AN OVERVIEW OF NUTMEG PRODUCTION IN SUMATERA BARAT BASED ON PRODUCTIVE LAND BY USING EXPONENTIAL SMOOTHING AND SUSTAINED BY PROFILE ANALYSIS

UNDERGRADUATE THESIS

Proposed as a partial requirement for bachelor degree in science

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ABSTRACT

The production of nutmeg in Sumatera Barat in 2011-2018 has decreased with fluctuation, thus affecting the regional income. Therefore, it is necessary to estimate the amount of production in the future sustained by an analysis that can determine the capability of each nutmeg producing area in utilizing the land. The research objective is to set up a forecasting model and calculate the predicted amount of production, as well as to find out if a nutmeg producing district/city is capable of optimally utilizing the production land.

The method used is Brown-type Triple Exponential Smoothing techniques with parameter α sustained by Profile Analysis. The smallest Mean Square Error is used as a measure to choose the α. In profile analysis, the average ideal nutmeg production is compared to the average actual amount of nutmeg production by performing a parallel, coincidence, and level test. The data used are sourced BPS publication “Sumatera Barat in Figures” from 2012 to 2019.

Nutmeg productions in 2019 to 2023 in tonnes are forecasted of respectively 1255.95, 1261.38, 1266.94, 1272.65, and 1278.49. Furthermore, the average ideal and actual amount of nutmeg production is found to be not equal. The profile analysis revealed that the eleven producing regions in Sumatera Barat can be categorized into three groups by the level of land optimization namely (1) under optimal areas, include districts of Kepulauan Mentawai, Pesisir Selatan, Padang Pariaman, and Agam, and Padang municipality, (2) almost optimal areas, include the districts of Solok, Tanah Datar, Pasaman Barat and the municipalities of Solok and Sawahlunto, and (3) optimal area includes Pariaman municipality.

Keywords: *Amount of Nutmeg Production, Brown Type Triple Exponential Smoothing, Profile Analysis.*

FOREWORD

Praise be to Allah SWT, for all His grace and guidance, so that I can complete the undergraduate thesis entitled "An Overview of Nutmeg Production in Sumatera Barat Based on Productive Land by Using Smoothing Exponential and Sustained by Profile Analysis”. This thesis was prepared as a requirement for a Bachelor of Science degree in Mathematics Department, Faculty of Mathematics and Natural Sciences, Padang State University.

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Hopefully all the guidance, inspiration, and input that I have received become a deed of worship and replied by Allah SWT with His blessing. I look forward to the best benefit this thesis can give to every reader and stakeholder using its content.

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Author

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CHAPTER I
INTRODUCTION

A. Research background

Indonesian plantation crops have become highly valued commodities and been produced to support the country's income. The government has also made efforts to raise the production of plantation subsector through intensification, extensification, diversification and rehabilitation. Among those potential crops, nutmeg plantation has been contributing significantly to Indonesian income (Tumanggor, 2009).

Indonesia has been recorded as the largest nutmeg exporting country in the world. Around 60% of total international demand for nutmeg are supplied by Indonesia. The rest is produced by Grenada, India and Madagascar. The export destination countries are Europeans and US, which have historically known nutmeg as valuable spices used for many purposes. Indonesian nutmeg is more preferable in international market since it produces typical scent and contain higher level of essential oil (Rijal, 2017:3)

According to Nugroho (2019), nutmeg is used for medicines, cosmetics and food spices and could be found widely in European kitchens. It is quite different to Indonesian where nutmeg utilization is sometime limited for seasoning purposes only. Foreigners seem to be more aware of the rich nutritional value in nutmeg that includes protein, fatty acid, carbohydrate, essential oils, sodium, calcium, vitamin A, vitamin C, vitamin B1, oleanolic acid, and some other more.

The main producing areas of nutmeg in Indonesia are Kepulauan Maluku, Sulawesi Utara, Sumatera Barat, Nanggroe Aceh Darusalam, Jawa Barat, and Papua (Rijal, 2017). Based on BPS data (2016) the highest planted area is located in Maluku Utara province with an area of 42,716 Ha. Meanwhile, Sumatera Barat is in the ninth largest producing province with an area of 4,372 ha. According to BPS of Sumatera Barat province, the amount of nutmeg production in the last three years has dropped quite significantly. Data on the amount of nutmeg production in Sumatera Barat from 2011 to 2018 is shown in Table 1.

Table 1. Amount of nutmeg production in Sumatera Barat, 2011 – 2018

No	Year	Nutmeg production (tonnes)
1	2011	1172
2	2012	1224
3	2013	1332
4	2014	1388
5	2015	1450.19
6	2016	1068.86
7	2017	998,7
8	2018	1378.3

Source: Statistics Indonesia - Sumatera Barat Province in Figures, 2012 to 2019

Nutmeg production in Sumatera Barat is illustrated by the following chart:

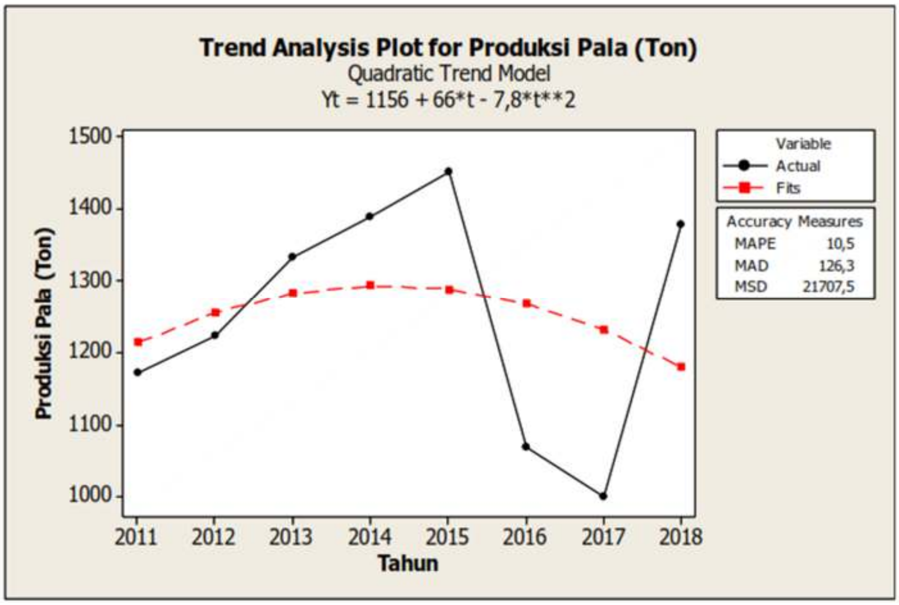


Figure 1. Trend analysis chart for the amount of nutmeg production in Sumatera Barat, 2011 - 2018

Based on data in Table 1, it can be seen that the recent nutmeg production has dropped by 1.45 tons compared to 2015. It is common to tell that the nutmeg productivity, like general plants, strongly correlate with productive land utilization. Productive land is a fertile land with potentials for agriculture or plantation. BPS data shows that there are still districts/cities in Sumatera Barat where the difference between nutmeg production area and the amount of nutmeg production is not yet ideal.

Among 12 districts and 7 cities in Sumatera Barat, only 11 of them are known as nutmeg production areas, according to BPS in their main publication "West Sumatra Province in Figures" (2019: 476). Other areas do not produce nutmeg due to climatic and soil conditions that are not suitable for growing nutmeg. Table 2 shows the data of productive land, production and productivity of nutmeg plantation in eleven district/cities in Sumatera Barat from 2011 to 2018.

Table 2. Average productive area, production amount and productivity of nutmeg plantation in districts and municipalities in Sumatera Barat, 2011 -2018

No	District/municipality	Productive area (Ha)	Production (Tonnes)	Productivity (Kg/Ha)
1	Kepulauan Mentawai reg.	731.1	412.0	563.5
2	Pesisir Selatan reg.	558.3	241.8	433.1
3	Solok reg.	47.8	21.0	438.1
4	Tanah Datar reg.	61.0	38.3	628.7
5	Padang Pariaman reg.	267.5	131.7	492.2
6	Agam reg.	620.5	339.3	546.7
7	Pasaman Barat reg.	8.3	4.2	514.4
8	Padang mun.	104.2	40.7	390.3
9	Solok mun.	4.9	3.1	621.3
10	Sawahlunto mun.	15.1	7.0	464.2
11	Pariaman mun.	10.0	7.5	754.1

Source: Statistics Indonesia - Sumatera Barat Province in Figures, 2012 to 2019

The average world nutmeg productivity reaches 451 kg/hectare, meanwhile the productivity of nutmeg in Indonesia is far below the world average, around 98.9 kg/hectare. Surprisingly, the productivity of nutmeg in Grenada, the second largest nutmeg producing country after Indonesia, reaches 275.4 kg/hectare (ILO-PCdP2 UNDP). Therefore, the core issue of nutmeg plantation in Indonesia lies on the productivity, since Indonesia is endowed with large plantation area but cannot utilize it the best way. The declining of nutmeg production in Sumatera Barat in the last three years should have become the reflection of the issue itself and it is important to find out how large the nutmeg production may fall within some years in the future. Necessarily, a forecasting aimed at estimating the amount of nutmeg production in Sumatera Barat in the future can be performed to predict what is going to happen and help getting ready the government and farmers to address the problem. The forecasting followed by a profile analysis method providing a quantitative comparison between the productive land area and the amount of nutmeg production are expected to help identifying the areas to be developed and increased in their productivity again.

In this context, forecasting is used as a statistical method for predicting the amount of nutmeg production based on past data. According to Makridakis (1999), forecasting is an activity to predict what will happen in the future. Generally, forecasting technique is divided into two, namely qualitative forecasting and quantitative forecasting. Qualitative forecasting is based on the thoughts, estimates and experiences of a number of specially trained people, while quantitative forecasting is based on past quantitative data.

According to Makridakis (1999), quantitative forecasting requirements can only be used if three conditions as follows are fulfilled: a) Availability of information about past circumstances, b) Such information can be quantified as numerical data, c) It can be assumed that the past pattern will hold in the future.

Specifically, quantitative forecasting consists of two, namely the time series and causal methods. In the time series method, by knowing the time series pattern of past data, extrapolation can be carried out to predict future conditions. The time series method consists of several methods such as the Smoothing Method, the Box Jenkins Method, and the Decomposition Method (Makridakis, 1999: 8). On another side, the causal method assumes a causal relationship between one or more independent variables.

Data on the amount of nutmeg production in Sumatera Barat from 2011 to 2018 has shown as fluctuating and is trendy. In this regard, the suitable forecasting technique for the data that contains trends is the exponential smoothing method (Arsyad, 1999: 52). The exponential smoothing method shows a parameter weighting decreases exponentially the longer values are observed.

The exponential smoothing consists of single, double, and triple exponential smoothing methods. The exponential smoothing method has several types including Brown's one-parameter double exponential smoothing method and Holt's two-parameter double exponential smoothing method and Brown's one-parameter triple exponential smoothing method and three Winter’s parameters. The single exponential smoothing method is only used for stationary time series. The double exponential smoothing method is used for non-stationary time series which forms a linear trend pattern, while the triple exponential smoothing method is used for quadratic trend time series.

The decrease in the amount of nutmeg production makes the data pattern not linear but rather forms a quadratic pattern. The suitable forecasting method for data with quadratic trend patterns is the Triple Exponential Smoothing Method. The advantage of this method is that it reduces excessive fluctuation in the time series data and this method has a constant smoothing factor (α) which functions as an adjustment for time series fluctuations.

The next step after forecasting is profile analysis, which is one of Multiple Variable Variance Analysis techniques. This analysis relates to a situation where a set of p treatments given to two or more groups, then the responses that occur are observed based on the profiles formed from each group. In this analysis it is assumed that the responses of the groups are independent, but all responses must be stated in the same unit so that they can be compared or added up (Agustia *et al*, 2013: 368).

To find out an estimate of the similarity of the profiles, both the profiles between treatments and between groups stated by the parallels, it can be seen from the plot graph between the mean value of each treatment for each group (population). To find out how much the meaning of parallels (similarity) from the population, hypothesis tests are needed related to this are needed (Mattjik and Sumertajaya, 2011: 101). The parallels of a population is defined as the same difference in the average of each variable in the first population and the mean of each variable in the second population.

Profile analysis can be used to picture difference between two or more populations where each population is given p treatment (variables) with some tests performed. The population used in this study is the ideal amount of production from the area of production land and the amount of nutmeg production in Sumatera Barat Province. While the areas that produce nutmeg consist of districts: Kepulauan Mentawai, Pesisir Selatan, Solok, Tanah Datar, Padang Pariaman, Agam, and Pasaman Barat, as well as for cities: Padang, Solok, Sawahlunto, and Pariaman.

Based on the description above, this research shall perform two steps analysis namely forecasting on nutmeg production using exponential smoothing and reviewing nutmeg production with profile analysis. The latter is aimed to look the similarity in the average ideal amount of production from the area of production land and the amount of nutmeg production in Sumatera Barat. Therefore, this research is entitled with "Overview of Nutmeg Production in Sumatera Barat Based on Productive Land Using Exponential Smoothing and Followed by Profile Analysis"

B. Statement of research problem

The research problem is stated as how to forecast nutmeg production in Sumatera barat based on land productivity.

C. Research scope

To mitigate the extensification of researched topic, this research is bounded to some extents as follows:

1. The data used to generate the situation of the past as the basis of forecasting is sourced from data on nutmeg production from 2011 to 2018 provided by BPS of Sumatera Barat Province
2. The data used for profile analysis is sourced from the data on nutmeg productive land and production amount in 11 nutmeg producing districts/cities in Sumatera Barat.

D. Research questions

The research questions are stated as follows:

1. How is the forecasting results on nutmeg production in Sumatera Barat?
2. Is the productive land available in districts and cities in Sumatera Barat has been utilized in order to increase nutmeg production in Sumatera Barat?

E. Research goals

This research is carried out to aim at the following goals:

1. To forecast the nutmeg production in Sumatera Barat from 2019 to 2023
2. To identify districts and cities in Sumatera Barat that have utilized productive land to increase nutmeg production

F. Research benefits

This research is expected to give the following benefits:

1. As a broader insight and practice on theoretical subjects obtained during the undergraduate study.
2. As an input for local government especially the Estate Plantation Agency of Sumatera Barat to arrange the policies for improving the nutmeg agricultural system in the future

3. As a reference for oncoming researches that possibly have similarities in topic or methodology

CHAPTER II
THEORITICAL FRAMEWORK

A. Nutmeg plant

The nutmeg plant (*Myristica Fragrans Houtt*) is an Indonesian native fruit plant with tall tree originating from Banda and Maluku (Rijal, 2017: 13). Nutmeg is one of the most important spice plants because it produces two valuable products, namely the nutmeg itself and the mace covering the seeds. It is used for essential oil, spices, medicinal ingredients, food and beverage preservative (Hamad, 2013).

General characteristics of this plant include medium trunk with a height of up to 18 meters, oval leaves that are always green throughout the year, round fruit with yellow skin when old, white flesh, which is a typical confectionery known in Bogor. A thin, rather hard skin, brownish black wrapped in a red mace, and the contents of the seeds are white, when dried it becomes dark brown with a distinctive aroma similar to cloves (Sayidin, 2009).

Nutmeg is a plant from the *Myristicaceae* family. Nutmeg grows ideally in areas with an altitude of 500-700 meters above sea level. Growing in area with altitude above 700 m can cause its productivity to be low. Nutmeg also needs a hot climate with high rainfall and does not change much throughout the year, ambient air temperature 20-30 C while the rainfall is regularly divided throughout the year. Nutmeg is a type of plant that can withstand the dry season for several months (Rijal, 2017: 17).

According to Rijal (2017), nutmeg need loose and fertile soil and preferably the volcanic soil that has good water drainage. Nutmeg grows well in soil textured from sand to clay with a high organic material content. Soil pH suitable for nutmeg is around 5.5-6.5. This plant is sensitive to water disturbances, so this plant must have a good drainage channel (Rijal, 2017: 17).

According to Nugroho (2019), nutmeg may give several benefits to body health which makes it everybody's favourite, some of them are:

1. The essential oil contained in nutmeg is effective to alleviate cold syndromes and warm up the body
2. The lipase enzyme contained in nutmeg is believed to increase appetite.

3. Water boiled with nutmeg helps improve sleeping quality if consumed
4. Saponin substances reduces the syndromes of high stomach acid reflux
5. Meristin substances is believed to maintain brain health, reduced nerve damage and degradation as found in Alzheimer, Parkinson and dementia.
6. Toxins detoxification in human body
7. Metanol substances prevent the growth of leukemia cells
8. Scolopetin substances stops skin inflammation and help restore skin from scar and ward traces
9. Normalizes blood pressure and increases immunity

According to Suryadi (2017), the implementation efficient of agriculture technology is an indicator of success in increasing nutmeg productivity and market competitiveness. The efficiency of agricultural technology is determined by the following factors:

1. The use of superior cutting plant part
2. Ideal planting distance to support the plant to grow with optimum amount of plant per area unit
3. Implementing efficient fertilization recommendation
4. Rehabilitating nutmeg plants with low productivity

B. Nutmeg production in Indonesia

Indonesia supplies about 60% of the world's total nutmeg market each year. The main producing areas for nutmeg in Indonesia are Kepulauan Maluku, Sulawesi Utara, Sumatera Barat, Nanggroe Aceh Darussalam, Jawa Barat and Papua. Indonesian nutmeg production in 2018, based on data from the Directorate General of Plantation, is 36,242 tons, with producing areas including Maluku Utara with a production of 8,325 tons, Aceh with a production of 6,273 tons, Maluku 5,774 tons, Papua Barat 5,675 tons, Sulawesi Utara 5,201 tons, Jawa Barat 1,319 tons, and Sumatera Barat 1,015 tons (Febrinastri and Hapsari: 2019). Nutmeg is known as a spice plant that has economic and multipurpose value because every part of the plant can be used in various industries (Rijal, 2017: 1).

Nutmeg is grown almost everywhere nationally, but currently the largest producer of nutmeg is still dominated by several provinces. This should become national main concern while Indonesia has numerous agricultural experts and scientists, yet the farmers still have to learn to cultivate their lands due to low technology adoption (Khaira Ir Djailani, 2018). This situation causes nutmeg plantations becomes not optimal whereas currently demand for nutmeg has been rising in positive trend globally.

C. Forecasting methods

Forecasting is a method to predict what is going to happen in the future based on past data. This method is categorized into two:

1. Qualitative forecasting, is based on qualitative past data. This method could be explorative or normative.
2. Quantitative forecasting

   Defined as forecasting method based on quantitative past data. The best forecasting method is based on criterion the least difference between forecasted value and actual value (minimum deviation). According to Makridakis (1999:8), quantitative forecasting method can perform with three conditions met: the availability of past circumstances; such circumstances is able to be quantified as numerical data; and the pattern happening in the past is assumed to hold in the future.

   There are two commonly known quantitative methods in forecasting:

   a. Causal method (using regression)

      The causal method is a forecasting method that assumes a causal relationship between one or more independent variables. The purpose of this model is to find a form of variables relationship and use it to predict the future value of the independent variable

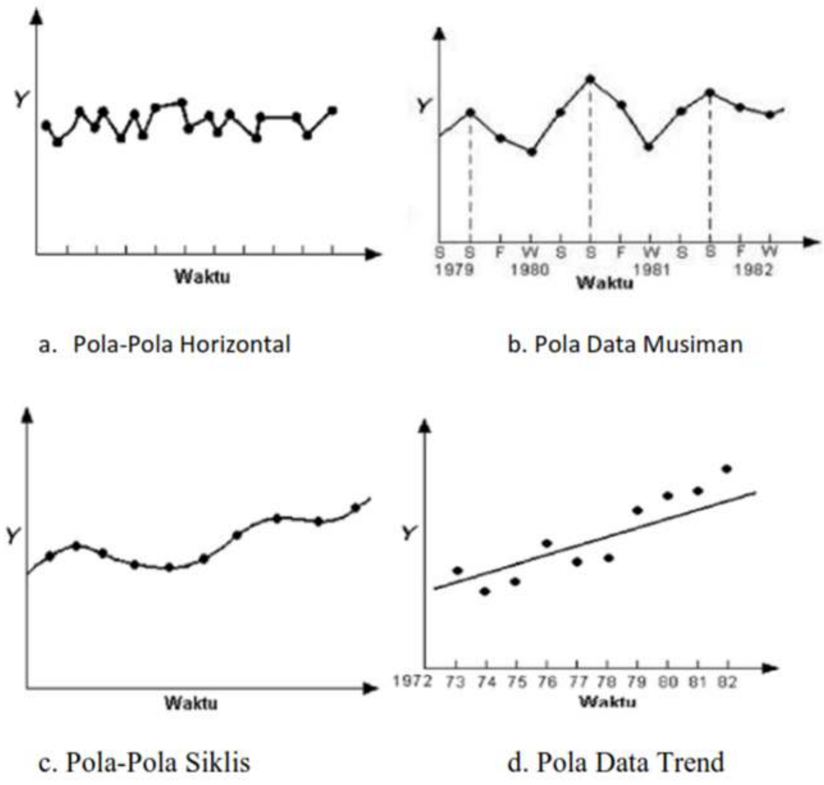
   b. Time series method

      The time series method is a method of forecasting that estimates future conditions based on past data. By knowing the pattern of past data series, extrapolation is carried out to predict future conditions (Makridakis, 1999: 9). According to Makridakis (1999: 9), an important step in choosing an appropriate time series method is to consider the type of data pattern. Data patterns can be divided into four, namely:

      1) Horizontal pattern (H), the data value fluctuates around a constant average value. Such a sequence is "stationary" to its average value.

Figure a below shows a typical pattern of horizontal or stationary data patterns.

2) Seasonal Pattern (S), a change pattern that repeats itself automatically from year to year. ARIMA Method and Winter Method. The data pattern can be seen in Figure b.
3) Cyclical pattern (C), the data is influenced by long-term fluctuations. This type of pattern can be seen in Figure c.
4) Trend pattern (T), there is a long-term secular increase or decrease in the data. This forecasting method used for trend-patterned data is the Linear Regression method and the Exponential Smoothing Method. Figure d shows one of the trend patterns.



a. Pola-Pola Horizontal

b. Pola Data Musiman

c. Pola-Pola Siklis

d. Pola Data Trend

Figure 2. Type of data patterns

D. Exponential smoothing methods

The exponential smoothing method consists of single, double, and triple smoothing levels. All of them have the same properties, the newer values are given a relatively greater weight than the older observed values (Makridakis, 1999:101.

1. Single Exponential Smoothing Method

The single exponential smoothing method is used for stationary time series. A stationary time series occurs when the data values fluctuate around a constant mean value. Single exponential smoothing can be written in the following equation:

$$F_{t+1} = F_t \left(\frac{Y_t}{N} - \frac{Y_t - N}{N}\right) \quad (1)$$

where:

F_t : forecasted value or data at time t

Y_t : actual value or data at time t

N : amount of value or data

(Makridakis, 1999: 79)

If the old observation Y_{t-N} is not available then the slot has to be replaced by the approximate value. One possible substitute is the predicted value for the previous period F_t in order to obtain the equation:

$$\begin{aligned} F_{t+1} &= F_t \left(\frac{Y_t}{N} - \frac{Y_t - N}{N}\right) \\ &= F_t + \left(\frac{1}{N}\right) Y_t - \left(\frac{1}{N}\right) F_t \quad (2) \\ &= \left(\frac{1}{N}\right) Y_t + \left(F_t - \left(\frac{1}{N}\right) F_t\right) \end{aligned}$$

$$F_{t+1} = \left(\frac{1}{N}\right) Y_t + \left(1 - \frac{1}{N}\right) F_t \quad (3)$$

(Makridakis, 1999: 80)

Based on equation (3) above it can be seen that the forecast for the next period F_{t+1} is based on the weighting of the last observation with a weight value $(1/N)$ and the weighting of the last previous prediction (F_t) with a weight of $1 - \frac{1}{N}$. Since N is a positive number, $1/N$ be a constant between 0 (if N is infinite) and 1 (if $N = 1$). By replacing $1/N$ with α, the above equation becomes:

$$F_{t+1} = \alpha Y_t + (1 - \alpha) F_t \quad (4)$$

Equation (4) is a general form of forecasts using the exponential smoothing method. This method significantly reduces the problem of data storage, because the exponential smoothing method requires only the last observation, the last forecast, and a value of α. According to Makridakis (1999: 84-85), for exponential smoothing, MSE must be determined through trial and error. A value of α is selected, the MSE is calculated in the test group, and then tested with another α. Then all the MSE is compared to determine the value α which gives the minimum MSE.

2. Double Exponential Smoothing Method

This method is appropriate if the data shows the nature of a trend or is affected by trend elements. In this double exponential smoothing method, the smoothing process is carried out twice, as follows:

$$S'_t = \alpha Y_t + (1-\alpha)S'_{t-1} \quad (5)$$

$$S''_t = \alpha S'_t + (1-\alpha)S''_{t-1} \quad (6)$$

$$b_t = S''_t - S''_{t-1}$$

where:

S'_t : single exponential smoothing value

S''_t : double exponential smoothing value

α : smoothing constant

b_t : t-period double exponential smoothing trend

The following equation:

$$(1-\alpha)S''_{t-1} = S''_t - \alpha S'_t$$

$$S''_{t-1} = \frac{1}{1-\alpha}S''_t - \frac{\alpha}{1-\alpha}S'_t$$

yields:

$$b_t = S''_t - \left(\frac{1}{1-\alpha}S''_t - \frac{\alpha}{1-\alpha}S'_t\right)$$

$$= \frac{(1-\alpha)S''_t - S''_t + \alpha S'_t}{1-\alpha}$$

$$= \frac{-\alpha S''_t + \alpha S'_t}{1-\alpha}$$

$$= \frac{\alpha}{1-\alpha}\left(S'_t - S''_t\right)$$

According to Makridakis (1999: 88), the equation used in forecasting the next period using the double exponential smoothing method is shown by the following equation:

$$F_{t+m} = a_t + b_t m$$

where:

$$a_t = S'_t + \left(S'_t - S''_t\right) \quad (7)$$

$$b_t = \frac{\alpha}{1-\alpha}\left(S'_t - S''_t\right) \quad (8)$$

and:

F_{t+m} : forecast for the next production

α : smoothing constant

a_t : adjusted value for period t

b_t : double smoothing trend

m : number of forecasted oncoming periods

(Makridakis, 1999: 88)

When $t = 1$, the values S'_{t-1} and S''_{t-1} are not available so the equations (5) and (6) is not usable. Therefore, by setting S'_t and S'_t equal to Y_t or by using the first value as the initial value, equations (5) and (6) is now usable.

3. **Brown-type Triple Exponential Smoothing Method**

This method is the method proposed by Brown. By using quadratic equations, this method is more suitable to forecast values that fluctuate or following tidal wave. In the triple exponential smoothing method, the smoothing process is carried out three times, as follows:

$$S'_t = \alpha Y_t + (1-\alpha)S'_{t-1} \text{ (first smoothing)} \quad (9)$$

$$S''_t = \alpha S'_t + (1-\alpha)S''_{t-1} \text{ (second smoothing)} \quad (10)$$

$$S'''_t = \alpha S''_t + (1-\alpha)S'''_{t-1} \text{ (third smoothing)} \quad (11)$$

(Makridakis, 1999: 94)

For the first time t (year for example), the values S'_t, S''_t, and S'''_t cannot be determined using equation (9), (10) and (11), so the values are determined independently, usually using actual value occurred in the first year. Equations

(9), (10), (11) are used to determine a_t, b_t, and c_t so that the forecasting function is formed using:

$$F_{t+m} = a_t + b_t m + \frac{1}{2} c_t m^2 \tag{12}$$

where:

$$a_t = 3S_t' - 3S_t'' + S_t''' \text{ (average value)} \tag{13}$$

$$b_t = \frac{\alpha}{2(1-\alpha)^2}\left[(6-5\alpha)S_t' - (10-8\alpha)S_t'' + (4-3\alpha)S_t'''\right] \tag{14}$$

(double smoothing trend)

$$c_t = \frac{\alpha^2}{(1-\alpha)^2}\left(S_t' - 2S_t'' + S_t'''\right) \tag{13}$$

(triple smoothing trend)

and:

F_{t+m} : forecast for the next production

S_t' : first exponential smoothing value

S_t'' : second exponential smoothing value

S_t''' : third exponential smoothing value

α : smoothing constant

a_t : adjusted average value for period t

b_t : double smoothing trend

c_t : triple smoothing trend

m : number of forecasted oncoming periods

(Makridakis, 1999: 94)

E. Trend Analysis

Trend analysis is an approach which is basically uses a line resulted by a regression of a time variable as explanatory or independent variable. Trend analysis is used to estimate the trend model of a time series data. There are several models of trend analysis, namely linear models and quadratic models. The linear model is associated with a trend data pattern in the form of a straight line. Meanwhile, the quadratic model associates with curved trend data pattern. According to Santoso (2009: 227), the best trend model is the trend model with the highest measurement accuracy or the model with the lowest error rate.

F. Measures of Model Accuracy

To measure the suitability of a particular forecasting method for the data set used a measure of model accuracy. Measures of the accuracy of the forecasting model include MAPE (Mean Absolute Percentage Error), MAD (Mean Absolute Deviation) and MSE (Mean Square Error). To determine the appropriate forecasting model among existing models, the criteria for the accuracy of the model according to Makridakis are used, namely:

1. **MAPE (Mean Absolute Percentage Error)**

   MAPE is a measure of model accuracy which is based on absolute error values. MAPE can be written as:

$$MAPE = \frac{\sum_{t=1}^{n} \left| \frac{Y_t - F_t}{Y_t} \right|}{N} \times 100$$

(Arsyad, 1999: 59)

MAPE is very effective for calculating the difference between the original data and the forecasted data. The absolute value of the difference is then calculated as a percentage of the original data. The percentage result is then obtained the mean value. According to Zainun and Majid (2003: 5), a model has very good performance if the MAPE value is below 10%, and has good performance if the MAPE value is between 10% and 20%.

2. **MAD (Mean Absolute Deviation)**

   MAD is a measure of model precision based on the mean absolute deviation. MAD can be written as:

$$MAD = \frac{\sum_{t=1}^{n} |Y_t - F_t|}{N}$$

(Arsyad, 1999: 58)

The ideal AD is zero (= 0), which means there are no forecast errors. Because MAD is the absolute value of the sum of the errors, it may increase the number and average size of the errors specified. However, large amount of data (thousands), MAD usage is not appropriate because the resulting error value can be very large.

3. **MSE (Mean Square Error)**

   MSE (Mean Square Error) is a measure of model accuracy based on the mean value of the squared error. MSE can be written as:

$$MSE = \frac{\sum_{t=1}^{n}(Y_t - F_t)^2}{N}$$

where:

Y_t : actual data for period t

F_t : forecast for period t

N : number of observations

(Arsyad, 1999: 58)

In Minitab software, MSE is also called MSD since both is defined by the same formula: $MSD = \frac{\sum_{t=1}^{n}(y_t - \hat{y}_t)^2}{N}$ where y_t denotes actual value and $\hat{y}_t$ denotes forecast value. MSE and MAPE measures are based on forecast error $e_t = Y_t - F_t$. The error basis for each measure is quadratic error, $(Y_t - F_t)^2$, for MSE and absolute error, $|Y_t - F_t|$, for MAPE. The MSE measures follow a procedure called the least squares method. The Least Squares method chooses an estimate that makes the sum of the squares of the vertical distance from the observation points to the estimate as small as possible. Mathematically, MSE and MAPE produce positive values. If MSE increases, MAPE also increases, and vice versa. Therefore, to measure the accuracy of the model, only one measure is used and MSE is more preferable since a model that produces the minimum MSE should become the best forecasting model (Makridakis, 1999: 60).

G. Matrix

Data on productive land area and the amount of nutmeg production in Sumatera Barat can be arranged in a form of matrix.

Definition 1: An $n \times p$ matrix is numbers arranged in n rows and p columns represented by:

$$A = (a_{ij}), \; i = 1,2,\dots,n; \; j = 1,2,\dots,p$$

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1p} \\ a_{21} & a_{22} & \cdots & a_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{np} \end{bmatrix}$$ (Suryanto, 1988:19)

A $n \times p$ matrix may represent a subject group with n amount of population affected by p treatments.

Definition 2: Square matrix is a matrix that consists of equal number of rows and columns, expressed as $A_{m\times n}$, where $m = n$, and thus can be denoted by $A_{n\times n} = (a_{ij})_{n\times n}$. A matrix of order $n \times n$ is also called a square matrix of order n (Suryanto, 1988: 21).

In the matrix operation performed later, a square matrix will be resulted. The size of the matrix depends on the number of variables used.

Definition 3: Inverse matrix

If A is a square matrix, and if exists a matrix B such that $AB = BA = I$, then A is said to be invertible and B is called the inverse of A, denoted by A^{-1} (Anton, 2004: 46).

$$AA^{-1} = I \text{ and } A^{-1}A = I$$

The inverse of a matrix only exists for a square matrix with non zero determinant value (Suryanto, 1988: 42).

Definition 4: Transpose matrix

If A is any $m \times n$ matrix, then the transpose of A is represented by A^t and defined by the $n \times m$ matrix with its first column is the first row of A, its second column is the second row of the matrix A, and likewise, its third column is the third row of A, and so forth (Anton, 2004: 36). Transpose matrix is used in solving profile analysis problems. At the test stage of the analysis, the transpose profile of the matrix A is denoted by A'.

H. Matrix of Variance – Covariance

In the forthcoming profile analysis, there are p variables, $X_1, X_2, \dots, X_p$, represented by a vector of $p \times 1$. In this study, there are 11 variables used representing nutmeg producing districts and cities in Sumatera Barat.

According to Jhonson (2002: 70) the expected value of each member of X is a vector of the mean, namely:

$$E(X) = \begin{bmatrix} E(X_1) \\ E(X_2) \\ \vdots \\ E(X_p) \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \\ \vdots \\ \mu_p \end{bmatrix} = \mu$$

and the variance and covariance matrices:

$$\Sigma = E(X-\mu)(X-\mu)'$$

$$= E\begin{bmatrix} (X_1-\mu_1)^2 & (X_1-\mu_1)(X_2-\mu_2) & \cdots & (X_1-\mu_1)(X_p-\mu_p) \\ (X_2-\mu_2)(X_1-\mu_1) & (X_2-\mu_2)^2 & \cdots & (X_2-\mu_2)(X_p-\mu_p) \\ \vdots & \vdots & \ddots & \vdots \\ (X_p-\mu_p)(X_1-\mu_1) & (X_p-\mu_p)(X_2-\mu_2) & \dots & (X_p-\mu_p)^2 \end{bmatrix}$$

$$= \begin{bmatrix} E(X_1-\mu_1)^2 & E(X_1-\mu_1)(X_2-\mu_2) & \cdots & E(X_1-\mu_1)(X_p-\mu_p) \\ E(X_2-\mu_2)(X_1-\mu_1) & E(X_2-\mu_2)^2 & \cdots & E(X_2-\mu_2)(X_p-\mu_p) \\ \vdots & \vdots & \ddots & \vdots \\ E(X_p-\mu_p)(X_1-\mu_1) & E(X_p-\mu_p)(X_2-\mu_2) & \dots & E(X_p-\mu_p)^2 \end{bmatrix}$$

$$= \begin{bmatrix} \sigma_{11} & \sigma_{12} & \cdots & \sigma_{1p} \\ \sigma_{21} & \sigma_{22} & \cdots & \sigma_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{n1} & \sigma_{n2} & \dots & \sigma_{np} \end{bmatrix}$$

I. Mean Vector and Covariance of Two Populations

According to Johnson (2002: 283), if $X_{11}, X_{12}, \dots, X_{1n}$ are n_1 random sample with size of the first population with a vector of means $\bar{X}_1 = \frac{1}{n_1}\sum_{j=1}^{n_1} X_{1j}$ then the covariance matrix for these samples is:

$$S_1 = \frac{1}{n_1-1}\sum_{j=1}^{n_1}(X_{1j}-\bar{X}_1)(X_{1j}-\bar{X}_1)' \tag{17}$$

$$\bar{X}_1 = \begin{bmatrix} \bar{X}_{11} \\ \bar{X}_{12} \\ \vdots \\ \bar{X}_{1p} \end{bmatrix}, \quad \bar{X}_{1i} = \sum_{j=1}^{n_1} X_{1ij}, i = 1,2,\dots,p \tag{18}$$

If $X_{21}, X_{22}, \dots, X_{2n_2}$ are n_2 sized random samples of the second population with mean vectors $\bar{X}_2 = \frac{1}{n_2}\sum_{j=1}^{n_2} X_{2j}$, then the covariance matrix for these samples is

$$S_1 = \frac{1}{n_2-1}\sum_{j=1}^{n_2}(X_{2j}-\bar{X}_2)(X_{2j}-\bar{X}_2)' \tag{19}$$

$$\bar{X}_2 = \begin{bmatrix} \bar{X}_{21} \\ \bar{X}_{22} \\ \vdots \\ \bar{X}_{2p} \end{bmatrix}, \quad \bar{X}_{2i} = \sum_{j=1}^{n_2} X_{2ij}, i = 1,2,\dots,p \tag{20}$$

To estimate joint covariance of both random samples:

$$S_p = \frac{1}{(n_1 - 1) + (n_2 - 1)}\left(\sum_{j=1}^{n_1}(X_{1j} - \bar{X}_1)(X_{1j} - \bar{X}_1)' + \sum_{j=1}^{n_2}(X_{2j} - \bar{X}_2)(X_{2j} - \bar{X}_2)'\right)$$

$$S_p = \frac{\sum_{j=1}^{n_1}(X_{1j} - \bar{X}_1)(X_{1j} - \bar{X}_1)' + \sum_{j=1}^{n_2}(X_{2j} - \bar{X}_2)(X_{2j} - \bar{X}_2)'}{n_1 + n_2 - 2}$$

$$S_p = \frac{n_1 - 1}{n_1 + n_2 - 2}S_1 + \frac{n_2 - 1}{n_1 + n_2 - 2}S_2 \quad (21)$$

J. Profile Analysis

Profile analysis is performed when the p series of treatments or variables are separated into two or more groups (populations). All responses must be arranged in the same unit, where all responses for different groups are exclusively independent. The purpose of profile analysis is to determine if each of these populations has an equal or different mean. In this study the group (population) used is represented by the ideal amount of production by considering the area of productive land and the amount of nutmeg production.

If population 1 and 2 are given p treatments on n_1 and n_2 samples, then the following two mean vectors respectively resulted: $\bar{x}_1' = [\bar{x}_{11}, \bar{x}_{12}, \dots, \bar{x}_{1p}]$ and $\bar{x}_2' = [\bar{x}_{21}, \bar{x}_{22}, \dots, \bar{x}_{2p}]$. Therefore, the profile of each population is a graphic generated by the pairs of points $(1, \bar{x}_{11}), (2, \bar{x}_{12}), \dots, (p, \bar{x}_{1p})$ and $(1, \bar{x}_{21}), (2, \bar{x}_{22}), \dots, (p, \bar{x}_{2p})$.

In the profile analysis the multivariate normal assumptions must be fulfilled. One of these assumptions is the normality of distribution data so that the data can be processed further. The multivariate normality test can be performed using the Kolmogrov-Smirnov test. The normality test hypothesis is:

H_0 : data is normally distributed

H_1 : data is not normally distributed

H_0 is rejected if p-value is lower than significance level (α), means that the data is not normally distributed.

If the data is not normally distributed, the next step taken is using the Levy's centre limit theorem that explains the sample distribution of means tends to form normal distribution if the sample size is fairly large (Dwinata, 2016: 24). To test the similarity of the profiles of two populations, one can use the parallels test, coincidence test and level similarity test in order to draw conclusions from the profiles of the two populations whether both are the same or different.

1. Parallels test

   Parallels test is used to determine whether the profiles of the two populations are similar or not. The profile is said to be similar if the average difference of each treatment in the first population and the average of each treatment in the second population is equal (Kusumastuti, 2007). In addition, parallel profiles are represented by non existing interaction between the two populations with p treatment (Mattjik and Sumertajaya, 2011: 102).

   Let $\mu_1' = [\mu_{11}, \mu_{12}, \dots, \mu_{1p}]$ and $\mu_2' = [\mu_{21}, \mu_{22}, \dots, \mu_{2p}]$ are mean vectors of respectively first and second population, then the hypothesis of parallels test is stated as follows:

$$H_0 : \begin{pmatrix} \mu_{11} - \mu_{12} \\ \mu_{12} - \mu_{13} \\ \vdots \\ \mu_{1(p-1)} - \mu_{1p} \end{pmatrix} = \begin{pmatrix} \mu_{21} - \mu_{22} \\ \mu_{22} - \mu_{23} \\ \vdots \\ \mu_{2(p-1)} - \mu_{2p} \end{pmatrix}$$
$$H_1 : \begin{pmatrix} \mu_{11} - \mu_{12} \\ \mu_{12} - \mu_{13} \\ \vdots \\ \mu_{1(p-1)} - \mu_{1p} \end{pmatrix} \neq \begin{pmatrix} \mu_{21} - \mu_{22} \\ \mu_{22} - \mu_{23} \\ \vdots \\ \mu_{2(p-1)} - \mu_{2p} \end{pmatrix} \quad (22)$$

   with p is the number of the variables being observed. Equation (22) can also be stated as follows:

   H_{01} : $C\mu_1 = C\mu_2$

   H_{11} : $C\mu_1 \neq C\mu_2$

   with C is a contrast matrix such that Equation (22) is resulted. Matrix C is defined as

$$C = \begin{bmatrix} -1 & 1 & 0 & 0 & \dots & 0 & 0 \\ 0 & 0 & 1 & 0 & \dots & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & 0 & 0 & \dots & -1 & 1 \end{bmatrix} \quad \text{(Mamankey, 2011)}$$

   The test this parallelism hypothesis uses the Hotelling T^2 statistic formulated as follows:

$$T^2 = (\bar{X}_1 - \bar{X}_2)'C' \left[\left(\frac{1}{n_1} + \frac{1}{n_2} \right) CSC' \right]^{-1} C(\bar{X}_1 - \bar{X}_2) > c^2 \quad (23)$$

   where

$$c^2 = \frac{(n_1 + n_2 - 2)(p-1)}{n_1 + n_2 - p} F_{p-1, n_1+n_2-p}(\alpha)$$

and S to be the covariance matrix of the variables. H_0 is rejected if $T^2 > c^2$ while the value of c^2 depends on the statistic of F in the distribution table (Mattjik and Sumertajaya, 2011:104).

An overview of the parallel profile of the two populations is illustrated by the chart below:

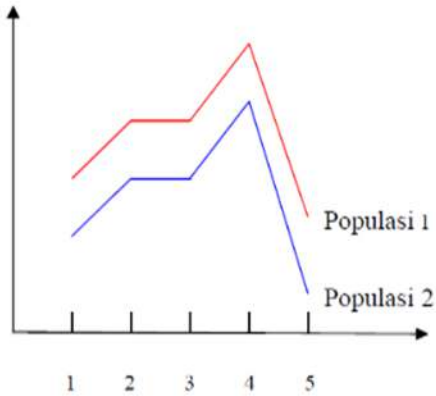


Figure 3. Two parallel profiles

Based on Figure 3, it can be seen that the first population and the second population are parallel, because the difference between each treatment is equal. In other words, the difference between the first treatment in the first population and the first treatment in the second population and between the second treatment in the first population and the second treatment in the second population is equal and always be equal until all treatments are given to both populations.

2. Coincidence test

If the parallel test is fulfilled, then the test is continued to coincidence test. The test is used to find out if the means of both populations are almost similar or exactly equal. According to Mamangkey (2011), profiles are said to be coinciding if the sum of $\mu_{11} = \mu_{12} = \cdots = \mu_{1p} = 1'\mu_1$ and the sum of $\mu_{21} = \mu_{22} = \cdots = \mu_{2p} = 1'\mu_2$ are equal, then the hypothesis of the coincidence test is:

$$H_0: 1'\mu_1 = 1'\mu_2$$

$$H_0: 1'\mu_1 \neq 1'\mu_2$$

The statistic used for this test is the Hoteling T^2 formulated as follows:

$$T^2 = 1'(\bar{X}_1 - \bar{X}_2)\left[\left(\frac{1}{n_1}+\frac{1}{n_2}\right)1S1'\right]^{-1} 1'(\bar{X}_1 - \bar{X}_2)$$

$$= \left(\frac{1'(\bar{X}_1 - \bar{X}_2)}{\sqrt{\left(\frac{1}{n_1}+\frac{1}{n_2}\right)1S1'}}\right)^2 \quad (24)$$

$$t^2_{n_1+n_2+2}\left(\frac{\alpha}{2}\right) = F_{1,n_1+n_2-2}(\alpha)$$

H_0 is rejected if $T^2 > t^2_{n_1+n_2+2}\left(\frac{\alpha}{2}\right)$ (Johnson, 2002:319).

If H_{02} is accepted, then the profiles of both populations are said to be similar or identical. Figure 4 below may illustrate two coincident profiles:

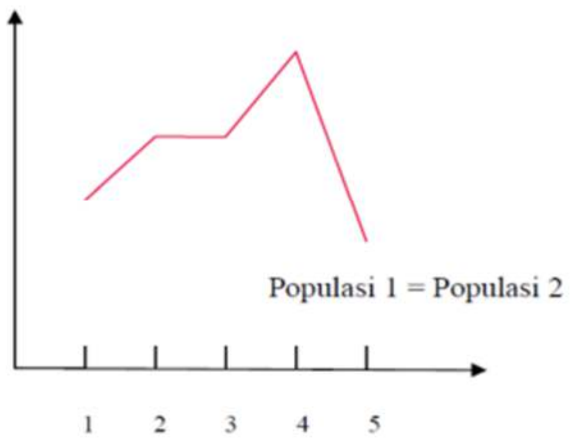


Figure 4. Two coincident profiles

3. Level test

If coincidence test is passed, then a level test shall be carried out to tell if each treatment on population results in equal mean, expressed as $\mu_1 = \mu_2 = \cdots = \mu_p$. The hypothesis to test is:

H_{03} : $C\mu = 0$

H_{13} : $C\mu \neq 0$

Joint mean μ of μ_1 and μ_2 is formulated as follows:

$$\mu = \bar{X} = \frac{\sum_{j=1}^{n_1} X_{1j} + \sum_{j=1}^{n_1} X_{2j}}{n_1 + n_2} = \frac{n_1}{(n_1+n_2)}\bar{X}_1 + \frac{n_1}{(n_1+n_2)}\bar{X}_2 \quad (25)$$

Statistic used for testing this hypothesis is T^2 formulated as follows:

$$T^2 = (n_1+n_2)\bar{X}'C'[CSC']^{-1}C\bar{X} > c^2 \quad (26)$$

with $c^2 = \frac{(n_1+n_2-1)(p-1)}{n_1+n_2-p+1}F_{p-1,n_1+n_2-p+1}(\alpha)$

H_{03} is rejected if $T^2 > c^2$

(Mattjik dan Sumertajaya, 2011:106)

If H_{03} is accepted, then it means that all treatments results in equal mean for each population. If the profile is level, both populations are represented by parallel lines as illustrated below in Figure 5:

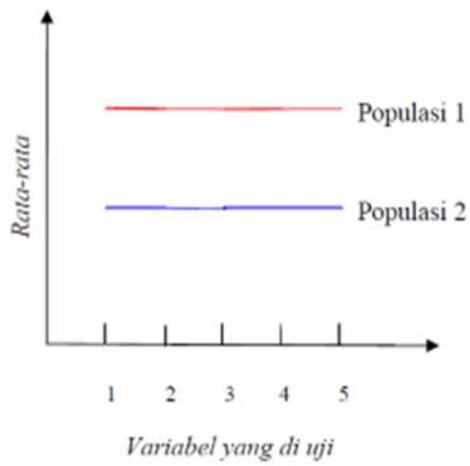


Figure 5. Two level profiles

The relationship between the parallel test, coincidence test and level test is concluded as follow:

1. Parallel test
   a. If the parallel test is rejected then the profiles will not either coincide or be level.
   b. If the parallel test is accepted, the profiles coincidence and parity need to be tested (undecided).
2. Coincidence test

   If the coincidence test is accepted then the profiles are parallel, but not necessarily level.
3. Level test

   If level test is accepted then the profiles are parallel, but not necessarily coincide.

CHAPTER III
RESEARCH METHODOLOGY

A. Type of research

This research is categorized as an applied research, starting with the analysis of relevant theories and continues with data processing and its application in daily practices.

B. Types and Sources of Data

The type of data used in this study is secondary data on the amount of production and the area of productive land for nutmeg in Sumatera Barat from 2011 to 2018. Secondary data is data obtained or collected from sources that have processed and provided data for distribution. The data source is obtained from the publication entitled "Sumatera Barat Province in Figures" from 2012 to 2019 published by BPS (Statistics Indonesia).

C. Object of Research

The research object are the amount of production and the productive land area of the nutmeg commodity in several districts and cities in Sumatera Barat as follows:

X_1	: Kepulauan Mentawai Regency	X_7	: Pasaman Barat Regency
X_2	: Pesisir Selatan Regency	X_8	: Padang Municipality
X_3	: Solok Regency	X_9	: Solok Municipality
X_4	: Tanah Datar Regency	X_{10}	: Sawahlunto Municipality
X_5	: Padang Pariaman Regency	X_{11}	: Pariaman Municipality
X_6	: Agam Regency		

D. Data analysis technique

The steps and techniques used in this research include:

1. Collecting production data and productive land area of nutmeg in Sumatera Barat by districts and cities and then performing forecasting process continued with profile analysis
2. Plotting the data on the amount of nutmeg production in Sumatera Barat using Minitab™.

3. Testing the trend analysis based on the generated data plots to determine if the methods used are appropriate with the generated data pattern. The behaviour of the data pattern is characterized by the smallest MAPE, MAD, and MSE or MSD values.
4. Determining the parameter value α to be used in forecasting by 'trial and error' method by using Microsoft Excel 2013™.
5. Performing Brown-type single smoothing value using Eq. 9, double smoothing value using Eq.10, and triple smoothing value using Eq.11.
6. Calculating mean values corresponding to t using Eq. 13.
7. Finding the value of the double smoothing trend using Eq. 14 and the value of the triple smoothing trend using Eq. 15.
8. Calculating the forecast of the amount of nutmeg production in Sumatera Barat using Eq. 12.
9. Testing the model accuracy obtained based on MSE
10. Calculating the forecasts of the amount of nutmeg production in Sumatera Barat for the oncoming years by using the model obtained.
11. Performing the profile analysis by first conducting a normality test of data on productive land area and the amount of nutmeg production. This is carried out by using SPSS ™ and Matlab ™.
12. Generating population data matrices, namely the X_1 and X_2.
13. Generating a graph describing the relationship between variables for each population.
14. Generating covariance matrices S_1 and S_2 by using Eq. 17 and Eq. 19.
15. Testing if the ideal production amount from the area of production land and the amount of nutmeg production is similar/identical by using the parallel test (Eq. 23)
16. Testing if the ideal production amount from the area of production land and the amount of nutmeg production is exactly equal using the coincidence test (Eq. 24)
17. Testing if each variable of the ideal production amount of the area of production land and the amount of production of nutmeg has equal mean by using the level test (Eq. 26).
18. Interpreting the analysis results.

In this study, data processing is performed with usage of Microsoft Excel 2013 ™, SPSS ™ and Matlab ™ softwares.

CHAPTER IV
RESULTS AND DISCUSSION

A. Main Results

1. Descriptive analysis

Table 1 shows the nutmeg production in Sumatera Barat from 2011 to 2018. The figures are total amount production that includes following regencies and cities: Kep. Mentawai, Pesisir Selatan, Solok, Tanah Datar, Padang Pariaman, Agam, West Pasaman, Padang, Solok, Sawahlunto, and Pariaman.

Table 1. Amount of nutmeg production in Sumatera Barat, 2011 – 2018

No	Year	Nutmeg production (tonnes)
1	2011	1172
2	2012	1224
3	2013	1332
4	2014	1388
5	2015	1450.19
6	2016	1068.86
7	2017	998,7
8	2018	1378.3

Source: Statistics Indonesia – Sumatera Barat Province in Figures, 2012 to 2019

Based on the data in Table 1, it can be seen that the lowest amount of nutmeg production was recorded in 2017 as of 998.7 tons, while the highest recorded in 2015 as of 1,450.19 tons. The average amount of nutmeg production within latest 8 years is calculated of:

$$\bar{X} = \frac{\sum_{t=1}^{N} Y_t}{N} = \frac{10012{,}05}{8} = 1251{,}51\ tonnes$$

The amount of nutmeg production in Sumatera Barat from 2011 to 2018 is not located close to average value therefore the data is said to be not stationary. In the last three years the amount of nutmeg production seems to decrease as shown in the following figure:

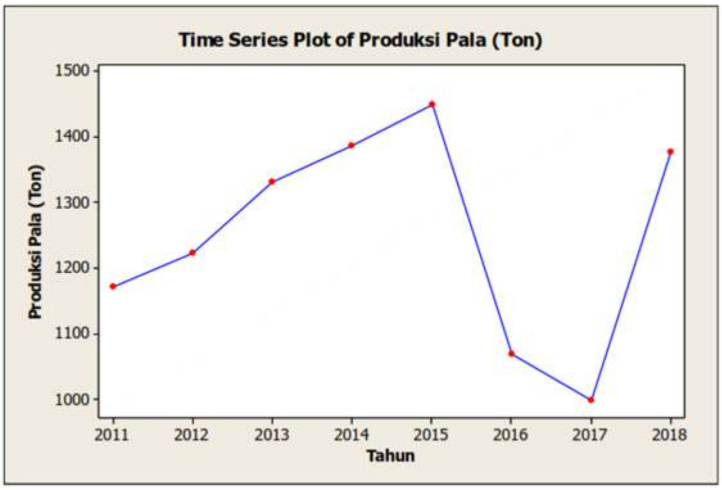


Figure 6. Amount of nutmeg production in Sumatera Barat, 2011 – 2018

Based on Figure 6, it can be seen that the amount of nutmeg production in Sumatera Barat from 2011 to 2018 has fluctuated throughout the years, spotted some decreases in 2016 and 2017. The amount of nutmeg production in Sumatera Barat in 2018 was increased, associated to some increases in the planted area, production and export of nutmeg.

Table 3. Amount of ideal and actual nutmeg production in districts and municipalities in Sumatera Barat, 2011 -2018

No	District/municipality	Ideal production Area (Ha)	Production (Tonnes)
1	Kepulauan Mentawai reg.	5849	3296
2	Pesisir Selatan reg.	4466	1934.2
3	Solok reg.	382.75	167.7
4	Tanah Datar reg.	487.8	306.7
5	Padang Pariaman reg.	2436	1053.23
6	Agam reg.	4964	2714.03
7	Pasaman Barat reg.	66	33.95
8	Padang mun.	833.5	325.3
9	Solok mun.	39.5	24.54
10	Sawahlunto mun.	121	56.17
11	Pariaman mun.	80	60.33

Source: Statistics Indonesia - Sumatera Barat Province in Figures, 2012 to 2019

Data on the amount of productive land area is obtained from data on the level of productivity and the amount of nutmeg production. Productivity data will show the amount of nutmeg production per hectare. If the data on the amount of nutmeg production is compared with the productivity of the nutmeg plant, the ideal amount of production will be obtained from the area of the nutmeg production area.

Table 3 shows that Kepulauan Mentawai Regency has the highest ideal amount of production from among other districts/cities, as recorded of 5849 hectares, with the amount of production obtained of 3296 tons. The second highest ideal amount of production area is Agam Regency, recorded of 4964 hectares with total production of 2714.03 tons. The third largest ideal production area is Pesisir Selatan Regency, as of 4466 hectares, with relatively small amount of production of 1934.2 tons.

2. Forecasting and Profile Analysis

Forecasting analysis of the productive amount of nutmeg in Sumatera Barat using the Brown Type Triple Exponential Smoothing method is carried out with the following steps:

a. Create a data plot analysis to determine the behaviour of the data plots.

The first step in conducting forecasting analysis is to plot the data. The plot of the amount of nutmeg production in Sumatera Barat is illustrated by Figure 2. The results of the data plot show an increase from 2011 to 2015 and hence the data pattern is said to be trendy.

b. Test trend analysis using Minitab™ software in order to determine the appropriate forecasting method to implement. The trend analysis test is carried out first against a linear trend. The following are the results of the linear trend in Figure 7.

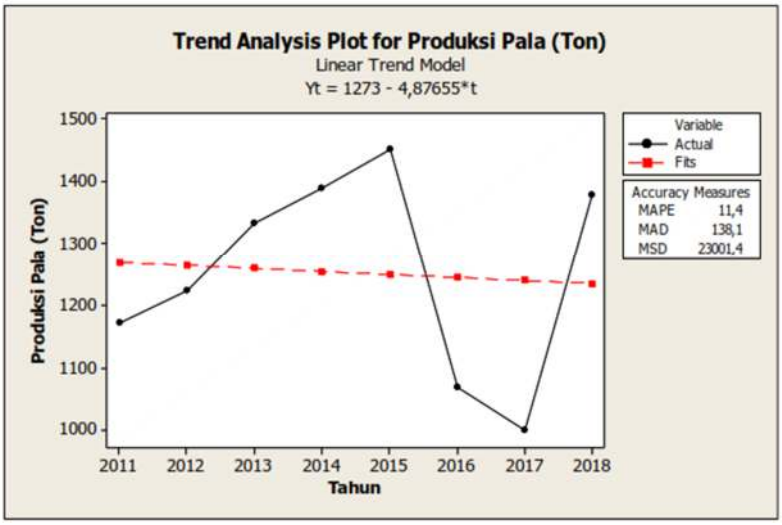


Figure 7. Linear trend for the amount of nutmeg production in Sumatera Barat, 2011 - 2018

Figure 7 shows that the production of nutmeg from 2011 to 2018 did not spread close to the linear trend line, from 2015 to 2017 the data spread outside the linear trend line. The MAPE value on the linear trend, as the measure of the accuracy of the model based on the absolute error value, is 11.4%. MAD value on the linear trend which states the absolute average value of forecasting errors to measure the accuracy of the technique used is 138.1. MSD value on the linear trend which states the measure of the accuracy of the model based on the mean squared error is 23001.4.

The trend analysis test is continued with the quadratic trend test with the following analysis results:

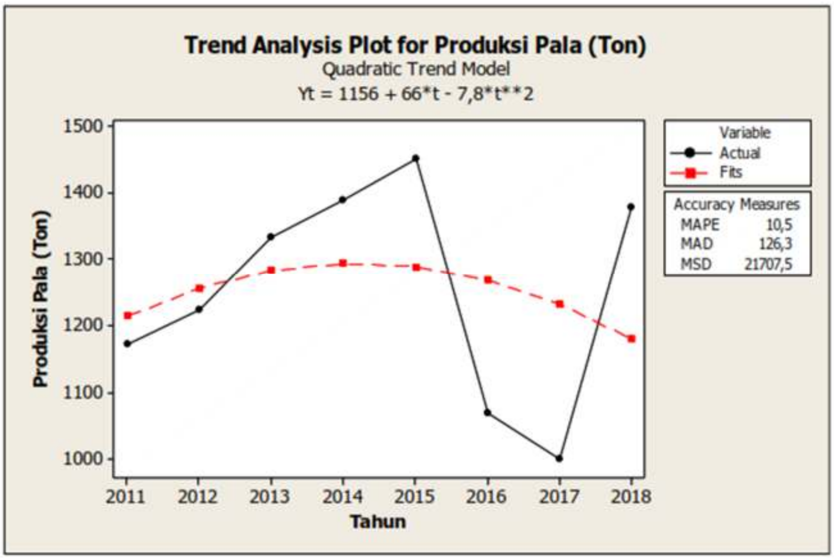


Figure 8. Quadratic trend for the amount of nutmeg production in Sumatera Barat, 2011 - 2018

In Figure 8, it can be seen that the MAPE value in the quadratic trend as a measure of the accuracy of the model based on the absolute error value is 10.5%. MAD value which is based on the absolute average value of the forecast error to measure the accuracy of the technique used is 126.3. MSD value based on the mean squared error is 21707.5.

The most appropriate trend analysis is trend analysis which has the smallest MAPE, MAD, and MSD values. The results of the trend analysis above can be tabulated in Table 4 as follows:

Table 4. Measures of trend analysis results for the amount of nutmeg production (tonnes) in Sumatera Barat, 2011 – 2018

Trend	MAPE	MAD	MSD
Linear	11.4%	138.1	23001.4
Quadratic	10.5%	126.3	21707.5

Based on Table 4, it can be seen that the smallest MAPE, MAD, and MSD values are in the quadratic trend. Therefore, the data on the amount of nutmeg production in Sumatera Barat forms a quadratic trend pattern. Thus, the appropriate forecasting method used to predict the amount of nutmeg production in Sumatera Barat is the Brown-type Triple Exponential Method.

c. Calculating the parameter values to be used in the forecast

The value of α for Brown-type triple exponential smoothing ranges from 0 to 1. α is obtained by 'trial and error' method in order to get the smallest MSE value. In this study, the value of α which produced the smallest MSE was 0.125. Complete data is available in Appendix 1.

d. Calculating the value of the Brown Type first smoothing parameter

The first smoothing value for the Brown type, S'_t at the period $t = 1$ with α of 0.125 is obtained by setting $S'_1 = Y_1 = 1172$ (using Eq. 9). Therefore, Brown type's first exponential smoothing value for Nutmeg production data in Sumatera Barat for the next period is calculated as follows:

$$
\begin{aligned}
S'_t &= \alpha Y_t + (1-\alpha)S'_{t-1} \\
S'_2 &= \alpha Y_2 + (1-\alpha)S'_1 \\
&= (0{,}125 \times 1224) + (0{,}875 \times 1172) \\
&= 153 + 1025{,}5 \\
&= 1178{,}5
\end{aligned}
$$

This process is repeated for the oncoming periods t and available in Appendix 4.

e. Calculating the value of the Brown Type second smoothing parameter

The second smoothing value for the Brown type, S''_t at the period $t = 1$ with α of 0.125 is obtained by setting $S''_1 = Y_1 = 1172$ (using Eq. 10). Therefore, Brown type's second exponential smoothing value for Nutmeg production data in Sumatera Barat for the next period is calculated as follows:

$$S_2'' = \alpha S_2' + (1-\alpha)S_1''$$
$$= (0{,}125 \times 1178{,}5) + (0{,}875 \times 1172)$$
$$= 147{,}313 + 1025{,}5$$
$$= 11782{,}81$$

This process is repeated for the oncoming periods t and available in Appendix 5.

f. Calculating the value of the Brown Type third smoothing parameter

The third smoothing value for the Brown type, S_t''' at the period $t = 1$ with α of 0.125 is obtained by setting $S_1''' = Y_1 = 1172$ (using Eq. 11). Therefore, Brown type's third exponential smoothing value for Nutmeg production data in Sumatera Barat for the next period is calculated as follows:

$$S_2''' = \alpha S_2'' + (1-\alpha)S_1'''$$
$$= (0{,}125 \times 1172{,}81) + (0{,}875 \times 1172)$$
$$= 146{,}60 + 1025{,}5$$
$$= 11782{,}101$$

This process is repeated for the oncoming periods t and available in Appendix 6.

g. Calculating average values

Average values adjusted for period t is calculated by using Eq. 13 after the value of the Brown Type first, second and third smoothing parameter have been obtained.

$$a_2 = 3S_2' - 3S_2'' + S_2'''$$
$$= 3 \times 3535{,}5 - 3 \times 3518{,}43 + 1172,$$
$$= 1189{,}16$$

This process is repeated for the oncoming periods t and available in Appendix 7.

h. Finding the double smoothing trend

To find the value of the double exponential smoothing trend with the help of Microsoft Excel 2013, Eq. 14 is used as follows.

$$b_t = \frac{\alpha}{2(1-\alpha)^2}[(6-5\alpha)S'_2 - (10-8\alpha)S''_2 + (4-3\alpha)S'''_2]$$
$$= 0{,}0816[(5{,}375)1178{,}5 - (9)1172{,}81 + (3{,}625)1172{,}1]$$
$$= 0{,}0816(6334{,}4375 - 10555{,}29 + 4248{,}8625)$$
$$= 0{,}0816(28{,}01)$$
$$= 2{,}2852$$

This process is repeated for the oncoming periods t and available in Appendix 8.

i. Finding the triple smoothing trend

To find the value of the triple exponential smoothing trend with the help of Microsoft Excel 2013, Eq. 15 is used as follows.

$$c_2 = \frac{\alpha^2}{(1-\alpha)^2}(S'_2 - 2S''_2 - S'''_2)$$
$$= 0{,}0204\ [1178{,}5 - (2 \times 1172{,}81) + 1172{,}1$$
$$= 0{,}0204\ (1178{,}5 - 2345{,}62 + 1172{,}1$$
$$= 0{,}0204\ (4{,}98)$$
$$= 0{,}102$$

This process is repeated for the oncoming periods t and available in Appendix 9.

j. Obtaining the accurate model by using MSE

By choosing α value of 0.125 gives the smallest MSE of 393191.75 ((see Appendix 1). Therefore, the following model is appropriate to use:

$$F_{t+m} = a_t + b_t m + \frac{1}{2}c_t m^2 = 1250{,}65 + 5{,}225m + 0{,}0068m^2$$

Based on the data on the amount of nutmeg production in Sumatera Barat with α of 0.125, the 8th forecast value is 1250.65, the 8th data double and triple smoothing trend values are respectively 5.225 and 0.137. Complete results are available in Appendix 9.

k. Forecasting for the amount of nutmeg production for the oncoming years

With the accurate model obtained, the prediction of the amount of nutmeg production in Sumatera Barat for the year 2019 (which is the 9th period) is performed as follows:

$$
\begin{aligned}
F_{t+m} &= a_t + b_t m + \frac{1}{2} c_t m^2 \\
&= 1250{,}65 + 5{,}225m + 0{,}0068m^2 \\
F_{8+1} &= 1250{,}65 + 5{,}225\ (1) + 0{,}068\ (1)^2 \\
&= 1250{,}65 + 5{,}225 + 0{,}068 \\
&= 1255.95 \\
F_{8+2} &= 1250{,}65 + 5{,}225\ (2) + 0{,}068\ (2)^2 \\
&= 1250{,}65 + 10{,}45 + 0{,}272 \\
&= 1261{,}38 \\
F_{8+3} &= 1250{,}65 + 5{,}225\ (3) + 0{,}068\ (3)^2 \\
&= 1250{,}65 + 15{,}675 + 0{,}612 \\
&= 1266{,}94 \\
F_{8+4} &= 1250{,}65 + 5{,}225\ (4) + 0{,}068\ (4)^2 \\
&= 1250{,}65 + 20{,}9 + 1{,}088 \\
&= 1272{,}65 \\
F_{8+5} &= 1250{,}65 + 5{,}225\ (5) + 0{,}068\ (5)^2 \\
&= 1250{,}65 + 26{,}125 + 1{,}7 \\
&= 12678{,}49
\end{aligned}
$$

The forecasting results on the amount of nutmeg production in Sumatera Barat from 2019 to 2023 using the Brown-type Triple Exponential Smoothing is shown in the Table 5 as follows:

Table 5. Forecast for the amount of nutmeg production in Sumatera Barat, 2019 – 2023

Year	**Period**	m	**Amount of production (tonnes)**
2019	9	1	1255.95
2020	10	2	1261.38
2021	11	3	1266.94
2022	12	4	1272.65
2023	13	5	1278.49

Based on Table 5, the amount of nutmeg production in Sumatera Barat from 2019 to 2023 is predicted to drop and lower than those in 2018. The next analysis to perform is the profile analysis on the data on the area of productive land and nutmeg production in each district/city in Sumatera Barat.

The next step is to set up data matrices, namely a 8×11 sized matrix, $\boldsymbol{X_1}$, that represents the productive land area and a 8×11 sized matrix, $\boldsymbol{X_2}$, that measures nutmeg production. Further details on data are available in Appendix 11. From each matrix, two mean vectors are generated, denoted by $\overline{\boldsymbol{X}}_{\boldsymbol{1}}$ and $\overline{\boldsymbol{X}}_{\boldsymbol{2}}$, which represent the average value of each variable observed.

Using Eq. 16, the average value for the first variable (ideal amount of nutmeg production area):

$$\bar{X}_{11} = \frac{(821 + 825 + \cdots + 648)}{8} = 731{,}125$$

$$\bar{X}_{12} = \frac{(367 + 512 + \cdots + 649)}{8} = 558{,}25$$

and so forth until the 11$^{\text{th}}$ regions. This process is repeated for the second variable. So, the mean vectors for each variable are written as follows:

$$\bar{X}_1 = \begin{bmatrix} 731,1 \\ 558,3 \\ 47,8 \\ 61 \\ 304,5 \\ 620,5 \\ 8,3 \\ 104,2 \\ 4,9 \\ 18,4 \\ 10 \end{bmatrix} \quad \text{and} \quad \bar{X}_2 = \begin{bmatrix} 412 \\ 241,8 \\ 21 \\ 38,3 \\ 131,7 \\ 339,3 \\ 4,2 \\ 40,7 \\ 3,1 \\ 7 \\ 7,5 \end{bmatrix}$$

The next step is to draw the chart to picture the relationship between $\bar{X}_1$ and $\bar{X}_2$:

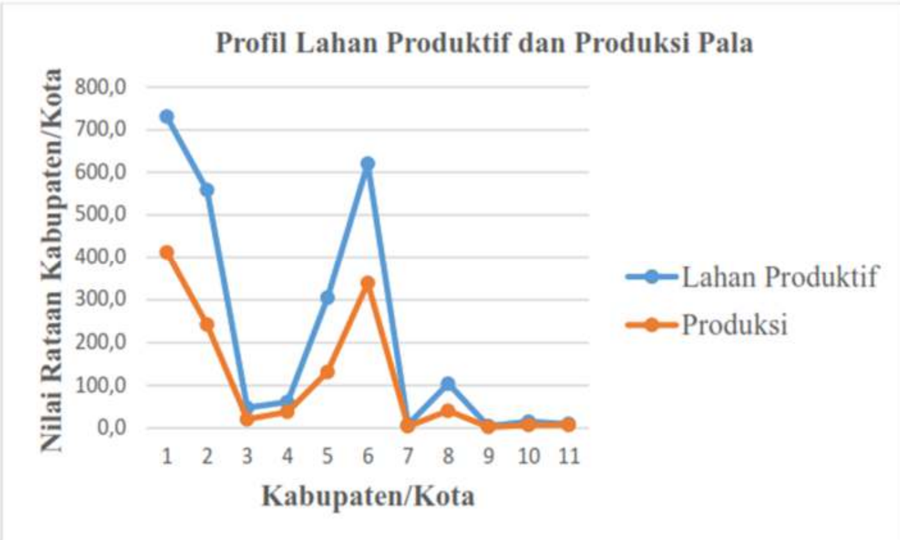


Figure 9. Realtionship between regions and their average amount of productive area and production

Based on Figure 9, it can be seen that the data on productive land area in general almost match the data on nutmeg production from eleven regions. However, there are still variables or districts/cities in which the amount of production is lower than ideal production as found in the first, second, fifth, sixth, and eighth regions.

The next step is to set up the covariance matrices based on the data on the ideal amount of production and the actual amount of production. The method is to use Eq. 17 and Eq. 19 to obtain the covariance matrix $\boldsymbol{S_1}$ for the productive land area and the covariance matrix $\boldsymbol{S_2}$ for the amount of production as shown in Appendix 12. After $\boldsymbol{S_1}$ and $\boldsymbol{S_2}$ are set up, Eq. 21 is then used to calculate joint covariance matrix $\boldsymbol{S_p}$, as formulated as follows:

$$\boldsymbol{S_p} = \frac{n_1 - 1}{n_1 + n_2 - 2}\boldsymbol{S_1} + \frac{n_2 - 1}{n_1 + n_2 - 2}\boldsymbol{S_2}$$

given $n_1 = n_2 = 8$. The value of matrices $\boldsymbol{S_1}$ and $\boldsymbol{S_2}$ is available in Appendix 12. Joint covariance calculation is performed as follows:

$$S_{p_{11}} = \frac{7}{14}(6524) + \frac{7}{14}(1170) = 3848$$

$$S_{p_{12}} = \frac{7}{14}(-4435) + \frac{7}{14}(2150{,}5) = -1142 = S_{p_{21}}$$

$$S_{p_{13}} = \frac{7}{14}(244) + \frac{7}{14}(143{,}8) = 194 = S_{p_{31}}$$

and so forth. Software helps on calculating joint covariance is very efficient, the following $\boldsymbol{S_p}$ matrix is obtained shortly:

$$1{,}0e+0{,}4^{*}\begin{bmatrix}
0{,}3848 & -0{,}1142 & 0{,}0194 & -0{,}0067 & 0{,}0788 & 0{,}4656 & -0{,}0133 & 0{,}0430 & -0{,}0018 & -0{,}0230 & 0{,}0070 \\
-0{,}1142 & 0{,}5999 & 0{,}0212 & 0{,}0215 & 0{,}1403 & -0{,}0043 & 0{,}0138 & 0{,}0005 & 0{,}0074 & 0{,}0276 & -0{,}0117 \\
0{,}0194 & 0{,}0212 & 0{,}0064 & 0{,}0037 & 0{,}0136 & 0{,}0722 & 0{,}0004 & 0{,}0081 & 0{,}0003 & -0{,}0002 & 0{,}0006 \\
-0{,}0067 & 0{,}0215 & 0{,}0037 & 0{,}0096 & -0{,}0082 & 0{,}0399 & 0{,}0018 & 0{,}0057 & 0{,}0005 & 0{,}0033 & 0{,}0012 \\
0{,}0788 & 0{,}1403 & 0{,}0136 & -0{,}0082 & 0{,}1455 & 0{,}1728 & -0{,}0062 & 0{,}0378 & 0{,}0026 & -0{,}0036 & -0{,}0017 \\
0{,}4656 & -0{,}0043 & 0{,}0722 & 0{,}0399 & 0{,}1728 & 1{,}4190 & -0{,}0163 & 0{,}1862 & 0{,}0014 & 0{,}0320 & 0{,}0236 \\
-0{,}0133 & 0{,}0138 & 0{,}0004 & 0{,}0018 & -0{,}0062 & -0{,}0163 & 0{,}0017 & -0{,}0053 & 0{,}0001 & 0{,}0013 & -0{,}0004 \\
0{,}0430 & 0{,}0005 & 0{,}0081 & 0{,}0057 & 0{,}0378 & 0{,}1862 & -0{,}0053 & 0{,}0490 & 0{,}0012 & -0{,}0017 & 0{,}0043 \\
-0{,}0018 & 0{,}0074 & 0{,}0003 & 0{,}0005 & 0{,}0026 & 0{,}0014 & 0{,}0001 & 0{,}0012 & 0{,}0002 & 0{,}0004 & 0{,}0001 \\
-0{,}0230 & 0{,}0276 & -0{,}0002 & 0{,}0033 & -0{,}0036 & 0{,}0320 & 0{,}0013 & -0{,}0017 & 0{,}0004 & 0{,}0059 & -0{,}0010 \\
0{,}0070 & -0{,}0117 & 0{,}0006 & 0{,}0012 & -0{,}0017 & 0{,}0236 & -0{,}0004 & 0{,}0043 & 0{,}0001 & -0{,}0010 & 0{,}0015
\end{bmatrix}$$

After joint covariance value has been obtained, the next step is to perform a profile analysis by testing the similarity of the productive land profile and the amount of production using the parallel test, coincidence test and level test. In this study, $\alpha = 0.05$ (or confidence level of 95%) was used.

Parallel Test

Parallel test is used to see whether the profiles of the two populations are similar or not. The hypothesis of the parallel test is:

H_{01} : $C\mu_1 = C\mu_2$

H_{02} : $C\mu_1 \neq C\mu_2$

where C is a $(p-1) \times p$ sized contrast matrix defined as follows:

$$\mathbf{C} = \begin{bmatrix} -1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 1 \end{bmatrix}$$

The difference between the average productive land area and the amount of production for each variable is obtained as follows:

$$\boldsymbol{\bar{X}_1} - \boldsymbol{\bar{X}_2} = \begin{bmatrix} 731{,}1 \\ 558{,}3 \\ 47{,}8 \\ 61 \\ 304{,}5 \\ 620{,}5 \\ 8{,}3 \\ 104{,}2 \\ 4{,}9 \\ 18{,}4 \\ 10 \end{bmatrix} - \begin{bmatrix} 412 \\ 241{,}8 \\ 21 \\ 38{,}3 \\ 131{,}7 \\ 339{,}3 \\ 4{,}2 \\ 40{,}7 \\ 3{,}1 \\ 7 \\ 7{,}5 \end{bmatrix} = \begin{bmatrix} 319{,}1 \\ 316{,}5 \\ 26{,}9 \\ 22{,}6 \\ 172{,}8 \\ 281{,}2 \\ 4 \\ 63{,}5 \\ 1{,}9 \\ 11{,}4 \\ 2{,}5 \end{bmatrix}$$

The Hotelling T^2 test statistic with value $n_1 = n_2 = 8$ is then calculated using Eq. 23:

$$T^2 = (\bar{X}_1 - \bar{X}_2)'C'\left[\left(\frac{1}{n_1} + \frac{1}{n_2}\right) CSC'\right]^{-1} C(\bar{X}_1 - \bar{X}_2)$$
$$= 830{,}6$$

and the comparison value of:

$$c^2 = \frac{(n_1 + n_2 - 2)(p - 1)}{n_1 + n_2 - p} F_{p-1, n_1+n_2-p}(\alpha)$$
$$= 72{,}8$$

where $F_{10,7}(0{,}05) = 3{,}64$. It is found that $T^2 > c^2$, therefore H_{01} is rejected which means that the ideal production and the actual production amounts have different profile. Thus, it can be concluded that the difference between average ideal amount of production and the average amount of production of nutmeg in Sumatera Barat is statistically significant. Figure 9 has shown that the difference occurs in regions: Kepulauan Mentawai Regency, Pesisir Selatan Regency, Padang Pariaman Regency, Agam Regency, and Padang Municipality

Based on the calculation, it turns out that the parallel test was rejected. Therefore, testing similarity of the profile of the ideal and actual amount of production using coincidence and level tests is no longer necessary. It has been stated in the relationships between the three tests that if the parallel test is rejected, then the profiles do not coincide and are not level.

The next step is to perform profile analysis of each region except for the previous five districts/cities since the test result has shown that there is significant difference between ideal and actual amount of nutmeg production in those regions. The period used in this step starts from 2011 to 2018. The result of profile analysis for six remaining regions is presented as follows:

1. **Solok Regency**

   Based on the data on the ideal and actual amount of nutmeg production as presented in Appendix 10, a graph of the relationship between both variables in Solok Regency is displayed in the following Figure 10:

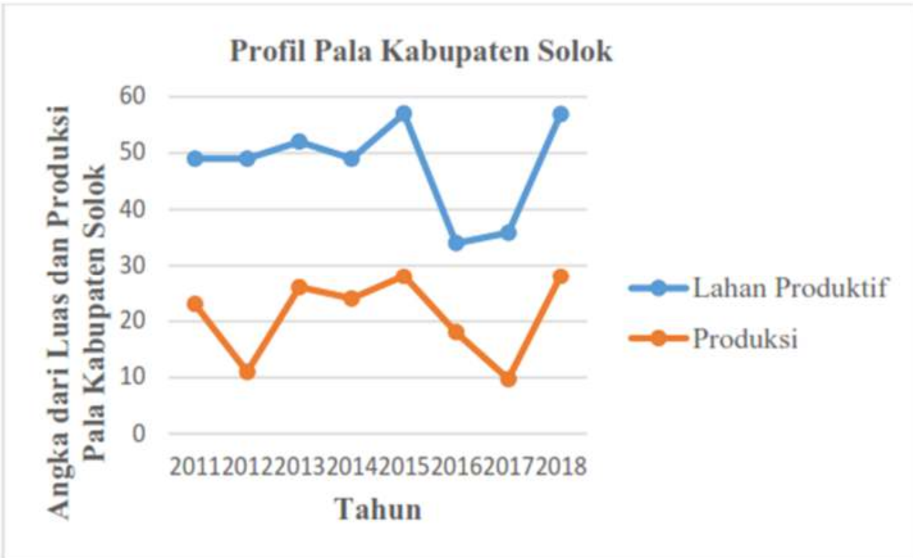


Figure 10. Relationship between nutmeg productive area and the amount of production in Solok Regency, 2011 – 2018

In Figure 10 it can be seen that the area of productive land in Solok Regency in several years has almost approached the amount of nutmeg production. After setting up the relationship chart between the ideal and the actual amount of nutmeg production for eight periods of year, the following tests is performed to tell if there is any parallels, coincidence and parity of both profiles for Solok Regency.

a. Parallels test

Hypothesis to test is:

$$H_{01}: C\mu_1 = C\mu_2$$
$$H_{11}: C\mu_1 \neq C\mu_2$$

with test statistic:

$$T^2 = (\bar{X}_1 - \bar{X}_2)'C'\left[\left(\frac{1}{n_1} + \frac{1}{n_2}\right)CSC'\right]^{-1} C(\bar{X}_1 - \bar{X}_2)$$
$$= 16{,}026$$

and a 7×8 sized contrast matrix C with $n_1 = n_2 = 8$. The comparison value is calculated as follows:

$$c^2 = \frac{(n_1 + n_2 - 2)(p - 1)}{n_1 + n_2 - p} F_{p-1, n_1+n_2-p}(\alpha) = 42{,}88$$

where $F_{7,8}(0{,}05) = 3{,}5$.

It is found that $T^2 < c^2$ therefore H_{01} is accepted, meaning that the profiles of ideal and actual amount of nutmeg production in Solok Regency are similar.

b. Coincidence test

Hypothesis to test is:

$$H_{02}: 1'\mu_1 = 1'\mu_2$$
$$H_{12}: 1'\mu_1 \neq 1'\mu_2$$

with matrix $\mathbf{1}' = [1\ 1\ 1\ 1\ 1\ 1\ 1\ 1]$. Test statistic used is Hoteling calculated as follows:

$$T^2 = 1'(\bar{X}_1 - \bar{X}_2)\left[\left(\frac{1}{n_1} + \frac{1}{n_2}\right)1S1'\right]^{-1} 1'(\bar{X}_1 - \bar{X}_2) = 361{,}58$$

and the comparison value calculated of:

$$t^2_{n_1+n_2+2}\left(\frac{\alpha}{2}\right) = F_{1,n_1+n_2-2}(\alpha) = F_{1,4}(0{,}05) = 4{,}6$$

It is found that $T^2 > t^2$ therefore H_{02} is rejected, meaning that the amount of ideal and actual nutmeg production in Solok Regency are not exactly equal. However, the both data do not coincide, the agricultural improvement on nutmeg plantation in this region is almost optimum.

c. Level test

Hypothesis to test is:

$$H_{03}: C\mu = 0$$

$$H_{13}: C\mu \neq 0$$

The Hoteling test statistic is calculated as follows:

$$T^2 = (n_1 + n_2)\bar{X}'C'[CSC']^{-1}C\bar{X} = 95{,}97$$

The value of $\bar{X}$ is obtained from $\bar{X} = \frac{n_1}{n_1+n_2}\bar{X}_1 + \frac{n_2}{n_1+n_2}\bar{X}_2$, with $n_1 = n_2 = 8$.

The comparison value is calculated as follow

$$c^2 = \frac{(n_1 + n_2 - 1)(p - 1)}{n_1 + n_2 - p + 1} F_{p-1,n_1+n_2-p+1}(\alpha) = 38{,}8$$

and the value of $F_{7,9}(0{,}05) = 3{,}29$.

It is found that $T^2 > c^2$ therefore H_{03} is rejected, meaning that there is difference between the amount of ideal and actual nutmeg production in Solok Regency in some periods.

2. **Tanah Datar Regency**

The following Figure 11 displays the relationship between the data on the ideal and actual amount of nutmeg production in Tanah Datar Regency:

Figure 11. Relationship between nutmeg productive area and the amount of production in Tanah Datar Regency, 2011 – 2018

Profile test analysis is to be performed as follows:

a. Parallels test

Hypothesis to test is:

$$H_{01}: C\mu_1 = C\mu_2$$
$$H_{11}: C\mu_1 \neq C\mu_2$$

with test statistic:

$$T^2 = (\bar{X}_1 - \bar{X}_2)'C'\left[\left(\frac{1}{n_1} + \frac{1}{n_2}\right) CSC'\right]^{-1} C(\bar{X}_1 - \bar{X}_2)$$
$$= 33{,}45$$

and a 7×8 sized contrast matrix C with $n_1 = n_2 = 8$. The comparison value is calculated as follows:

$$c^2 = \frac{(n_1 + n_2 - 2)(p - 1)}{n_1 + n_2 - p} F_{p-1, n_1+n_2-p}(\alpha) = 42{,}88$$

where $F_{7,8}(0{,}05) = 3{,}5$.

It is found that $T^2 < c^2$ therefore H_{01} is accepted, meaning that the profiles of ideal and actual amount of nutmeg production in Tanah Datar Regency are similar.

b. Coincidence test

Hypothesis to test is:

$$H_{02}: 1'\mu_1 = 1'\mu_2$$
$$H_{12}: 1'\mu_1 \neq 1'\mu_2$$

Test statistic used is Hoteling's calculated as follows:

$$T^2 = 1'(\bar{X}_1 - \bar{X}_2)\left[\left(\frac{1}{n_1} + \frac{1}{n_2}\right) 1S1'\right]^{-1} 1'(\bar{X}_1 - \bar{X}_2) = 172{,}04$$

and the comparison value calculated of:

$$t^2_{n_1+n_2+2}\left(\frac{\alpha}{2}\right) = F_{1, n_1+n_2-2}(\alpha) = F_{1,4}(0{,}05) = 4{,}6$$

It is found that $T^2 > t^2$ therefore H_{02} is rejected, meaning that the amount of ideal and actual nutmeg production in Tanah Datar Regency are not exactly equal. However, the both data do not coincide, the agricultural improvement on nutmeg plantation in this region is almost optimum.

c. Level test

Hypothesis to test is:

$$H_{03}: C\mu = 0$$
$$H_{13}: C\mu \neq 0$$

The Hoteling test statistic is calculated as follows:

$$T^2 = (n_1 + n_2)\bar{X}'C'[CSC']^{-1}C\bar{X} = 78{,}55$$

The comparison value is calculated as follows

$$c^2 = \frac{(n_1 + n_2 - 1)(p - 1)}{n_1 + n_2 - p + 1} F_{p-1, n_1+n_2-p+1}(\alpha) = 38{,}38$$

and the value of $F_{7,9}(0{,}05) = 3{,}29$.

It is found that $T^2 > c^2$ therefore H_{03} is rejected, meaning that there is difference between the amount of ideal and actual nutmeg production in Tanah Datar Regency in some periods.

3. Pasaman Barat Regency

The following Figure 12 displays the relationship between the data on the ideal and actual amount of nutmeg production in Pasaman Barat Regency:

Figure 12. Relationship between nutmeg productive area and the amount of production in Pasaman Barat Regency, 2011 – 2018

Profile test analysis is to be performed as follows:

a. Parallels test

Hypothesis to test is:

$$H_{01}: C\mu_1 = C\mu_2$$

$$H_{11}: C\mu_1 \neq C\mu_2$$

with test statistic:

$$T^2 = (\bar{X}_1 - \bar{X}_2)'C'\left[\left(\frac{1}{n_1}+\frac{1}{n_2}\right)CSC'\right]^{-1} C(\bar{X}_1 - \bar{X}_2)$$
$$= 23{,}2$$

and a 7×8 sized contrast matrix C with $n_1 = n_2 = 8$. The comparison value is calculated as follows:

$$c^2 = \frac{(n_1 + n_2 - 2)(p-1)}{n_1 + n_2 - p} F_{p-1,n_1+n_2-p}(\alpha) = 42{,}88$$

where $F_{7,8}(0{,}05) = 3{,}5$.

It is found that $T^2 < c^2$ therefore H_{01} is accepted, meaning that the profiles of ideal and actual amount of nutmeg production in Pasaman Barat Regency are similar.

b. Coincidence test

Hypothesis to test is:

$$H_{02}: 1'\mu_1 = 1'\mu_2$$
$$H_{12}: 1'\mu_1 \neq 1'\mu_2$$

Test statistic used is Hoteling's calculated as follows:

$$T^2 = 1'(\bar{X}_1 - \bar{X}_2)\left[\left(\frac{1}{n_1}+\frac{1}{n_2}\right)1S1'\right]^{-1} 1'(\bar{X}_1 - \bar{X}_2) = 30{,}67$$

and the comparison value calculated of:

$$t^2_{n_1+n_2+2}\left(\frac{\alpha}{2}\right) = F_{1,n_1+n_2-2}(\alpha) = F_{1,4}(0{,}05) = 4{,}6$$

It is found that $T^2 > t^2$ therefore H_{02} is rejected, meaning that the amount of ideal and actual nutmeg production in Pasaman Barat Regency are not exactly equal. However, the both data do not coincide, the agricultural improvement on nutmeg plantation in this region is almost optimum.

c. Level test

Hypothesis to test is:

$$H_{03}: C\mu = 0$$
$$H_{13}: C\mu \neq 0$$

The Hoteling test statistic is calculated as follows:

$$T^2 = (n_1 + n_2)\bar{X}'C'[CSC']^{-1}C\bar{X} = 447{,}13$$

The comparison value is calculated as follows

$$c^2 = \frac{(n_1 + n_2 - 1)(p - 1)}{n_1 + n_2 - p + 1} F_{p-1,n_1+n_2-p+1}(\alpha) = 38{,}38$$

and the value of $F_{7,9}(0{,}05) = 3{,}29$.

It is found that $T^2 > c^2$ therefore H_{03} is rejected, meaning that there is difference between the amount of ideal and actual nutmeg production in Pasaman Barat Regency in some periods.

4. Solok Municipality

The following Figure 13 displays the relationship between the data on the ideal and actual amount of nutmeg production in Solok Municipality:

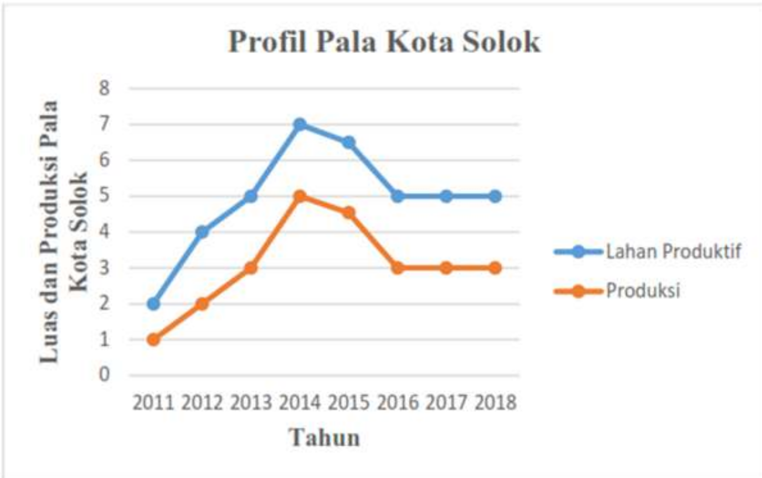


Figure 13. Relationship between nutmeg productive area and the amount of production in Solok Municipality, 2011 – 2018

Profile test analysis is to be performed as follows:

a. Parallels test

Hypothesis to test is:

$$H_{01}: C\mu_1 = C\mu_2$$
$$H_{11}: C\mu_1 \neq C\mu_2$$

with test statistic:

$$T^2 = (\bar{X}_1 - \bar{X}_2)'C'\left[\left(\frac{1}{n_1} + \frac{1}{n_2}\right) CSC'\right]^{-1} C(\bar{X}_1 - \bar{X}_2)$$
$$= 1{,}76$$

and $(\bar{X}_1 - \bar{X}_2)$ is obtained by substracting the ideal to actual amount of nutmeg production in Solok Municipality. The comparison value is calculated as follows:

$$c^2 = \frac{(n_1 + n_2 - 2)(p - 1)}{n_1 + n_2 - p} F_{p-1, n_1+n_2-p}(\alpha) = 42{,}88$$

where $F_{7,8}(0{,}05) = 3{,}5$.

It is found that $T^2 < c^2$ therefore H_{01} is accepted, meaning that the profiles of ideal and actual amount of nutmeg production in Solok Municipality are similar.

b. Coincidence test

Hypothesis to test is:

$$H_{02}: 1'\mu_1 = 1'\mu_2$$
$$H_{12}: 1'\mu_1 \neq 1'\mu_2$$

Test statistic used is Hoteling's calculated as follows:

$$T^2 = 1'(\bar{X}_1 - \bar{X}_2)\left[\left(\frac{1}{n_1} + \frac{1}{n_2}\right)1S1'\right]^{-1} 1'(\bar{X}_1 - \bar{X}_2) = 56{,}86$$

and the comparison value calculated of:

$$t^2_{n_1+n_2+2}\left(\frac{\alpha}{2}\right) = F_{1,n_1+n_2-2}(\alpha) = F_{1,4}(0{,}05) = 4{,}6$$

It is found that $T^2 > t^2$ therefore H_{02} is rejected, meaning that the amount of ideal and actual nutmeg production in Solok Municipality are not exactly equal. However, the both data do not coincide, the agricultural improvement on nutmeg plantation in this region is almost optimum.

c. Level test

Hypothesis to test is:

$$H_{03}: C\mu = 0$$
$$H_{13}: C\mu \neq 0$$

The Hoteling's test statistic is calculated as follows:

$$T^2 = (n_1 + n_2)\bar{X}'C'[CSC']^{-1}C\bar{X} = 110{,}24$$

The comparison value is calculated as follows

$$c^2 = \frac{(n_1 + n_2 - 1)(p - 1)}{n_1 + n_2 - p + 1} F_{p-1, n_1+n_2-p+1}(\alpha) = 38{,}38$$

and the value of $F_{7,9}(0{,}05) = 3{,}29$.

It is found that $T^2 > c^2$ therefore H_{03} is rejected, meaning that there is difference between the amount of ideal and actual nutmeg production in Solok Municipality in some periods.

5. Sawahlunto Municipality

The following Figure 14 displays the relationship between the data on the ideal and actual amount of nutmeg production in Sawahlunto Municipality:

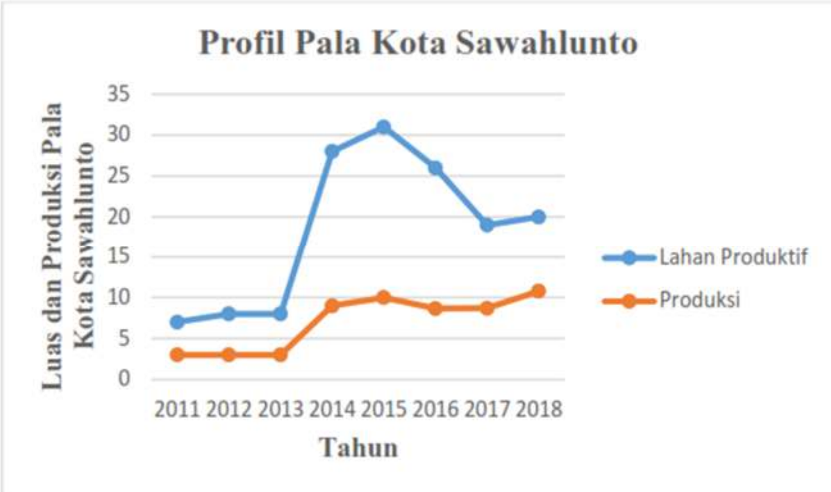


Figure 14. Relationship between nutmeg productive area and the amount of production in Sawahlunto Municipality, 2011 – 2018

Profile test analysis is to be performed as follows:

a. Parallels test

Hypothesis to test is:

$$H_{01}: C\mu_1 = C\mu_2$$
$$H_{11}: C\mu_1 \neq C\mu_2$$

with test statistic:

$$T^2 = (\bar{X}_1 - \bar{X}_2)'C'\left[\left(\frac{1}{n_1} + \frac{1}{n_2}\right)CSC'\right]^{-1} C(\bar{X}_1 - \bar{X}_2)$$
$$= 28{,}84$$

and $(\bar{X}_1 - \bar{X}_2)$ is obtained by substracting the ideal to actual amount of nutmeg production in Sawahlunto Municipality. The comparison value is calculated as follows:

$$c^2 = \frac{(n_1 + n_2 - 2)(p - 1)}{n_1 + n_2 - p} F_{p-1, n_1+n_2-p}(\alpha) = 42{,}88$$

where $F_{7,8}(0{,}05) = 3{,}5$.

It is found that $T^2 < c^2$ therefore H_{01} is accepted, meaning that the profiles of ideal and actual amount of nutmeg production in Sawahlunto Municipality are similar.

b. Coincidence test

Hypothesis to test is:

$$H_{02}: 1'\mu_1 = 1'\mu_2$$
$$H_{12}: 1'\mu_1 \neq 1'\mu_2$$

Test statistic used is Hoteling's calculated as follows:

$$T^2 = 1'(\bar{X}_1 - \bar{X}_2)\left[\left(\frac{1}{n_1} + \frac{1}{n_2}\right)1S1'\right]^{-1} 1'(\bar{X}_1 - \bar{X}_2) = 78{,}15$$

and the comparison value calculated of:

$$t^2_{n_1+n_2+2}\left(\frac{\alpha}{2}\right) = F_{1,n_1+n_2-2}(\alpha) = F_{1,4}(0{,}05) = 4{,}6$$

It is found that $T^2 > t^2$ therefore H_{02} is rejected, meaning that the amount of ideal and actual nutmeg production in Sawahlunto Municipality are not exactly equal. However, the both data do not coincide, the agricultural improvement on nutmeg plantation in this region is almost optimum.

c. Level test

Hypothesis to test is:

$$H_{03}: C\mu = 0$$
$$H_{13}: C\mu \neq 0$$

The Hoteling's test statistic is calculated as follows:

$$T^2 = (n_1 + n_2)\bar{X}'C'[CSC']^{-1}C\bar{X} = 87{,}17$$

The comparison value is calculated as follows

$$c^2 = \frac{(n_1 + n_2 - 1)(p - 1)}{n_1 + n_2 - p + 1}F_{p-1,n_1+n_2-p+1}(\alpha) = 38{,}38$$

and the value of $F_{7,9}(0{,}05) = 3{,}29$.

It is found that $T^2 > c^2$ therefore H_{03} is rejected, meaning that there is difference between the amount of ideal and actual nutmeg production in Sawahlunto Municipality in some periods.

6. **Pariaman Municipality**

The following Figure 14 displays the relationship between the data on the ideal and actual amount of nutmeg production in Pariaman Municipality:

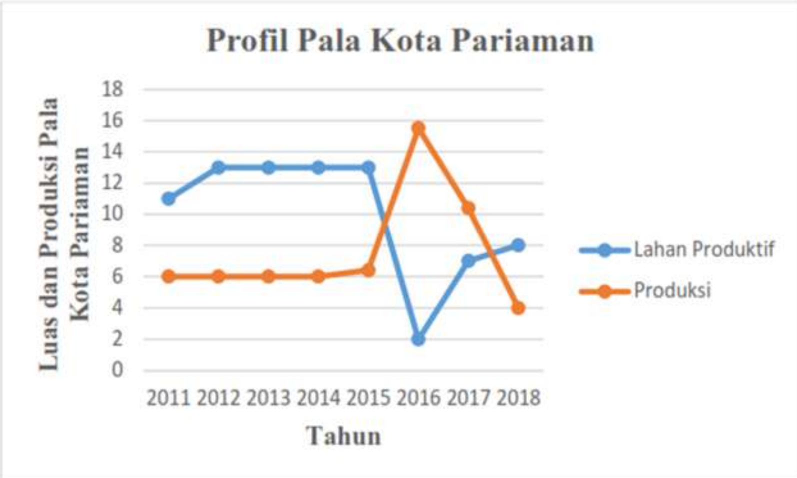


Figure 15. Relationship between nutmeg productive area and the amount of production in Pariaman Municipality, 2011 – 2018

Profile test analysis is to be performed as follows:

a. Parallels test

Hypothesis to test is:

$$H_{01}: C\mu_1 = C\mu_2$$
$$H_{11}: C\mu_1 \neq C\mu_2$$

with test statistic:

$$T^2 = (\bar{X}_1 - \bar{X}_2)'C'\left[\left(\frac{1}{n_1} + \frac{1}{n_2}\right)CSC'\right]^{-1} C(\bar{X}_1 - \bar{X}_2)$$
$$= 28{,}84$$

and $(\bar{X}_1 - \bar{X}_2)$ is obtained by substracting the ideal to actual amount of nutmeg production in Pariaman Municipality. The comparison value is calculated as follows:

$$c^2 = \frac{(n_1 + n_2 - 2)(p - 1)}{n_1 + n_2 - p} F_{p-1,n_1+n_2-p}(\alpha) = 101{,}07$$

where $F_{7,8}(0{,}05) = 3{,}5$.

It is found that $T^2 < c^2$ therefore H_{01} is accepted, meaning that the profiles of ideal and actual amount of nutmeg production in Pariaman Municipality are similar.

b. Coincidence test

Hypothesis to test is:

$$H_{02}: 1'\mu_1 = 1'\mu_2$$
$$H_{12}: 1'\mu_1 \neq 1'\mu_2$$

Test statistic used is Hoteling's calculated as follows:

$$T^2 = 1'(\bar{X}_1 - \bar{X}_2)\left[\left(\frac{1}{n_1} + \frac{1}{n_2}\right)1S1'\right]^{-1} 1'(\bar{X}_1 - \bar{X}_2) = 12{,}94$$

and the comparison value calculated of:

$$t^2_{n_1+n_2+2}\left(\frac{\alpha}{2}\right) = F_{1,n_1+n_2-2}(\alpha) = F_{1,4}(0{,}05) = 4{,}6$$

It is found that $T^2 > t^2$ therefore H_{02} is rejected, meaning that the amount of ideal and actual nutmeg production in Pariaman Municipality are not exactly equal. However, the both data do not coincide, the agricultural improvement on nutmeg plantation in this region is almost optimum.

c. Level test

Hypothesis to test is:

$$H_{03}: C\mu = 0$$
$$H_{13}: C\mu \neq 0$$

The Hoteling's test statistic is calculated as follows:

$$T^2 = (n_1 + n_2)\bar{X}'C'[CSC']^{-1}C\bar{X} = 10{,}93$$

The comparison value is calculated as follows

$$c^2 = \frac{(n_1 + n_2 - 1)(p - 1)}{n_1 + n_2 - p + 1} F_{p-1,n_1+n_2-p+1}(\alpha) = 38{,}38$$

and the value of $F_{7,9}(0{,}05) = 3{,}29$.

It is found that $T^2 < c^2$ therefore H_{03} is accepted, meaning that there is difference between the amount of ideal and actual nutmeg production in Pariaman Municipality in some periods.

B. Discussion

The actual data on nutmeg production in Sumatera Barat from 2011 to 2018 has been used to estimate production for the oncoming 5 years i.e from 2019 to 2023 by using Brown-type Triple Exponential Smoothing Method. The estimated model is obtained by choosing a theoretical parameter value α of $\frac{1}{N} = \frac{1}{8} = 0{,}125$. By using 'try and error' method it is found that such parameter value gives the smallest MSE. It means that the error rate of the predicting the amount of nutmeg production Sumatera Barat is 12.5%. Furthermore, to forecast the production values for the next 5 years, the following model equation is used:

$$F_{t+m} = 1250{,}65 + 5{,}225m + 0{,}068m^2$$

Based on the equation above, it is found that the production is predicted to increase since the equation coefficients (smoothing factors) and intercept are positive. The forecasting on nutmeg production in Sumatera Barat from 2019 to 2023 results in increasing values. The amount of nutmeg production is estimated to range from 1255.95 tons to 1278.49 tons. This shows that the production of nutmeg in Sumatera Barat for the oncoming years is potentially larger than previous years.

The variables used in testing the similarity of profiles between the ideal and actual amount of nutmeg production in Sumatera Barat are the nutmeg producing districts including: Kepulauan Mentawai, Pesisir Selatan, Solok, Tanah Datar, Padang Pariaman, Agam, and Pasaman Barat, as well as cities: Padang, Solok, Sawahlunto, and Pariaman. Both population (ideal and actual production) profiles are tested for their parallelism, coincidence and parity (levelness).

The first profile analysis performed is to test if the average of the ideal and actual nutmeg production amount in each district/city is equal or not by using parallels test. List of regions having a different average between the ideal and actual production amount in Sumatera Barat Province is displayed in Figure 6. In the figure it can be seen that there are 5 districts/ cities where the average amount of ideal and actual production differs significantly. The areas are Kepulauan Mentawai, Pesisir Selatan, Padang Pariaman, Agam, and Padang. In these areas, the actual production of nutmeg is far beyond the ideal production. Contrast to this, the average of the ideal and actual nutmeg production does not significantly differ or tends to be similar in the remaining nutmeg producing regions in Sumatera Barat.

The second analysis is to perform a profile test on each district/city except for the five ‘unparallel’ regions. In districts of Solok, Tanah Datar, Pasaman Barat, Solok and Sawahlunto Municipalities, the parallels test results in accepting the null hypothesis, meaning that the data on the ideal and actual amount of nutmeg production are similar in observed years. Next, the coincidence test results in rejecting the H_{02} hypothesis, which means that the ideal and actual production of nutmeg are not exactly equal. The level test also results in rejecting the null hypothesis H_{03}, meaning that in these latest years there is some inequal data on the ideal and actual amount of nutmeg production even though the area has the potential to develop nutmeg. Thus, it can be concluded that the development of nutmeg in Kab. Solok, Tanah Datar, Pasaman Barat, Solok and Sawahlunto Municipalities is close to optimal even though there is unexpected condition like those tested using coincidence test.

CHAPTER V
SUMMARY

A. Conclusion

Based on the results of analysis and discussion delivered in the previous chapter, several conclusions can be drawn as follows:

1. The model obtained by implementing Brown-type triple exponential smoothing technique for forecasting nutmeg production in Sumatera Barat can be written:

$$F_{t+m} = 1250{,}65 + 5{,}225m + 0{,}068m^2$$

where:

m : periods to forecast

F_{t+m} : forecast for nutmeg production

a_t : adjusted average value for period t

b_t : double smoothing trend

c_t : triple smoothing trend

2. The forecast for the amount of nutmeg production (tonnes) in Sumatera Barat from 2019 to 2023 using Brown-type Triple Exponential Smoothing Method:

Year	Period	m	Amount of production (tonnes)
2019	9	1	1255.95
2020	10	2	1261.38
2021	11	3	1266.94
2022	12	4	1272.65
2023	13	5	1278.49

The forecast results for 2019 to 2023 indicate a decrease of nutmeg produced compared to that of 2018. The average production amount for nutmeg in Sumatera Barat is predicted of 1267,08 tonnes.

3. By land optimization level, eleven nutmeg producing areas in Sumatera Barat can be categorized into three groups: (1) Below optimal areas, include Kepulauan Mentawai, Pesisir Selatan, Padang Pariaman, and Agam regencies, and Padang municipality, (2) Almost optimal areas include Solok, Tanah Datar

and Pasaman Barat regencies, and Solok and Sawahlunto municipalities, and (3) Completely optimal area includes Pariaman municipality

B. Recommendation

Based on the research carried out, the following recommendations are proposed for related stakeholders:

1. Based on the forecast results, the amount of nutmeg production is predicted to decrease in the future and this possibly causes lower contribution to regional income. It is necessary to promote the opening and expansion of expertise jobs in related spheres so that the nutmeg production and regional income can be escalated in Sumatera Barat.
2. Regions specializing in producing nutmeg is expected to invest more seriously to develop their potentials in order to reach optimal level of nutmeg production.
3. Further research on this topic may consider to implement profile analysis with tests for more than two populations.

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APPENDIX

Appendix 1. Simulating trial and error technique to choose α value that gives smallest MSE of nutmeg production for oncoming 5 years in Sumatera Barat

α	MSE	α	MSE	α	MSE
0,125	393191,8	0,135	394022,7	0,145	394868,7
0,126	393274,1	0,136	394106,7	0,146	394954,1
0,127	393356,6	0,137	394190,8	0,147	395039,5
0,128	393439,3	0,138	394275,0	0,148	395125,2
0,129	393522,2	0,139	394359,4	0,149	395210,9
0,13	393605,2	0,14	394443,9	0,15	395296,8
0,131	393688,4	0,141	394528,6	0,151	395382,8
0,132	393771,7	0,142	394613,4	0,152	395468,9
0,133	393855,2	0,143	394698,4	0,153	395555,2
0,134	393938,9	0,144	394783,5	0,154	395641,6

Appendix 2. MSE of forecasted value with $\alpha = 0.125$

J11 f_x =J10/8

	A	B	C	D	E	F	G	H	I	J
1	Tahun	Produksi Pala (Yt)	S't	S''t	S'''t	at	bt	ct	Ramalan (Ft)	(Yt-Ft)^2
2	2011	1172,00	1172,00	1172,00	1172,00	0	0	0	0	1373584
3	2012	1224,00	1178,5	1172,81	1172,10	1189,16	2,28516	0,10156	0	1498176
4	2013	1332,00	1197,69	1175,92	1172,58	1237,88	8,56104	0,37598	1191,5	19740,25
5	2014	1388,00	1221,48	1181,62	1173,71	1293,29	15,1498	0,6521	1246,625	19986,89063
6	2015	1450,19	1250,07	1190,17	1175,77	1355,45	22,0168	0,92832	1308,76563	20000,85384
7	2016	1068,86	1227,42	1194,83	1178,15	1275,91	9,36306	0,32467	1377,9277	95522,84029
8	2017	998,70	1198,83	1195,33	1180,30	1190,79	-2,913	-0,23536	1285,43661	82217,88148
9	2018	1378,30	1221,26	1198,57	1182,58	1250,65	5,22496	0,13679	1187,76045	36305,32134
10						Jumlah				3145534,04
11	Alfa	0,125				MSE				393191,75
12										

Appendix 3. Forecast for nutmeg production in Sumatera Barat for oncoming years with $\alpha = 0.125$

I10 =F9+(G9*1)+((0,5*H9)*(1^2))

	A	B	C	D	E	F	G	H	I
1	Tahun	Produksi Pala (Yt)	S't	S"t	S"'t	at	bt	ct	Ramalan (Ft)
2	2011	1172,00	1172,00	1172,00	1172,00	0	0	0	0
3	2012	1224,00	1178,5	1172,81	1172,10	1189,16	2,28516	0,10156	0
4	2013	1332,00	1197,69	1175,92	1172,58	1237,88	8,56104	0,37598	1191,5
5	2014	1388,00	1221,48	1181,62	1173,71	1293,29	15,1498	0,6521	1246,625
6	2015	1450,19	1250,07	1190,17	1175,77	1355,45	22,0168	0,92832	1308,76563
7	2016	1068,86	1227,42	1194,83	1178,15	1275,91	9,36306	0,32467	1377,9277
8	2017	998,70	1198,83	1195,33	1180,30	1190,79	-2,913	-0,23536	1285,43661
9	2018	1378,30	1221,26	1198,57	1182,58	1250,65	5,22496	0,13679	1187,76045
10	2019								1255,94674
11	2020								1261,37688
12	2021								1266,94381
13	2022								1272,64752
14	2023								1278,48802
15									
16	Alfa	0,125							

Appendix 4. First smoothing factor calculation using Microsoft Excel

C3 =(B11*B3)+((1-B11)*C2)

	A	B	C	D
1	Tahun	Produksi Pala	S't	
2	2011	1172,00	1172,00	
3	2012	1224,00	1178,5	
4	2013	1332,00	1197,69	
5	2014	1388,00	1221,48	
6	2015	1450,19	1250,07	
7	2016	1068,86	1227,42	
8	2017	998,70	1198,83	
9	2018	1378,30	1221,26	
10				
11	Alfa	0,125		
12				
13				
14				

Appendix 5. Second smoothing factor calculation using Microsoft Excel

D3 =(B11*C3)+((1-B11)*D2)

	A	B	C	D	E	F
1	**Tahun**	**Produksi Pala**	**S't**	**S"t**		
2	2011	1172,00	1172,00	1172,00		
3	2012	1224,00	1178,5	1172,81		
4	2013	1332,00	1197,69	1175,92		
5	2014	1388,00	1221,48	1181,62		
6	2015	1450,19	1250,07	1190,17		
7	2016	1068,86	1227,42	1194,83		
8	2017	998,70	1198,83	1195,33		
9	2018	1378,30	1221,26	1198,57		
10						
11	Alfa	0,125				
12						
13						
14						

Appendix 6. Third smoothing factor calculation using Microsoft Excel

E3 =(B11*D3)+((1-B11)*E2)

	A	B	C	D	E
1	**Tahun**	**Produksi Pala**	**S't**	**S"t**	**S"'t**
2	2011	1172,00	1172,00	1172,00	1172,00
3	2012	1224,00	1178,5	1172,81	1172,10
4	2013	1332,00	1197,69	1175,92	1172,58
5	2014	1388,00	1221,48	1181,62	1173,71
6	2015	1450,19	1250,07	1190,17	1175,77
7	2016	1068,86	1227,42	1194,83	1178,15
8	2017	998,70	1198,83	1195,33	1180,30
9	2018	1378,30	1221,26	1198,57	1182,58
10					
11	Alfa	0,125			
12					
13					
14					

Appendix 7. Calculation on adjusted average value (a_t) using Microsoft Excel

F3 =(3*C3)-(3*D3)+E3

	A	B	C	D	E	F
1	Tahun	Produksi Pala	S't	S''t	S'''t	at
2	2011	1172,00	1172,00	1172,00	1172,00	
3	2012	1224,00	1178,5	1172,81	1172,10	1189,16
4	2013	1332,00	1197,69	1175,92	1172,58	1237,88
5	2014	1388,00	1221,48	1181,62	1173,71	1293,29
6	2015	1450,19	1250,07	1190,17	1175,77	1355,45
7	2016	1068,86	1227,42	1194,83	1178,15	1275,91
8	2017	998,70	1198,83	1195,33	1180,30	1190,79
9	2018	1378,30	1221,26	1198,57	1182,58	1250,65
10						
11	Alfa	0,125				
12						
13						
14						

Appendix 8. Calculation on double smoothing trend (b_t) using Microsoft Excel

G3 =(B11/(2*((1-B11)^2)))*(((6-(5*B11))*C3)-((10-(8*B11))*D3)+((4-(3*B11))*E3))

	A	B	C	D	E	F	G
1	Tahun	Produksi Pala	S't	S''t	S'''t	at	bt
2	2011	1172,00	1172,00	1172,00	1172,00		
3	2012	1224,00	1178,5	1172,81	1172,10	1189,16	2,28516
4	2013	1332,00	1197,69	1175,92	1172,58	1237,88	8,56104
5	2014	1388,00	1221,48	1181,62	1173,71	1293,29	15,1498
6	2015	1450,19	1250,07	1190,17	1175,77	1355,45	22,0168
7	2016	1068,86	1227,42	1194,83	1178,15	1275,91	9,36306
8	2017	998,70	1198,83	1195,33	1180,30	1190,79	-2,913
9	2018	1378,30	1221,26	1198,57	1182,58	1250,65	5,22496
10							
11	Alfa	0,125					

Appendix 9. Calculation on triple smoothing trend (c_t) using Microsoft Excel

H3 fx =((B11^2)/((1-B11)^2))*(C3-(2*D3)+E3)

	A	B	C	D	E	F	G	H
1	**Tahun**	**Produksi Pala**	**S't**	**S''t**	**S'''t**	**at**	**bt**	**ct**
2	2011	1172,00	1172,00	1172,00	1172,00			
3	2012	1224,00	1178,5	1172,81	1172,10	1189,16	2,28516	0,10156
4	2013	1332,00	1197,69	1175,92	1172,58	1237,88	8,56104	0,37598
5	2014	1388,00	1221,48	1181,62	1173,71	1293,29	15,1498	0,6521
6	2015	1450,19	1250,07	1190,17	1175,77	1355,45	22,0168	0,92832
7	2016	1068,86	1227,42	1194,83	1178,15	1275,91	9,36306	0,32467
8	2017	998,70	1198,83	1195,33	1180,30	1190,79	-2,913	-0,2354
9	2018	1378,30	1221,26	1198,57	1182,58	1250,65	5,22496	0,13679
10								
11	Alfa	0,125						
12								
13								
14								
15								
16								

Appendix 10. Ideal and actual nutmeg production

No	Tahun	Daerah										
		Kabupaten							Kota			
	Produksi Ideal Lahan	Kep.Men-tawai	Pesisir Selatan	Solok	Tanah Datar	Pd. Pariaman	Agam	Pasaman Barat	Padang	Solok	Sawah-lunto	Pariaman
1	2011	821	367	49	58	261	705	4	104	2	7	11
2	2012	825	512	49	58	328	705	6	106	4	8	13
3	2013	825	581	52	56	328	705	6	106	5	8	13
4	2014	706	574	49	57	335	721	5	143	7	28	13
5	2015	718	627	57	77,5	335	769	5	151	6,5	31	13
6	2016	658	606	34	56	295	388	10	80	5	26	2
7	2017	648	550	35,85	49	281	332	10	72	5	19	7
8	2018	648	649	56,9	76,3	273	639	20	71,5	5	20	8
	Jumlah (Σ)	5849	4466	382,75	487,8	2436	4964	66	833,5	39,5	147	80
	Rata-Rata	731,125	558,25	47,84375	60,975	304,5	620,5	8,25	104,1875	4,9375	18,375	10

No	Tahun	Daerah										
		Kabupaten							Kota			
	Jumlah Produksi	Kep.Men-tawai	Pesisir Selatan	Solok	Tanah Datar	Pd. Pariaman	Agam	Pasaman Barat	Padang	Solok	Sawah-lunto	Pariaman
1	2011	369	172	23	28	141	338	2	49	1	3	6
2	2012	423	252	11	28	129	340	1	29	2	3	6
3	2013	423	287	26	29	174	347	4	30	3	3	6
4	2014	439	271	24	35	179	369	4	47	5	9	6
5	2015	447	305	28	48	179	368,5	3,75	50	4,54	10	6,4
6	2016	378	182	18	48,4	75,03	292,13	7,5	40,6	3	8,67	15,53
7	2017	370	150,2	9,7	44,6	72,2	289,4	3,7	36,9	3	8,7	10,4
8	2018	447	315	28	45,7	104	370	8	42,8	3	10,8	4
	Jumlah (Σ)	3296	1934,2	167,7	306,7	1053,23	2714,03	33,95	325,3	24,54	56,17	60,33
	Rata-Rata	412	241,775	20,9625	38,3375	131,6538	339,2538	4,24375	40,6625	3,0675	7,02125	7,54125

Appendix 11. Matrices of the amount of ideal and actual nutmeg production

$$\boldsymbol{X_1} = \begin{bmatrix} 821 & 367 & 49 & 58 & 261 & 705 & 4 & 104 & 2 & 7 & 11 \\ 825 & 512 & 49 & 58 & 328 & 705 & 6 & 106 & 4 & 8 & 13 \\ 825 & 581 & 52 & 56 & 328 & 705 & 6 & 106 & 5 & 8 & 13 \\ 706 & 574 & 49 & 57 & 335 & 721 & 5 & 143 & 7 & 28 & 13 \\ 718 & 627 & 57 & 77{,}5 & 335 & 769 & 5 & 151 & 6{,}5 & 31 & 13 \\ 658 & 606 & 34 & 56 & 295 & 388 & 10 & 80 & 5 & 26 & 2 \\ 648 & 550 & 35{,}85 & 49 & 281 & 332 & 10 & 72 & 5 & 19 & 7 \\ 648 & 649 & 56{,}9 & 76{,}3 & 273 & 639 & 20 & 71{,}5 & 5 & 20 & 8 \end{bmatrix}$$

$$\boldsymbol{X_2} = \begin{bmatrix} 369 & 172 & 23 & 28 & 141 & 338 & 2 & 49 & 1 & 3 & 6 \\ 423 & 252 & 11 & 28 & 129 & 340 & 1 & 29 & 2 & 3 & 6 \\ 423 & 287 & 26 & 29 & 174 & 347 & 4 & 30 & 3 & 3 & 6 \\ 439 & 271 & 24 & 35 & 179 & 369 & 4 & 47 & 5 & 9 & 6 \\ 447 & 305 & 28 & 48 & 179 & 368{,}5 & 3{,}75 & 50 & 4{,}54 & 10 & 6{,}4 \\ 378 & 182 & 18 & 48{,}4 & 75{,}03 & 292{,}13 & 7{,}5 & 40{,}6 & 3 & 8{,}67 & 15{,}53 \\ 370 & 150{,}2 & 9{,}7 & 44{,}6 & 72{,}2 & 289{,}4 & 3{,}7 & 36{,}9 & 3 & 8{,}7 & 10{,}4 \\ 447 & 315 & 28 & 45{,}7 & 104 & 370 & 8 & 42{,}8 & 3 & 10{,}8 & 4 \end{bmatrix}$$

Appendix 12. Covariance matrices

Covariance matrix for ideal nutmeg production

1.0e+04 *

0.6525	-0.4435	0.0244	-0.0152	0.0658	0.8347	-0.0276	0.0842	-0.0062	-0.0589	0.0220
-0.4435	0.7827	0.0104	0.0420	0.1032	-0.1914	0.0247	-0.0005	0.0108	0.0564	-0.0078
0.0244	0.0104	0.0075	0.0068	0.0074	0.1267	0.0002	0.0130	0.0002	-0.0006	0.0025
-0.0152	0.0420	0.0068	0.0106	0.0023	0.0862	0.0020	0.0086	0.0004	0.0038	0.0008
0.0658	0.1032	0.0074	0.0023	0.0927	0.2328	-0.0078	0.0674	0.0031	0.0078	0.0070
0.8347	-0.1914	0.1267	0.0862	0.2328	2.7315	-0.0320	0.3635	0.0012	-0.0256	0.0575
-0.0276	0.0247	0.0002	0.0020	-0.0078	-0.0320	0.0028	-0.0110	0.0001	0.0008	-0.0011
0.0842	-0.0005	0.0130	0.0086	0.0674	0.3635	-0.0110	0.0913	0.0021	0.0096	0.0089
-0.0062	0.0108	0.0002	0.0004	0.0031	0.0012	0.0001	0.0021	0.0002	0.0012	0.0001
-0.0589	0.0564	-0.0006	0.0038	0.0078	-0.0256	0.0008	0.0096	0.0012	0.0094	-0.0010
0.0220	-0.0078	0.0025	0.0008	0.0070	0.0575	-0.0011	0.0089	0.0001	-0.0010	0.0016

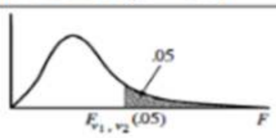
Covariance matrix for actual nutmeg production

1.0e+03 *

1.1700	2.1505	0.1438	0.0184	0.9178	0.9638	0.0111	0.0184	0.0261	0.0354	-0.0807
2.1505	4.1701	0.3202	0.0101	1.7739	1.8282	0.0292	0.0139	0.0407	0.0469	-0.1562
0.1438	0.3202	0.0532	0.0063	0.1969	0.1775	0.0065	0.0317	0.0033	0.0059	-0.0127
0.0184	0.0101	0.0063	0.0857	-0.1873	-0.0634	0.0160	0.0278	0.0056	0.0283	0.0161
0.9178	1.7739	0.1969	-0.1873	1.9824	1.1271	-0.0448	0.0811	0.0217	-0.0372	-0.1039
0.9638	1.8282	0.1775	-0.0634	1.1271	1.0648	-0.0049	0.0880	0.0152	0.0102	-0.1026
0.0111	0.0292	0.0065	0.0160	-0.0448	-0.0049	0.0058	0.0036	0.0009	0.0057	0.0030
0.0184	0.0139	0.0317	0.0278	0.0811	0.0880	0.0036	0.0665	0.0031	0.0140	-0.0025
0.0261	0.0407	0.0033	0.0056	0.0217	0.0152	0.0009	0.0031	0.0016	0.0029	-0.0000
0.0354	0.0469	0.0059	0.0283	-0.0372	0.0102	0.0057	0.0140	0.0029	0.0116	0.0024
-0.0807	-0.1562	-0.0127	0.0161	-0.1039	-0.1026	0.0030	-0.0025	-0.0000	0.0024	0.0136

Appendix 13. F-distribution table

TABLE 5 F-DISTRIBUTION PERCENTAGE POINTS ($\alpha = .05$)



ν_2 \ ν_1	1	2	3	4	5	6	7	8	9	10	12	15	20	25	30	40	60
1	161.5	199.5	215.7	224.6	230.2	234.0	236.8	238.9	240.5	241.9	243.9	246.0	248.0	249.3	250.1	251.1	252.2
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40	19.41	19.43	19.45	19.46	19.46	19.47	19.48
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.74	8.70	8.66	8.63	8.62	8.59	8.57
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.91	5.86	5.80	5.77	5.75	5.72	5.69
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.68	4.62	4.56	4.52	4.50	4.46	4.43
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.00	3.94	3.87	3.83	3.81	3.77	3.74
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.57	3.51	3.44	3.40	3.38	3.34	3.30
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.28	3.22	3.15	3.11	3.08	3.04	3.01
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.07	3.01	2.94	2.89	2.86	2.83	2.79
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.91	2.85	2.77	2.73	2.70	2.66	2.62
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.79	2.72	2.65	2.60	2.57	2.53	2.49
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.69	2.62	2.54	2.50	2.47	2.43	2.38
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.60	2.53	2.46	2.41	2.38	2.34	2.30
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.53	2.46	2.39	2.34	2.31	2.27	2.22
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.48	2.40	2.33	2.28	2.25	2.20	2.16
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.42	2.35	2.28	2.23	2.19	2.15	2.11
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	2.38	2.31	2.23	2.18	2.15	2.10	2.06
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.34	2.27	2.19	2.14	2.11	2.06	2.02
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38	2.31	2.23	2.16	2.11	2.07	2.03	1.98
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.28	2.20	2.12	2.07	2.04	1.99	1.95
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32	2.25	2.18	2.10	2.05	2.01	1.96	1.92
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30	2.23	2.15	2.07	2.02	1.98	1.94	1.89
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27	2.20	2.13	2.05	2.00	1.96	1.91	1.86
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25	2.18	2.11	2.03	1.97	1.94	1.89	1.84
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28	2.24	2.16	2.09	2.01	1.96	1.92	1.87	1.82
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22	2.15	2.07	1.99	1.94	1.90	1.85	1.80
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25	2.20	2.13	2.06	1.97	1.92	1.88	1.84	1.79
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24	2.19	2.12	2.04	1.96	1.91	1.87	1.82	1.77
29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22	2.18	2.10	2.03	1.94	1.89	1.85	1.81	1.75
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.09	2.01	1.93	1.88	1.84	1.79	1.74
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08	2.00	1.92	1.84	1.78	1.74	1.69	1.64
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99	1.92	1.84	1.75	1.69	1.65	1.59	1.53
120	3.92	3.07	2.68	2.45	2.29	2.18	2.09	2.02	1.96	1.91	1.83	1.75	1.66	1.60	1.55	1.50	1.43
∞	3.84	3.00	2.61	2.37	2.21	2.10	2.01	1.94	1.88	1.83	1.75	1.67	1.57	1.51	1.46	1.39	1.32