CHAPTER 1

INTRODUCTION

1.1. Background of the Study

Bond market in Indonesia plays an important role Indonesia overall economy. It is an integral part of Indonesia financial market in order to help to drive the economic growth. One important role is to cover the budget deficit which are funded by the issuance debt securities both in domestic and foreign currency. As per August 2019, total government debt securities are Rp 3,874 trillion with 74% are in Rupiah denominated currency. The government is taking a large part of overall business activity in one country. Risk taking over the business cycle is influenced by monetary policy and macroprudential policies such as regulations and taxes (Cociuba, et al., 2019)

Indonesia bond market consist of two main sectors, the government bond and corporate bond. Government bond dominates the Indonesia bond market in terms of outstanding nominal issue, market capitalization, and trading activity. The main instruments are fixed rate (FR), retail bond (ORI), zero coupon bond (ZC), treasury bills (SPN) and variable rate (VR). The total issuance comparison between government bond and corporate bond usually between 75% and 25% respectively (Kemenkeu, 2017), thus it important to focus on the government bond due to market domination.

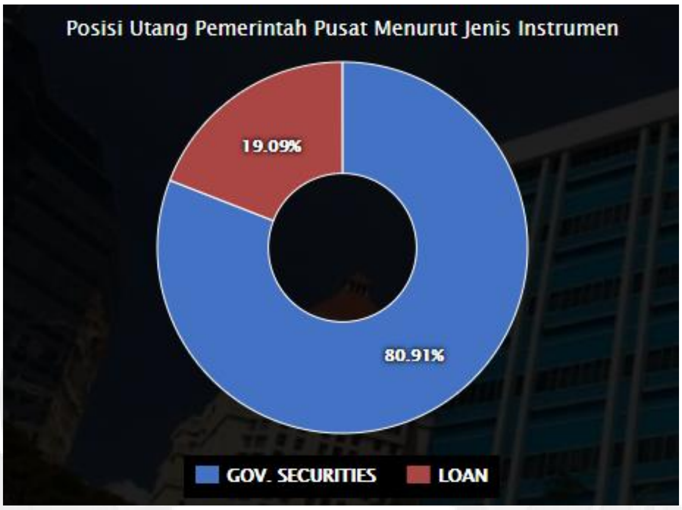


Figure 1. Government Debt Position (Source: DJPPR Kemenkeu)

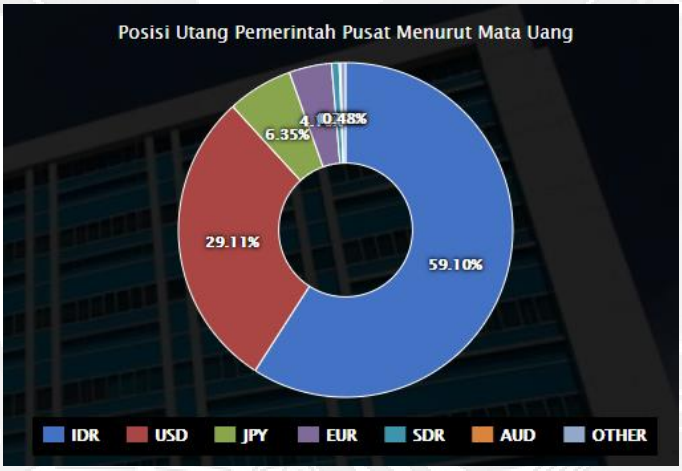


Figure 2. Government Debt Position By Currency (Source: DJPPR Kemenkeu)

Mata Uang	Jenis Instrumen	eq. Ori	eq. USD	eq. IDR
IDR	GOV. SECURITIES	2,279,647.66	168.96	2,279,647.66
	LOAN	5,527.26	0.41	5,527.26
		2,285,174.91	169.37	2,285,174.91
USD	GOV. SECURITIES	51.45	51.45	694,163.40
	LOAN	31.96	31.96	431,228.30
		83.41	83.41	1,125,391.70
JPY	GOV. SECURITIES	455.00	4.04	54,509.55
	LOAN	1,594.13	14.16	190,978.94
		2,049.13	18.20	245,488.49
EUR	GOV. SECURITIES	6.30	7.42	100,138.06
	LOAN	3.68	4.34	58,564.01
		9.98	11.76	158,702.07
SDR	LOAN	1.48	2.09	28,203.03
		1.48	2.09	28,203.03
AUD	LOAN	0.48	0.38	5,063.61
		0.48	0.38	5,063.61
OTHER	LOAN	225.70	1.37	18,427.02
TOTAL			286.57	3,866,450.83

Figure 3. Government Debt Position by Currency (Source: DJPPR Kemenkeu)

Government bond not only traded in primary market, but also in secondary market. The existence of secondary market that has liquidity helps market participants to manage their risk and return profile (Dajcman, 2015). While the primary market is the primary source of government budget funding, the secondary market provide liquidity for the investors. An active and liquid secondary market is one of a positive signs signaling the economy is doing well (Caceres & Unsal, 2013).

In order to support both primary and secondary market, the yield curve and term structure of interest rate should be established. The yield curve of government bond plays a central role in pricing financial assets and form market expectation on the economy. It is also having great importance to build an accurate discount curve in order to give better fair value forecast in the individual bond market as for the market reference. Therefore, accurately estimating and forecasting yield curve has great importance for Central Bank, Ministry of Finance and market participants. In the recent study, there are causal link between bond yield curve that is specified by the Nelson-Siegel model and the equity markets (Parker, 2017). To capture the relationship between real sector, equity and bond market; panel causality testing approached was used to find the causal relationship (Durusu, 2019).

Accurately fitting the yield curve is an important topic in finance that has received considerable attention in past decade. There are three classes of curve fitting technique: The Spline method, non arbitrage method and parametric method. Development of the last method is mainly based on research by Nelson Siegel in 1987. The Nelson Siegel based family is the most common model used in reconstructing the yield curve that use by central banks especially in the developed market for instance central banks of European Central Bank, South Korea, Belgium, Finland, France, Germany, Italy, Norway, Spain, and Switzerland.

Yield curve contruction in Indonesia is also using the Nelson Siegel family that is based on Svensson method which the theory was established in 1994. Government of Indonesia has appointed Indonesia Bond Price Agency or IBPA as the official mandated body from Indonesia government to assess and determine the fair market price of debt securities. Fair market price data for debt securities issued by IBPA are used by the financial industry as a reference for debt securities transactions, asset valuation, reference to auction of state debt securities, references in audit activities, and references in portfolio performance assessment. IBPA has done extensive effort and has been successfully led as the sole bond pricing and yield curve in Indonesia. However due to generic Svensson model that have been widely use globally, IBPA has tighter opportunity to develop the generic model.

1.1.1. Term Structure of Interest Rate Theory Evolution

Understanding the relationship between interest rate and yield curve is a prerequisite for developing financial theory and evaluating whether it holds up in the real world (Arouba, 2019). Thus, accurately fitting the yield curve is the backbone of a full functioning financial market therefore the observation of various model for estimating and predicting the yield curve is an important topic in finance that has received large attention from researcher aroud the globe (Dovis, 2019).

The yield curve itself is the graphical repsentation of the term structure of interest rate, therefore those two are acrononim to each other. In this dissertation, I will use the yield curve as the important term. The yield curve contains information about the yield of zero-coupon bonds of various maturities at certain date (Alfeus, et al., 2020). The process of contructing yield curve is a not straight forward process due to limitation on the zero-coupon bonds on the market which are the essential ingredient of yield curve. In fact, majority of bonds traded in the market bear coupons. The yield to maturity on coupon bonds in which has different maturities and coupons are not direcly comparable to each other. As a result, a method that uniform is needed in order to obtain yield curve. The spot interest rate or the yields earned on bond that pay no coupon must be estimated from coupon bond prices with different maturities by using several method that been developed in three major groups, such as Spline method, non Arbitrage method and Nelson Siegel family method (Nelson & Siegel, 1987; Diebold, et al., 2007; McCulloch, 1975; Fisher, et al., 1995).

The first well known method is Spline method. Basically, the Spline model is arranged by the piecewise polynomial method (or also called the spline function), when there are several individual segments arranged together. The initial Spline method was developed by the cubic spline method (McCulloch, 1971; McCulloch, 1975) when the yield curve of the zero-coupon bond is divided into several intervals. McCulloh is a pioneer in the field of yield curve modeling using the spline method with a simple approach. The developed model parameterizes the present value function as cubic spline and provides term structure estimation through simple linear regression. Further development is made by Fisher, Nyckha and Zervos. They developed a better technique for smoothing the spline curve without including the penalty factor of "excess roughness" in the extraction of forward rate curves. The roughness penalty factor is used as a constant for all maturities so that the results of the spline become firmer or in other words reduce the possibility of swinging (Fisher, et al., 1995). However, FNZ method also has a weakness that is the accuracy will be slightly reduced due to the roughness penalty which is used as a constant has the tendency of price errors in short-term bonds (Bliss, 1996). Bliss stated that shortages in the short term resulted in the flexibility of the FNZ method being more limited so that it would affect the modeling of the yield curve. In order to solve such problem, Waggoner in 1997 proposed the same method as that of FNZ in cubic spline modeling in the approximation of the forward rate function. But in applying penalties, Waggoner uses a different approach, namely a different penalty value for each maturity and the use of three tier step-wise functions to refine the curve.

The second model is based on Non-Arbitrage studies. Non-arbitrage model has the main goal that the curve is strived as precisely as possible at a certain point so that there is no possibility of an opportunity for arbitration. This theory was developed by Hull and White (1990) and Heath et al. (1992). The first study was conducted by Vasicek in 1977. The term structure of interest rate regulates the relationship between the yields of default free bonds that have different maturity schedules. With the availability of large-scale bonds at different maturity schedules, yield curves can be arranged which will be able to predict future economic events. Further research was developed by Cox, Ingersoll and Rand (CIR) in 1985. CIR approached the rational price valuation of assets to study the term structure. With this research, CIR provides a simple solution which involves various economic variables. The model developed by CIR is an important tool in valuing European bonds and call options. Further development was carried out by John Hull and Alan White in 1990. Research based on the one-state-variable Vasicek and CIR models can be extended so that they can be consistent both for the term structure of interest rate, spot interest rate volatility and for forward interest volatility rate. Subsequent research was conducted by David Heath, Robert Jarrow and Andrew Morton in

1992. The focus of this research is a new method for solving problems of assessing interest rate contingent claims from various zero-coupon bonds. The fundamental difference between this method and the CIR method in contingent claim valuation on the yield curve is that this model uses an existing forward rate curve and the arbitrage price valuation is built with that curve. Thus, this model does not depend on market risk factors. Duffie and Kan (1996) provide seminal research where a modeling of interest rate approaches for all due dates was a linear function (affine) of a small number on underlying factors. Affine term structure model consists of dynamic models of time series dimensions and cross section dimensions. De Jong through his publication in 2000 tested the affine model of Duffie and Kan with the test was conducted with a database of US month bonds. The method that combines time series and cross sectional can be concluded theoretically consistent (de Jong, 1997). Affine term structure models (ATSM) which had previously been developed by Duffie and Kan (1996) and De Jong (2000), followed by studies conducted by Qiang Dai and Kenneth Singleton in 2000.

1.1.3. Nelson Siegel Family

The third model is Nelson Siegel family that based on seminal study by Charles Nelson and Andrew Siegel in 1987. This model is a parametric model that has several factors that describes the important component in yield curve, such as: flat, hump and S shapes. Nelson Siegel is one of the most common models in reconstructing the yield curve with the summary below from BIS (2005):

Table 1. Common Yield Curve Model by Countries (Source: Bank of International Settlement)

Central Bank	Yield Curve Model
Finland	Nelson Siegel
Italy	Nelson Siegel
Belgium	Nelson Siegel-Svennson
Canada	Nelson Siegel-Svennson
France	Nelson Siegel-Svennson
Germany	Nelson Siegel-Svennson
Norwegia	Nelson Siegel-Svennson
Spain	Nelson Siegel-Svennson
UK	Nelson Siegel-Svennson
Switzerland	Nelson Siegel-Svennson
EU	Nelson Siegel-Svennson
USA	Fisher, Nychka, Zervos (Spline)
Japan	Fisher, Nychka, Zervos (Spline)
Sweden	Fisher, Nychka, Zervos (Spline)

Nelson and Siegel introduced a simple parsimonius model which can adapt easily to the range of shapes of yield curves (ie flat, humped and S shape). Nelson Siegel model is relatively efficient in capturing the general shapes of yield curve, thus it is applicable is most cases and extensively been used by central banks and market practitioners. Next model was developed by Svensson in 1994. Basically, Svennson adding adding an extra exponential term to increase the fit and flexibility of the yield curve. This extra term provides the capability of possible hump in the yield curve. Despite the popularity among central banks, the Svensson model has number of weakness such as limited ability to adapt irregular shapes of yield curve, a relatively strong dependence on the estimation on different segments of yield curve and tendency to take extreme value at the bottom of the curve (Marciniak, 2006).

In order to solve the problem of Svensson model, the next development was conducted by Diebold and Li in 2006. The main purpose of this development is to get better fit on the yield curve, especially in the longer term of the curve. They showed that three factors presented in Nelson Siegel model can be interpreted as level, slope and curvature. Diebold, Rudebusch and Aruoba in 2006 combined the Diebold Li model with macroeconomic variable to analyze the relationship between the economy and yield curve. And furthermore, Diebold et at (2008) extended the Diebold Li model into global context in which large sets of yield curves from various countries modeled and allowed country specific factors and global factors. Christensen et al (2011) added the arbitrage free restriction thus combining the classic Nelson Siegel and arbitrage free into arbitrage free Nelson Siegel (AFNS) model. Yu and Zivot in 2011 empirically tested Diebold Li model to be superior to other models in the out-of-sample forecast accuracy. De Rezende and Ferreira (2013) by using Brazilian bond market data compared in-sample and out-of-sample forecasting performance between four different Nelson Siegel family models.

To conclude above explanation, below is the three model in Nelson Siegel family that will be used and discussed further in this dissertation:

Table 2 Nelson Siegel Model Development

Model	Equation
Nelson Siegel (1987)	$S_m = \beta_1 + \beta_2 \frac{1 - \exp\left(\frac{-\tau_1}{\lambda}\right)}{\frac{m}{\lambda}} + \beta_3 \left(\frac{1 - \exp\left(\frac{-\tau_1}{\lambda}\right)}{\frac{m}{\lambda}} - \exp\left(\frac{-\tau_1}{\lambda}\right) \right)$
Nelson Siegel Svensson (1994)	$S_m = \beta_1 + \beta_2 \frac{1-\exp\left(\frac{-\tau_1}{\lambda}\right)}{\frac{\tau_1}{\lambda}} + \beta_3 \left(\frac{1-\exp\left(\frac{-\tau_1}{\lambda}\right)}{\frac{\tau_1}{\lambda}} - \exp\left(\frac{-m}{\tau_1}\right) \right) + \beta_4 \left(\frac{1-\exp\left(\frac{-\tau_1}{\lambda}\right)}{\frac{\tau_1}{\lambda}} - \exp\left(\frac{-\tau_1}{\lambda}\right) \right)$
Dynamic Nelson Siegel (2006)	$S_m(\tau_1) = L_t + S_t \left(\frac{1 - e^{-\lambda \tau_1}}{\lambda \tau_1} \right) + C_t \left(\frac{1 - e^{-\lambda \tau_1}}{\lambda \tau_1} - e^{-\lambda \tau_1} \right) + \varepsilon_{i,m}$

Where:

S_m	= denotes the set of spot yield curve
$\beta_1, \beta_1, \beta_1$	= linear parameter
τ_1	= corresponding maturity
L_t	= level
S_t	= slope
C_t	= curvature
λ	= lambda

1.2. IBPA Yield Curve and Pricing

Indonesia Bond Price Agency or IBPA is the official mandated body from Indonesia government to assess and determine the fair market price of debt securities in Indonesia on daily basis. The fair price data that been released are used widely by financial industry as a reference for debt securities transactions, asset valuations, reference to auction of state debt securities, audit activities and portfolio performance assessment. Therefore, IBPA plays an important role in overall financial market scheme and has done extensive effort and has been successfully led as the sole bond pricing and yield curve in Indonesia.

In general, there are two policies in order to obtain fair market price and yield curve of Indonesia government bond:

a) The valuation of fair market prices uses a "mark-to-market" approach
b) If on that day there is no or limited trading data, then the valuation of fair market prices as the basis of the yield curve will use the scientific calculation method

IBPA overall process on building the yield curve is set by the comprehensive procedures that combines between mathemathical model and executive decisions. The following procedures is the complete step that was stated in IBPA White Paper (Indonesia Bond Pricing Agency, n.d.):

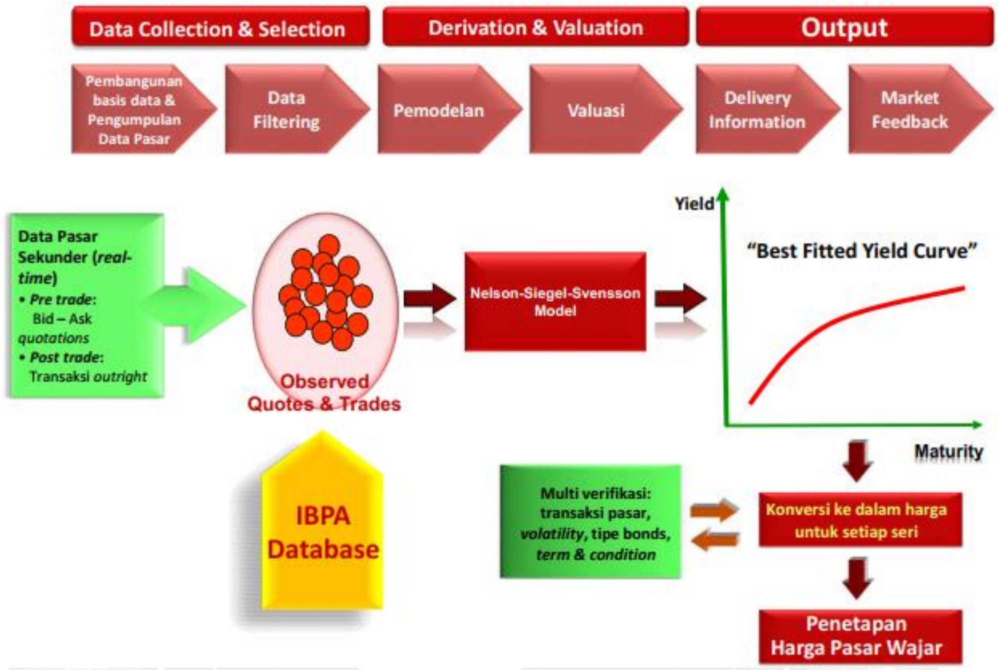


Figure 4 IBPA Yield Curve Process (Source: IBPA White Paper)

In general, IBPA has three important steps. The first step is data collection and selection that collects trading information from various sources and filtered out the outliers. The process of filtering out the price outlier is done by subjective analysis by IBPA analyst and to be decided by executive committee. The second step is modeling and fair price valuation. The model being used by IBPA is Nelson Siegel Svensson which also widely use by central banks. In the situation of illiquid market, some series of bond are sometimes are not traded on particular day. Therefore, interpolated yield is used in order to create the yield curve. Furthermore, the yield will be converted into fair value bond price with the classical fixed rate bond pricing. The last step is the output or publications that are provided by IBPA in various channels.

Since IBPA has followed international standard for the yield construction, bond pricing and implementation of Svensson model; IBPA has limitation on observing the other yield curve modeling. Therefore, in this dissertation, I dedicate to research the other yield curve modelling in order to find better pricing model especially in illiquid bond series. The subjective decision by IBPA analyst has known to be important part in overall yield curve building and pricing process. However, in this research I will to give different angel on the yield curve modeling to fill in the observation gap for Indonesia market. I hope my contribution from this research could bring development in more accurate bond pricing.

In this research, IBPA has also provided trade data information that will be widely use in modelling process. The sets of data are as follows:

1. Indonesia government bond yield curve: 2014 - 2019
2. Price and Yield Fixed Rate bond: 2014 - 2019

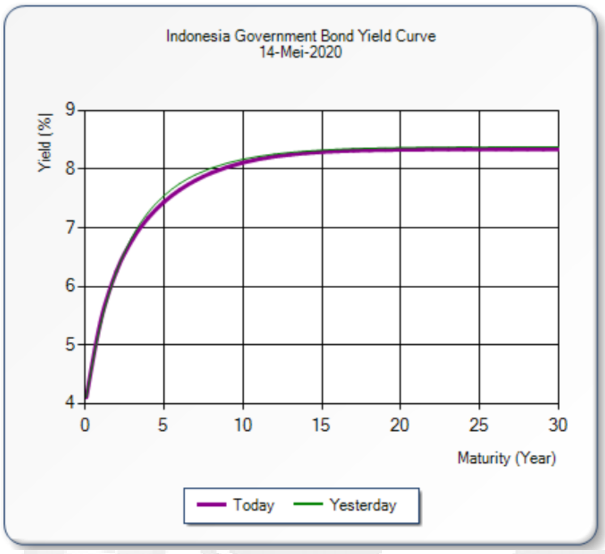
1.2.1. IBPA Historical Yield Curve and Pricing Performance

On daily basis, IBPA published Indonesia government bond yield curve and benchmark price on their website. The example of benchmark bond price and official yield curve shown at Figure 5 and Figure 6 (IBPA, 2020).

TTM (Years)	Series	Today		Yesterday		Coupon (%)
		Yield (%)	Price (%)	Yield (%)	Price (%)	
5.09	FR0081	7.1855	97.1131	7.2184	96.9761	6.5000
10.35	FR0082	7.8192	94.2500	7.8339	94.1500	7.0000
15.10	FR0080	8.0690	95.0750	8.1449	94.4449	7.5000
19.93	FR0083	8.0581	94.5000	8.1736	93.4196	7.5000

Figure 5. Example of IBPA Publication of Benchmark Bond Price (Source: IBPA Website)

HARGA DAN YIELD WAJAR OBLIGASI PEMERINTAH INDONESIA
SERI BENCHMARK



Tenor Year	Today	Yesterday	Tenor Year	Today	Yesterday
0.1	4.1065	4.1076	16.0	8.3079	8.3401
1.0	5.4021	5.3442	17.0	8.3177	8.3502
2.0	6.2536	6.2436	18.0	8.3248	8.3579
3.0	6.7942	6.8448	19.0	8.3299	8.3638
4.0	7.1661	7.2566	20.0	8.3335	8.3683
5.0	7.4388	7.5455	21.0	8.3361	8.3716
6.0	7.6472	7.7531	22.0	8.3379	8.3741
7.0	7.8096	7.9052	23.0	8.3392	8.3760
8.0	7.9368	8.0185	24.0	8.3401	8.3774
9.0	8.0362	8.1041	25.0	8.3407	8.3785
10.0	8.1132	8.1692	26.0	8.3411	8.3793
11.0	8.1723	8.2191	27.0	8.3414	8.3799
12.0	8.2171	8.2573	28.0	8.3416	8.3803
13.0	8.2508	8.2868	29.0	8.3418	8.3806
14.0	8.2759	8.3094	30.0	8.3419	8.3808
15.0	8.2944	8.3268			

Figure 6. Example of Govenment Bond Yield Curve (Source: IBPA Website)

Fair value or empirical value of bond price derived from the contractual future cash flow of the bond and to be discounted with the yield curve. Therefore, an accurate yield curve is very important aspect for the financial market. The official curve is being used for many financial market participants for their pricing purposes.

The pricing performance based on IBPA yield curves are shown in two figures as example. Researchers took two bond series, FR0059 as example from benchmark series as pictured in Figure 7 and FR0039 as example from non benchmark series as in Figure 8.

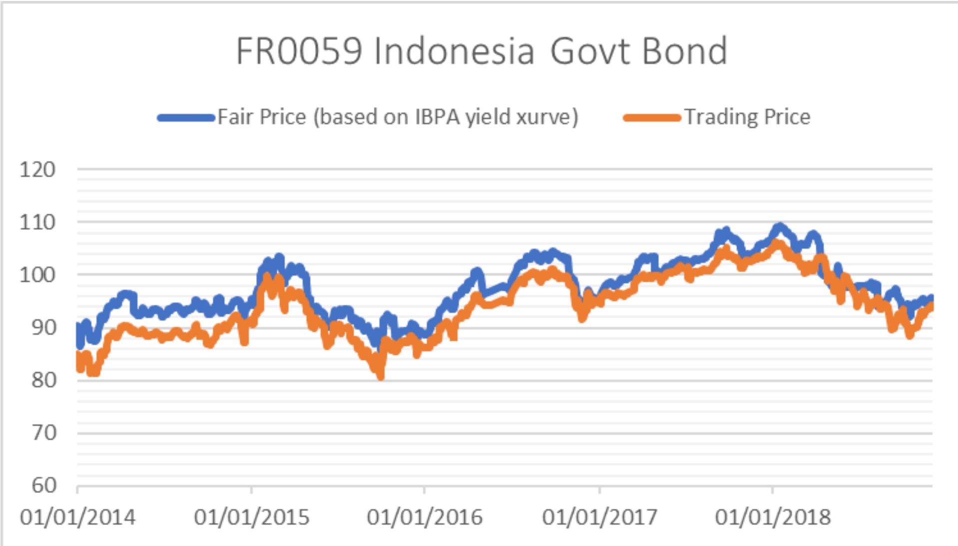


Figure 7. Pricing Performance Example - FR0059

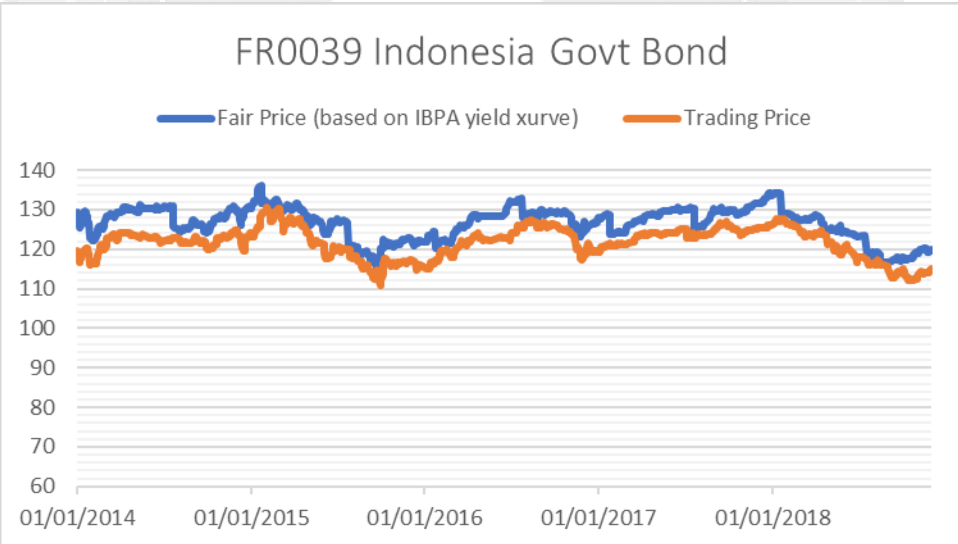


Figure 8. Pricing Performance Example - FR0039

1.3. Model Exploration for Bond Pricing

1.3.1. Observation Data

For the empirical analysis of this dissertation, Researcher used daily data consisting of bond prices of fixed rate series from the Republic Indonesia government bond. The dataset was mainly taken from IBPA and Bloomberg for daily bond price, bond yield and yield curve. The daily yield curve between 1 until

30 years and daily bond price were available since January 2014 until December 2019, thus will help the exploration of alternative model in researcher dissertation.

The observation of both benchmark and non benchmark bond should have legitimate comparison in bond price. In order to check the forecasting performance of such model, we will need sole pricing source in which for this dissertation researcher relied on Himdasun (Perhimpunan Pedagang Surat Utang) daily government bond price and Bloomberg data from Ministry of Finance. Himdasun was started in April 2002 whereby Bank Indonesia, Bapepam, State Bond Management Center, Bursa Efek Surabaya recommend establishment of Inter Dealer Market. In 18 March 2003, Himdasun is officially formed as association whose business activities are as Government Bond operator.

Table 3. Data Source

Data	Range	Source
Indonesia Yield Curve	January 2014 - December 2019	IBPA
Fixed Rate bond price	January 2014 - December 2019	IBPA, Bloomberg
Fixed Rate bond yield	January 2014 - December 2019	IBPA, Bloomberg
End of day trading price	January 2014 - December 2019	Himdasun

1.3.2. Workflow of Model Observation

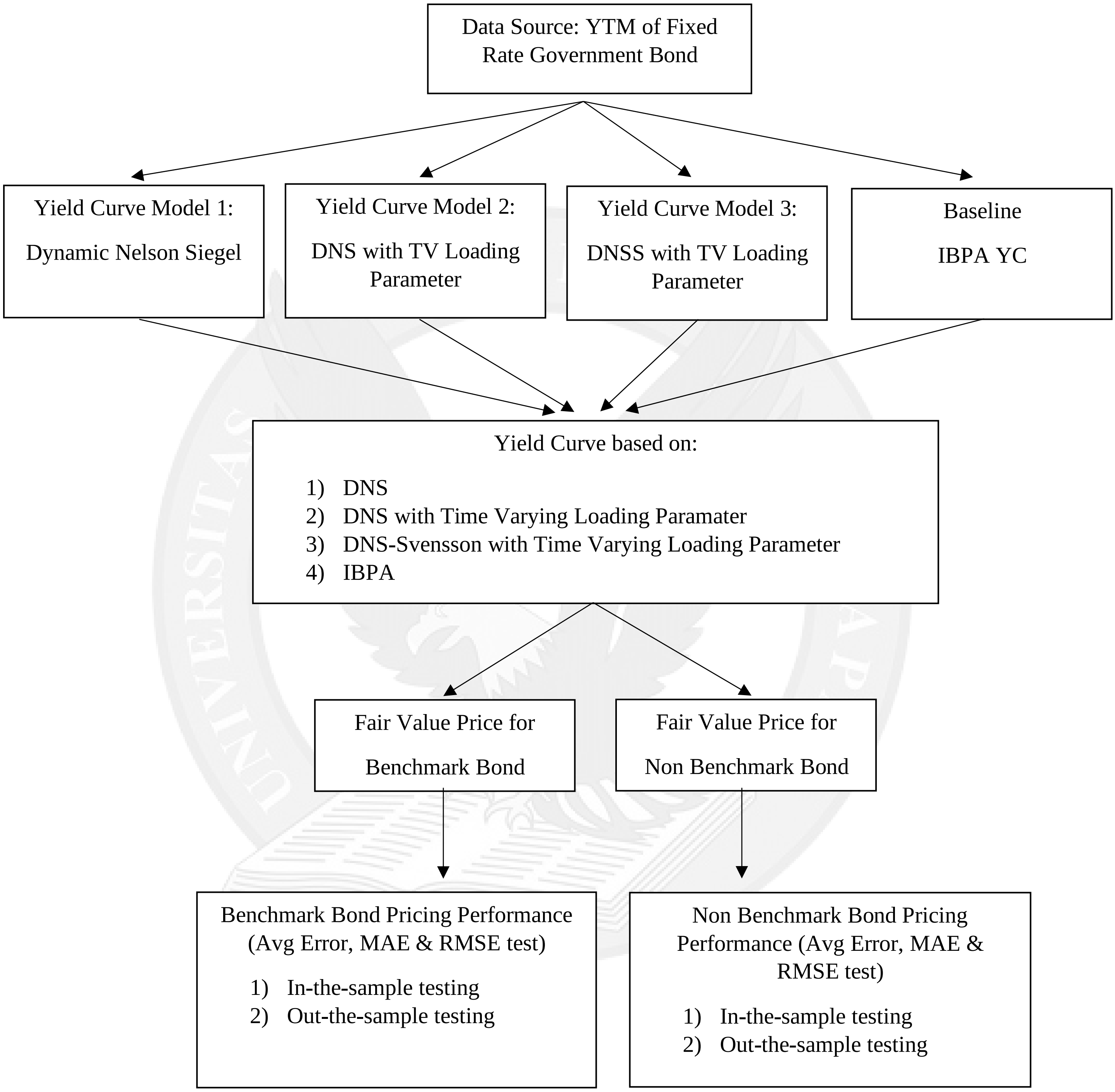


Figure 9. Workflow of Research

Figure 9 shown the overall process under this dissertation. On first step, researcher prepared YTM data for all maturities that sourced from Ministry of

Finance. The YTM data further being used as the data input for three models, all data were being processed with Matlab. The result from Matlab software are level, yield, curvature, and dynamic lambda. Those values further being constructed into yield curve on every dates. The constructed yield curve data later would be the input for theoretical spot rates for discount factor in bond fair price calculation. And as for the comparison result, the fair price from each models will be compared to the trading price at every dates.

1.4. Problem Statement

The yield curve that published by IBPA has known as powerful as fair pricing tool for benchmark series. However, it shown less accurate as shown in Figure 8. Therefore, in this research, researcher would like to develop yield curve model in order to get better fair price performance that has stability for both benchmark and non benchmark IDR series of Indonesia government bonds.

The benchmark bonds and on the run bond series usually trade on higher frequency compared to the non benchmark bond. Thus, the price benchmark would be easy since it was taken directly from the last price or the most price traded in the market. However, for the non benchmark bond it widely known that it may not traded on particular day. Therefore, the fair price valuation would fill in this gap and this research would become important.

Researcher believe if the better fair value in both situation series could be established, the investor appetite will be improved and at the end would help overall liquidity in Indonesia bond market.

1.5. Research Questions

In order to find the better fair price valuation in IDR Fixed Rate series, several yield curve model should be made. To help the observation process, below are the research questions:

1. Research Question 1

   What is the fair price valuation result Model 1 - Dynamic Nelson Siegel (DNS) compared to actual trading price?

2. Research Question 2

   What is the fair price valuation result under Model 2 – Dynamic Nelson Siegel with Dynamic Lambda compared to actual trading price?

3. Research Question 3

   What is the fair price valuation result under Model 3 – Proposed Model compared to actual trading price?

4. Research Question 4

   What is the fair price valuation result under Baseline - IBPA yield curve Parameter compared to actual trading price?

5. Research Question 5

   How is the comparison or fair price valuation performance between Model 1, Model 2, Model 3 and Baseline?

1.6. Research Objective

Research objective of this dissertation is to examine yield curve model that is better than official Indonesia government bond yield curve in order to improve the fair price bond valuation performance. IBPA as the official mandated body has restriction to seek altenative model for yield curve method in which they are following Svensson method that are being adapted from South Korea market. Due to this restriction, researcher took initiatives to explore the other model as the altenative of Svensson model.

The focus of this dissertation is fair value price performance of which comparison between Model 1 - DNS, Model 2 - DNS with TVLP, proposed Model 3 - DNSS with TVLP and baseline model. Researcher introduced the dynamic lambda as for the contribution of this research. With the dynamic lambda, the curvature of the yield curve would change and adapt with the latest historical trading data. So that with the dynamic model, researcher believe the yield curve and fair price valuation will improve to be more accurate with the trading data from market. Therefore to relate with the research questions, the research objectives are further explained as below:

1. Related to Research Question #1, researcher will use the yield curve from Model 1 as the discount factor as the main input of fair price valuation of bonds. The fair price on Benchmark bonds are compared to trading value on each day to see the pricing performance of Model 1.
2. Related to Research Question #1, researcher will use the yield curve from Model 1 as the discount factor as the main input of fair price valuation of bonds. The fair price on Non-Benchmark bonds are compared to trading value on each day to see the pricing performance of Model 1.

3. Related to Research Question #2, researcher will use the yield curve from Model 2 as the discount factor as the main input of fair price valuation of bonds. The fair price on Benchmark bonds are compared to trading value on each day to see the pricing performance of Model 2.
4. Related to Research Question #2, researcher will use the yield curve from Model 2 as the discount factor as the main input of fair price valuation of bonds. The fair price on Non-Benchmark bonds are compared to trading value on each day to see the pricing performance of Model 2.
5. Related to Research Question #3, researcher will use the yield curve from Model 3 as the discount factor as the main input of fair price valuation of bonds. The fair price on Benchmark bonds are compared to trading value on each day to see the pricing performance of Model 3.
6. Related to Research Question #3, researcher will use the yield curve from Model 3 as the discount factor as the main input of fair price valuation of bonds. The fair price on Non-Benchmark bonds are compared to trading value on each day to see the pricing performance of Model 3.
7. Related to Research Question #3, researcher will use the yield curve from Baseline as the discount factor as the main input of fair price valuation of bonds. The fair price on Benchmark bonds are compared to trading value on each day to see the pricing performance of Baseline.

8. Related to Research Question #2, researcher will use the yield curve from Baseline as the discount factor as the main input of fair price valuation of bonds. The fair price on Non-Benchmark bonds are compared to trading value on each day to see the pricing performance of Baseline.
9. At last, researcher will statistically compare the pricing performance of each Models & Baseline

1.7. Research Limitation

There are several limitations in this research in which could be discovered as the input for further study. Those limitations are as follows:

1. Data period sample

   The period of data that researcher choose was from 2014 until 2019. This period has known as normal economic condition in Indonesia; therefore, this research would not count for shock or recession scenario.
2. Bond selection as sample observation

   Researcher took five series on both benchmark and non benchmark bond based on maturity dispersion in order to cover various area of yield curve. Due to heavy computational process on Matlab yield curve observation and Excel fair price valuation, only total ten series of Indonesia government bond were being used in the research.

3. Model methodology alternatives

Researcher observed only three alternative model for the yield curve. It is known that are many yield curves models that were being developed in the last 20 years. Future study on other alternative model are highly possible in order to find the best fit model for Indonesia government bond

4. Does not include shock period in economy

   The research was conducted in 2014 to 2019 that was under upward sloping yield curve or expansionary economic conditions. It is not including the shock or high volatility period in 2020 due to Covid-19 pandemic.