Final Paper

Optimising Cost of Quality (COQ) through Predictive Insights

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Abstract

COQ is a measure that quantifies costs of conformance and failure - where failure comprises of the internal and external failure. The holistic representation of failure or non-conformance outcomes is defects. Defects are pervasive across the IT lifecycle and include review comments, functional, user experience, exploratory and post production defects.

Defects influence the cost of failure and high defect leakage can be attributed to poor process controls and absence of smarter processes. Cost of Failure is currently handled in a reactive manner by fixing defects when encountered. The industry shift to digital and continuous integration demands a proactive approach. Predictability is key in achieving this.

Predictability is a function of visibility, vulnerability, level, trend, seasonality, and arrival rate.

This paper presents a model which integrates and predicts defects across IT lifecycle. This model can work even during absence of historical data, arrival pattern. It predicts the defect density, process yield and reliability by grouping similar releases, processes, and programs. It uses Montgomery Adaptive Regressions, Rayleigh distributions or Time Series Models. The model also helps in identifying opportunities to improve review effectiveness and defect containment/avoidance.

A pilot of this model has been implemented for clients in healthcare, retail and insurance verticals in areas of SDLC, STLC and AVM. The prediction accuracy achieved was between 70% and 95%. This model enabled clients to migrate to proactive quality approach and become competitive on factors like quality, cost and agility by reducing project’s COQ by approximately 30% and achieve 95% test effectiveness.
Introduction

Today industry is shifting towards improving business outcomes and IT is becoming an outcome driver. The role of applications, business model development and the implementation mechanism has gone through a paradigm shift. With respect to lifecycle and methodology, industry is migrating to agile and nimble models that can continuously drive features through story pointing and user stories. In these programs a major challenge is to measure the project value, earned value and sequencing of sprints to deliver project benefits across the business and product team. Today this need for integration of Business Outcomes, IT enablement and Customer experience have opened up new avenues to assure and drive value, that helps in overall cost optimization and cost rationalization.

The Business or the firm loses money because of low quality of the Outcome; this lost money is termed as Cost of Quality (COQ). Outcome can be tangible as in a product or intangible as in a service. COQ consists of Cost of conformance and Cost of Non-Conformance. One of the key things that burdens COQ is poor quality or cost of failure (COF).

The holistic representation of failure or non-conformance to Business/IT outcomes is defects. Defects are pervasive across the IT and Business lifecycle. A proactive drive using the analytical capabilities could drastically minimize these risks and exposures that significantly influence the organization for competitive advantage.

Industry has reached the phase where analytics has started acting as a disruptor for failed outcomes and this makes the enterprise wide focus around predictive way of managing assurance rather than typical verification and validation which only adds to the overall cost of quality and works, as an effective strategy for the CIO to adopt.

Predictive Industry Trends that evolved and enabled our Ecosystem

According to the C-Suite survey done by KPMG to understand the state of data and analytics in major global organization, some of the major challenges identified include:
Business and IT life cycle should essentially operate in an ecosystem that could self-sustain.

CIO’s have challenges in integrating business outcome predictions in line to planned IT investments and expect the business model and revenue traction to run through this engine. Outcome based models are trending hugely due to the breakthrough of ecommerce and start up initiatives in the markets because of this reason. Outcome prediction can be done for Strategic, Tactical and Operational levels.

In the current state where data is copiously available, turning information into real-time insights in response to the movements in market and executing them to achieve business outcomes at the right time, quick, nimble and in a cost effective manner remains the top priority of organizations in all domains of business.

Garner states that analytics has moved from a descriptive phase to being in predictive phase and is moving towards Prescriptive phase where it prescribes the method to reach best outcome.

**Facts as per Gartner’s Analytics predictions of 2016:**

- By 2020, predictive and prescriptive analytics will attract more than 40% of enterprises net investment in analytics
- By 2020, 50% of CAO will have successfully created a link between financial objectives to BI and analytics initiatives and investments
- By 2018, nearly 75% of technology-oriented BI will evolve into strategy-oriented analytics centers of excellence that will focus on information value generation

Testing and Quality assurance is being looked upon as a key strategic enabler focusing towards driving business outcomes and assures value. Outcome driven proactive assurance brings forth the need for an end-to-end integrated analytics driven prevention model that scales the ecosystem.
Our Ecosystem: End to end integrated analytics driven prevention model

Our ecosystem shows how Cost of Quality is a metric that drives CIO, CXO and CEO agenda’s and it is a single enabler that could drive business outcomes and pursuits. Data analytics can create a tree or chain of events that start with descriptive data and end at inferences that identifies root causes that are buried or inside the iceberg in case of deviations. Cost of failure not only includes lost opportunity but also the failed outcomes that were promised either as a part of IT or Business. The physical hard cash spend is closely related to proximity of multiple buried triggers that actually influence this engine operationally and strategically

Integrated Quality Assurance has to be driven based on data validating descriptive analytics and inferential chain of events that can verify each possible outcome with associated risks and cost that will be required to mitigate the same.

We initiated our analytics eco system with top most influencers that basically drives outcomes, customer satisfaction, non-conformance and support costs

Predictive Insights – Eco system – A Integrated view of Business and IT lifecycle along with key analytical measures and impacted outcomes
How does COQ fit in the Eco System?

Cost of Quality includes all costs incurred in the pursuit of achieving quality or quality enablement. Optimization is the buzz word across the industry. Specifically in cost optimization, there is no mechanism available today to assure on the opportunity cost, how long the planned outcomes stays competitive in the market despite forgoing the opportunity and what are the hidden vs. notional cost that still influences business outcomes. Business level COQ computation factors this into account.

To drill down “Cost of Quality is defined as the proportion of cost (effort) spent to ensure that the delivered product is of highest Quality”. The Cost of Poor Quality represents any and all costs that the organization incurs from having to repeat a process more than once in order to complete the work correctly. Integrating Cost of attaining quality that includes cost of software quality and cost of achieving business outcome and failure costs that includes opportunity cost will form up the overall cost of quality.

The Cost of attaining quality (Prevention Costs & Appraisal Costs). This includes the costs of having a quality system in place even if no defects occur. Costs of quality engineers, inspectors, data collection, and report publishing will fall in this group. The Costs attributable to poor quality (Internal and External Failure Cost) includes the costs associated with unacceptable products. Rejections, scrap, rework and investigations will fall in this group.

Business COQ Tree diagram

Insights of Cost of Failure/Poor Quality: Industry views

- COPQ is big, usually 15-20% of sales
- COPQ is usually 3-5X profits, can be 10X due to lost opportunities and sunk costs
- Understanding poor cost of quality drivers is the key to business or IT Outcomes
- Capture white collar/indirect costs which falls into Prevention/Appraisal cost
- Costs will go up, before the overall COQ can go down. There are no exceptions to this
- If processes are predictable PONC and COPQ could be drastically optimized with proactive integrated quality assurance supporting product and process outcomes
**Cost of Quality Equation**

Cost of Quality (CoQ) is a CEO metric that helps in making decisions at the leadership level for making sure that the right amount of investment is done on Quality initiatives and organization level change management initiatives.

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\text{CoQ} = \frac{\text{CoPQ}}{\text{Total Cost}} \times 100
\]

P\text{ac} - Cost incurred in prevention activities
APP\text{c} - Cost incurred towards appraisal activities
F\text{ac} - Cost incurred towards failure activities
CoP\text{Q} - Cost of Poor Quality
CoQ - Cost of Quality
CE\text{C} - Core Effort cost
OC = Opportunity Cost is a part of failure cost
Predictive Inputs for Cost of Quality

Predictive analytics can be used in developing models that would be useful for planning and establishing expectation that align with the established business outcomes. Models can be deployed in various areas including predicting defects in products, latent defects in process, product characteristics prediction, reliability prediction etc... The areas of application of these models for impacting business outcomes include:

**Business**
- Demand
- Market Sentiment
- Profitability
- Market Share

**Customer**
- Customer Experience
- Customer Satisfaction
- Customer Retention
- Customer Loyalty

**Financial**
- Profits
- Return On Investment
- Return On Asset
- Return ON Equity
- Earning Per Share

**Quality**
- Cycle Time Measures
  - Throughput / Latency
- Defect predictions
  - Defect density
  - Code / test coverage
- Productivity/ Performance
- Incident prediction
- User volume transition

The development of prediction model is carried out using statistical approach that uses either of causal or econometric forecasting methods or time series forecast methods. Selection of forecast method depends on various factors including the context, relevance and availability of historical data, degree of accuracy that is desirable, time period to be forecast, the cost/ benefit of forecast, and the time available for making the forecast and analysis.

Each of the above categories form a part of predicting data sets that shows the root causes/trigger causes that drive the exceptions either against industry benchmarks or with organization level baselines. The Quality outcomes drive operational cost of quality and the business and financial analytics drives the opportunity costs and sunk costs. Customer sentiments and customer analytics drives the key metrics those impact customer satisfaction.
Time series forecast methods make use of historical data as the basis of forecasting the future estimates. The predictability $p$ is a factor of visibility, vulnerability, Detection controls, Level, Trend, Seasonality, or the arrival rate. This relationship is established by the model based on the factors observed in the historic data. The type of time series forecasting method is determined by the analysing these factors in the historic data set.

The causal method of forecasting generally uses the regression models. The construction of the prediction model starts with identifying the predictors for the model. Predictive function is given as

$$\text{Predicted} = f (\text{Predictor1}, \text{Predictor2}...)$$

Various methods that are considered for developing the model include:

1. Moving average methods
2. Distributions starting from Binomial, Poisson, Reliability, Exponential and Central limits and tendencies
3. Exponential smoothing methods such as basic, double or Holt Winters exponential smoothing
4. The various regression methods include multiple regression, multivariate analysis or Raleigh distributions and Auto regressive models including ARIMA, SARIMA, and GARIMA

These techniques aid in prediction of various business parameters including reliability, defects, delivery schedule and user satisfaction. In the Iceberg model items marked in red are the ones which we piloted with our client organisations and witnessed that it had a lot of impact on defect leakage, cost of failure and defect containment. The parameters that are visible as direct impacts are more often predicted to identify and optimize some of the visible and hidden parameters.

**Iceberg with our predictors and Buried factors**
How did we help our customer?

One of our retail customers had been experiencing a lot of defect leakage, which are ongoing from start till production and they had handheld, and middleware integration across factory. This was impacting the business timelines as well and these were called Escaped Defects. The financial impact of in effective delivery and defect leakage could not be quantified financially to show the impact to the stakeholders. They wanted to measure the failure cost and show that the process corrections need to be done upstream to ensure a significant reduction in Cost of Quality. They were trying to establish a proactive QA approach that will measure and optimize the overall cost of failure leading to Cost of Quality Optimization (CoQ).

Key Objectives to be done as a part of the engagement:

- Investigate if there is a relationship between RSI (Requirements Stability Index) or Requirements Management process to Escaped defects
- Implement Defect prediction model for SDLC life cycle and recommend of defect avoidance
- Conduct RCA (Root Cause Analysis) of escaped defects and come up with recommendations to contain defects and improve QA effectiveness
- Compute Cost of failure and establish an end to end COQ metric to identify the upstream process corrections/improvements along with the predictive insight that leads to preventive action plans
- Implement a Ticket prediction model for application maintenance and service management/production Support operations

We started off with creating a basic Cost of Quality scorecard that included parameters relating to prevention, appraisal and failure costs and a release level scorecard to improve cost of a release and a comprehensive scorecard to drive proactive QA based on predictive insights.
We also worked towards configuring the Service reliability index where by higher the reliability optimized is the cost of quality and the CoQ effectiveness scorecard is currently build for defects and tickets in production support environment.

Our analysis started with identification of current state planning on the data collection and base lining. We understood that the test coverage and outcomes driven testing was not in place and to improve this a Prediction mechanism/model was needed. This would accelerate test life cycle across testing phases in the projects, and pave the way for accelerators that would fulfil objectives such as optimization, productivity improvements & delivery excellence across test life cycle.

A prediction model was developed using statistical modelling techniques of adaptive regression and time series non regression models. The data considered was the online release QA data which includes defect density for QA and exploratory defects. Defect density was estimated from the historical data. Prior to the modelling the data cleansing was done by removing the outliers. Holt Winters - a time series forecasting model was used and it decomposed the historical data into level trend and seasonality. The model initially started with an accuracy of 15% and at the end of third iteration the accuracy increased to 72%. The model on the input of defect case count predicted the next four weeks of defects count with a sensitivity analysis reporting range of optimistic, most likely and pessimistic count.

The impact created was high. This model helped in tracking the defects that could occur in the Software even prior to the testing phase thereby enabling proactive and preventive quality practices. This has led to improvement in review effectiveness and 20% increase in defect containment.

The second major ask from the customer was around enabling end to end QA enablement as a part of integrating the overall lifecycle and a lot of challenges were seen around rising support cost, availability challenges and on time resolution challenges. QA coverage was implemented across IT lifecycle including the production support and application maintenance landscape.

The data considered was the production tickets logged into the ticketing tool for the past three years. The data was segregated based on the lines of business and technology. Prior to the modelling
the data trend was studied and hot spots was identified. Holt Winters a time series analytics model was used and it decomposed the historical data into level, trend and seasonality. R was used to model. The model predicted the inflow of tickets for the next one year. The model prediction was 95% accurate.

Impact:
The impact created was high. This model helped in predicting the tickets thereby enabling Proactive measures for the capacity estimation and preparedness for high influx of tickets. This has led to improvement in budget adherence to 80%.

Overall Benefits:
Below mentioned are the major benefits to the client derived out of the prediction model:

- Requirements prescription, identified level for requirements clarity and quality before business outcome to feature mapping at a scenario or a user story level was set. Peer review processes inline to shift left in early engagement of QA and shit right for integration of past escape defects in requirement life cycle lead to 30% upfront escape defect density level.
- Competitive on quality, cost and agility through reduction of CoQ
- Estimated the cost of quality and escape defect cost and integrated them with requirements planning for the subsequent release
- Scenario driven end to end QA for integration both Development and Infrastructure environment and DevOps integration for agile life cycle was inbuilt as a part of Integrated QA. Due to the release level exploratory defects an interim sprint was moved for regression. And continuous integration from end user perspective before nationwide rollout resulted in increasing the overall test coverage to 90%
- End-to-end quality assurance framework also addressing the business components that enable agility and DevOps integration continuously
- Framework agnostic predictive insights that improved root causes and trigger causes identification that was actually driving towards higher cost of failure —(close to 39% and reduced to 24%)
- Improved demand and capacity prediction thus bettering the baselines
- Proactive problem management to eliminate or reduce stale tickets. About 150 tickets that were predicted as stale tickets weekly were eliminated by addressing top contributing root causes based on our foresight
- Visibility to customer on the end-to-end quality of the service with proactive Approach
- Cost of ownership was clearly articulated. Testing cost that was driving cost of quality by impacting appraisal and failure cost was reduced by incurring a slight incremental cost in prevention part to achieve long term breakthrough improvements. And total cost of QA ownership was driven towards optimization and customer experience improvement
- High competition on quality, cost, agility and speed
  - Time to market optimization through reduction of testing cycle and user integrated testing
  - Attain test effectiveness of 95%+ through improved code/test coverage
  - Cost of QA reduction from 30% to 18% of project cost with improved coverage
Conclusion and Next Steps

Testing has become much more dynamic and there is need for integrated quality assurance to shift from reactive verification and validation system. Cost of quality measurement and improvement will build quality as a part of the core processes itself. With gamut of predictive tools and defect insights what we could articulate is that the tip of ice berg if predicted can lead us to hidden factors that actually impact the overall business outcomes and value delivery. Cost of Quality is the leadership metric that needs to be continuously governed and improved. Cost of Failure includes lost opportunities that go as a part of lost opportunity value and sunk cost incurred due to alternative investments and choices. Today there has been a lot of business outcomes delivered through IT enablers and these outcomes are actually requiring the shift from requirements elicitation to requirement prescription process. This means shifting right where the right set of features are built in the software to accomplish identified objectives and planned outcomes. Shift right helps to prescribe defects based on history both from business and IT outcomes. Shift left also helps in obtaining perspective insights through predictive insights to continuously monitor and make situational decisions that will minimize the overall cost of failure and opportunity cost.
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THANK YOU!