Analysis of Innovation based on Technometric Model to Predict Technology Life Cycle in Indonesian SME

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Abstract - Forecasting technology is one way that can be used to predict product life cycle. Product life cycle is very important to know, especially by organizations, that are in small medium level, like SME. This research will be conducted in SME Surya Usaha Mandiri, Daerah Istimewa Yogyakarta.Forecasting product life cycle that has been done, will direct this research toward the stage of product development. Stages of development of the products are a necessary stage for an organization, especially in SME, to innovate the product. The purpose of this research is to propose the development of products, such as the stages of innovation that can be done in SME Surya Usaha Mandiri, forecasting conducted based on life cycle assessment of products and technology components using technometric model. The results of this research are proposed innovation based forecasting and product life cycle assessment in SME Surya Usaha Mandiri using technometric model.

Keywords - product life cycle, innovation, technometric model, SME

I. INTRODUCTION

Technology has a life cycle. The life cycle also will make the technology related to the field of economics, especially in the manufacturing industries that produce finished products physically. Just as technology, products produced by an industry also has a life cycle. A product is said to be in the highest levels of the life cycle if the product is already known and used by many people. However, these products would experience a period of saturated, so the life cycle can be decreased.

The life cycle of technology usually becomes less noticeable, even ignored by most SME in Indonesia. Usually SME in Indonesia often focus on making a product that characterize a particular of region or culture. This is what makes the condition of the technology life cycle in the SME becomes unstable. They often pay less attention to symptoms of decreased levels of the technology life cycle, so that over time, their products can suddenly be in the degraded condition.

Conditions in the SME can be caused due to worker's lack of knowledge of the importance of the life cycle of technology and its relationship to the development of SME. Starting from this idea, I am interested in doing research based on forecasting technology to introduce the importance of the life cycle of technology and its relationship to the development of SME in the future.

Place of the SME where the research did was located in Bantul, Yogyakarta. SME is one of the organizations that produce handicrafts. This SME called SME Surya Usaha Mandiri. SME Surya Usaha Mandiri was founded in 2000.

Products produced by this SME are very diverse, such as handbags, purses, mirrors, accessories like; necklaces, key chains, brooches, belts, even to the household needs like; cutlery, curtains, and so on. The products produced by these SME using raw materials such as coconut shells. The reason the use of coconut shell as the main ingredient for the manufacture of a product is, it is a form of waste recycling.

This research aims to provide recommendations to the SME of the forecasting method that suitable to be applied in SME Surya Usaha Mandiri, and suggestions for product development.

II. LITERATURE REVIEW

Technology can be defined as the knowledge, products, processes, tools, methods, and systems used in the creation of a good or service provision [1].

Economic and Social Commission for Asia and the Pacific (ESCAP) divides technology into four components. The fourth components of this technology, are [2] :

1. Technoware (object-embodied technology) :
   Includes tools, equipment, machinery, motor vehicles, plant, and human physical infrastructure used to operate the transformation.
2. Humanware (person-embodied) :
   Includes knowledge, skills / expertise, wisdom, creativity, achievement, and experience of a person or group of people in utilizing natural resources and available technological resources.

3. Infoware (document-embodied technology) : Associated with the process, procedures, techniques, methods, theory, specification, design, observation, manuals and other facts revealed through publications, documentation, and blueprints.
4. Orgaware (institution-embodied technology) : Facilities needed to accommodate the physical, human capacity, and the fact, which consists of management practices, linkages, and organizational arrangements to achieve positive results.

The fourth assessment of component technology using technometric approach, aims to measure the combined contribution (contribution of technology / technology contribution coefficient) of the four components of the technology in a process of transformation of inputs into outputs, which can be used as the basis for planning technology (technology planning). TCC formula is [3]:

$$TCC = T^{\beta t} * H^{\beta h} * I^{\beta i} * O^{\beta o}$$

TCC calculation steps are [3]:

1. Describe the description of the process of transformation (production process) an organization or company.
2. Determine the upper limit and lower limit to the level of sophistication of the technology components using the qualitative assessment scores (range 1-9).
3. Assess the level of sophistication (state of the art) technology component (score range 1-10). State of the art formula (STI) is :
$$ST_i = \frac{1}{10}\left(\sum \frac{k_{ik}}{k_t}\right)$$
4. Calculate the contribution component. The calculation of the contribution of each component technology can be done through the formula :
$$T_i = \frac{1}{9}[LT_i + ST_i(UT_i - LT_i)]$$
$$H_j = \frac{1}{9}[LH_j + SH_j(UH_j - LH_j)]$$
$$I = \frac{1}{9}[LI + SI(UI - LI)]$$
$$O = \frac{1}{9}[LO + SO(UO - LO)]$$
5. Calculate the intensity of importance.
6. Calculate Technology Contribution Coefficient (TCC).
7. Present the interpretation of the results of the calculations in THIO diagram.

TCC value may not be zero, because there is no transformation activity without the involvement of all components of the technology [4]. That means, the function does not allow THIO zero. The maximum value of TCC is one. TCC of a company shows the contribution of technology to output a total transformation operations. The calculated value of TCC will then be compared to Table 1 and Table 2 below [4].

TABLE 1
QUALITATIVE ASSESSMENT BASED ON THE RANGE OF TCC

TCC Value	Classification
0 < TCC < 0,1	Very Low
0,1 < TCC ≤ 0,3	Low
0,3 < TCC ≤ 0,5	Standard
0,5 < TCC ≤ 0,7	Good
0,7 < TCC ≤ 0,9	Very Good
0,9 < TCC ≤ 1,0	Absolute Sophisticated

TABLE 2
TCC TECHNOLOGY LEVEL

TCC Value	Classification
0 < TCC ≤ 0,3	Traditional
0,3 < TCC ≤ 0,7	Semi Modern
0,7 < TCC ≤ 1,0	Modern

For small companies, forecasting technology methods are used to forecast adoption or diffusion of innovations, where parameters such as rate of imitation by other adopters or rate of response to advertising can be measured [5]. After learning about the various methods of forecasting technology, the next important thing to do is the selection of the appropriate method to be applied in an organization. There are three basic factors to consider in the technology forecasting selection method. These three basic factors are [5] :

1. The extents of the data availability
2. The degree of validity of data
3. The degree of similarity between the proposed technology and existing technologies

There are several methods of forecasting technology that can be used [5]:

1. Expert Opinion
2. Trend Analysis
3. Monitoring and Intelligence Method
4. Statistical Methods
5. Modeling and Simulation
6. Scenarios
7. Valuing / Decision / Economic Methods
8. Descriptive and Matrices Methods
9. Creativity

Technology typically has a life cycle consisting of several different stages. These stages usually include

the early stages of adoption, growth stage, the stage of maturity and decline stage.

There are four stages in product life cycle : stage of introduction (introduction), stage of development (growth), stage of maturation (maturity), and the stage of decline (decline) [6]. Product life cycle scheme mentioned by Levitt, can be seen in the following Figure 1 [7].

Lenz in the book Cetron and Ralph, and Martino developed a method called Trend Correlation [8]. The main assumption that is used in this method is the relationship between the dependent and independent variables is constant and predictable in the future [8]. Large amounts of reliable data are necessary to use this technique.

Flyn states that innovation becomes an important base for the development of quality products company [10]. The adaptation process of technological innovation is an important thing to do on SME. Sumarno on his journal mentions, that one of the ways the adoption of technological innovations in Industri Kecil Kerajinan Gerabah Kasongan (IKKGK) can be seen in the activities of entrepreneurs in generating new products or modify products in order to meet the tastes of the market, including the design of components, products, and marketing [3].

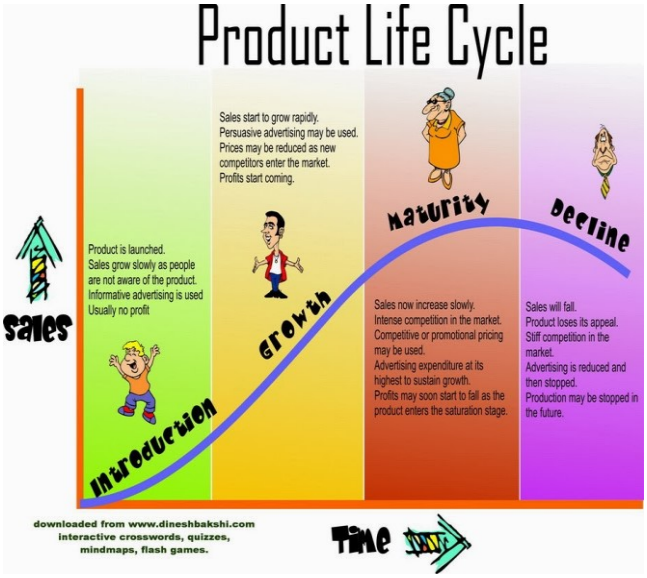

Fig.1 Product Life Cycle Scheme

III. RESEARCH METHODOLOGY

The research methodology is a complete stage outlining the stages or steps required in the manufacture of the final project report. These stages are encountered during the process of preparing reports, starting from the determination of the research topic, to the provision of suggestions to SME Surya Usaha Mandiri. The purpose of the research methodology is to limit the research and make research focused on the main goal of research made. Scheme overall of research methodology, starting from the determination of the research topic to conclusions and suggestions can be seen in Figure 2 below.

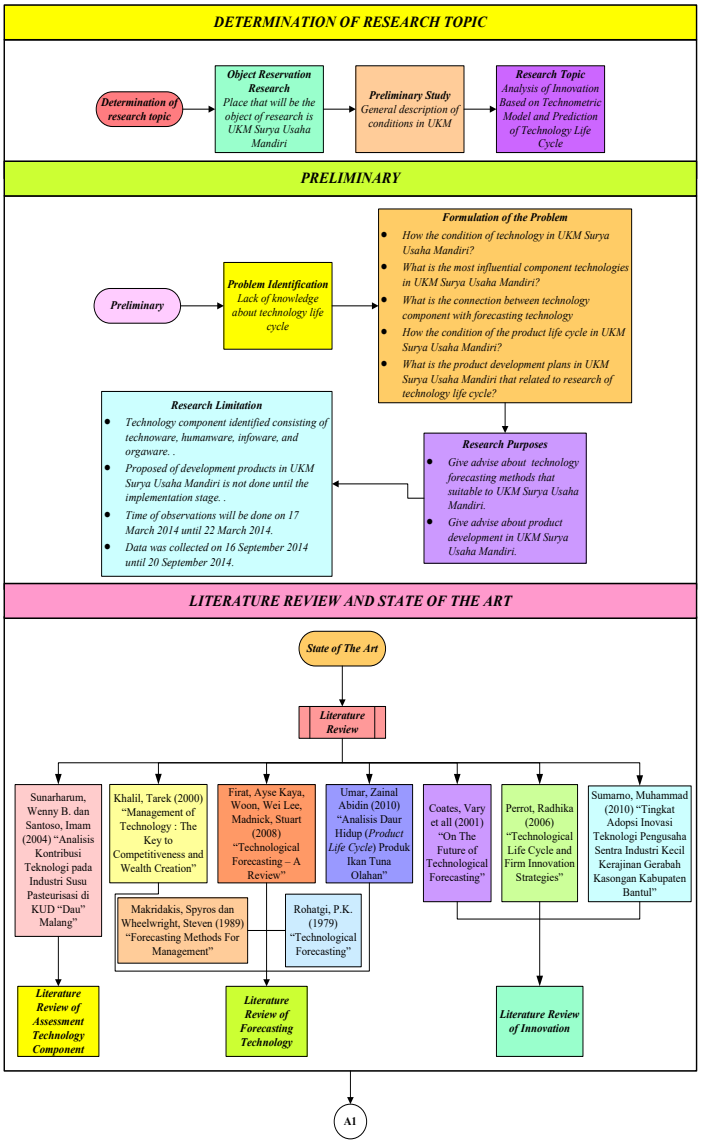

Fig.2 Scheme of Research Methodology

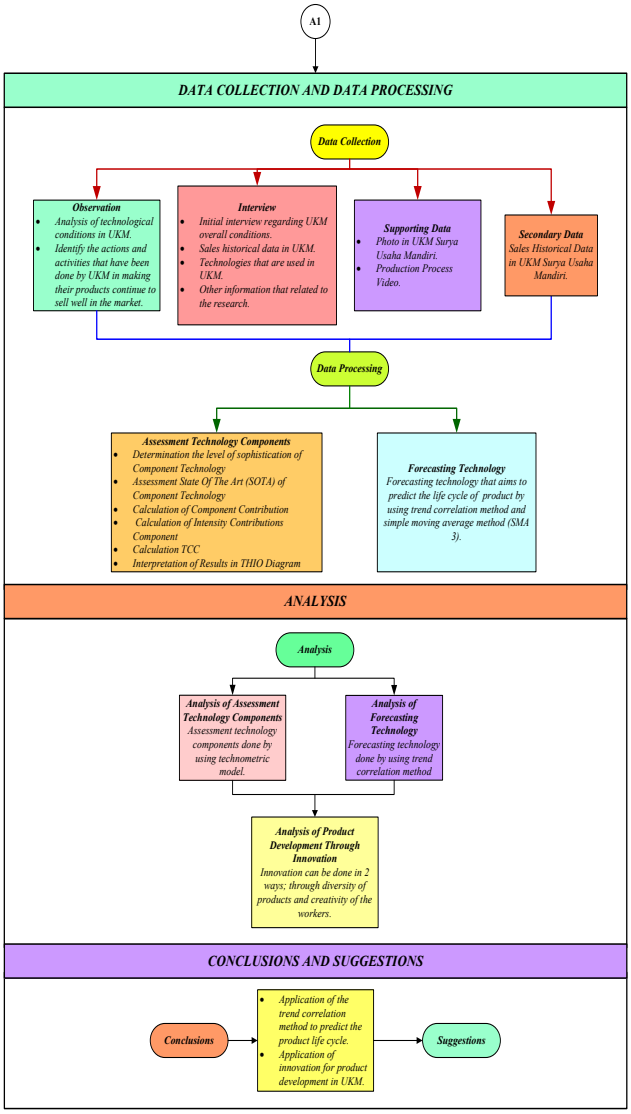

Fig.2 Scheme of Research ethodology(continuation)

IV. DATA PROCESSING

4.1. Assessment of Component Technology

1. Description of production processes in SME Surya Usaha Mandiri :
   a. Raw Material Cutting Process
   b. The process of sanding Raw Materials
   c. Making a Hole in Raw Materials Process
   d. Process Coating Raw Materials
   e. Process Sewing
2. Determination the level of sophistication of Component Technology

TABLE 3
DETERMINATION OF LEVEL OF SOPHISTICATION COMPONENT TECHNOLOGY

Component			LL	UL	Explanatory Words
TECHNOWARE	1	Raw Material Cutting Process	2	4	Powered Facilities
	2	The Process of Sanding Raw Material	3	5	General Purpose Facilities
	3	Making a Hole in Raw Material Process	2	4	Powered Facilities
	4	Process Coating Raw Material	1	3	Manual Facilities
	5	Process Sewing	1	3	Manual Facilities
HUMANWARE		Worker	1	3	Operating Abilities
		Technisians	5	7	Adapting Abilities
		Owner	7	9	Innovation Abilities
INFOWARE		Description of the Process and Machine	2	4	Describing Facts
		Safety Instructions	5	7	Utilizing Facts
ORGAWARE			3	5	Venturing Framework

1) Assessment State Of The Art (SOTA) of Component Technology

TABLE 3
ASSESSMENT SOTA OF COMPONENT TECHNOLOGY

Component			LL	UL	Value	Explanatory Words
TECHNOWARE	1	Raw Material Cutting Process	2	4	3	Powered Facilities
	2	The Process of Sanding Raw Material	3	5	5	General Purpose Facilities
	3	Making a Hole in Raw Material Process	2	4	3	Powered Facilities
	4	Process Coating Raw Material	1	3	1	Manual Facilities
	5	Process Sewing	1	3	1	Manual Facilities
HUMANWARE		Worker	1	3	3	Operating Abilities
		Technisians	5	7	7	Adapting Abilities
		Owner	7	9	9	Innovation Abilities
INFOWARE		Description of the Process and Machine	2	4	3	Describing Facts
		Safety Instructions	5	7	5	Utilizing Facts
ORGAWARE			3	5	4	Venturing Framework

$$ST_i = \frac{1}{10}\left(\sum \frac{k_{ik}}{k_t}\right) = \frac{1}{10}\left(\frac{3+5+3+1+1}{5}\right) = 0{,}26$$

$$SH_i = \frac{1}{10}\left(\sum \frac{m_{im}}{m_h}\right) = \frac{1}{10}\left(\frac{3+7+9}{3}\right) = 0{,}633$$

$$SI_i = \frac{1}{10}\left(\sum \frac{n_{in}}{n_i}\right) = \frac{1}{10}\left(\frac{3+5}{2}\right) = 0{,}4$$

$$SO_i = \frac{1}{10}\left(\sum \frac{o_{io}}{o_o}\right) = \frac{1}{10} x \frac{4}{1} = 0{,}4$$

2) Calculation of Component Contribution

a) Technoware

$$T_i = \frac{1}{9} x[LT_i + ST_i(UT_i - LT_i)]$$

$$T_{pemotongan} = \frac{1}{9} x[2 + 0{,}26(4-2)]$$

$$T_{pemotongan} = 0{,}28$$

b) Humanware

$$H_i = \frac{1}{9} x[LH_i + SH_i(UH_i - LH_i)]$$

$$H_{pekerja} = \frac{1}{9} x[1 + 0{,}633(3-1)]$$

$$H_{pekerja} = 0{,}252$$

c) Infoware

$$I_i = \frac{1}{9}x[LI_i + SI_i(UI_i - LI_i)]$$

$$I_{deskripsi} = \frac{1}{9}x[2 + 0{,}4(4-2)]$$

$$I_{deskripsi} = 0{,}311$$

d) Orgaware

$$O = \frac{1}{9}x[LO_i + SO_i(UO_i - LO_i)]$$

$$O = \frac{1}{9}x[3 + 0{,}4(5-3)]$$

$$O = 0{,}422$$

TABLE 5
RECAPITULATION RESULTS OF CALCULATION CONTRIBUTIONS COMPONENTS

Component			Contribution Component
TECHNOWARE	1	Raw Material Cutting Process	0.280
	2	The Process of Sanding Raw Material	0.391
	3	Making a Hole in Raw Material Process	0.280
	4	Process Coating Raw Material	0.169
	5	Process Sewing	0.169
HUMANWARE		Worker	0.252
		Technisians	0.696
		Owner	0.919
INFOWARE		Description of the Process and Machine	0.311
		Safety Instructions	0.644
ORGAWARE			0.422

3) Calculation of Intensity Contributions Component The calculation of the average value of the contribution for each component :

a. Techoware $= \frac{(0{,}28+0{,}39+0{,}28+0{,}17+0{,}17)}{5} = 0{,}258$

b. Humanware $= \frac{(0{,}25+0{,}70+0{,}92)}{3} = 0{,}622$

c. Infoware $= \frac{(0{,}31+0{,}64)}{2} = 0{,}478$

d. Orgaware $= 0{,}422$

Calculation of Intensity Contribution Component :

a. Techoware $= \frac{0{,}26}{0{,}258} = 1{,}009$

b. Humanware $= \frac{0{,}633}{0{,}622} = 1{,}018$

c. Infoware $= \frac{0{,}4}{0{,}478} = 0{,}837$

d. Orgaware $= \frac{0{,}4}{0{,}422} = 0{,}947$

TABLE 6
COMPARISON RESULTS SOTA AND CONTRIBUTIONS COMPONENTS

Technometric Component	State Of The Art	Component Contribution	β
Techoware	0.260	0.258	1.009
Humanware	0.633	0.622	1.018
Infoware	0.400	0.478	0.837
Orgaware	0.400	0.422	0.947

4) Calculation Technology Contribution Coefficient (TCC)

$$TCC = T^{\beta t} * H^{\beta h} * I^{\beta i} * O^{\beta o}$$

TCC = 0,037

5) Interpretation of Results in THIO Diagram

The last stage in the assessment of the component technology using technometric model is the interpretation of the results of the calculation technometric into THIO diagram.

THIO diagram describes the condition of current technologies in SME Surya Usaha Mandiri can be based on the value of the State Of The Art, whereas THIO diagram for technological conditions that should exist in SME Surya Usaha Mandiri can be seen in the value of the contribution of the component.

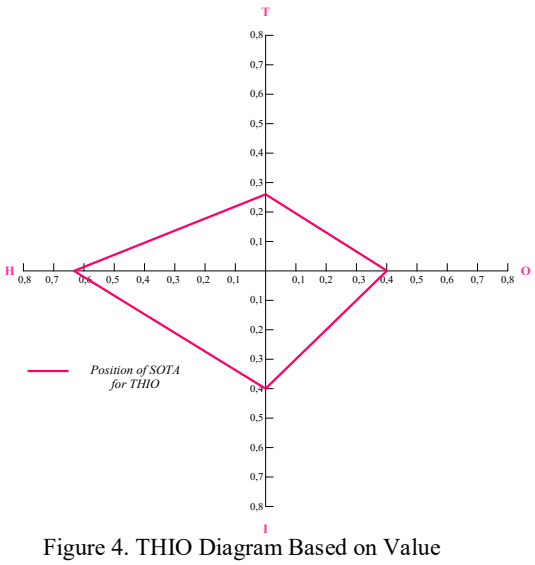

Figure 4. THIO Diagram Based on Value State Of The Art

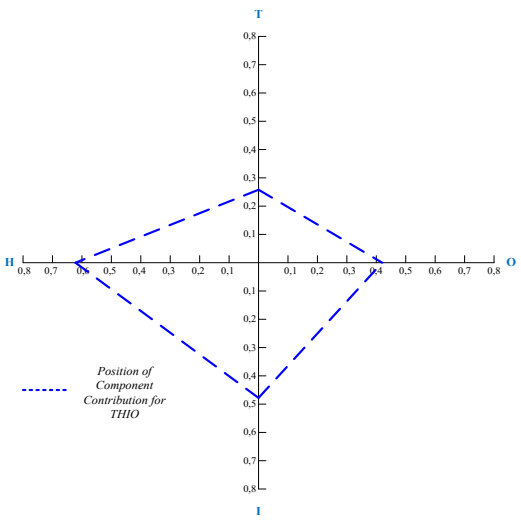

Figure 5. THIO Diagram Based Value Contributions Components

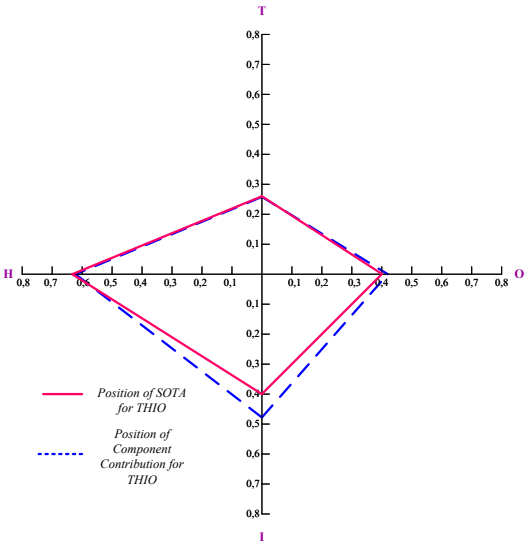

Fig.6 Comparison Chart THIO with SOTA Value and Value Contributions Components

4.2. Forecasting Technology

TABLE 7
HISTORICAL DATA SME SURYA USAHA MANDIRI

Period	Year	Sales (pcs)	Period	Year	Sales (pcs)
1	2004	1728	16	2009	1790
2		1722	17		1800
3		1735	18		1810
4	2005	1710	19	2010	1825
5		1717	20		1850
6		1705	21		1878
7	2006	1716	22	2011	1880
8		1725	23		1895
9		1735	24		1910
10	2007	1750	25	2012	1900
11		1770	26		1925
12		1775	27		2000
13	2008	1770	28	2013	2050
14		1768	29		2100
15		1765	30		2200

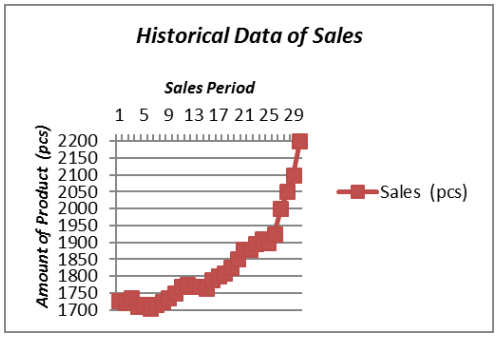

Fig.7 Graph of Sales Based on Historical Data Historis

Forecasting sales for the period 11:

$$F_{11} = \frac{X_{10}+X_9+X_8}{3}$$

$$F_{11} = \frac{5750+5700+5635}{3}$$

$$F_{11} = 5695$$

TABLE 8
TABLE RESULTS OF FORECASTING

Period	Year	Sales (pcs)	F(t)
1	2004	1728	
2		1722	
3		1735	
4	2005	1710	1729
5		1717	1723
6		1705	1721
7	2006	1716	1711
8		1725	1713
9		1735	1716
10	2007	1750	1726
11		1770	1737
12		1775	1752
13	2008	1770	1765
14		1768	1772
15		1765	1771
16	2009	1790	1768
17		1800	1775
18		1810	1785
19	2010	1825	1800
20		1850	1812
21		1878	1829
22	2011	1880	1851
23		1895	1870
24		1910	1885
25	2012	1900	1895
26		1925	1902
27		2000	1912
28	2013	2050	1942
29		2100	1992
30		2200	2050
31	2014		**2117**
32			**2139**
33			**2152**
34	2015		**2136**
35			**2143**
36			**2144**
37	2016		**2141**
38			**2143**
39			**2143**
40	2017		**2143**
41			**2143**
42			**2143**
43	2018		**2143**
44			**2143**
45			**2143**

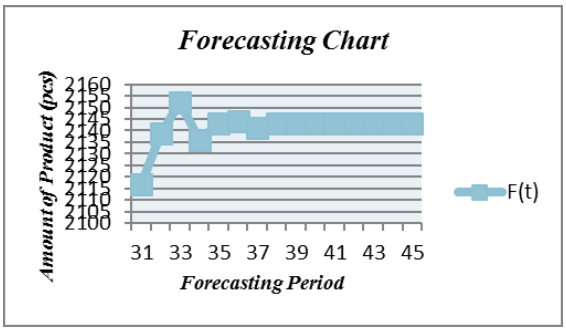

Fig.8 Results of Forecasting

V. ANALYSIS

5.1. Technometric Model

TCC calculation results in SME Surya Usaha Mandiri produces a value of 0.037. Based on Table 1, the components of the technology results to SME Surya Usaha Mandiri are still very low. Based on Table 2, it can be seen that the level of technology in SME Surya Usaha Mandiri is still quite traditional.

5.2. Forecasting Technology

Suitable method used in this research is Trend Correlation method. Reasons for the trend correlation method is because this method are a method that is quite easy to apply to SME. It can be said that this forecasting method is easily implemented in SME because it does not spend a lot of time and effort, and cost.

Another consideration in the selection of trend correlation method is because this method considers various external factors, such as economic factors, social, political, and technological. Beyond these

factors become important to consider, because they are often (,)in an effort(,) influenced by these factors, especially economic and social factors. Another thing that also strengthen the selection of trend correlation method is the use of historical data that is quite simple, which is derived from the historical data of SME Surya Usaha Mandiri.

5.3. Analysis of Product Development Through Innovation

TABLE 8
PRODUCT LIFE CYCLE STAGES

Period	Year	F(t)	Total per year	Stages of Product Life Cycle	Stages of Innovation	Innovation
31	2014	2117	6408	Growth	Planning	Make a structured production schedule
32		2139				
33		2152				
34	2015	2136	6423	Growth	Application	Producing product based on schedule
35		2143				
36		2144				
37	2016	2141	6427	Growth	Observe	Looking at the product motif that demand by the public
38		2143				
39		2143				
40	2017	2143	6429	Maturity	Training	Give training to the workers
41		2143				
42		2143				
43	2018	2143	6429	Maturity	Improve	Improve standards on the products (quality control)
44		2143				
45		2143				

VI. CONCLUSIONS AND SUGGESTIONS

6.1. Conslusions

1. The proposed forecasting method applied to the SME Surya Usaha Mandiri is a trend correlation forecasting method, and the simple moving average method (SMA = 3) for the calculation.
2. The proposed development of the product are:
   a) The proposed innovation stage which is given based on the results of forecasting states that the products in SME Surya Usaha Mandiri experiencing growth stage and maturity stage.
   b) The proposed development of the product which is given by the calculation of the value of the contribution component of the SME Surya Usaha Mandiri, states that the technology component orgaware not fully utilized.
   c) Phase innovation given to prevent decline stage are, planning stage, applicating stage, observing stage, training stage, and improving stage.
   d) Innovation that is given are consisting of ;
      - Planning Stage: production scheduling routine and structured.
      - Applicating Stage: producing on a regular basis.
      - Observing Stage: see trends motive for products of interest to the society.
      - Training Stage: provide training to workers on trends in the market interesting motif.
      - Improving Stage: improving product standard (quality control).

6.2. Suggestions

1. Suggestion for further research:
   In determining the value SOTA technology component, needs to be checked with the SME Surya Usaha Mandiri whether the specified value is in conformity with the conditions of the SME technology or not.
2. Suggestion for SME Surya Usaha Mandiri:
   a) SME Surya Usaha Mandiri needs to maximize orgaware technology component by creating a structured plan production schedules and start doing it.
   b) To increase sales, SME Surya Usaha Mandiri can make observations about the motives that are favored by the public.
   c) Training for workers as an act that can benefit the SME in terms of sales, and in favor of the workers in terms of self-development.
   d) Increasing product standards in SME Surya Usaha Mandiri as an important way so that, the product has the same quality even with different types.

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