

CHAPTER II

LITERATURE REVIEW

In this chapter, the researcher will explain about inductive and deductive studies. The inductive study is a study derived from previous researches that have already scientifically published. The deductive study is a study that explains the basic theory used in this research generally. Both of the studies are required to identify the gaps between previous studies and current study to avoid any plagiarism.

2.1. Inductive Study

The inductive study below is derived from the previous researches accumulated from total 15 journals. It is mentioned the title of researches, authors, years, problems, method used, and solutions.

Kurniawan et al. (2013) mentioned that risks occur in onshore receiving fields which are caused by failures in equipment on purification and gas compression. The researchers applied probabilistic FMEA and 5 whys method RCA. The finding of the research is improvement program to reduce critical risk such as maintenance and long term pressure calibration.

Strang (2013) researched on a way to understand how a research guideline of risk management can be improved. The applied methods are general analytic approach and descriptive statistics. The research finding consists of usage comparison between post positivist, pragmatic or social constructivists.

Kloberkoch et al. (2017) researched the problem of operative risks during the production process that reduce the quality requirement. The applied method was risk modelling. The research finding was an operative production risk system.

Duphily (2014) researched the problem that can help to determine suitable method and software tools when detailed root cause analysis is needed. The research applied RCI method. It resulted comparison over 17 methods of RCA.

Kemblowski (2017) researched on a demonstration about how bayesian network can be used to assess and manage risks. The used method was Bayesian network with findings that consists of model of BBN and model of DDSM.

Setiawan et al. (2017) researched the identification on potential failure impact of risk in fabrication process with 23 failure modes. The method used was FMEA, which is commonly employed in this research field. The finding was a strategy to carry out regular inspection and maintenance.

Rolik (2016) researched on the analysis of possible risk, the measurement, and a way to reduce the negative impacts. The methods applied were SWOT and Mc Kinsey matrix. The findings consist of analyzed possible risk and risk input in project management.

Millan and Merlo (2014) researched on an identification the appropriate use of causal analysis techniques. The used method was NERC. The findings were the comparison between ACA and RCA.

Pittiglio et al. (2014) researched on the change of legislation from risk based on risk rates. The used method was advanced KB techniques. The finding consists of result of risk assessment on new rules implementation that focused on equipment.

Hu and Wang (2016) researched on the potential risk in assembly. The used method was job hazard analysis. The finding was technical and management measures as risk strategies.

Aurisichio et al. (2016) researched the understanding of the causes on adverse events associated with complex engineered systems. The used method was RCA approach based on the IBIS and FAD notations. The finding proposed IBIS-FAD approach to provides a rich description of the causes for an accident presented in a manner that facilitated information access and understanding.

Hrbackova (2016) researched the risk-based thinking incorporated with quality management system. The used methods were QAM and FMEA. The finding of the research was utilization methods of FMEA and QAM for identification, analysis, and risk assessment in production process.

Denas (2015) researched on the decrease deviations in time and cost estimation at complete. The method applied was EVM while the finding resulted the proposed model that can be efficiently applied through real case software projects.

York et al. (2014) researched the way to reduce loss of failure in global competitive market. The research method was cause mapping. The research finding indicated that cause mapping is efficient, effective, and easy to use.

Healy (2013) researched about the importance of RCA and its role in the continuous improvement of equipment over the life of the plant. The methods used by researcher were top down and bottom up. The finding explains that a RCA undertaking was only beneficial to the organization if it has been well focused.

After conducting review to all of above journals reviews, the comparison among 15 journals and the current research will be done and presented on the table 2.1 named as journal ticking table.

Table 2.1 Journal ticking table

Authors (Year)	Scalability	Clearly Define Problem	Multiple Root Causes	Corrective Action	Solution Rank	Software	Articulate the Need	All Stakeholder Encouragement	Result
Kurniawan et al. (2013)	√	√	√	√					Improvement program to reduce critical risk such as maintenance and long term pressure calibration Usage comparison between post positivist, pragmatic or social constructivists.
Strang (2013)					√		√		
Kloberkoch et al. (2017)	√	√				√			An operative production risk system
Duphily (2014)		√			√	√			Comparison over 17 methods of RCA
Kemblowski (2017)	√	√				√	√		Model of BBN and model of DDSM

Authors (Year)	Scalability	Clearly Define Problem	Multiple Root Causes	Corrective Action	Solution Rank	Software	Articulate the Need	All Stakeholder Encouragement	Result
Setiawan et al. (2017)	√	√	√	√					A strategy to carry out regular inspection and maintenance.
Rolik (2016)	√	√		√			√		Analyzed possible risk and risk input in project management
Millan and Merlo (2014)	√	√	√		√		√		Comparison of ACA and RCA.
Pittiglio et al. (2014)	√			√				√	Result of risk assessment on new rules implementation that focused on equipment.
Hu and Wang (2016)	√	√	√				√		Technical and management measures as risk strategies.
Aurisichio et al. (2016)	√	√	√				√		Proposed IBIS-FAD approach

Authors (Year)	Scalability	Clearly Define Problem	Multiple Root Causes	Corrective Action	Solution Rank	Software	Articulate the Need	All Stakeholder Encouragement	Result
									provides a rich description of the causes for an accident presented in a manner that facilitates information access and understanding.
Hrbackova (2016)	√				√		√		Utilization methods of FMEA and QAM for identification, analysis, and risk assessment in production process The proposed model can be efficiently applied through real case software projects.
Denas (2015)	√	√			√		√		

Authors (Year)	Scalability	Clearly Define Problem	Multiple Root Causes	Corrective Action	Solution Rank	Software	Articulate the Need	All Stakeholder Encouragement	Result
York et al. (2014)	√	√	√	v			√		Cause mapping is efficient, effective, and easy to use method. A RCA undertaking is only beneficial to the organization if it has been well focused.
Healy (2013)		√	√				√		
Mayanti (2018)	√	√	√	√	√	√	√	√	Current research

2.2. Deductive Study

2.2.1 Risk Management

Based on Defense (2015), risk can be defined as the combination of the probability of an event and its consequences. Risk management is a central part of any organization's strategic management. It is the process whereby organizations methodically address the risks attaching to the activities with the goal of achieving sustained benefit within each activity and across the portfolio of all activities.

The focus on risk management to identify and treat the risks. The risk can be caused from both internal and external factors. Figure 2.1 is the risk management process from Defense (2015):

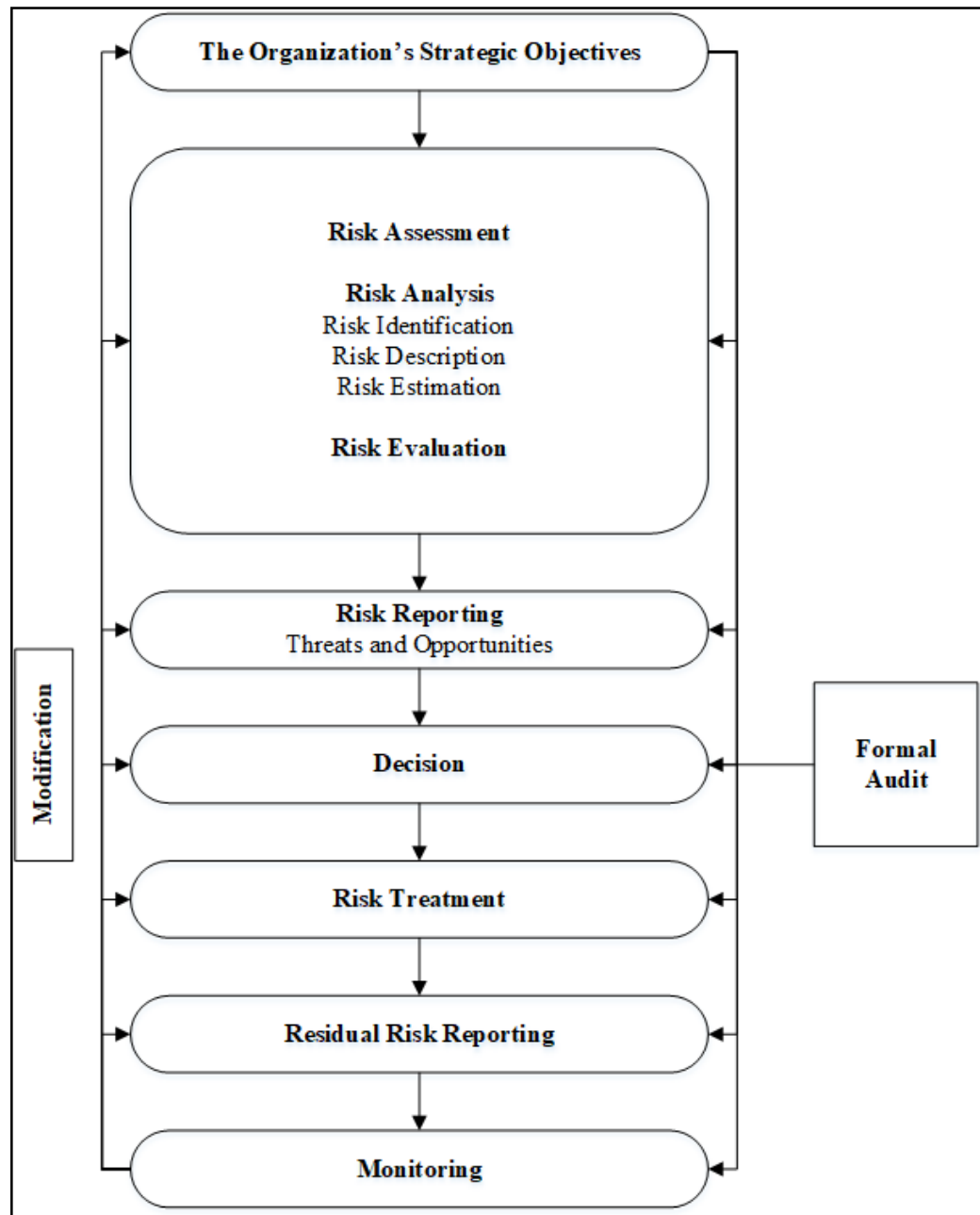


Figure 2.1 Risk management process

The process taken from risk management for this research are risk identification and risk treatment. The risk identification is implemented by using root cause analysis, while the risk treatment is implemented by calculating the risk mitigation which also known as defect mitigation. Defect mitigation itself is the calculation of defect reduction. The reduction value and defect residual are obtained from the following formulas by Goa (2017). The total reduction value itself is obtained by totalize the reduction value for each problem solutions.

$$Defect\ Reduction\ Value = \frac{EC-CC}{\Sigma(EC-CC)} \times 100\% \dots\dots\dots (2.1)$$

$$Defect\ Residual = Defect\ Frequency - (Defect\ Frequency \times \Sigma\ DRV) \dots\dots\dots (2.2)$$

Goa (2017) stated that risk assessment is the overall process of risk analysis and evaluation. The risk analysis includes risk identification, risk description, and risk estimation. Risk identification is to identify organization's uncertainty. The identification should be done in methodological way. The risk description is to display the identified risks in structured format. The risk estimation can be quantitative or semi quantitative/qualitative in terms of the probability of the occurrence. The risk evaluation is used to make decisions about the significance of risks to the organization.

Goa (2017) stated that risk reporting is divided into two, internal reporting and external reporting. The internal reporting includes board of directors, business units, and individuals. The external reporting includes government and stakeholders.

Goa (2017) stated that risk Treatment is process of selecting and implementing measures to modify the risk. Based on Goa (2017), risk financing refers to the mechanisms (e.g. insurance programs) for funding the financial consequences of risk. Risk financing is not generally considered to be the provision of funds to meet the cost of implementing risk treatment. Table 2.2 shows several techniques used in risk management:

Table 2.2 Techniques in risk management

Risk Identification	Risk Analysis		
	Upside Risk	Both	Downside Risk
1. Brainstorming	1. Market survey	1. Dependency modelling	1. Threat analysis
2. Questionnaires	2. Prospecting	2. SWOT	2. Fault tree analysis
3. Business studies which look at each business process and describe both the internal processes and external factors which can	3. Test marketing	3. Event tree analysis	3. FMEA (Failure Mode & Effect Analysis)
	4. Research and Development	4. Business continuity planning	4. RCA
	5. Business impact analysis	5. BPEST	

Risk Identification	Risk Analysis		
	Upside Risk	Both	Downside Risk
influence those processes		6. Real Option Modelling	
4. Industry benchmarking		7. Decision taking under conditions of risk and uncertainty	
5. Scenario analysis		8. Statistical inference	
6. Risk assessment workshops		9. Measures of central tendency and dispersion	
7. Incident investigation		10. PESTLE	
8. Auditing and inspection			
9. HAZOP (Hazard & Operability Studies)			
10. RCA			

2.2.2 Root Cause Analysis

Vorley (2008) stated that root cause analysis is a method used to address a problem or non-conformance, in order to get to the “root cause” of the problem. It is used so the causes can be corrected or eliminated, and to prevent the problem from recurring. The root cause analysis itself is application of a series of well known, common sense techniques which can produce a systematic, quantified and documented approach to the identification, understanding and resolution of underlying causes.

Organizations especially companies tend to respond to problems with short term solutions. Vorley (2008) mentioned that the organizations tend to rely on quick fixes which result in repetition of the same tasks due to the problem recurrence. Focusing on short term solutions is not a recipe for increased profitability and organizational growth.

Vorley (2008) explained about the basic steps of completing a root cause analysis. The basic steps consist of defining the problem, understanding the problem, immediate action, corrective action, and confirming solutions. There are also several root cause analysis techniques mentioned by Vorley (2008) which are 5 why’s, pareto analysis, cause and effect diagram, brainstorming, Apollo, fault tree diagram, check sheet, etc.

2.2.3 Apollo Root Cause Analysis

Gano (1999) stated that traditional root cause analysis is a believe that finding and eliminating the single root cause will solve the problem. However, Gano (1999) realized that traditional root cause analysis methods were not working to be implemented in large and severe problems. The single root cause is a myth that was preventing problems from truly getting solved.

Gano (1999) proposed a method called Apollo root cause analysis. This method utilized a process called reality charting which encompasses all known causes as well as the relationships between each other to provide more complete picture. Meanwhile, Gano (1999) also stated that the other methods of problem solving are linear and subjective according to the point of view of the storyteller.

In reality charting, the process of the analysis explained by Gano (1999) is started by defining a problem, asking why the problem occurred, ensuring that the answer includes both action and condition, and asking why of each action and condition, while other forms of problem solving often focus only on the action causes and ignore the condition causes. Figure 2.2 shows the reality charting implemented in Apollo root cause analysis.

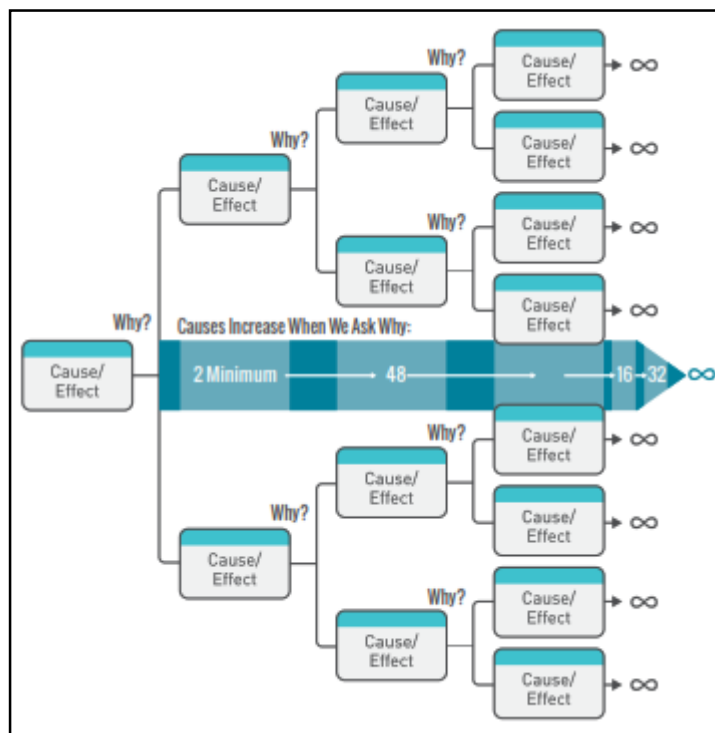


Figure 2.2 Reality chart by Gano (1999)

There are several benefits of Apollo root cause analysis and reality charting. The benefits were mentioned by Gano (1999) shown as follows:

1. Create a common reality, since all stakeholders can see the causal relationship in reality chart.
2. Eliminate recurring problem, Apollo root cause analysis trains the user to identify solutions within organization's control, prevent recurrence, and meet the organizations goals and objectives.
3. Get a definite result, Apollo root cause analysis is used to find clear causal connection between solutions and the defined problem, so the user can be confident that the problem is directly addressed and resolved effectively.
4. Address any size of problem.
5. Eliminate assumptions, the evidence required for each cause ensures the there is no story telling involved.
6. Avoid pointing fingers, since the goal is to find solutions that prevent recurrence, not find a guilty party.

2.2.4 Forecasting

Diebold (2017) stated that forecasting is an activity to calculate or predict some future events or conditions, usually as a result of rational study or analysis of pertinent data. Forecasting is widely used today in many fields, especially in industry, marketing, economy and finance. Such as in consumable product manufacturing, an accurate prediction of the future demand is very helpful in providing precise inventory, reducing transportation costs, then increasing profit.

Diebold (2017) mentioned that there are several considerations that are relevant for any forecasting tasks. Those considerations are forecast object, information set, model uncertainty and improvement, forecast horizon, structural change, forecast statement, forecast presentation, decision environment and loss function, model complexity and the parsimony principle, and the last is unobserved components.

One mathematical approach to forecast time series is known as the Box Jenkins method and was suggested by Box and Jenkins (1970). Technically, the Box Jenkins technique is an integration of the autoregressive and the moving average methods, so it is also named ARIMA (Autoregressive, Integrated, Moving Average) model. Since its first introduction, this ARIMA approach has become widely used in many fields such as specification, estimation, and diagnostic (Thomas 1983).

Box and Jenkins (1970) mentioned on the book that the ARIMA methodology is a statistical method for analyzing and building a forecasting model which best represents a time series by modeling the correlations in the data. In the empirical research, many advantages of the ARIMA model were found and support it as a proper way in especially short-term time series. Taking advantage of its strictly statistical approach, the ARIMA method only requires the prior data of a time series to generalize the forecast. Hence, the ARIMA method can increase the forecast accuracy while keeping the number of parameters to a minimum.

Thomas (1983) stated on the book that a significant difference between the ARIMA methodology and previous methods is that ARIMA excludes assumptions about

the number of terms or the relative weights to be assigned to the terms. To specify the model, the analyst first selects the appropriate model, including the number of p , d , q terms, then calculates the coefficients and gives a refined suggestion of the model parameters by using a nonlinear least squares method.

Box and Jenkins (1970), stated that ARIMA has several data requirements in order to be able to better use the ARIMA method. The requirements consist of at least 40 historical data points, and this research has 43 historical data points. Also, it works best when the data exhibits a stable or consistent pattern, tested using homoscedasticity test. It will be superior to be implemented in exponential smoothing, where the data is reasonably long and the correlation between past observation is stable.

2.2.5 ARIMA Model

Kit (2015) stated that ARIMA modelling is an approach to time series forecasting that has flexibility to fit a model which is adapted from the data structure itself. ARIMA model is the most widely used to time series forecasting, and provides complementary approaches to the problem. ARIMA model aims to describe the autocorrelations in the data. Time series itself is a collection of observations of well-defined data items obtained through repeated measurements over time. As example of time series data is measurement of the unemployment level each month of the year. The data obtained in this research is also time series data, because it measures the machine defect frequency each month from 2016 until 2018. The ARIMA model has three main components, mentioned as follows:

1. Autoregressive (AR) refers to a model that shows changing variable that regresses on its own lagged.
2. Integrated (I) represents the differencing of raw observations to allow the time series to be stationary.
3. Moving Average (MA) incorporates dependency between observation and residual error from moving average model applied to lagged observation.

Kit (2015) mentioned that the AR component represents the autocorrelation between current and past observations while the MA component describes the

autocorrelation of the error. The integrated component itself represent the level of differencing required to transform a non-stationarity series into stationarity series. The non-seasonal ARIMA model is denoted by (p, d, q) where p represents AR, d represents differencing, and q represents MA. Below are several tests conducted within ARIMA Model.

Kit (2015) mentioned that ARIMA is a form of regression analysis that gauges the strength of one dependent variable relative to other changing variables. The goal is to predict future condition by examining the differences between values in the series.

A. Stationarity

There are several tests that can be used to define the stationarity of the data. The stationarity test needs to be done to identify whether the data needs differencing or not. The common tests used are unit root tests, and trend tests. After the differencing is exposed, yet the data are not stationary, Box-Jenkins approach can be applied. However, if the data is stationary, Box-Jenkins approach can be directly applied. Box-Jenkin approach itself is an approach to find the best fit of a time series model to past values of a time series. Figure 2.3 shows the difference between stationary and non-stationary time series by Kit (2015).

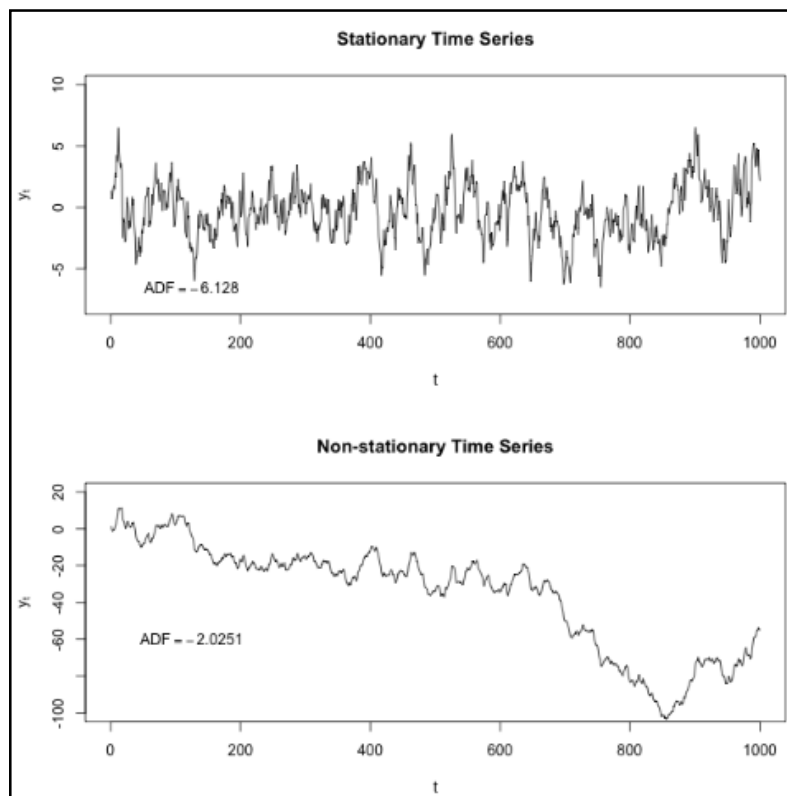


Figure 2.3 Stationary and non-stationary time series

Kit (2015), stated that in Box Jenkins approach, the approach starts with an assumption that the process generated the time series can be approximated using ARIMA if the model is non stationary. The process itself is stochastic modelling which has 3 steps which are identification of the data, estimation of the parameter, and diagnostic checking to evaluate the fitted model in the context of the available data and check for areas where the model may be improved. In diagnostic checking, the XLSTAT is used to compute the AICC for ARIMA models. The minimum AICC is chosen.

As for the model generation, the parameters consist of AICC, MSE, AR, MA, and constant. AICC stands for AIC with a correction for small sample sizes, while AIC stands for Akaike Information Criterion which is an estimator of the relative quality of statistical models for a given set of data. AICC has the advantage of tending to be more accurate than AIC. MSE stands for mean square error, which tells about how close a regression line is to a set of points. The smaller the MSE, the closer in finding the line of best fit. The one that gave the smallest MSE would be the line of best fit. AR stands for auto regression, which is representation of a type of random processes. AR in

ARIMA, indicates that the evolving variable of interest is regressed on its own lagged values. MA stands for moving average, which indicates the regression error, that actually a linear combination of error terms whose values occurred contemporaneously and at various times in the past.

a. ADF Test

The test for unit root's presence in a time series is Augmented Dickey-Fuller (ADF) test. The formula of ADF test can be seen below. The testing procedure of ADF test is applied to the following model.

$$\Delta Y_t = \alpha + \beta_1 t + \beta_2 t^2 + \gamma Y_{t-1} + \phi_1 \Delta Y_{t-1} + \dots + \phi_{p-1} \Delta Y_{t-p+1} + \varepsilon_t \dots\dots\dots (2.3)$$

Where:

Δ is the first different operator

α is a constant

β_1 is the coefficient on a time trend

β_2 is the coefficient on a squared time trend

$\gamma = 0$

The ADF test has hypothesis as follows:

H0 = The series is non-stationary (presence of unit root), $\gamma = 0$

Ha = The series is stationary, $\gamma < 0$

b. KPSS Test

KPSS test which also known as Kwiatkowski-Phillips-Schmidt-Shin test, is a test for stationarity as the null hypothesis opposed to the ADF test. Kit (2015) stated that KPSS test is oversized for processes that are highly autoregressive because it uses a semiparametric heteroscedasticity and autocorrelation consistent covariance estimator with positive finite sample bias. Below is the hypothesis of KPSS test.

The KPSS test, on the other hand, has the following hypotheses:

H0 = The series is stationary

H_a = The series is non-stationary (presence of unit root).

The formula for KPSS test is shown below.

$$X_t = r_t + \beta t + \varepsilon_1 \dots\dots\dots (2.4)$$

Where:

βt is deterministic trend

r_t is a random walk

ε_1 is a stationary error

c. Mann-Kendall Trend Test

Mann-Kendall trend test is used to test the presence of trend in a time series. The tested data do not have to be normally distributed since it is not a parametric test. The statistic obtained from the tests are S statistic and Kendall's tau. The S statistic divided into two categories which are positive and negative. The positive S means the upward trend while the negative S means a downward trend. The Kendall's tau itself measures the strength of dependence between two variables. The example of trend in a time series by Kit (2015) can be seen on Figure 2.4.

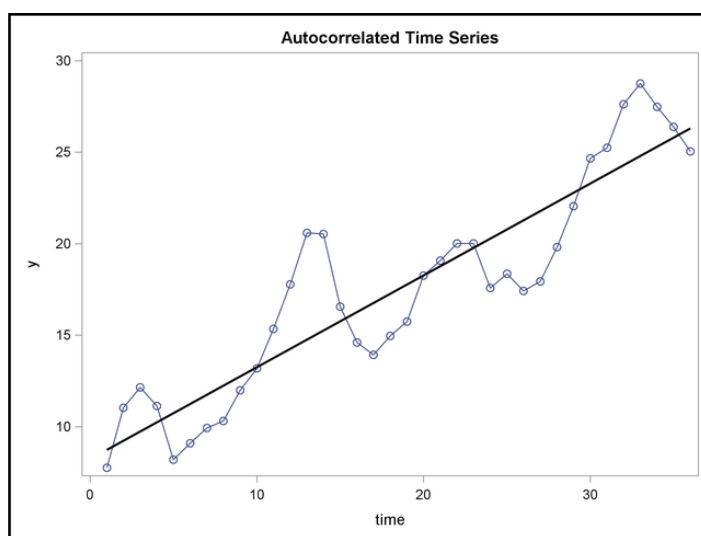


Figure 2.4 Example of trend in a time series

B. Independency

The basic assumption about the residual of ARIMA model is white noise. A white noise series have uncorrelated random shock with zero mean and constant variance. If the residuals are independent, it means that there is no more information could be extracted from the series. The way to determine the independence is to inspect the correlogram of the residuals. If the correlogram shows values that are close to zero, it means that the residuals are uncorrelated and independent. Figure 2.5 shows an example of correlogram or ACF that exhibits white noise by Kit (2015).

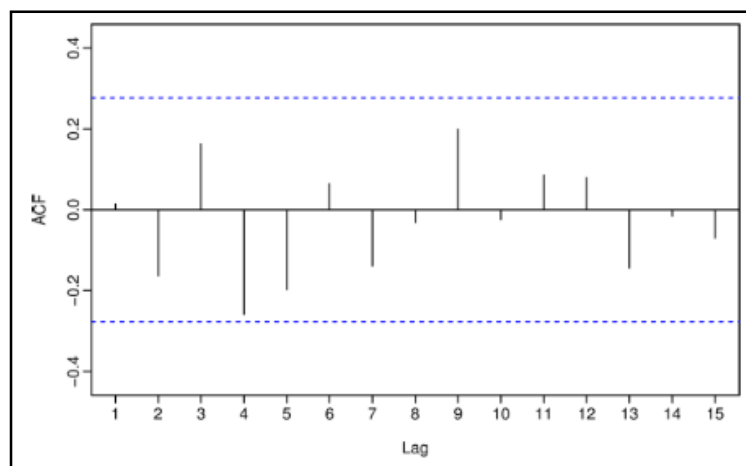


Figure 2.5 Example of correlogram or ACF that exhibits white noise

C. Homoscedasticity

Homoscedasticity is used to define the variance of the disturbance term in each observation is constant. If the residuals are homoscedastic, then the variances are stable. Kit (2015) stated that there are two main reasons why homoscedasticity is important. First is that it involves with the regression coefficients' variances, the variances should be as small as possible in order to produce maximum precision. Second is chances that the estimators of the standard errors of the regression coefficients could be wrong. The homoscedasticity can be detected using different tests, such as Spearman Rank Correlation test, the Goldfield-Quandt test, the Glejser test, and the Breusch-Pagan test.

In homoscedasticity test, especially Breusch Pagan test, the parameter used is LM observed value, LM critical value, and DF. The LM stand for Lagrange Multiplier. LM is a strategy for finding the local maxima and minima of a function subject to equality constraints.

D. Transformation

In many cases, analysis are done based on an assumption that the population is normally distributed stated by Kit (2015). However, the relevant assumptions are violated. Another researcher chooses to design a new model that retains the important aspect of the original model and satisfies the assumption rather than ignore the violation and continue with the analysis. This decision requires a transformation to the original data. One of the transformation methods is Box-Cox transformation. The Box-Cox transformation has a function to transform the original data to obtain new data with higher normality value. The transformation can be done using software. One of the software that provide this Box-Cox transformation is XLSTAT software.

In Box-Cox transformation, the used parameter is lambda. The value of the optimized lambda is obtained from the XLSTAT software. However, there is an operational action that may affect the value of the lambda. The example of the operational action is the risk mitigation itself. As example, in this case there is a proposed solution as operational action such as, conducting material studies. It can change the value of the lambda based on the implementation of the operational action. The difference way of implementing the operational action or the solutions will result in the difference of defect frequency value itself which also will result in the difference value of lambda.

E. Forecasting Comparison

The forecasting comparison is being conducted in order to measure the efficiency level of the defect prevention activities. Zawadzki (2012) stated that defect prevention effectiveness is a measure of how effective an organization's processes, procedures, and controls are at preventing defects occurring in the first place. The value of DPE is commonly obtained based on the past project. However, due to the condition where PT.

Yoska Prima Inti does not have historical DPE value for past projects, the DPE values are chosen based on Zawadzki (2012) which are 75% and 85% for manufacturing company. The number of possible defects in terms of detailed requirement (DRQ) is also defined based on Zawadzki (2012), which is 1.84 as constant. Below is the formula of the maximum possible defects.

$$\textit{Maximum Possible Defects} = \textit{Defect Frequency} \times 1.84 \dots\dots\dots (2.5)$$