CHAPTER 4

Empirical results

The study of model and forecast the sky train ridership analyzes the secondary data which is the monthly data of the BTS or sky train ridership from January in 2011 to December in 2016, consisting of 72 observations collected from the Bangkok Mass Transit System Public Company. However, this research limits the scope of the study as in BTS ridership due to limited availability of data, and it has enough data that will be useful for the public good or public services.

There are two purposes of this study. That is, to model a public rail transportation use in Bangkok and to forecast the growth rate of ridership. So, the empirical results of this study divided into 2 parts with related to our purposes which detailed as follow:

4.1 Historical Data

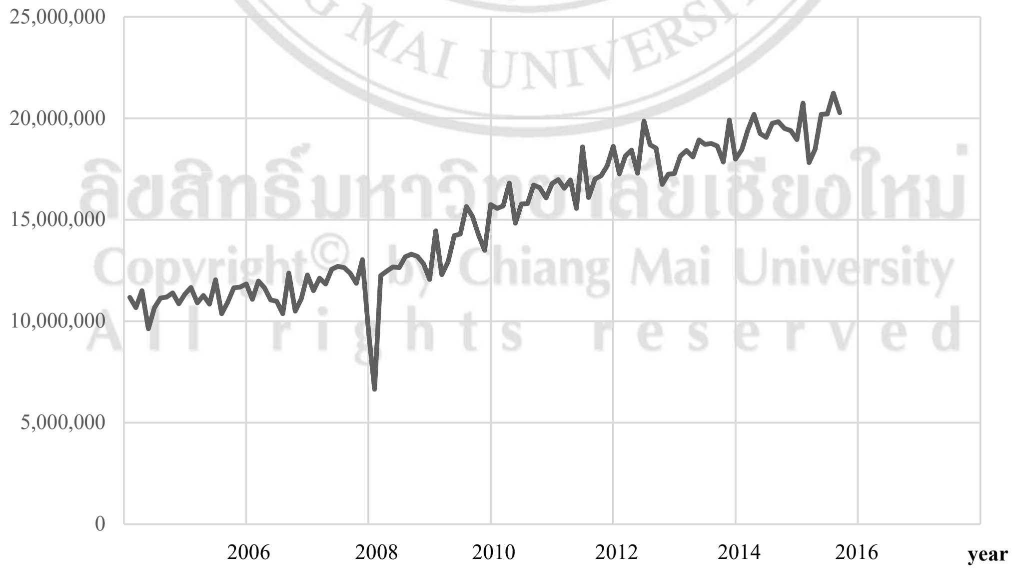

Figure 4.1 Annual user numbers of BTS

According to the past history data of BTS from 2006 to 2016 is shown in Figure 4.1, it can be seen that the growth in user numbers have exponential trends. In addition, there exists the uncertainty of growth. Consequently, the stochastic exponential growth model will be employed to model the temporal variation of user numbers.

From the information of Office of the National Economic and Social Development Board (2017) found that GDP growth rate is continuously increasing in 2016 has GDP growth rate at 3.2 percent. An increase in income has led to Bangkok's ridership has more power to pay for public rail transportation due to an increase in population and an expansion of economic. Therefore, the ridership will turn to use public rail transportation that is fast and convenient instead of road transportation.

Most of the area of BTS routes are in a central business district that has experienced continuous growth as it can we see in the condominium growth in the centre of Bangkok and the growth is still high. In 2017, CBRE (2017) reported that there is a condominium in city centre scheduled to sell 7,870 units. Moreover, this year will have as new projects up to 8,000 units more than last year. It can be useful for the BTS system that services the area in the central business district.

"Public transport is the backbone that will drive the process of economic growth"(Ngqaleni, 2016). From the study of Systematics and Group (2006) found that Investment in transportation, including public rail transit, supports jobs for the immediate project or activity and investment or spending by suppliers whose goods and services are used in the project or activity also supports jobs. These investments provide business revenue and personal income, and income is spent throughout the economy and supports other jobs. The economic stimulation brought about by increased personal and business income resulting from transit investment and use increases government revenues from increased sales taxes, income taxes and property taxes.

The factors leading the growth of the public rail transportation users. People will turn to use public rail transportation in order to reduce cost of transportation, save time to travel for faster than their personal vehicle, and also reduce pollution. From the people save time and cost lead to they will have more income or increase their saving. Furthermore, labors can easily access a market for a job.

The increasing in public transportations results from following factors; the travel cost savings, an improvements in public transportation services may lead to change in travel cost to existing public transportation ridership due to changes in fare structures associated with new services and change in travel cost for those shifting from automobile use due to the difference between public transportation fares and previously-paid vehicle operating costs including fuel, parking, toll, and maintenance expenses. Besides, travel time savings, improvements in public transportation services may lead to Time savings for the existing and new public transportation ridership due to improved services such as faster travel, reduced waiting or transfer times and Time savings for automobile and truck travelers on congested routes, who can now travel faster.

Using the public rail transportation will help to reduce cost of living and cost of transportation because people use public rail transportation instead of their own vehicles that help to save cost from fuel, toll, or maintenance expense. When workers in business turn to use public rail transportation instead of business's cars, it will help business reduce cost of fuel and maintenance expense.

Moreover, an infrastructure such as utilities, transport, telecommunications, and, etc. as well as a property in an urban induces people using public transports. Since a capitalization of the access cost savings and travel time savings associated with those locations.

An urbanization that is the heart of the country's investment and development lead to economy growth. Thus, people will move from rural area to urban area for finding their jobs to make their income. The progress of urban area face many problem such as public utility, traffic jam, pollution, poverty, crime, crowed, and etc. But, it obviously seen that the traffic jam is the main problem that effect to the people unavoidably, therefore people will use public rail transportation instead of their own vehicles for avoiding traffic jam and maybe faster than use their own vehicles.

Therefore, to know the growth rate of public rail transportation user trend is important for economic and urban planning in order to support the users or ridership in the future. Moreover, the obtained user growth rate can be used as a guideline to determine the service capacity or for planning of new and similar characteristic routes for more efficient and effective.

4.2 Parameter Estimation Using MCMC

This study is going to model the growth rate of public rail transportation use in Bangkok based on the historical data, this study will apply the exponential solution of stochastic differential equation from a standard Brownian motion and determine the parameters of the model from the Bayesian inference which are the growth rate (μ) and diffusion term (σ)

The inference applies the following priors:

$$f(\mu,\sigma) = f(\mu) f(\sigma) \tag{4.2.1}$$

, where

$$f(\mu) = N(0.05,1) \tag{4.2.2}$$

$$f(\sigma) = INVGAMMA(1,1) \tag{4.2.3}$$

It is free to choose the prior but, in this model, for the sigma must greater than or equal to zero, so it has to choose the prior that have a positive value. Therefore, it will use inverse gamma to apply in this model.

Total number of realizations is 1,000,000 with the 10,000-realization burn-in. The histogram corresponding to the marginal posterior distribution of each parameter is shown in Figure 4.2 and Figure 4.3, respectively.

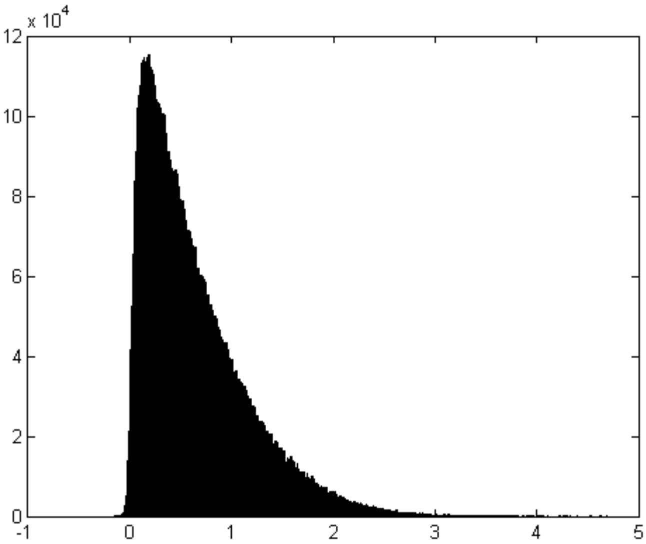

Figure 4.2: Histogram of μ with the sample size of 10,000.

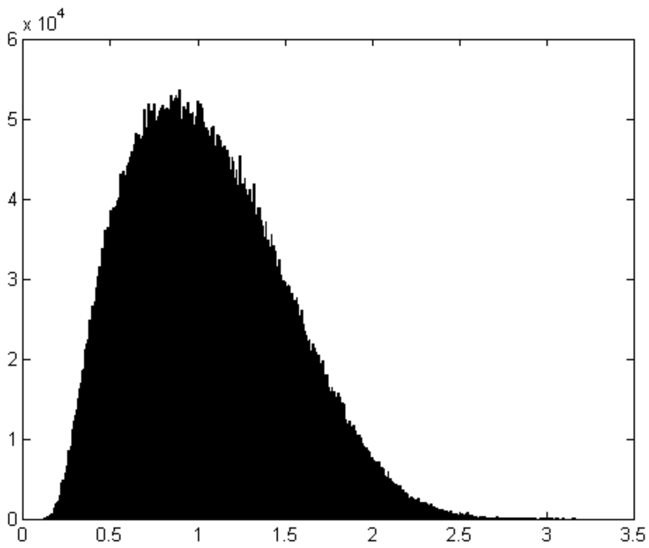

Figure 4.3: Histogram of σ with the sample size of 10,000.

When applying MCMC, the convergence to the target density function must be validated. Accordingly, the trace plot, running mean plot, and autocorrelation plot of respective inferred parameters are performed for the purpose of the convergence diagnostic. The results are graphically given in Figure 4.4 and Figure 4.5, respectively.

When the mean is taken as the estimate, the following values are obtained:

$$\hat{\mu} = 0.6381 \quad (4.2.4)$$

$$\hat{\sigma} = 1.0539 \quad (4.2.5)$$

$\hat{\mu}$ signifies the growth rate of ridership has a growth rate average 0.6381 percent per year whereas $\hat{\sigma}$ implies the degree of fluctuation in the model that the value is obtained 1.0539 percent.

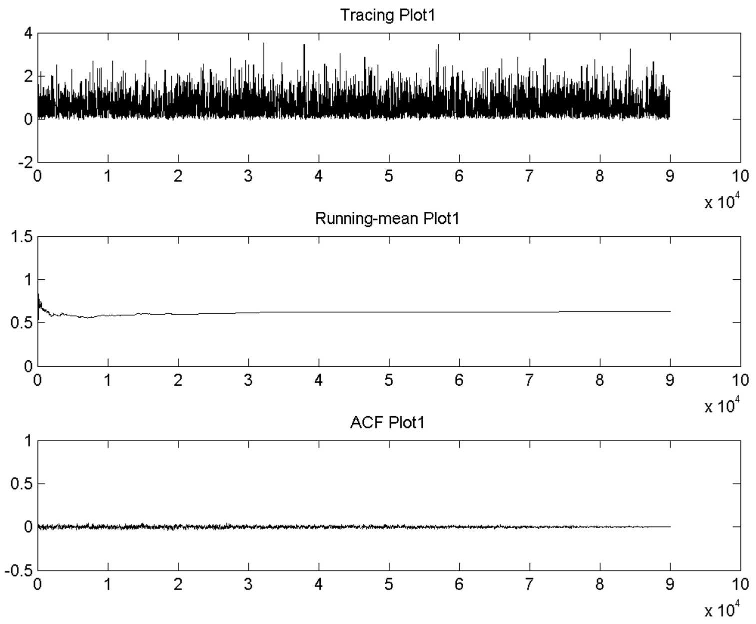

Figure 4.4: Convergence diagnostic of μ trace plot, running mean plot, autocorrelation plot.

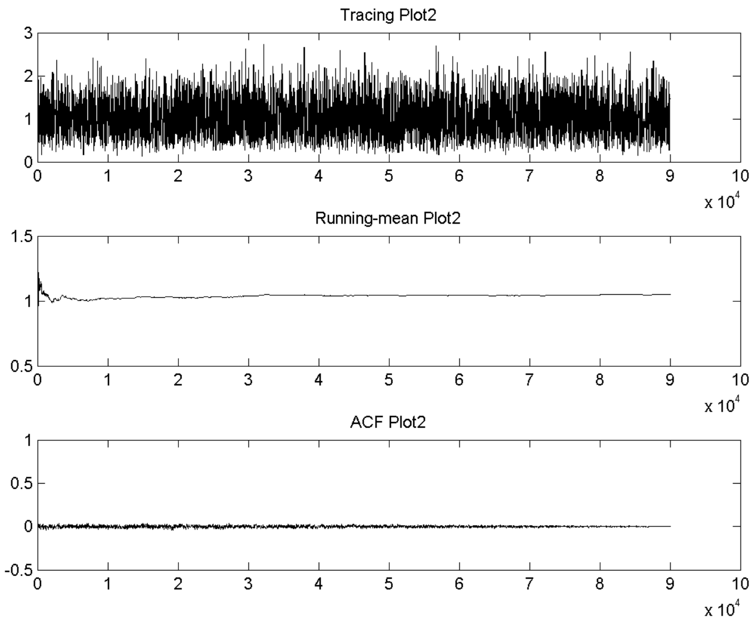

Figure 4.5: Convergence diagnostic of σ trace plot, running mean plot, autocorrelation plot.

The trace plot, running mean plot, autocorrelation function plot use for checked the convergence of diagnostic of the parameters identification. The trace plot and running mean plot in all cases indicate the good-mixing behaviour of the simulated chain. The autocorrelation associated with each parameter is considerably reducing for higher values of lag. This indicates a low degree of correlation among samples. The independence among sample-size can be thus accepted.

4.3 Forecasting the Ridership

Based on the estimates of model parameters, Monte Carlo simulation is applied to obtain the sample paths. Monte Carlo simulation is a method which is applied to simulate a probability apace by taking independent samples from the space regarding the probability distribution. By using MCMC simulation, we obtain Figure 4.5 which shows Five sample paths.

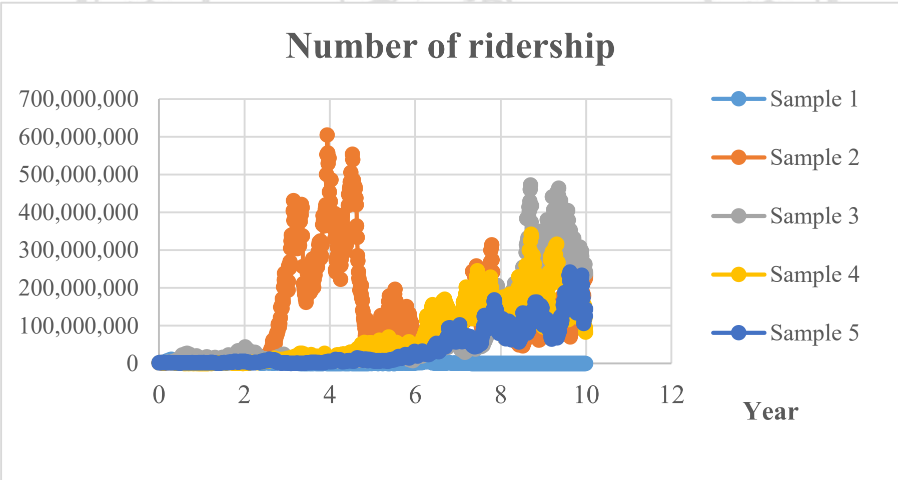

Figure 4.6: Five sample paths from Monte Carlo simulation.

Figure 4.6 shows the uncertainty due to Brownian motion is exhibited through the fluctuation in the evolution. Therefore, at a specific time moment, there can be a different value of ridership each of with as a particular probability of occurrence.

For example, the probabilistic prediction of the use at time t is $P[St \geq s]$, where s is the threshold value. The computation of such a probability, Monte Carlo simulation is applied again, i.e.

$$P[S_t \geq s] = \frac{1}{N_{sim}} \sum_{i=1}^{Nsim} I[g(S_t)] \tag{4.3.1}$$

, where $$I[g(S_t)] = \begin{cases} 1 & ; S_t \geq s \\ 0 & ; S_t < s; \end{cases} \quad (4.3.2)$$

For example, if it is interested in the event that what the probability that the number of ridership at year 10 after 2016 will exceed the threshold 1.8x10^6, then the probabilistic prediction is $P[S_{10} \geq 1.8\text{x}10^6]$. Using the Monte Carlo simulation, the prediction is $P[S_{10} \geq 1.8 \times 10^6] = 0.097$.

The mean of annual ridership from 10 years after 2016 is shown in Figure 4.7.

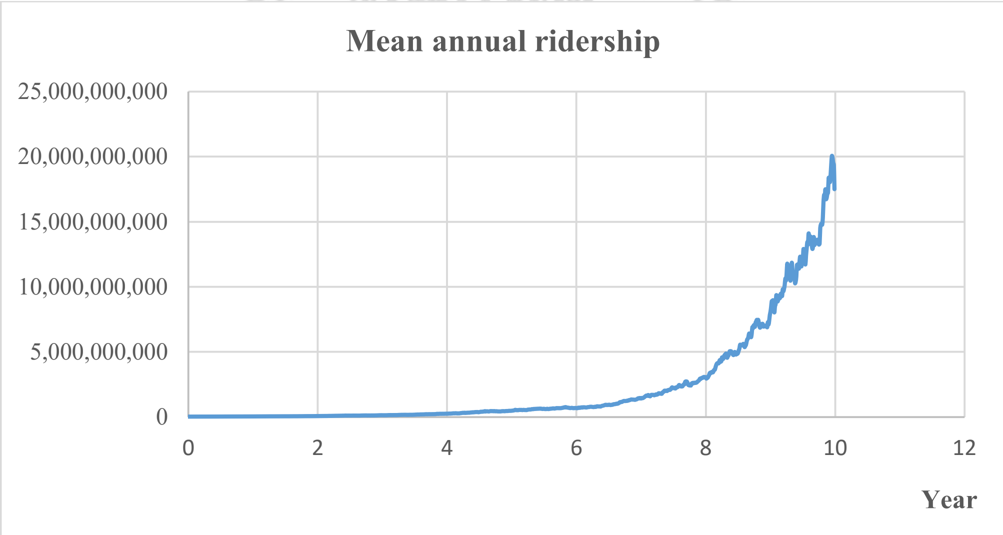

Figure 4.7 Mean annual ridership.

Figure 4.7 shows the mean annual ridership at different times. Growth in ridership is an exponential trend as can we see in the figure but there is still uncertainty in the growth. This indicates that in 10 years, maybe the ridership can be better than this capacity or not. The decision maker can use the prediction for planning an investment. For example, if the design capacity is at 5.0x10^9, then BTS should increase the service capacity or the infrastructure to accommodate the increasing number of ridership before year 9 after 2016, or in 2025.