

The constraints include:

$$Any\ operating\ efficiency\ \ \theta\ \leq 1$$

$$v_1, v_2, \dots, v_m \geq 0$$

$$u_1, u_2, \dots, u_s \geq 0$$

The main goal of this model is to calculate the operating efficiency Θ and the optimal value of Θ* = 1.

The above fractional program can be converted to the linear program

$$\theta = u_1 y_{1q} + \cdots + u_s y_{sq} = \sum_{i=1}^{s} u_i y_{iq}$$

Subject to $$v_1 x_{1q} + \cdots + v_m x_{mq} = \sum_{j=1}^{m} v_j x_{jq} = 1$$

$$u_1 y_{1j} + \cdots + u_s y_{sj} \leq v_1 x_{1j} + \cdots + v_m x_{mj} \ (j = 1, \dots, n)$$

$$v_1, v_2, \dots, v_m \geq 0$$

$$u_1, u_2, \dots, u_s \geq 0$$

BCC Model

In the previous section, we discussed about the CCR model, which is built on the assumption that number of returns to scale is constant. In other words, it is assumed that the set of data point has a property that if (x, y) is a data point, then $(\mathrm{t}x, \mathrm{t}y)$ is also a feasible data point for any positive t. Changing (x, y) to $(\mathrm{t}x, \mathrm{t}y)$ will not affect the result of the analysis. However, BCC Model assumes variant returns to scale. Because of this, the frontiers of BCC Model is piece-wise linear.

The input-oriented BCC Model evaluates the efficiency of DMUs by solving the following linear program:

$$\min_{\theta_B,\ \lambda} \ \theta_B$$

Subject to $$\theta_B \cdot x_o - X \cdot \lambda \geq 0$$

$$Y \cdot \lambda \geq y_o$$

$$e \cdot \lambda = 1$$

$$\lambda \geq 0$$

where

θ_B is the efficiency we are trying to solve for.

x_o and y_o are values of corresponding indicator of DMU_o

λ is a column vector that defines the weight of each input.

X and Y are input and output data sets.

We applied input-oriented BCC Model to our evaluation of banks' operating efficiency. The inputs and outputs remained the same, where inputs comprised Asset, Equity, and Operating Expenses, and outputs contained Net Income and Net Revenue. By solving the above BCC Model in MATLAB, we got the annual operating efficiency of all 19 banks from FY2007 to FY2011, as displayed in Table 9.

Efficiency and Stability Analysis

In addition to calculating the operating efficiency using two models, we still conducted analysis for the efficiency and stability. Two indicators we used are average operating efficiency among the five years and the standard deviations. From the average value, we can determine whether the bank has high operating efficiency or not. Meanwhile, the standard deviation reveals the stability of the bank over the five years. Based on these two indicators, we divided the banks into four categories

- Category 1. Consistently efficient (high average and small standard deviation)
- Category 2. Efficient but unsteady (high average but large standard deviation)
- Category 3. Neither efficient nor steady (low average and large standard deviation)
- Category 4. Consistently inefficient (low average and small standard deviation)

Result

After cleaning the data, we used MATLAB to conduct calculation for each model. Table 8 presents the result from CCR Model and Table 9 presents the result from BCC Model.

Table 8. Result from CCR Model

	2011	2010	2009	2008	2007	Average	Standard Deviation
Bank of America Corporation	0.73	0.89	0.93	0.99	0.9	0.89	8.6E-02
Barclays Group	0.83	0.8	1	0.86	0.85	0.87	6.9E-02
BMO Financial Group	0.85	0.82	0.66	0.75	0.71	0.76	7.0E-02
BNP Paribas	0.84	0.82	0.83	0.64	0.78	0.78	7.4E-02
Citigroup Inc.	0.88	0.98	0.86	0.5	0.71	0.79	1.7E-01
Credit Suisse Group	0.75	0.81	0.89	0.21	1	0.73	2.7E-01
Deutsche Bank	0.78	0.66	0.92	0.32	0.76	0.69	2.0E-01
The Goldman Sachs Group, Inc.	0.71	0.96	1	0.67	0.99	0.87	1.4E-01
HSBC Holdings PLC	1	1	1	0.97	1	0.99	1.2E-02
JPMorgan Chase & Co.	0.89	0.95	0.98	0.85	0.89	0.91	4.7E-02
Lazard Ltd	1	1	1	1	1	1.00	0
Mizuho Bank Ltd	0.75	0.72	0.56	0.76	0.63	0.68	7.7E-02
Morgan Stanley	0.71	0.66	0.63	0.2	0.51	0.54	1.8E-01
Nomura Holdings, Inc.	1	1	1	1	1	1.00	0
Royal Bank of Canada	0.8	0.82	0.79	0.27	0.99	0.73	2.4E-01
Royal Bank of Scotland Group	1	1	0.98	1	1	1.00	8.0E-03
The Bank of Nova Scotia	0.69	0.77	0.48	0.01	0.5	0.49	2.6E-01
Union Bank of Switzerland	1	1	1	0.93	1	0.99	2.8E-02
Wells Fargo & Company	0.93	1	1	1	1	0.99	2.8E-02

Table 9. Result from BCC Model

	2011	2010	2009	2008	2007	Average	Standard Deviation
Bank of America Corporation	0.89	1	1	1	0.96	0.970	4.3E-02
Barclays Group	0.93	0.86	1	1	1	0.958	5.6E-02
BMO Financial Group	1	0.89	0.81	0.92	0.83	0.890	6.8E-02
BNP Paribas	0.96	0.9	0.91	0.97	1	0.948	3.8E-02
Citigroup Inc.	0.93	1	0.87	0.86	1	0.932	6.0E-02
Credit Suisse Group	0.63	0.72	0.7	0.21	0.97	0.646	2.5E-01
Deutsche Bank	1	0.68	0.99	0.6	0.85	0.824	1.6E-01
The Goldman Sachs Group, Inc.	0.72	1	1	0.75	1	0.894	1.3E-01
HSBC Holdings PLC	1	1	1	1	1	1.000	0
JPMorgan Chase & Co.	1	1	1	1	1	1.000	0
Lazard Ltd	1	1	1	1	1	1.000	0
Mizuho Bank Ltd	0.77	0.72	0.57	1	0.81	0.774	1.4E-01
Morgan Stanley	0.66	0.63	0.63	0.21	0.56	0.538	1.7E-01
Nomura Holdings, Inc.	1	1	1	1	1	1.000	0
Royal Bank of Canada	0.81	0.84	0.93	0.71	1	0.858	1.0E-01
Royal Bank of Scotland Group	1	1	1	1	1	1.000	0
The Bank of Nova Scotia	0.75	0.8	0.57	0.06	0.65	0.566	2.7E-01
Union Bank of Switzerland	1	1	1	1	1	1.000	0
Wells Fargo & Company	0.97	1	0.86	1	1	0.966	5.4E-02

For CCR Model, the distribution of the average values presents a pattern that generally can be classified into two groups. Each group has relatively same number of banks and there is a clear gap between them. Thus, we used this gap to divide these banks into high average group and low average group. We named this approach as "Gap Analysis". As for standard deviation, the gap among these values is not that clear, so we used median to separate them. Finally, we summarized our results for CCR Model in Table 10.

Table 10. Efficiency and Stability Analysis for CCR Model

	High average	Low average
Small standard deviation	**Consistently efficient** Bank of America Corporation Barclays Group HSBC Holdings PLC JPMorgan Chase & Co. Lazard Ltd Nomura Holdings, Inc. Royal Bank of Scotland Group Union Bank of Switzerland Wells Fargo & Company	**Consistently inefficient** BMO Financial Group BNP Paribas Mizuho Bank Ltd
Large standard deviation	**Efficient but unsteady** (None)	**Neither efficient nor steady** Citigroup Inc. Credit Suisse Group Deutsche Bank The Goldman Sachs Group, Inc. Morgan Stanley Royal Bank of Canada The Bank of Nova Scotia

As for BCC Model, the distribution has a significant gap in average and standard deviation. Therefore, we used the Gap Analysis again to categorize these banks. The result was listed in Table 11:

Table 11. Efficiency and Stability Analysis for BCC Model

	High average	Low average
Small standard deviation	**Consistently efficient** Bank of America Corporation Barclays Group BMO Financial Group BNP Paribas Citigroup Inc. HSBC Holdings PLC JPMorgan Chase & Co. Lazard Ltd Nomura Holdings, Inc. Royal Bank of Scotland Group Union Bank of Switzerland Wells Fargo & Company	**Consistently inefficient** (None)
Large standard deviation	**Efficient but unsteady** Deutsche Bank The Goldman Sachs Group, Inc. Mizuho Bank Ltd Royal Bank of Canada	**Neither efficient nor steady** Credit Suisse Group Morgan Stanley The Bank of Nova Scotia

Conclusions

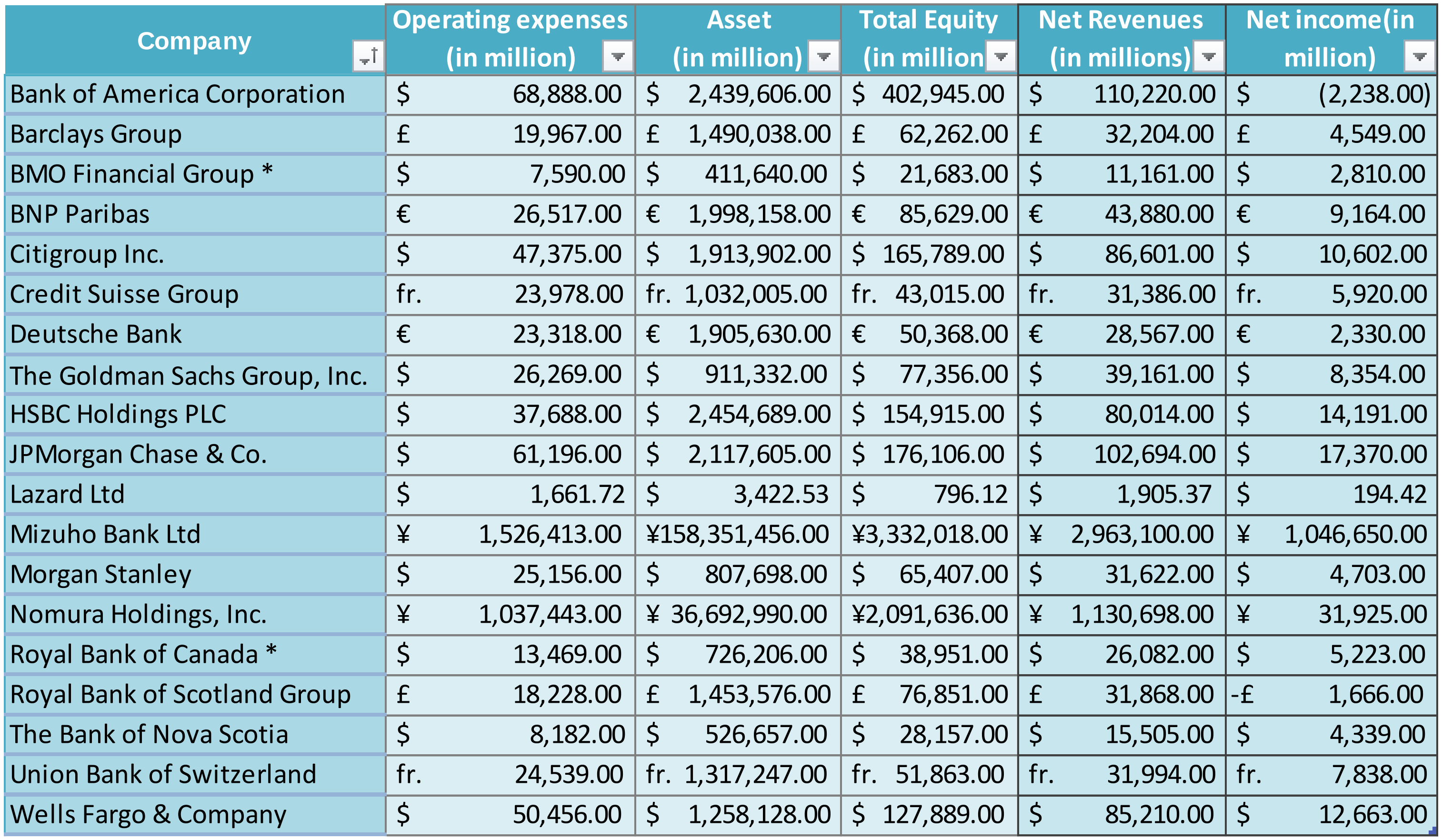
Based on the data analysis from two models, we concluded that Bank of America Corporation, Barclays Group, HSBC Holdings PLC, JPMorgan Chase & Co., Lazard Ltd, Nomura Holdings, Inc., Royal Bank of Scotland Group, Union Bank of Switzerland, Wells Fargo & Company have fully consistent efficiency. Credit Suisse Group, Morgan Stanley and The Bank of Nova Scotia are neither efficient nor steady.

On the other hand, the evaluation process is not very comprehensive. People can improve it in following aspects:

- **Increasing the number of DMUs**
  The DEA model works better for large dataset. Insufficient data will lead to inaccurate result. Currently, this project targeted on the top 20 banks worldwide. Taking more banks or banks in different revenue levels into account can create more comprehensive evaluation result.
- **Considering unrelated input/output factors**
  Since DEA model takes each input/output factor as an independent variable, correlated input/output may cause uneven weight to each factor.
- **Considering more input/output factors**
  This project only used five factors. Feeding more elements into the model will make the evaluation result more convincing and comprehensive.

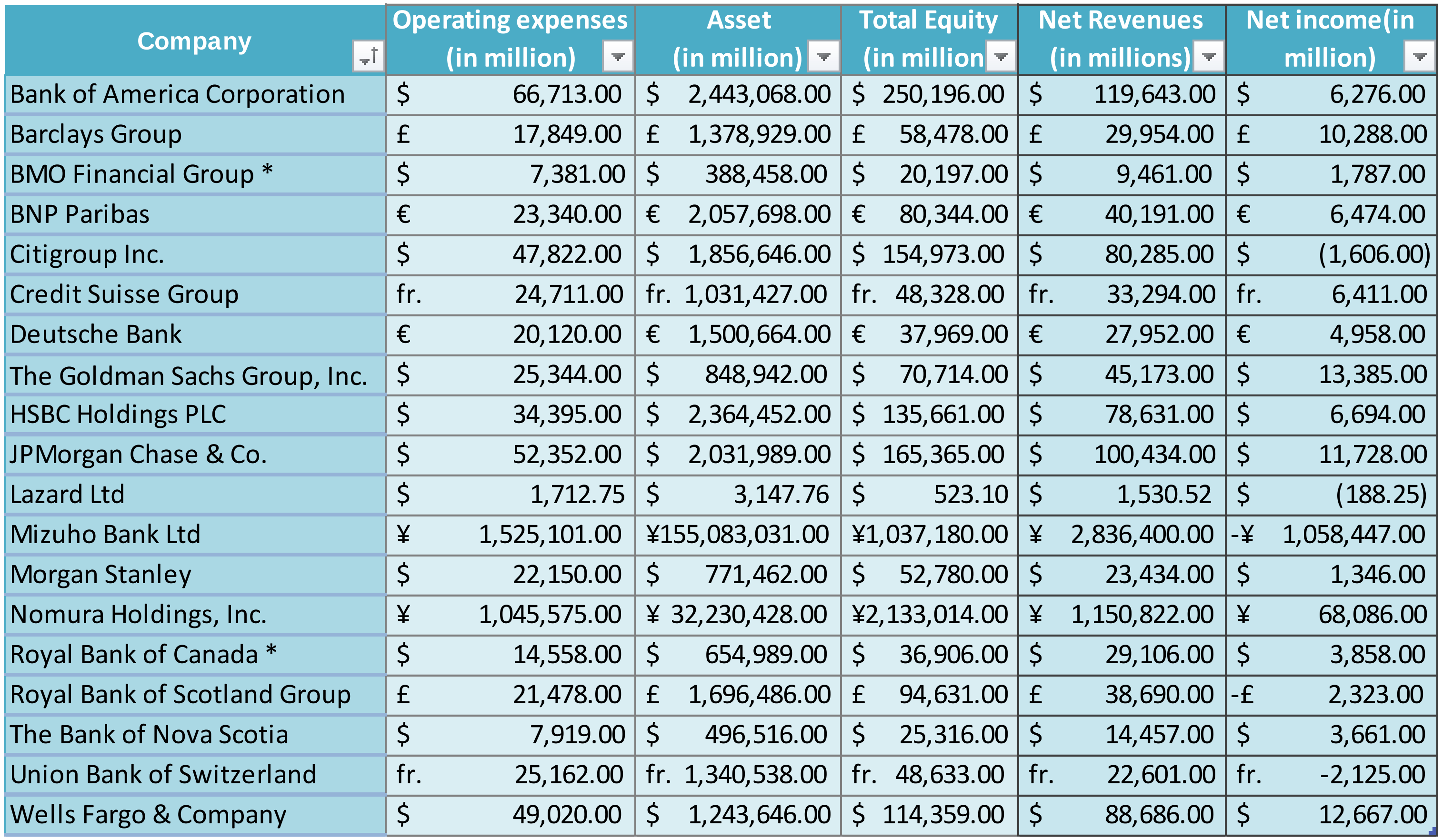
Appendix A. Input/Ouput Data for FY 2007 – FY 2010

Table 12. Input/Output for FY2010



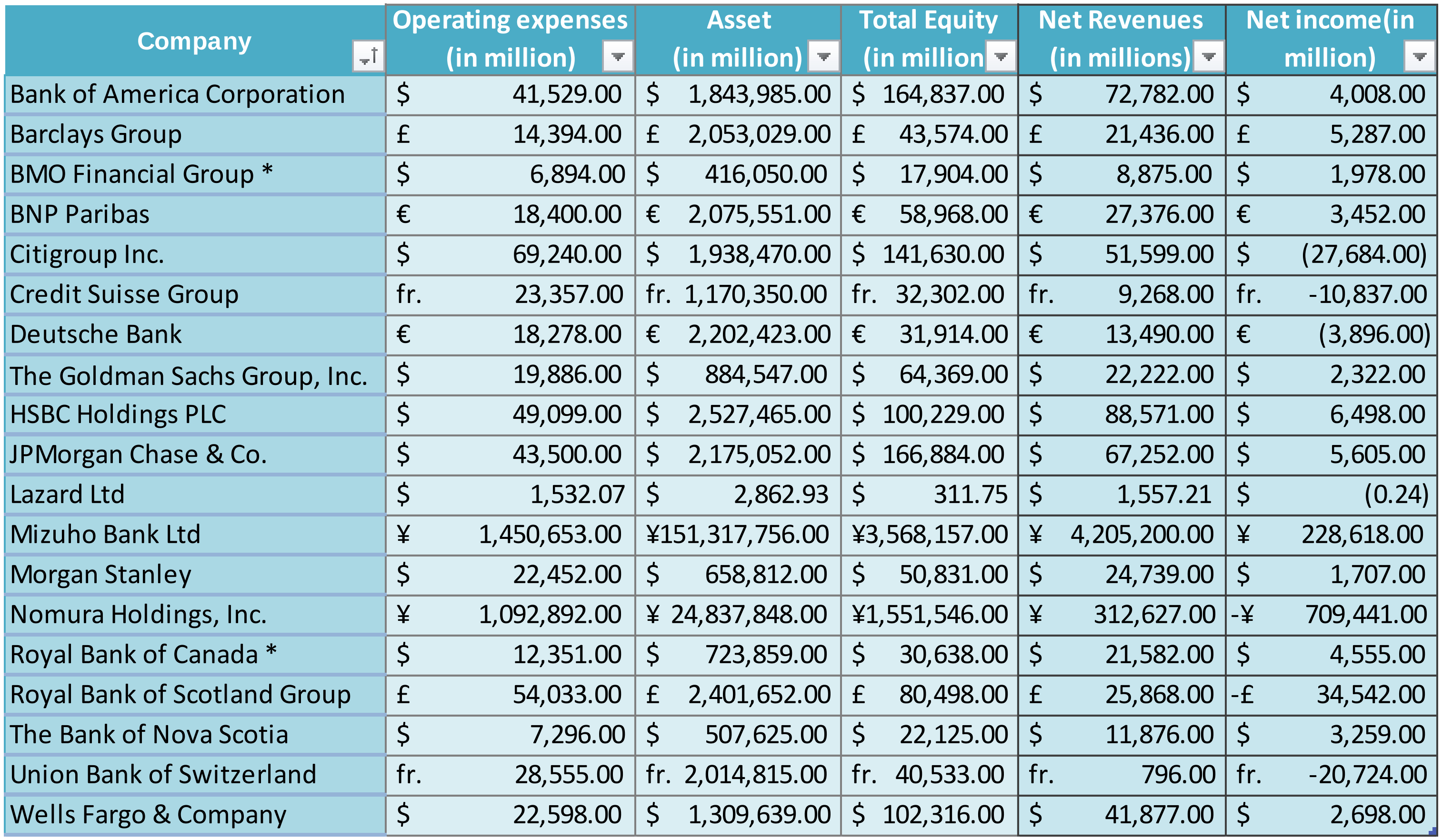
Company	Operating expenses (in million)	Asset (in million)	Total Equity (in million	Net Revenues (in millions)	Net income(in million)
Bank of America Corporation	$ 68,888.00	$ 2,439,606.00	$ 402,945.00	$ 110,220.00	$ (2,238.00)
Barclays Group	£ 19,967.00	£ 1,490,038.00	£ 62,262.00	£ 32,204.00	£ 4,549.00
BMO Financial Group *	$ 7,590.00	$ 411,640.00	$ 21,683.00	$ 11,161.00	$ 2,810.00
BNP Paribas	€ 26,517.00	€ 1,998,158.00	€ 85,629.00	€ 43,880.00	€ 9,164.00
Citigroup Inc.	$ 47,375.00	$ 1,913,902.00	$ 165,789.00	$ 86,601.00	$ 10,602.00
Credit Suisse Group	fr. 23,978.00	fr. 1,032,005.00	fr. 43,015.00	fr. 31,386.00	fr. 5,920.00
Deutsche Bank	€ 23,318.00	€ 1,905,630.00	€ 50,368.00	€ 28,567.00	€ 2,330.00
The Goldman Sachs Group, Inc.	$ 26,269.00	$ 911,332.00	$ 77,356.00	$ 39,161.00	$ 8,354.00
HSBC Holdings PLC	$ 37,688.00	$ 2,454,689.00	$ 154,915.00	$ 80,014.00	$ 14,191.00
JPMorgan Chase & Co.	$ 61,196.00	$ 2,117,605.00	$ 176,106.00	$ 102,694.00	$ 17,370.00
Lazard Ltd	$ 1,661.72	$ 3,422.53	$ 796.12	$ 1,905.37	$ 194.42
Mizuho Bank Ltd	¥ 1,526,413.00	¥158,351,456.00	¥3,332,018.00	¥ 2,963,100.00	¥ 1,046,650.00
Morgan Stanley	$ 25,156.00	$ 807,698.00	$ 65,407.00	$ 31,622.00	$ 4,703.00
Nomura Holdings, Inc.	¥ 1,037,443.00	¥ 36,692,990.00	¥2,091,636.00	¥ 1,130,698.00	¥ 31,925.00
Royal Bank of Canada *	$ 13,469.00	$ 726,206.00	$ 38,951.00	$ 26,082.00	$ 5,223.00
Royal Bank of Scotland Group	£ 18,228.00	£ 1,453,576.00	£ 76,851.00	£ 31,868.00	-£ 1,666.00
The Bank of Nova Scotia	$ 8,182.00	$ 526,657.00	$ 28,157.00	$ 15,505.00	$ 4,339.00
Union Bank of Switzerland	fr. 24,539.00	fr. 1,317,247.00	fr. 51,863.00	fr. 31,994.00	fr. 7,838.00
Wells Fargo & Company	$ 50,456.00	$ 1,258,128.00	$ 127,889.00	$ 85,210.00	$ 12,663.00

Table 13. Input/Output for FY2009



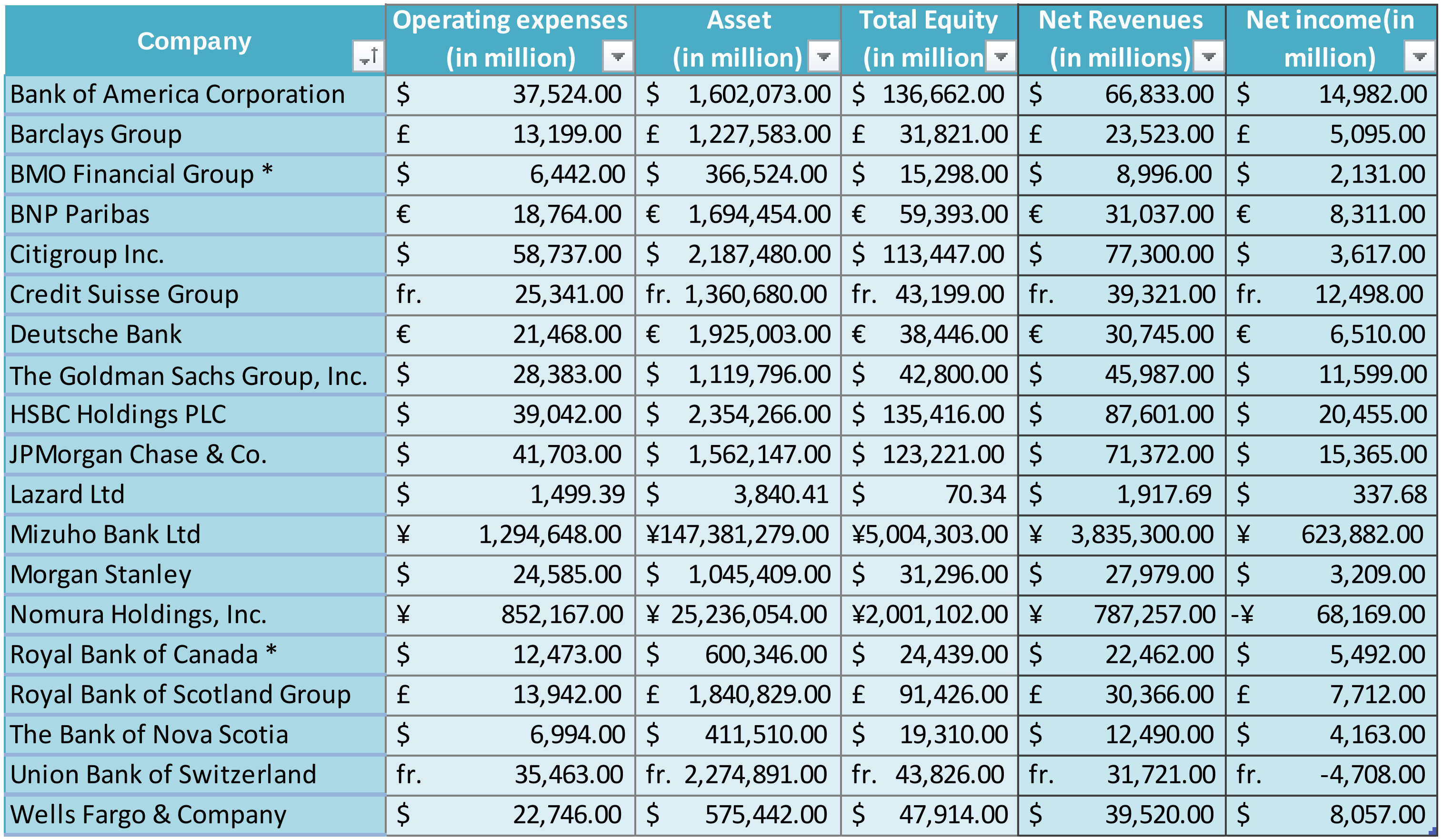
Company	Operating expenses (in million)	Asset (in million)	Total Equity (in million	Net Revenues (in millions)	Net income(in million)
Bank of America Corporation	$ 66,713.00	$ 2,443,068.00	$ 250,196.00	$ 119,643.00	$ 6,276.00
Barclays Group	£ 17,849.00	£ 1,378,929.00	£ 58,478.00	£ 29,954.00	£ 10,288.00
BMO Financial Group *	$ 7,381.00	$ 388,458.00	$ 20,197.00	$ 9,461.00	$ 1,787.00
BNP Paribas	€ 23,340.00	€ 2,057,698.00	€ 80,344.00	€ 40,191.00	€ 6,474.00
Citigroup Inc.	$ 47,822.00	$ 1,856,646.00	$ 154,973.00	$ 80,285.00	$ (1,606.00)
Credit Suisse Group	fr. 24,711.00	fr. 1,031,427.00	fr. 48,328.00	fr. 33,294.00	fr. 6,411.00
Deutsche Bank	€ 20,120.00	€ 1,500,664.00	€ 37,969.00	€ 27,952.00	€ 4,958.00
The Goldman Sachs Group, Inc.	$ 25,344.00	$ 848,942.00	$ 70,714.00	$ 45,173.00	$ 13,385.00
HSBC Holdings PLC	$ 34,395.00	$ 2,364,452.00	$ 135,661.00	$ 78,631.00	$ 6,694.00
JPMorgan Chase & Co.	$ 52,352.00	$ 2,031,989.00	$ 165,365.00	$ 100,434.00	$ 11,728.00
Lazard Ltd	$ 1,712.75	$ 3,147.76	$ 523.10	$ 1,530.52	$ (188.25)
Mizuho Bank Ltd	¥ 1,525,101.00	¥155,083,031.00	¥1,037,180.00	¥ 2,836,400.00	-¥ 1,058,447.00
Morgan Stanley	$ 22,150.00	$ 771,462.00	$ 52,780.00	$ 23,434.00	$ 1,346.00
Nomura Holdings, Inc.	¥ 1,045,575.00	¥ 32,230,428.00	¥2,133,014.00	¥ 1,150,822.00	¥ 68,086.00
Royal Bank of Canada *	$ 14,558.00	$ 654,989.00	$ 36,906.00	$ 29,106.00	$ 3,858.00
Royal Bank of Scotland Group	£ 21,478.00	£ 1,696,486.00	£ 94,631.00	£ 38,690.00	-£ 2,323.00
The Bank of Nova Scotia	$ 7,919.00	$ 496,516.00	$ 25,316.00	$ 14,457.00	$ 3,661.00
Union Bank of Switzerland	fr. 25,162.00	fr. 1,340,538.00	fr. 48,633.00	fr. 22,601.00	fr. -2,125.00
Wells Fargo & Company	$ 49,020.00	$ 1,243,646.00	$ 114,359.00	$ 88,686.00	$ 12,667.00

Table 14. Input/Output for FY2008



Company	Operating expenses (in million)	Asset (in million)	Total Equity (in million	Net Revenues (in millions)	Net income(in million)
Bank of America Corporation	$ 41,529.00	$ 1,843,985.00	$ 164,837.00	$ 72,782.00	$ 4,008.00
Barclays Group	£ 14,394.00	£ 2,053,029.00	£ 43,574.00	£ 21,436.00	£ 5,287.00
BMO Financial Group *	$ 6,894.00	$ 416,050.00	$ 17,904.00	$ 8,875.00	$ 1,978.00
BNP Paribas	€ 18,400.00	€ 2,075,551.00	€ 58,968.00	€ 27,376.00	€ 3,452.00
Citigroup Inc.	$ 69,240.00	$ 1,938,470.00	$ 141,630.00	$ 51,599.00	$ (27,684.00)
Credit Suisse Group	fr. 23,357.00	fr. 1,170,350.00	fr. 32,302.00	fr. 9,268.00	fr. -10,837.00
Deutsche Bank	€ 18,278.00	€ 2,202,423.00	€ 31,914.00	€ 13,490.00	€ (3,896.00)
The Goldman Sachs Group, Inc.	$ 19,886.00	$ 884,547.00	$ 64,369.00	$ 22,222.00	$ 2,322.00
HSBC Holdings PLC	$ 49,099.00	$ 2,527,465.00	$ 100,229.00	$ 88,571.00	$ 6,498.00
JPMorgan Chase & Co.	$ 43,500.00	$ 2,175,052.00	$ 166,884.00	$ 67,252.00	$ 5,605.00
Lazard Ltd	$ 1,532.07	$ 2,862.93	$ 311.75	$ 1,557.21	$ (0.24)
Mizuho Bank Ltd	¥ 1,450,653.00	¥151,317,756.00	¥3,568,157.00	¥ 4,205,200.00	¥ 228,618.00
Morgan Stanley	$ 22,452.00	$ 658,812.00	$ 50,831.00	$ 24,739.00	$ 1,707.00
Nomura Holdings, Inc.	¥ 1,092,892.00	¥ 24,837,848.00	¥1,551,546.00	¥ 312,627.00	-¥ 709,441.00
Royal Bank of Canada *	$ 12,351.00	$ 723,859.00	$ 30,638.00	$ 21,582.00	$ 4,555.00
Royal Bank of Scotland Group	£ 54,033.00	£ 2,401,652.00	£ 80,498.00	£ 25,868.00	-£ 34,542.00
The Bank of Nova Scotia	$ 7,296.00	$ 507,625.00	$ 22,125.00	$ 11,876.00	$ 3,259.00
Union Bank of Switzerland	fr. 28,555.00	fr. 2,014,815.00	fr. 40,533.00	fr. 796.00	fr. -20,724.00
Wells Fargo & Company	$ 22,598.00	$ 1,309,639.00	$ 102,316.00	$ 41,877.00	$ 2,698.00

Table 15. Input/Output for FY2007



Company	Operating expenses (in million)	Asset (in million)	Total Equity (in million	Net Revenues (in millions)	Net income(in million)
Bank of America Corporation	$ 37,524.00	$ 1,602,073.00	$ 136,662.00	$ 66,833.00	$ 14,982.00
Barclays Group	£ 13,199.00	£ 1,227,583.00	£ 31,821.00	£ 23,523.00	£ 5,095.00
BMO Financial Group *	$ 6,442.00	$ 366,524.00	$ 15,298.00	$ 8,996.00	$ 2,131.00
BNP Paribas	€ 18,764.00	€ 1,694,454.00	€ 59,393.00	€ 31,037.00	€ 8,311.00
Citigroup Inc.	$ 58,737.00	$ 2,187,480.00	$ 113,447.00	$ 77,300.00	$ 3,617.00
Credit Suisse Group	fr. 25,341.00	fr. 1,360,680.00	fr. 43,199.00	fr. 39,321.00	fr. 12,498.00
Deutsche Bank	€ 21,468.00	€ 1,925,003.00	€ 38,446.00	€ 30,745.00	€ 6,510.00
The Goldman Sachs Group, Inc.	$ 28,383.00	$ 1,119,796.00	$ 42,800.00	$ 45,987.00	$ 11,599.00
HSBC Holdings PLC	$ 39,042.00	$ 2,354,266.00	$ 135,416.00	$ 87,601.00	$ 20,455.00
JPMorgan Chase & Co.	$ 41,703.00	$ 1,562,147.00	$ 123,221.00	$ 71,372.00	$ 15,365.00
Lazard Ltd	$ 1,499.39	$ 3,840.41	$ 70.34	$ 1,917.69	$ 337.68
Mizuho Bank Ltd	¥ 1,294,648.00	¥147,381,279.00	¥5,004,303.00	¥ 3,835,300.00	¥ 623,882.00
Morgan Stanley	$ 24,585.00	$ 1,045,409.00	$ 31,296.00	$ 27,979.00	$ 3,209.00
Nomura Holdings, Inc.	¥ 852,167.00	¥ 25,236,054.00	¥2,001,102.00	¥ 787,257.00	-¥ 68,169.00
Royal Bank of Canada *	$ 12,473.00	$ 600,346.00	$ 24,439.00	$ 22,462.00	$ 5,492.00
Royal Bank of Scotland Group	£ 13,942.00	£ 1,840,829.00	£ 91,426.00	£ 30,366.00	£ 7,712.00
The Bank of Nova Scotia	$ 6,994.00	$ 411,510.00	$ 19,310.00	$ 12,490.00	$ 4,163.00
Union Bank of Switzerland	fr. 35,463.00	fr. 2,274,891.00	fr. 43,826.00	fr. 31,721.00	fr. -4,708.00
Wells Fargo & Company	$ 22,746.00	$ 575,442.00	$ 47,914.00	$ 39,520.00	$ 8,057.00

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