Organisational Sustainability Modelling for Return on Investment (ROI): Case Studies presented by a National Health Service (NHS) Trust UK

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Abstract – Organisational Sustainability Modelling is a new way to measure Cloud business performance quantitatively and accurately. It combines statistical computation and 3D Visualisation to present the Return on Investment arising from the adoption of Cloud Computing by organisations. The Cloud Return On Investment methodology described in this paper makes use of a highly structured and organised process to review and evaluate Cloud business performance. We illustrate its use with two case studies. The first case study concerns a National Health Service (NHS) Trust UK Infrastructure and confirms that using Cloud infrastructures can improve efficiency. It also results in raising benchmark, the minimum acceptance level to complete concurrent tasks. The second case study shows 3D Visualisation being used to confirm incremental improvements to an NHS Bioinformatics project. The low risk-free rate may imply code development allows reduced time to complete, and objective is clearly met and project delivery is straightforward. We introduce a structured Quality Assurance process, and demonstrate how to ensure the quality of our data analysis, which other researchers miss out.

Keyword: Cloud Computing; Cloud Computing Business Framework; Organisational Sustainability Modelling; 3D Visualisation; Cloud Challenges in Business context; Return of Investment (ROI); Quality Assurance for ROI and National Health Service (NHS) Trust UK Cloud case studies.

1. INTRODUCTION

Cloud Computing provides added value for organisations, which include saving costs in operations, resources and staff as well as new business opportunities for service-oriented models [2, 6, 7, 26, 27]. Cloud Computing focusing on operational savings and green technology has literature reviews to demonstrate its value on investment. Cost-saving offered by CC is a key benefit [3, 4, 16, 19, 26], potentially able to contribute to long-term sustainability which is an important success factor for organisations, particularly in economic downturn [5]. The definition and deployment of Return on Investment (ROI) varies in different sectors and research institutes. Our ROI measurement is a systematic and innovative methodology based on Nobel-prize models [25], including Capital Asset Pricing Models (CAPM); economic and statistical computation for data analysis, 3D visualisation to present cloud business performance and a new technique using Quality Assurance (QA) to improve the quality of data and research outputs. This leads to the development of Organisational Sustainability Modelling (OSM) for measuring cloud business performance. Data is defined and thoroughly measured, which is used by CAPM statistics and 3D Visualisation for analysis.

2. WORK COMPLETED

Literature review is presented as follows. Three challenges in business context and Software as a Service (SaaS) are explained. This paper is focused on the second issue, Organisational Sustainability, and demonstration how Organisational Sustainability Modelling (OSM) can be achieved.

2.1 Challenges in a business context

There are three Cloud Computing problems experienced in the current business context [9, 11]. Firstly, all cloud business models and frameworks proposed by several leading researchers are either qualitative [2, 14, 20, 26 28] or quantitative [3, 4, 17, 23]. Each framework is self-contained, and not related to other work. Apart from a few research, there are few whose frameworks or models can demonstrate linking both quantitative and qualitative aspects, and where they do, the work is still at early stage.

Secondly, there is no accurate method for analysing cloud business performance other than the stock market. A drawback with the stock market that it is subject to accuracy and reliability issues [7, 10]. There are researchers focusing on business model classifications and justifications for how cloud business can be successful [14, 28]. But these business model classifications need more cases to support and more data modelling to validate them for sustainability. Ideally, a structured framework is needed to review accurate cloud business performance and sustainability in systematic ways.

Thirdly, communications between different types of clouds from different vendors are often not easy to implement. Often work-arounds require writing additional layers of APIs, or an interface or portal to allow communications. This brings interesting research question such as portability; portability of some applications from desktop to cloud is challenging [1, 23]. Portability concerns moving enterprise applications and services.

2.2 Cloud Computing Model and Software as a Service (SaaS)

The term "Software as a Service" (SaaS) was first used by Saleforce.com in 1999 when they saw the vision of merging Web Services (WS) and Service Oriented Architecture (SOA). SaaS is a popular type of cloud service and provides added values on top of WS and SOA [2, 3, 17]. In addition, there are Infrastructure as a Service and Platform as a Service for Cloud Computing (CC) and Web Services. They can be defined as follows.

*   ***Infrastructure as a Service*** (IaaS) is divided into Compute Clouds and Resource Clouds. Compute Clouds provide users access to computational resources such as

CPUs, virtual machines and utilities. Resource Clouds contain managed and scalable resources as services to users – in other words, they provide enhanced virtualisation capabilities.

- *Platform as a Service* (PaaS): provides computational resources via a platform upon which applications and services can be developed and hosted. PaaS typically makes use of dedicated APIs to control the behaviour of a server hosting engine that executes and replicates the execution according to user requests (e.g., access rate).
- *Software as a Service* (SaaS), referred to as Service or Application Clouds, offer implementations of specific business functions and business processes that are provided with cloud capabilities. Therefore, they provide applications and/or services using a cloud infrastructure or platform, rather than providing cloud features themselves.

SaaS is the research interest for WS and CC, where there are papers to describe how SaaS is achieved for WS and CC. Firstly, Lu, Jackson and Berka [21] demonstrate how their applications can be used as a WS and as a SaaS in the Cloud. They also demonstrate their framework and their experiments to validate. Secondly, O'Reilly [22] presents his vision for Web 2.0 and explains how WS and Web 2.0 are SaaS.

3 THE CLOUD COMPUTING BUSINESS FRAMEWORK
To address the three challenges in business context earlier, the Cloud Computing Business Framework (CCBF) is proposed. CCBF aims to help organisations achieve good Cloud design, deployment and services. The core concept of CCBF is an improved version from Weinhardt's et al. Cloud Business Model Framework (CBMF) where they demonstrate how technical solutions and Business Models fit into their CBMF [28].

3.1 The CCVF Overview
The CCBF is proposed to deal with four research areas:
- Classification of business models to offer Cloud-adopting organisations right strategies and business cases.
- Offer a framework to review cloud business performance accurately.
- Deal with communications between desktops and clouds, and between different clouds offered by different vendors, which focus on enterprise portability.
- Provide linkage and relationship between different cloud research methodologies, and between IaaS, PaaS, SaaS and Business Models.

CCBF currently focuses on conceptual and then architectural frameworks and this allows a series of conceptual methodologies to apply and fit into Cloud Architecture and Business Models. Based on the summary in Section 2.1, our research questions can be summed up as: (i) Classification; (ii) Sustainability; (iii) Portability and (iv) Linkage. This paper focuses on the second research question, a framework to review and measure cloud business performance accurately. The term Organisational Sustainability is described as follows:
- Organisational Sustainability: This includes modelling to review and evaluate cloud business projects in the past and present, and enables forecasting for cloud businesses in the future. Organisational Sustainability Modelling is suitable for all IaaS, PaaS and SaaS.

3.2 Organisational sustainability and its two objectives
Organisational sustainability is defined as a collection of methodologies, business models and best practices to enable organisations establishing long-term business operations and funding [5]. For some business context, it refers to growth of user community, or profitability, or both. This paper focuses organisational sustainability for cloud organisations or any services adopting cloud computing. Pay-as-you-go models are commonly used, yet its drawback is that it deals with the operational level. A better approach is to define the problem in strategic ways with top-down approaches, and use the bottom-up approaches to validate. This includes all levels of IaaS, PaaS and SaaS. Organisational Sustainability has two objectives for the CCBF for all levels of IaaS, PaaS and SaaS:
- It is a framework to model the organisational sustainability of IT services or projects provided by collaborating organisations;
- It defines a new mode of visualisation which enables organisational sustainability of the provision of a service to be reviewed more easily.

Two case studies are presented in Section 4.1 and 4.2 which fall into SaaS.

3.3 Organisational Sustainability Modelling
Organisational Sustainability Modelling (OSM) is mentioned in Section 1 and is a method to validate the CCBF. SM is based on the extended Capital Asset Pricing Model (CAPM), which is the analysis of return and risks for organisations or projects. It has two major advantages. Firstly, it is based on a Nobel-prize winning model and has been used in industry since 1960s. Secondly, it is suitable for IT and software industry as it has less volatility compared to finance and has fitted several case studies well [7]. Its one drawback is that organisational metrics and/or detailed interviews are required. Some firms find it difficult to quantify risk or risk free rate. For cost-saving, it refers to the minimum costs to run a firm.

Measurement of return and risk can be a difficult and huge task without prior focus. The proposed approach is to divide return and risk in three areas: Technical, Costs (Financial) and Users (or clients) before and after deploying cloud solutions or products/services. In some context, it can be defined as expected return and actual return. The data to be collected are dependent on organisational focus, which is flexible dependent on different characteristics for any type of technical or business cloud solutions.
- Technical: This can be improvements in performance, or improvement in reliability, or any added values or technical gains supported by experiments. This type of data is easier to obtain as experiments can be performed by researcher or collaborators. Risks can be time reduction or percentage of break down or relevant technical risks.
- Costs (Financial): This can be profits, or cost-saving gains, or any fund related. Risks can be loss, or sharp rise in operational or electricity costs.
- Users (or clients): This may mean increases in user confidence, or user community growth or user related area. Risks include reductions in user confidence or numbers or community growth due to factors such as funding, or quality of software, etc.

3.3.1 Capital Asset Pricing Model (CAPM) for organisations and Modern Portfolio Theory (MPT) for start-ups

Publications on organisational sustainability focus on qualitative approaches such as business model classifications and its respective methods and strategies for reaching sustainability [5]. There are not many quantitative modelling approaches for this topic. We review mathematical models and selectively study Monte Carlo, ARIMA, Black Scholes and CAPM, the later of which is the most appropriate for quantitative organisational sustainability [8]. There are two main reasons. Firstly, CAPM is suitable in predicting the firms' growth and organisational sustainability if data is defined and given. Secondly, there is more freedom to define the organisational focus, which can be translated as data, and then used for modelling. Some mathematical models are stringent with rules with conditions applied, which is not subjective in CAPM. Furthermore, CAPM is the most effective for linear regression modelling. Linear regression has been used for Organisational Sustainability Modelling [7, 9, 11].

Modern Portfolio Theory (MPT) is a theory of investment aiming to maximise return and minimise risk by carefully selecting different assets. MPT models an asset's return as a normally distributed random variable, defines risk as the standard deviation of return, and models a portfolio as a weighted combination of assets [18]. Despite criticisms about MPT's suitability for finance, the concept of MPT is relevant to organisational sustainability, particularly for start-ups. This is because software organisation is less volatile than the finance industry where more complex models are required and if organisations follow the linear regression, MPT offers an easier way for calculation, for tracking organisational growth in particular.

3.3.2 Capital Asset Pricing Model (CAPM)

The Capital Asset Pricing Model (CAPM) is a model to calculate investment risks and to determine what the expected return on investment is. In the context of cloud computing, it is a quantitative model for organisational sustainability. CAPM was introduced by Jack Treynor in 1961, William Sharpe in 1964, John Lintner in 1965 and Jan Mossin in 1966, based on Harry Markowitz' work on diversification and modern portfolio theory. CAPM divides risk into two groups. The first group is Systematic Risk (also known as beta), the market of which cannot be diversified away, including recessions and interest rates. The second group is unsystematic risk, the risk of which is specific to individual stocks and can be diversified and managed by investors (Hull, 2009). In CAPM, beta is the only relevant measure of a stock's risk and measures a stock's volatility.

In some interpretations, the security market line (SML) is used to calculate the reward-to-risk ratio. When the expected rate of return for any security is deflated by its beta coefficient, the reward-to-risk ratio for any individual security in the market is equal to the market reward-to-risk ratio, thus:

$$(r - r_f)/\beta = \ r_m - r_f \ (1)$$

$$(r - r_f) = \beta \ (r_m - r_f) \ \text{[the security market line (SML)]}.$$

Finally, to best represent CAPM, the formula is given as:

$$r = r_f + (\ \beta \times (r_m - r_f)) \ (2)$$

where r is the expected return of a capital asset

r_f is the risk free rate
r_m is the expected return on the market and
β is the beta of the cash flows or security being valued.

The term $r_m - r_f$ is the market risk premium, which is usually considered implicitly rather than explicitly. Therefore, the term $\beta \times (r_m - r_f)$ is the risk premium on the cash flows (or security) being valued.

CAPM example: If the risk-free rate is 1.5%, the beta (risk measure) of the firm is 2 and the expected market return over the period is 4%, the stock is expected to return (1.5%+2(4%-1.5%)) = 6.5%.

Prechter and Parker [24] designed their own measurement technique called the Finance/Economic Dichotomy originally based on the CAPM. They demonstrate that CAPM works for financial modelling and business performance review. Chang, Wills and De Roure [7, 9] demonstrate that CAPM can be used to measure business performance for cloud-oriented organisations, and explain how CAPM works in their case studies. However, a drawback is that CAPM tends to compute in terms of linear graphs or regression. In some cases, business performance need not be in a straight line. To offset this, organisational data must be required before performing organisational sustainability modelling to minimise errors. This can be a difficult task for some organisations due to their reluctance. Some models such as Monte Carlo Methods (MCM) and Black Scholes Model (BSM) do not require organisational data but those models are not suitable to measure cloud business performance [10].

3.3.3 The 3D organisational sustainability modelling and other systems

The CAPM organisational sustainability modelling is represented by statistical computation. Despite more data can be analysed, a drawback with statistical computing is that more data CAPM statistical computation will then convert into the 3D visualisation enabled by Mathematica. While referring back to the market standard for business performance, the stock market is widely accepted and presented business performance in 2D format. Despite stock market is an indication for business performance, it is not a fair system as stock markets are subjective to speculations and a great extent of fluctuations in particular to volatile and uncertain economic periods [24]. On the other hand, Service Level Agreements (SLA) are often used to present cloud business performance. A drawback is that SLA tends to review cloud business at operational level in terms of usage per hour [3, 4], which lacks of strategic directions for achieving cloud sustainability. This means SLA approach permits calculation of a periodic income over time from usage scenarios, however, if the business models are not proposed and executed according to the winning strategy, income over time can be low or below investors' expectations.

To present cloud business performance best, a graphical and dynamic system independent of human-oriented speculations is ideal, and this also provides the best correlation between the organisational focus, strategies and data related to each organisation's cloud computing business models. Our 3D visualisation within the SM is a proposal for measuring the cloud business performance.

4. CASE STUDIES

Case Studies are commonly used to support research frameworks, and provide added values for research challenges, including

business models and organisational sustainability. Here are three examples. Firstly, Chang, Mills and Newhouse [5] propose open source business models and organisational sustainability, and classify five different categories of successful models. Each category has a number of case studies to validate and support it. Chang, Wills and De Roure [7] have proposed the Hexagon Model and explain how case studies work for the model. In addition, they introduce the CAPM theory and statistical computation, and use the OMII-UK to demonstrate a good example for Organisational Sustainability Modelling (SM). They also convert their statistics into 3D visualisation, allowing researchers to review cloud business performance with ease. The OMII-UK case study is used for the Hexagon Model to analyse the growth between 2007 and 2010. Thirdly, Chen et al. [13] have published a JISC cloud computing report, and have explained case studies for several sections of their report to support their analysis and rationale. Three detailed case studies are presented in this paper. The first two case studies are from a participating National Health Service (NHS) Trust UK, and are summed up as below.

- NHS Infrastructure, focusing on efficiency
- NHS Bioinformatics, focusing on time reduction

4.1 Case Study: A National Health Service (NHS) Trust UK Infrastructure

A London-based National Health Service (NHS) Trust and a London-based University have worked together in various medicine, healthcare cloud and cloud-related projects. Due to compliance to both organisations' requests, details for neither institution can be revealed, but the data and analysis can be presented. Both institutes have used our recommended business models and cloud implementations starting from August 2008.

Research methodologies mainly include action research, which include quantitative methods (infrastructure set-ups, experiments, modelling and simulations) and qualitative methods (including surveys and interviews). Action research is the best way to obtain research data for this case study because it uses both qualitative and quantitative methods that provide well-balanced outcomes containing the best sides from each method. Also the lead researcher has been actively involved in the design, development, test and usability in the cloud development and business model and thus can provide reliable data.

4.1.1 CAPM Statistics for a NHS Infrastructure

The NHS Infrastructure is focused on technical implementation and has undergone two phases: (i) design and implementation of Cloud infrastructure and (ii) upgrade form IaaS to PaaS. The NHS Infrastructure was started from September 2008 and the upgrade was fully completed in July 2010. Referring to Section 3.3, this case study is a technical area, and focused on added values in efficiency - how much more amount of work, or jobs, can be done in the same period of time prior to introduction of using Cloud infrastructure. Clouds can be used as a platform of automation to complete concurrent tasks. Similarly, they provide added value in storage, backup, database engine and a high performance calculation.

Metrics were obtained in the following ways: log files from systems, or data provided by systems and/or careful measurement of each technical project and delivery. Data is carefully examined and calculated. Up to twenty two months of data can be statistically computed to present organisational sustainability

from the initial phase to production and support phase for this case study. The coding algorithm is as follows:

```
data nhs;
input r_m r_f nhs @@;
r_nhs = nhs - r_f;
r_mkt = r_m -r_f;
label r_m='Market Rate of Return'
     r_f='Risk-Free Rate of Return'
 nhs='Rate of Return for NHS Infrastructure'
 r_nhs='Risk Premium for NHS Infrastructure'
 r_mkt='Risk Premium for Market';
datalines;

proc gplot data=nhs;
  plot r_nhs * r_mkt / haxis=axis1 hminor=4
cframe=ligr
        vaxis=axis2 vminor=4;
  symbol1 c=blue v=star;
  axis1 order=(1 to 4.5 by 0.25);
  axis2 label=(angle=90 'NHS Infrastructure
Risk Premium')
        order=(-1 to 3 by 0.25);
  title 'NHS Infrastructure CAPM';
  title2'Plot of Risk Premiums';
  title3'NHS Infrastructure versus the
Market';
run;
```

The research interest is to compute and identify differences between expected and actual values, and compute any area worthy of study. In this case, Market is referred as Expected values. The risk-free rate is the minimum time required and minimum amount of work that automation platform can complete. Risk premium is the difference between the expected value and risk-free rate. An exception can be made if risk-free rate fluctuates greatly [11]. However, risk-free rate is reliable and stable supported and verified from system metrics, thus risk premium is defined as the difference between expected value and risk-free rate. Auto regression can be used to compute organisational sustainability modelling in statistical formats. Table 1 summarises the results.

NHS Infrastructure CAPM		The AUTOREG Procedure			
Dependent Variable	r_nhs	Risk Premium for NHS			
	Ordinary Least Squares Estimates				
SSE	21.3675544	DFE		107	
MSE	0.19970	Root MSE		0.44687	
SBC	141.098602	AIC		135.715906	
Regress R-Square	0.1333	Total R-Square		0.1333	
Durbin-Watson	1.2259	Pr < DW		<.0001	
	Pr > DW		1.0000		
		Standard		Approx	
Variable DF Estimate		Error	t Value	Pr > |t|	Variable Label
Intercept 1	-0.1912	0.3277	-0.58	0.5609	
r_mkt 1	0.4509	0.1111	4.06	<.0001	Risk Premium for Market
		Mean			
Source	DF	Square	F Value	Pr > F	
Numerator	1	4.875916	24.42	<.0001	
Denominator	107	0.199697			
Note SSE: Sum of Squares Error; DFE: Degree of Freedom Error; MSE (Mean Square Error) = SSE / DFE					

Table 1: Auto regression summary for participating NHS Infrastructure

Ordinary Least Squares is a method for estimating parameters in a linear regression model, and it minimises the sum of squared vertical distances between the observed responses in the dataset, and the responses predicted by the approximation such as CAPM [18]. The lower the Mean Square Error, the more accurate the regression result is. In addition, Durbin-Watson is a test commonly used in statistics. Pr > DW is the p-value for testing negative auto-correlation, and Pr < DW is the p-value for testing positive auto-correlation.

4.1.2 The NHS Infrastructure Performance Forecast

Apart from organisational sustainability modelling, forecasting is an important way to predict how a cloud business or project can perform based on the existing data provided. This is similar to financial analysis where forecasting is based on previous data, except that the software market is less volatile than other financial markets. Forecasting is part of the CCBF to help organisations predict their likely business performance [8] and works extremely well in parallel with organisational sustainability modelling. A key variable 'nhsout' is defined and obtained, followed by defining four variables, r_nhs, p (predicted), l (lower limit) and u (upper limit), whose values are recorded in an array, and later on used for forecasting. To present this idea further, the next step is to present both actual and predicted values for NHS infrastructure, with its upper and lower limit.

```
proc sort data=nhsout;
  by r_mkt;
run;

data regdata(keep=y_value pt_type r_mkt);
  set nhsout;
  label pt_type='Observation Type';
  array regvar{4} r_nhs p l u;
  array varlabel{4} $12 _temporary_
    ('Actual' 'Predicted' 'Lower Limits'
'Upper Limits');
  do i=1 to 4;
    y_value=regvar{i};
    pt_type=varlabel{i};
    output;
  end;
run;

proc gplot data=regdata;
  plot y_value*r_mkt=pt_type / haxis=axis1
hminor=4 cframe=ligr
                vaxis=axis2 vminor=4;
  symbol1 c=black v=star;
  symbol2 c=blue i=join l=2;
  symbol3 c=green i=join l=1;
  symbol4 c=red i=join l=2;
  axis1 order=(1 to 4.5 by .25);
  axis2 label=(angle=90 'NHS Infrastructure
Risk Premium')
        order=(-1 to 3 by .25);
  title1 "NHS Infrastructure: Actual and
Predicted Values";
  title2 "with Upper and Lower Confidence
Limits";
run;
```

Another procedure is written to plot actual and predicted values - see Figure 1 that has Risk Premium for NHS Infrastructure versus Risk Premium for market. The plotted data are actual values based on our data. The green line at the middle is the predicted value, the red line as the upper limit and the blue dotted line as the lower limit. The y-axis represents the NHS Infrastructure Risk premium, and the x-axis represents the Risk Premium for Market (expected values). All the risk premium estimates in y-axis are between -0.60% and 2.60%, which are considered relatively acceptable. The green line is the most likely prediction, which ranges from 0.5% to 1.45%. The low positive values do not imply they are bad results, and a strong possibility is that the benchmark is high. It means the minimum amount of task and time required by Cloud automation presents high value, resulting in lower risk premium.
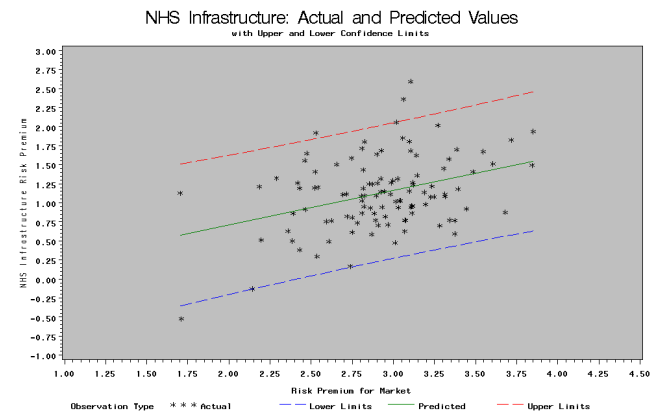

Figure 1: NHS Infrastructure Risk Premium: Actual and Predicted values

4.1.3 The 3D Visualisation for NHS Infrastructure

Organisational Sustainability models are presented in terms of statistical analysis in Table 3 and this needs statistical backgrounds to interpret. 3D Visualisation simplifies such requirement, so that those without backgrounds can understand it much better. A number of selected data computed in Section 4.1.2 is used by Mathematica, which allows data conversion and presents it in visual format. Data is then computed in Mathematica and the 3D visualisation models are presented in Figure 2 and 3 respectively, where Figure 3 is the 90 degree rotation of Figure 2. Both figures have less volatile movements than OMII-UK data in our published paper [7], but have more volatile movements than SAP for small and medium enterprises discussed in another paper [11].

x-axis: the return of NHS Infrastructure (6% - 7.2%)
y-axis: risk premium for the market (4.3% - 6%)
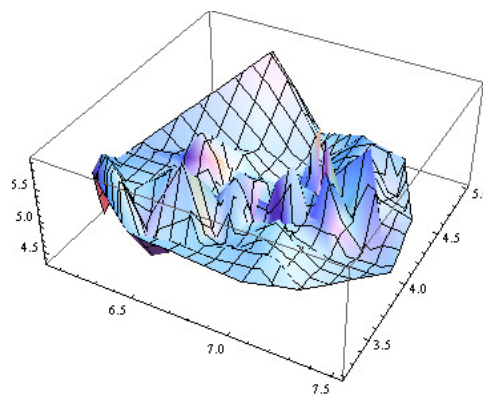z-axis: risk-free rate of the market (3% - 5%)

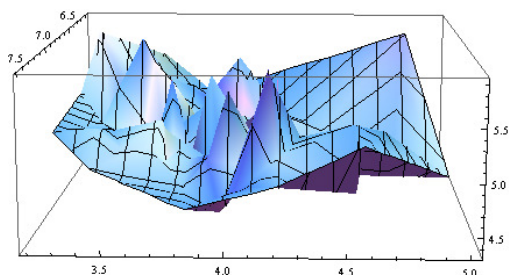Figure 2: 3D organisational sustainability modelling for NHS Infrastructure

Figure 3: 3D organisational sustainability modelling for NHS Infrastructure, with 90 degrees rotation.

The volatility in Figure 2 and 3 also correlate to the cloud project management, where more problems were experienced in the middle period of project development and required more resources, collaboration, technical expertise and funding to sort out. In this case, 3D Visualisation not only presents simplified analysis than statistical outcomes, but volatility also corresponds to tougher problems encountered in project development. Referring to Figure 2, x-axis shows the return of NHS Infrastructure, and y-axis is the risk premium for the market and z-axis shows the risk-free rate of the market.

3D Visualisation can provide a summary about project progress. The NHS Infrastructure project has experienced several periods of ups and downs, and has encountered technical, organisational and policy problems. Most of these issues have been resolved. The 3D Visualisation presents the return of NHS Infrastructure is between 6 and 7.5%, and the risk-premium of the market is between 4.3 and 6%, and the risk-free rate is between 3 and 5 %. This also confirms the risk-free rate is close to the expected values (market), and thus the sum of its difference is in low value. This case study suggests using Cloud infrastructure has raised the benchmark. In this way, efficiency has improved for various technical tasks. However, more data will be required to further support this.

4.2. Case Study: A National Health Service (NHS) Trust UK Bioinformatics

This is another NHS case study focusing on Bioinformatics, where the development started in September 2008. There are two active projects in Bioinformatics. The first one is Inforsense workflow, which allows scientists to work either independently or collaboratively with others, and is not the focus in this paper. The second project is a Bioinformatics PaaS for developers, which is platform to simulate dynamic 3D modelling and visualisation for proteins, genes, molecules and genomes, which are written by Visual C++, Mathematica and R.

4.2.1 CAPM Statistics for a NHS Bioinformatics

This project started in July 2009, and data is taken up to November 2010 since this project is still ongoing. The technical focus for Bioinformatics is the agility, or time reduction in terms of producing 3D bioinformatics simulations prior and after using Cloud approach. The data is taken jointly and thoroughly by (i) system metrics collection and (ii) careful measurement in each of 3D development and project delivery. Data is carefully examined and calculated. Up to sixteen months of data is can best represent organisational sustainability from the initial phase to

establishment for this case study. The coding algorithm is explained as follows:

```
data nhs2;
  input r_m r_f nhs2 @@;
  r_nhs2 = nhs2 - r_f;
  r_mkt = r_m -r_f;
  label r_m='Market Rate of Return'
        r_f='Risk-Free Rate of Return'
        nhs2='Rate of Return for NHS
Bioinformatics'
        r_nhs2='Risk Premium for NHS
Bioinformatics'
        r_mkt='Risk Premium for Market';
datalines;

proc gplot data=nhs2;
  plot r_nhs2 * r_mkt / haxis=axis1 hminor=4
cframe=ligr
        vaxis=axis2 vminor=4;
  symbol1 c=blue v=star;
  axis1 order=(0 to 4 by 0.25);
  axis2 label=(angle=90 'NHS Bioinformatics
Risk Premium')
        order=(-1 to 3 by 0.25);
  title 'NHS Bioinformatics CAPM';
  title2'Plot of Risk Premiums';
  title3'NHS Bioinformatics versus the
Market';
run;
```

Similar to Section 4.1.1, Market is referred as Expected values, and risk-free rate in this case study is stable and reliable. The risk-free rate is the minimum time required to complete 3D Visualisation. The risk premium is the difference between the expected values and risk-free rate. Table 2 shows the summary of auto regression with Ordinary Least Squares used. The lower the Mean Square Error, the more accurate the regression result is. In addition, Durbin-Watson is a test commonly used in statistics. Pr > DW is the p-value for testing negative auto-correlation, and Pr < DW is the p-value for testing positive auto-correlation.

NHS Bioinformatics CAPM		The AUTOREG Procedure	
Dependent Variable	r_nhs2	Risk Premium for NHS	
	Ordinary Least Squares Estimates		
SSE	19.3484214	DFE	107
MSE	0.18083	Root MSE	0.42524
SBC	130.278958	AIC	124.896262
Regress R-Square	0.2793	Total R-Square	0.2793
Durbin-Watson	1.5564	Pr < DW	0.0076
Pr > DW	0.9924		

Variable	DF	Estimate	Standard Error	t Value	Approx Pr > |t|	Variable Label
Intercept	1	0.0752	0.1277	0.59	0.5571	
r_mkt	1	0.3340	0.0519	6.44	<.0001	Risk Premium for Market

Source	DF	Mean Square	F Value	Pr > F
Numerator	1	29.807799	164.84	<.0001
Denominator	107	0.180826		

Note SSE: Sum of Squares Error; DFE: Degree of Freedom Error; MSE (Mean Square Error) = SSE / DFE

Table 2: Auto regression summary for NHS Bioinformatics

4.2.2 The NHS Bioinformatics Performance Forecast

Similar to Section 4.1.2, forecasting is an important aspect to predict how a cloud business or project can perform in the near future, and this is helpful to determine the Bioinformatics project performance based on the existing data provided. A key variable 'nhs2out' is defined and obtained, followed by defining four variables, r_nhs2, p (predicted), l (lower limit) and u (upper limit), whose values are recorded in an array, and later used for forecasting. To present this idea further, the next step is to present both actual and predicted values for NHS Bioinformatics, with its upper and lower limit.

```
proc sort data=nhs2out;
  by r_mkt;
run;

data regdata(keep=y_value pt_type r_mkt);
  set nhs2out;
  label pt_type='Observation Type';
  array regvar{4} r_nhs2 p l u;
  array varlabel{4} $12 _temporary_
    ('Actual' 'Predicted' 'Lower Limits'
'Upper Limits');
  do i=1 to 4;
    y_value=regvar{i};
    pt_type=varlabel{i};
    output;
  end;
run;

proc gplot data=regdata;
  plot y_value*r_mkt=pt_type / haxis=axis1
hminor=4 cframe=ligr
        vaxis=axis2 vminor=4;
  symbol1 c=black v=star;
  symbol2 c=blue i=join l=2;
  symbol3 c=green i=join l=1;
  symbol4 c=red i=join l=2;
  axis1 order=(0 to 4 by .25);
  axis2 label=(angle=90 'NHS Bioinformatics
Risk Premium')
        order=(-1 to 3 by .25);
  title1 "NHS Bioinformatics: Actual and
Predicted Values";
  title2 "with Upper and Lower Confidence
Limits";
run;
```

Figure 4 shows NHS Bioinformatics Risk Premium. The y-axis represents the NHS Infrastructure Risk premium, and the x-axis represents the Risk Premium for Market (expected values).
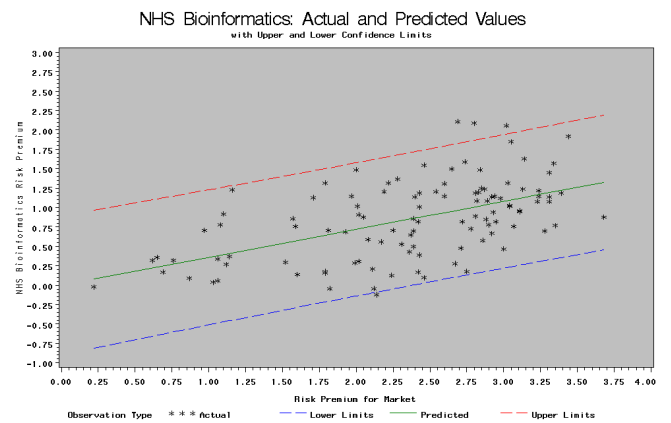

Figure 4: NHS Bioinformatics Actual and Predicted values for Risk Premium

The plotted points are actual values based on our data, the green line at the middle is the predicted value, the red line as the upper limit and the blue dotted line is the lower limit. All the risk premium estimates in y-axis are between -0.30% and 2.30%, which are relatively acceptable. The green line is the most likely prediction, which ranges from 0.1% to 1.30%. Similar to Section 4.1.2, it may suggest the benchmark is high.

4.2.3 The 3D Visualisation for NHS Bioinformatics

3D Visualisation is used to present the NHS Bioinformatics project performance. Selected data computed in Section 4.2.2 is used by Mathematica, which allows data conversion and presents it in visual format. Data is then computed in Mathematica and the 3D visualisation models are presented in Figure 5 and 6 respectively, where Figure 6 is a detailed review of Figure 5. The x-axis is the return of NHS Bioinformatics, and is between 1.2% and 7.2%. The y-axis is the risk premium for the market, and is between 0.2% and 4%. The axis is the risk-free rate of the market, and is between 0.1% and 4.8%.

x-axis: the return of NHS Bioinformatics (1.2% - 7.2%)
y-axis: risk premium for the market (0.2% - 4%)
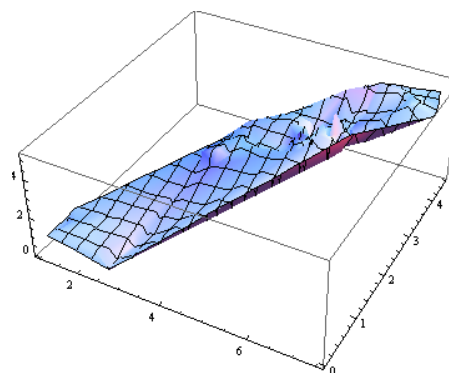z-axis: risk-free rate of the market (0.1% - 4.8%)

Figure 5: 3D organisational sustainability modelling for NHS Bioinformatics
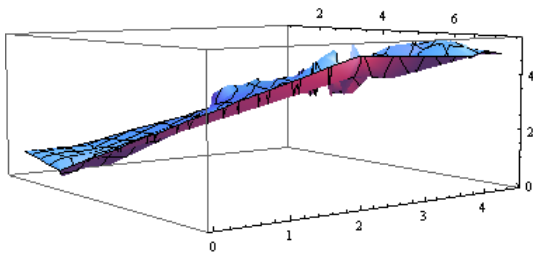
Figure 6: 3D organisational sustainability modelling for NHS Bioinformatics (from a different angle)

Unlike the analysis in Section 4.1.3, Figures 5 and 6 indicate that the NHS Bioinformatics project has always been progressive and heading upwards, despite the percentage of the return not being as high as NHS Infrastructure. Explanations are likely due to three reasons. Firstly, 3D Bioinformatics itself is a challenging topic, and often more time and resources are required to make a vast improvement. The incremental improvement already suggests good progress has made. Secondly, the extreme low risk-free rate may suggest the use of Mathematica and R language make development more agile, which means short lines of codes can produce 3D modelling in this case. Thirdly, the project performance keeps near the centre, which means there are less deviations and may suggest objective is clearly met and project delivery is straightforward. Apart from this, benchmark is great as the risk premium for the market can be as low as 0.2%, where the lower the value, the better time reduction is. It may also mean the higher the risk premium, the higher the return. However, more data will be required to further consolidate these hypotheses.

5 DISCUSSIONS

Two case studies have been presented to demonstrate cloud project and business performance via Organisational Sustainability Modelling, which presents the CAPM statistics and 3D Visualisation. The NHS Infrastructure case study shows that its actual return is between 6% and 7.2%, and the risk premium for the market is between 4.3% and 6%, and the risk-free rate of the market is between 3% and 5%. The analysis confirms that the Cloud Computing infrastructure provides an efficiency improvement and it also results in raising the benchmark, the minimum acceptance level to complete concurrent tasks such as automation, storage, backup and high performance calculations.

The NHS Bioinformatics case study shows that its actual return is between 1.2% and 7.2%, the risk-free rate of the market is 0.2% and 4%, and the risk-free rate of the market is between 0.1% and 4.8%. 3D Visualisation confirms the NHS Bioinformatics project has been progressive with incremental improvements. The low risk-free rate may imply the use of Mathematica and R language makes code development very agile. Furthermore, 3D Visualisation suggests there is less deviation in the project, which may mean objective is clearly met. Benchmark is considered excellent since it allows agile development in 3D modelling in some aspects. In addition, estimated and actual plots in Figure 1 and 4, are all within 95% confidence level.

The NHS Cost-Saving and User data are still in the progress of data collection and preliminary analysis. Once further details are obtained, analysis and discussions will be presented. In addition to these two case studies presented, there are several topics worth for further discussions, and they are described as follows.

5.1 Added values offered by Quality Assurance (QA)

Data quality is an important aspect because it checks for data structure and consistency, and rectifies any errors, thus quality of data is improved on ongoing basis. It also ensures statistical analysis, whether in computational or visualisation format, is at a high quality of research output. Performing Quality Assurance (QA) can be a costly business, as it often needs structured methodology, system design and administration skills and automated tools to perform. Without having automated tools, writing and improving code for a single test is an acceptable method, but this is not ideal to run an increasing number of test cases, as this will take longer time to complete, and less time to focus on research output.

QA process must be improved and made as efficient as possible. This means time reduction to deliver the same level of services using a tool, and/or automation. This is how STATA fits in. Although STATA offers numerous ways for desktop statistical computing that users without much experience can perform statistics, it is not recommended for the accurate and in-depth analysis to be performed for CAPM statistics as this is prone to errors. However, STATA is includes many testing algorithms and data diagnoses, including verifying what has been computed to improve the standard of QA [15]. Hence, STATA is chosen as a QA tool to execute several tests and to verify statistical accuracy, which saves time in writing a growing number of QA codes. A number of statistical tests and diagnosis is performed, including the following well-known tests:

1. Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
2. Cameron and Trivedi's decomposition of Information Matrix-test
3. Variance inflation factors for the independent variables
4. Durbin-Watson d statics (shown in Table 1, 2 and 3)
5. Information criteria
6. Covariance matrix estimate
7. Skewness/Kurtosis tests for Normality

However, not all the tests are required. For this paper, Durbin-Watson tests are presented in Table 1, 2 and 3, and at least an additional in-depth test from STATA is required. Skewness/Kurtosis tests for Normality are chosen as it investigates the fundamental quality and accuracy of the data, and can be used to inspect quality of the 3D Visualisation [12].

NHS Infrastructure Skewness/Kurtosis tests for Normality				
Variable | Obs	Pr(Skewness)	Pr(Kurtosis)	adj chi2(2)	Prob>chi2
x-axis | 109	0.0432	0.9277	4.20	0.1223
y-axis | 109	0.0728	0.0602	6.35	0.0418
z-axis | 109	0.0054	0.2865	7.97	0.0186
NHS Bioinformatics: Skewness/Kurtosis tests for Normality				
Variable | Obs	Pr (Skewness)	Pr(Kurtosis)	adj chi2(2)	Prob>chi2
x-axis | 113	0.0002	0.4468	12.01	0.0025
y-axis | 113	0.0000	0.0834	16.35	0.0003
z-axis | 113	0.0000	0.0919	19.59	0.0001

Table 3: Skewness/Kurtosis tests for Normality tests for NHS Infrastructure and NHS Bioinformatics.

Definitions for related terms are explained as follows. Skewness is a measure of the asymmetry of the probability distribution of a real-valued random variable. Kurtosis is a

measure of the "peaked behaviour" of the probability distribution of a real-valued random variable. In this case, Chi-square is the sum of Skewness and Kurtosis and Chi-squared tests are used in tests of goodness of fit.

The Skewness/Kurtosis test in Table 3 is the detailed QA for the 3D visualisation. The smaller the values for Skewness, Kurtosis, and the difference between chi-square distribution and likely probability (known as Prob>chi2), the more accurate the 3D data presents. This test is to check difference between theoretical and our computational results. The x-, y- and z-axis in 3D Visualisation of all three case studies correspond to the x-, y- and z-axis in their respective test in Table 4. This ensures the QA of 3D Visualisation is at a high level of quality. In this respect, it also meets the objective of our second research question – to measure cloud business performance with accuracy.

5.2 The Hexagon Model for the NHS
The Hexagon Model is used to present strengths and weaknesses of any cloud projects, and is highly relevant to demonstrate current status for the NHS [7, 9]. Figure 9 to the participating NHS's Hexagon model in August 2008, which has more scores for innovation and GTJD. This Hexagon model is supporting CAPM statistics, which computes an auto regression suggesting slow but steady growth in NHS Bioinformatics. In addition, 3D Visualisation suggests volatility experienced in the middle period of their project development for NHS Infrastructure. Figure 10 shows this participating NHS's Hexagon Model in October 2010, which is supported by data obtained in action research, where the growth is seen at: (1) consumers; (2) popularity (mild increase); and (3) investors. Growth in consumers is due to the collaborative nature of the participating NHS and its partner University that researchers (who are users) have been actively involved and supportive to the project development. Popularity increases modestly because some operational staff and researchers still hardly or do not use cloud-related services. The strategy is to implement another sophisticated private cloud that integrates operational and research activities together, which will take a few more years. Growth is incurred for investors, as they have supported financially and get funding approved.
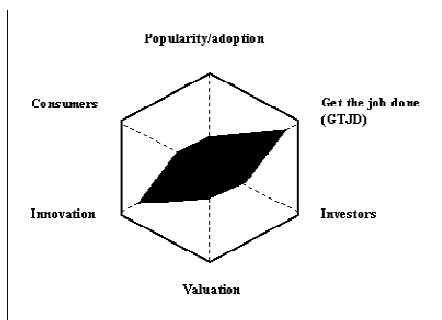

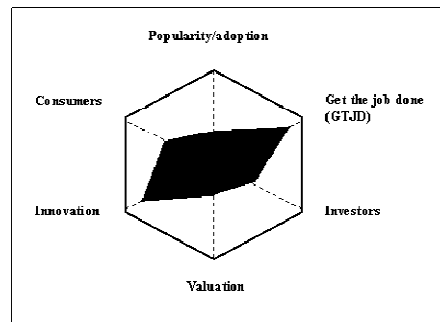Figure 9: The Hexagon Model of NHS, in August 2008

Figure 10: The Hexagon Model of NHS in October 2010

5.3 Added values offered by 3D Visualisation
Our 3D Visualisation can present cloud business performance for any projects and organisations, and this simplifies analysis, since strengths and weaknesses can be identified easily. 3D visualisation figures are dynamic, which means it can be rotated 360 degrees, so any drawbacks or any 'glitch' which happened in the businesses, can be reviewed in greater detail. This includes the hike and trough in the 3D figure that should be more aware of. We have 3D Visualisation for SAP, Vodafone, NHS UK and a few more organisations to provide added values.

5.4 A good process for Organisational Sustainability Modelling
Organisational Sustainability Modelling involves with structured process and the suitable use of models in each process. This can be described as follows. The first step involves working with collaborators defining what is to be measured, and to assist them to extract and further analyse the data required. The second step of SM involves the use of modelling. The CAPM statistics with SAS programming described in Section 4 and 5 is a commonly used technique for statistical computing. Durbin-Watson tests are used to ensure the quality of analysis. In addition, if a project or a business is a start-up, then the use of the Modern Portfolio Theory and R language with the CAPM statistics can be jointly used to determine the status of SM, where the use of OMII-UK case study is demonstrated [7]. The third step is for 3D Visualisation, and this involves the followings: (i) review all the data generated by SAS, and determine what need to be further analyzed; (ii) if we are uncertain what needs to be further analyzed, then use STATA for testing regression to double check; (iii) determine what need to be further analysed, and then make them into a format readable by Mathematica; (iv) use Mathematica to compute dynamic 3D Visualisation and finally (iv) use STATA to double check the validity of 3D Visualisation. This process is highly structured and organized to ensure our 3D Visualisation and analysis is of the highest calibre.

Buyya et al. [4] has described their version of ROI based on SLA. As discussed in Section 2.1, SLA deals with issues in the operational level, and does not fully reflect cloud business performance, which needs input from strategic level to deal with business challenges. Despite Buyya et al. [4] show very well-presented 3D Visualisation, there is no detailed description about how this is generated, whether by system applications available in servers, or their own software, or other third-party software. They explain how this leads to their ROI development, but ROI theory itself does not have detailed description of whether a structured process is involved in this, and there is no detail about QA of their ROI method. Our ROI has the edge because it involves systematic and structured approach, and also provides details how to model our statistics, 3D Visualisation and QA.

6. CONCLUSION AND FUTURE WORK

Cloud Computing Business Framework (CCBF) is a relatively new area, and finding the right methods to review business performance can enhance organisational sustainability. Our CCBF identifies three business challenges, and proposes the area of Organisational Sustainability to review cloud business performance with accuracy, the second research question. CCBF can help organisations achieve good Cloud design, deployment and services.

Two Cloud ROI case studies are presented. The NHS Infrastructure is the first case study to confirm Cloud infrastructure has an efficiency improvement. This results in raising benchmark, the minimum acceptance level to complete concurrent tasks such as automation, storage, backup and high performance calculations. NHS Bioinformatics is the second case study, where 3D Visualisation confirms NHS Bioinformatics project has been progressive with incremental improvements. The low risk-free rate may imply the use of Mathematica and R language makes code development very agile. Furthermore, 3D Visualisation suggests there is less deviation to the project, which may mean the objective is clearly met. The benchmark is considered excellent since it allows agile development in 3D modelling. There are plans to obtain Cost-Saving and User data, which will be presented in the coming future.

Our Cloud ROI methodology involves using a highly structured and organised process to review and evaluate. Firstly, it includes the use of the CAPM statistics to compute analysis. Secondly, it involves conversion to a 3D Visualisation to present cloud business performance. Thirdly, it involves a series of QA tests to ensure high quality of 3D Visualisation. There are not many Cloud ROI methods available, and among available one, our method is the only one demonstrating QA and high quality of analysis. Organisational Sustainability Modelling is the recommended ROI and it enables the following two advantages: (i) allows performance reviews at any time; and (ii) provides strategic directions and added-values for adopting right types of cloud business for organisational sustainability.

The two NHS case studies reflect the summary of work done for Phase 1. Moving to the Phase 2, NHS Infrastructure project is divided into three different areas: Automation, Cloud Storage and Statistical Computing. Data will be obtained from these three projects to present our future work. In addition, we are collaborating with a number of industrial and academic partners, and have some data for further analysis. This is an ongoing process, since to present a high calibre of 3D Visualisation for cloud business performance with accuracy, is one of our objectives to meet cloud business challenges. We plan to compare our model with other ROI or cost-saving models. This well fits into the strategic plan for the NHS and the participating organisations.

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