CHAPTER 2

Theoretical and Review Literature

2.1 Theoretical

2.1.1 Economic impact of rail system on transportation

Transportation includes transporting people, goods or services from one place to another place. The objective of transportation is to reduce costs by increasing efficiencies using the same resources. Ideally, one wants to maximize customer satisfaction, save time, and transport goods and services to the customers faster than a competitor. Moving products into the market quicker can maximize profit, increase the safety of working with the commodity, and so forth.

Transportation has several ways to transport goods or services such as Land transportation (Road Transportation and Rail Transportation), Water transportation (Inland water transportation and Sea and Ocean Transportation), and Air transportation (Logistic Corner, 2016).

The alternative of transportation that important is rail transportation that is important for Thai people for a long time and in the future if the country has developed rail transportation, it will have benefit for county more or less. If investors invest more, the economy of rail transportation in Thailand will be increased twice.

Rail Transportation has influent to economy and society. Rail Transportation can travel from one place to another place with low cost. Almost every country in the world turns to develop rail transport because these make elasticity of economy have tendency increase more than before. Therefore, rail transportation is important in our economy.

Rail systems have been using for many years and increasing continuously due to their convenient, fast, safe, efficient and reliable natures. Rail transit is public transportation, and now rail transit has been widely accepted in many departments, especially in the department of the planning of urban and regional scale. The JICA expert presented 2 types of rail transit, i.e. urban rail transit and regional rail transit. The classification depends on distance, speed, and capacity (OCMLT, 2001).

Urban rail transit composes heavy rail and light rail. Heavy rail's capacity is about 40,000 – 60,000 persons per hour and Light rail's capacity is about 8,000 - 20,000 persons per hour. Regional rail transit has more distance than urban rail transit and has served by ordinary train and high-speed train.

Light rail and heavy rail are from "Light Capacity Rail Transit" and Heavy Capacity Rail Transit". Light rail or Light Capacity Rail is served in several formats such as monorail, people mover, tram, and etc. that based on servicer needs. Moreover, light capacity rail employs a Multiple Unit (MU) system that composes at least 2 wagons for having 2 control room of train lead to the ability of system become to medium capacity. Therefore, light capacity rail most electric train use monorail or people mover due to saving cost, duration, and low maintenance cost. The route that appropriates with light capacity rail is the minor route that accesses the community or light capacity rail can use to substitute bus or motorbike taxi. The light rail system is used in the city that has high-density population due to use speed less than heavy rail system that is safe for people. Therefore, light rail is widely used in many countries for public transportation use in the city.

Medium Capacity Rail or condense of Heavy Rail that consist of 3-4 wagons per train and the most of the routes are circle connect to the main train around the city for helping people have to connect train by not to come into the city.

In Thailand, it nowadays uses just 2 systems that are heavy capacity rail and medium capacity rail. Thailand has only one heavy capacity rail which is BTS. BTS in the past had used medium-capacity rail until in 2012 that it increased wagon and jump from medium-capacity rail to heavy capacity rail. However, BTS does not use full capacity, if BTS had used full capacity, it would compose of 6 wagons.

For Light Capacity Rail in Thailand have only 2 routes that are pink line train and yellow line train. Both lines use monorail system to serve.

New York in the USA has the most stations in the world about 468 stations and served by 24 hours, and transport passengers have average 1.75 billion persons and the fare is not expensive (UNDUB ZAPP, 2016).

Japan is served by a network of high-speed train lines that connect Tokyo with most of the country's major cities. Japan's high-speed trains (bullet trains) are called shinkansen and are operated by Japan Railways (JR) with running at speeds of up to 320 kilometres per hour, the shinkansen is known for punctuality that is most trains depart on time, comfortable, safety and efficiency (Japan-guide, 2016).

Taiwan High-Speed Rail runs about 349.5 km, along with the west coast of Taiwan, from the national capital Taipei to the southern city of Kaohsiung that Taiwan High-Speed Rail response to increasing ridership and new stations that would begin operation in 2015. The system is based primarily on Japan's Shinkansen technology (Wikipedia, 2016).

Bangkok, Thailand is currently served by three rapid transit systems compose of the Bangkok Mass Transit System or BTS Sky train, the underground MRT or Mass Rapid Transit and the elevated Airport Rail Link or ARL. Although proposals for the development of rapid transit in Bangkok had been made since 1975, it was only in 1999 that the BTS finally began operation. The BTS consists of two lines, Sukhumvit and Silom, with thirty stations along 30.95 kilometres (19.23 mi). The MRT opened for use in July 2004 and currently consists of two line, the Blue Line and Purple Line. The Airport Rail Link, opened in August 2010, connects the city centre to Suvarnabhumi Airport to the east. Its eight stations span a distance of 28 kilometres (17 mi) (Michael Cobb, 2016).

The economy will not go down if developing of transportation is not at a standstill and progress forward and develop soon. The development of rail transportation will be progress to globalization because of the demand for human have infinities.

In conclusion, planning of rail system needs many factors for decision making, especially for future use. Incorrect planning leads to inefficiency and may be a waste of resources. (Bangkok Trains Knowledge Center, 2016)

De Rus and Nash analyzed the economic impact on the electric rail system. They concluded that the main benefits of developing the electric rail system into 5 groups as saving time to travel, increasing the capacity of the system, reducing external environment impact from other travel, benefits from travelling, and benefits from social and economic.(De Rus Mendoza, 2012)

Having electric rail system lead to saving time to travel. The study of Value of Time Saving in England found that value of time saving depends on the objective of travelling. Traveling for business has a high value of time at 40 pounds per hour while travelling for relax just has a value of time 4.46 pounds per hour.

Increasing capacity of the system, even though the target of the electric rail system is the development of a route to cope with the growth of tourism among the big city but the developing of the electric rail route, high speed contributes to reducing congestion of travel in the last system as well.

Reducing of an external impact besides other transport. Invest in fundament infrastructure, the electric rail system effect to travel transformation especially in travel with air transportation transform to travel by electric train that has less environmental impact.

The benefit of travelling that increase effect to more traffic jam that is benefits of people travel more include economic activities increase as well.

Impact on social and economic, from the study of the electric rail system impact in term of comparison of 3 countries, Germany, France, and Japan among the cities that electric train stop and the cities have no electric train. In Germany studied the amount of electric train stop 12 cities found that the cities were to have an impact on population growth 4 cites, impact on employment 1 city, impact on economic growth 2 cities, impact on tourism 4 cities, and impact on land price 1 city. In concluding, the cities that have electric train stop might not get the same benefits but depend on the factors of economic in each city. In France, development of electric train impact found that the cities that have an impact are starting electric train station and destination that have electric trains stop. The cities were to have an impact on population growth 2 cites, impact on employment 3 cities, impact on tourism 4 cities, impact on land price 1 city, and impact on a number of students 1 city due to having electric train lead to student go to school convenient. In Japan, the cities where have an impact on population growth 4 cites, impact on GDP 1 city, impact on economic growth 3 cities, and impact on the number of students 3 cities.

2.1.2 Stochastic exponential growth model

Ordinary differential equation (ODE) is the function that has one or more functions of one independent variable and its derivatives. The term ordinary is used to compare with the term partial differential equation that may be related to more than one independent variable (Goodman, Moon, Szepessy, Tempone, & Zouraris, 2002). The ordinary equation without random variable is (M Khodabin, Maleknejad, Rostami, & Nouri, 2012)

$$\frac{dX_t}{dt} = \mu(X_t, t) \cdot X_t \text{ that } X_{t0} = X_t \qquad (2.1.2.1)$$

where X_t is the number of individuals at time t

X_{t0} is the initial number at time t=0

μ is the growth rate at time t

If $\mu(X_t, t) = r(t)$ that is correct and non-random give function, then the exponential model is

$$X_t = X_0 \exp\left(\int_0^t r(s)ds\right) \qquad (2.1.2.2)$$

If $r(t) = r$

Then, $X_t = X_0 \exp(rt)$ (2.1.2.3)

In some case, the ordinary differential equation is not enough when it confronts with some random variables and concerning about uncertainty, so the stochastic differential equation is introduced.

The stochastic differential equations provide a relationship between probability theory, the ordinary and partial differential equations. Moreover, the stochastic differential equation is arranged to express dynamical models or time-dependent model including, both random effect and non-random effect. (MIT Open Course Ware, 2013)

The stochastic differential equation is

$$\frac{dX_t}{dt} = \mu(X_t,t)X_t + \sigma(X_t,t)X_t\delta_t \tag{2.1.2.4}$$

that equal to

$$dX_t = \mu(X_t,t)X_t dt + \sigma(X_t,t)X_t\delta_t dt \tag{2.1.2.5}$$

and

$X_{t0} = X_0$ and $0 \le t \le T$

where

δ_t is a Gaussian white noise

The Gaussian white noise process is derived from Brownian motion as follow,

$$dB_t = \delta_t dt \tag{2.1.2.6}$$

and refer to the rules (Øksendal, 2003)

$$dB_t \cdot dB_t = dt \tag{2.1.2.7}$$

Then, the stochastic differential equation is

$$dX_t = \mu(X_t,t)X_t dt + \sigma(X_t,t)X_t dB_t \tag{2.1.2.8}$$

where μ is adrift term or Riemann integral

σ is diffusion term or an ItÔ integral

B_t is one-dimensional Brownian motion

A standard Brownian motion or B_t is a one-dimensional stochastic process that is a continuous-time analogue of the simple random walk (MIT Open Course Ware, 2013). The properties of a standard Brownian motion are as follow,

$B_0 = q$ absolutely almost fixed for $q \in R$

1) All sample paths are almost continued absolutely

2) B_t is normally distributed with mean zero and variance t

3) $(B_{t+u} - B_t)$ is a normal distribution with mean zero and variance $u : (B_{t+u} - B_t) \sim \mathrm{N}(0,\mathrm{u})$

4) If the internal $[t_1, t_2]$ and $[u_1, u_2]$ are mom-overlapping, then $(B_{t2} - B_{t1})$ and $(B_{u2} - B_{u1})$ are independent.

For constant drift and diffusion terms, the exponential solution of stochastic differential equation from a standard Brownian motion is

$$X_t = X_0\, exp\left(\mu t - \frac{\sigma^2}{2} t + \sigma B_t\right) \qquad (2.1.2.9)$$

$$Y_t = \left(\mu t - \frac{\sigma^2}{2} t + \sigma B_t\right) \qquad (2.1.2.10)$$

where

$$Y_t = \ln\left(\frac{S_t}{S_0}\right) \qquad (2.1.2.11)$$

2.1.3 Bayesian inference

The drift and diffusion terms in the model will be determined using Bayesian inference. The Bayesian inference uses probability to express belief in a statement about unknown quantities. Bayesian inference uses subjective probability that can describe the uncertainty of a statement about an unknown parameter in terms of probability. Moreover, Bayesian inference explains how to obtain the posterior distribution of model parameters and how to obtain useful model summaries and predictions for future data (Glickman & van Dyk, 2007).

The posterior distribution equation is

$$f(\mu, \sigma \mid D) = CL(D \mid \mu, \sigma) f(\mu, \sigma) \qquad (2.1.3.1)$$

where

$f(\mu, \sigma \mid D)$ is the posterior distribution

$L(D \mid \mu, \sigma)$ is the likelihood function

$f(\mu,\sigma)$ is the prior

C is a normalization constant

D is the research data

The structure of D is

$$D = (t_i, Y_i),...,(t_N, Y_{tN}) \quad (2.1.3.2)$$

where t_i is time instant,

Y_i is the user number at the time t_i

The likelihood function is

$$L(D \mid \mu,\sigma) = \frac{1}{(2\pi)^{N2} \mid \sum \mid^{12}} \exp[-Z^T \sum^{-1} Z] \quad (2.1.3.3)$$

where N is the number of data in the implication

and

$$Z_k = \frac{1}{\sigma}\left(Y_{tk} - \mu t_k - \frac{\sigma^2}{2} t_k\right); k = 1,..., N \quad (2.1.3.4)$$

and

$$\sum_{ij} = E[B_{ti} B_{tj}] = \frac{1}{2}(t_i + t_j - \mid t_i - t_j \mid); i.j = 1,..., N \quad (2.1.3.5)$$

2.1.4 Markov Chain Monte Carlo (MCMC) method

The probability distribution of the variable is parameterized and uses a Markov Chain Monte Carlo (MCMC) method to determine the posterior (2.1.3.1) (N. Harnpornchai&K. Autchariyapanitkul, 2016).

Given

$\theta = [\theta_1 ... \theta_p]$ is a vector of the parameters $\theta_j; j = 1,..., p$

where

p is the total number of the parameters that were calculated.

The method runs as follow

1). Draw an individual θ_{l+1} from $q(\theta_{l+1} \mid \theta_l; l = 1,..., M)$

2.) Accept the individual θ_{l+1} with the probability of $\alpha(\theta_l, \theta_{l+1})$; otherwise set $\theta_{l+1} = \theta_t$

Therefore, the probability of acceptance is

$$\alpha(\theta_l, \theta_{l+1}) = \min\left(\frac{\pi(\theta_l + 1) / q(\theta_{l+1} \mid \theta_l)}{\pi(\theta_l) / q(\theta_l \mid \theta_{l+1})}, l\right) \tag{2.1.4.1}$$

The independent density, regard a probability density function (PDF), the next individual does not depend on the current one: $q(\theta_{l+1}) = q(\theta_{l+1})$

Refer to the independent density, the probability of acceptance is

1.) Draw an individual θ_{l+1} from $q(\theta_{l+1})$

2.) Accept the individual θ_{l+1} with the probability of $\alpha(\theta_l, \theta_{l+1})$.

and the probability of acceptance is

$$\alpha(\theta_l, \theta_{l+1}) = \min\left(\frac{\pi(\theta_l + 1) / q(\theta_{l+1})}{\pi(\theta_l) / q(\theta_l)}, l\right) \tag{2.1.4.2}$$

2.2 Literature Review

Menges (1992) studied Stochastic modelling of extinction in plant population. Population viability analyses (predicting the future of small populations) have developed concepts relating largely to genetic threats, although environmental and demographic factors may be of greater immediate concern. Using twenty-eight published empirically derived projection matrices of various perennial herbs and trees, I model the behaviour of plant populations by introducing temporal variation (stochasticity) in demographic parameters (mortality, growth, reproductive status, and reproductive output) into matrix projections of stage-structured populations. Stochastic modelling of population behaviour allows estimation of extinction probabilities and minimum viable population.

Katsamaki and Skiadas (1995) studied Analytic Solution and Estimation of Parameter on Stochastic Exponential Model for a Technological Diffusion Process. In their paper "r" we examine the behaviour of a stochastic model that describes a technological diffusion process continuously increasing process). Furthermore, they obtain a solution for the proposed model through the estimation of the volatility using three different approximations. The adjustment of real data to the final stochastic model confirms its ability to describe and forecasting real cases.

Barreto and de Andrade (2000) studied Bayesian inference, and Markov Chain Monte Carlo Methods applied to streamflow forecasting. In this work, they propose a Bayesian approach for the parameter estimation problem of stochastic autoregressive models of order p, AR (p), applied to the streamflow forecasting problem. Procedures for model selection, forecasting and robustness evaluation through Monte Carlo Markov Chain (MCMC) simulation techniques are also presented. The proposed approach is compared with the classical one by Box-Jenkins (maximum likelihood estimation) on a monthly streamflow time series from Furnas reservoir. They conclude that the use of Bayesian statistics and MCMC simulation gives more flexibility and powerful results than those obtained from the classical approach.

Ruiz-Gómez, Ruiz-Gómez, and Martínez Morillo (2006), they studied stochastic modelling for a better approach of the in vitro observed growth of colon adenocarcinoma cells. The definition of a stochastic model that reflects the cell growth and the use of computer software could be very useful in modelling the cell behaviour due to the possibility to introduce alterations in biology parameters to obtain different growth patterns without the use of laboratory material. Human colon adenocarcinoma cells were cultured, and a growth curve was made by a daily count of the cell number. Pielou modelling was applied for stochastic simulation of deterministic growth, making stochastic the cell division, the death rates and the transition time between division and death, by using different probabilities. A greater growth was produced when the cell division rate increased, considering the density dependence constant. By contrast, a lower growth was observed when density dependence increased, with a constant value of cell division rate. This type of modelling could be useful to simulate the cell response under different environmental conditions.

Araveeporn (2011) studied the Estimation of Bayes Estimator with WinBUGS Program. WinBUGS is statistical software to estimate Bayes estimator using Markov Chain Monte Carlo (MCMC) method. For parameter estimation, the Bayesian estimator is one method to use over a wide range because there is a prior distribution to evaluate parameter. However, this method is rather complicated to be proved in the form of the distribution function, but WinBUGS program can help to calculate Bayes estimator from the posterior distribution. Therefore the user can estimate parameter without proving in order to know the distribution function.

Morteza Khodabin, Maleknejad, Rostami, and Nouri (2011) studied Numerical solution of stochastic differential equations by second order Runge–Kutta methods. In their paper, they propose the numerical solutions of stochastic initial value problems via random Runge–Kutta methods of the second order and mean square convergence of these methods is proved. A random mean value theorem is required and established. The concept of the mean square modulus of continuity is also introduced. Expectation and variance of the approximating process are computed. Numerical examples show that the approximate solutions have a good degree of accuracy.

M Khodabin et al. (2012) studied Interpolation solution in generalized stochastic exponential population growth model. In the paper, first they consider a model of exponential population growth, then they assume that the growth rate at time t is not completely definite and it depends on some random environmental effects. In that case, the stochastic exponential population growth model is introduced. Also, they assume that the growth rate at time t depends on many different random environment effects, in this case, the generalized stochastic exponential population growth model is introduced. The expectations and variances of solutions are obtained. In a case study, they consider the population growth of Iran and obtain the output of models for this data and predict the population individuals in each year.

Sauer (2012) studied Numerical Solution of Stochastic Differential Equations in Finance. This chapter is an introduction and survey of numerical solution methods for stochastic differential equations. The solutions will be continuous stochastic processes that represent diffusive dynamics, a common modelling assumption for financial systems. He includes a review of fundamental concepts, a description of elementary numerical methods and the concepts of convergence and order for stochastic differential equation solvers. In the remainder of the chapter, he describes applications of SDE solvers to Monte-Carlo sampling for financial pricing of derivatives. Monte-Carlo simulation can be computationally inefficient in its basic form, and so he explores some common methods for fostering efficiency by variance reduction and the use of quasi-random numbers. In addition, he briefly discusses the extension of SDE solvers to coupled systems driven by correlated noise, which is applicable to multiple asset markets.

Iyer-Biswas, Crooks, Scherer, and Dinner (2014) studied Universality in Stochastic Exponential Growth. Recent imaging data for single bacterial cells reveal that their mean sizes grow exponentially in time and that their size distributions collapse to a single curve when rescaled by their means. An analogous result holds for the division-time distributions. A model is needed to delineate the minimal requirements for these scaling behaviours. They formulate a microscopic theory of stochastic exponential growth as a Master Equation that accounts for these observations, in contrast to existing quantitative models of stochastic exponential growth (e.g., the Black-Scholes equation or geometric Brownian motion). Their model, the stochastic Hinshelwood cycle (SHC), is an autocatalytic reaction cycle in which each molecular species catalyzes the production of the next. By finding exact analytical solutions to the SHC and the corresponding first passage time problem, they uncover universal signatures of fluctuations in exponential growth and division. The model makes minimal assumptions, and they describe how more complex reaction networks can reduce to such a cycle. They thus expect similar scaling to be discovered in stochastic processes resulting in exponential growth that appear in diverse contexts such as cosmology, finance, technology, and population growth.

Akinbo, Faniran, and Ayoola (2015) studied Numerical Solution of Stochastic Differential Equations, and this paper provides an introduction to the main concepts and techniques necessary for someone who wishes to carry out numerical experiments involving Stochastic Differential Equation (SDE). As SDEs are frictionless generally and the solutions are a continuous stochastic process that represents diffusive dynamic especially in finance, it is required of us to take into account random effects and influences in real-world systems which are essential in the accurate description of such situations.

Anderson, Rubenstein, Guinan, and Patel (2015), they studied Oncogenic mutational/epigenetic events: Deterministic, stochastic or random: Implications for hypoxic cancer cells and tumour heterogeneity. Many cancers have been characterized by their expression of multiple “driver” oncogenes. This implies a sequence of crucial developmental “decisions” required to implement an oncogenic “program”. Are all or at least most of these decisions deterministic and others "stochastic" in implementation? Certain inborn errors of metabolism and hereditary cancers are largely deterministic. And yet to account for the widespread differences in detail of gene expression within and between cancer cells from different regions of the same cancer, to what extent are these variations at a fine-grained level subject to "decision trees" or "nodes" that may often depend upon stochastic events, engrafted on to more fundamental cell, tissue, organ or unfolding aberrant cancer-oriented deterministic programs? Considering that many epithelial cancers develop over a number of years, does an admixture of determinative and stochastic decision-events contribute to a protracted maturation of epithelial cancers? The potential effect of cellular stress such as that due to hypoxia on the outcomes from stochastic events is uncertain. They consider some of these questions, employing a differential – logistic Monte Carlo simulation with continued stochastic input to a fixed carrying capacity, K, of slowly and rapidly proliferating daughter cancer cells as a visual model for this discussion.