The analysis of PM2.5 dust and other factors' effects on factory industries

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ABSTRACT

This research aims to study the impacts of contributes PM2.5 smog and other factors that affect industrial factories in Chiang Mai by study the factors that contribute PM2.5 smog from industrial perspectives. Due to the annual PM 2.5 smog, it requires the government to have measures to cooperate with factories to solve the problem. Therefore, the researcher studied these measures to find out factories' opinion about them and also other factors that affect industrial revenues. This research collected data by questionnaire and telephone interviews with the samples who are the members of the Federation of Thai industries, Chiang Mai Chapter. They can be categorized into different types which are ordinary-factories (owning factory), ordinary-trade association (without factory) and associate-legal entity (business entrepreneurs). It was found that PM2.5 smog affected industry to some extent. They had adjusted themselves in accordance with the measures from the government. Simultaneously, the other factor that affected them the most was instead the COVID-19 outbreak, which critically wreaks their industrial revenues. Consequently, this factor decreased revenues in all types of industries.

CONTENT

CHAPTER 1

INTRODUCTION

1.1 Statement of the Problem

In the past, Thai people had to face air pollution during the course of the cold season to the hot season every year. Especially in the northern region of Thailand, it has been extremely facing a pollution problem from particulate matter (PM2.5). In addition, from December to March, Thailand receives high atmospheric pressure extending from China together with overcast weather and calm wind. Therefore, it prevents smog from dispersing and causes dust concentration in the air. Air pollution is not a newly emerging problem, but it is indeed an important and ongoing issue. The PM2.5 pollution is also damaging people health and perhaps causing respiratory diseases. (Industrial Environment Technology Promotion Division)

Economic growth during the past 10 years had investment growth rate as 10 percent. Thailand GDP has increased for 2 percent from the original base at 3 percent from educational development and industrial technology. Industry is the main potential factor that drives Thailand's economy forward. Thailand's air pollution tends to increase because the country is focusing on economic growth rather than paying attention to the environment. The environmental budget had the least proportion compared to other budgets by 3,929 - 10,945 million baht from the government budget of 2.56 - 3.06 trillion baht. As shown in the past, Thailand paid low attention to environmental protection by accounting for only 0.4 percent of the government budget in 2019. (Office of the National Economic and Social Development Council, 2019)

From the increasing problems caused by smog, the Ministry of Industry eagers to find a measure to control and prevent air quality problems from PM2.5 smog, urges industrial entrepreneurs to be more responsible on improving working processes to prevent or reduce smog problem caused by industrial processes, and calls for cooperation from industrial entrepreneurs to reduce production capacity as well. (Suchada Tangsub, 2020)

1.2 Objectives of the study

1. Study the factors that contributes PM2.5 smog from industrial perspectives.

2. Study how PM2.5 preventive measures from the government, urges industry to adapt and how they affect its income.

3. Study other factors that affect industry and compare among those factors whether which one is the most influential.

1.3 Expected Results

The researcher hopes to find out the result of increasing PM2.5 smog. From the industrial perspectives, which factors are the most necessary problem to contribute PM2.5 smog that leads to changing of the values of PM2.5? Apart from PM2.5 smog, there also are other factors that affects industry. Therefore, the researcher have to find out the result from industrial perspectives to suggest the government to help solve the problem.

1.4 Scope of the study

1. The topographical area of the study is the industrial factories in Chiang Mai.

2. Interview the factories about the impacts of PM2.5 smog and how they adjust their production processes.

3. Population of the study is the members of the Federation of Thai Industries, Chiang Mai Chapter.

1.5 Definitions

1. The Federation of Thai industries, Chiang Mai Chapter is the medium between the government sector and the private sector that supports industry in Chiang Mai.

2. The other current factors such as PM2.5 smog, COVID-19, and interest rate.

CHAPTER 2

LITERATURE REVIEW

2.1.1 Air pollution

Air pollution is an occurrence where the air contains considerable amount of pollutants or smog for a long time, enough to endanger to human, animals, plants, and assets.

Air pollution can be divided into 2 types which are: pollution from natural sources, where the nature itself creates pollutants without human involvement, such as volcanic eruption and natural wildfire; and another one is pollution from man-made sources, where human activities creates pollutants, such as pollution from exhaust pipes, pollution from production process of industrial factories, and etc. (Pollution Control Department, 2011)

According to information from the Pollution Control Department, it is said that PM2.5 smog is caused by vehicle (Diesel-powered vehicles) for 52%, open-air burning for 35%, 7% from other areas, soil dust and heavy metal dust from industrial factories that particularly use fossil fuels with high sulfur content (diesel, coal, fuel, and etc.) for 6%, and biomass about 3-5%. Besides, during the course of December to March in Thailand, it has high atmospheric pressure extending from China together with overcast weather and calm wind which prevent smog from dispersing. Therefore, it causes dust concentration in the air and leads to PM2.5 smog. (Pornwithu Ritthinon, 2018)

2.1.2 Particulate Matter; PM

Particulate matter is solid particles and droplets of liquid suspending and spreading in the air. Some types of these PM are very large and black that they are visible as smog. Some of them are very tiny that they are not visible by human eyes. In general, the size of particulate matter is around 100 microns or less in which this smog affects human health, animals, and plants, and damages buildings. It also causes poor visibility. That is, human ability to extend their eyesight near or far is greatly reduced by black smog caused by air pollution. The tinier particulate matter is more dangerous to health from that of the larger one because it can enter alveoli in the respiratory system. Nowadays, Thailand has set three standard sizes of dust

in the atmosphere, which are Total Suspended Particulate (TSP), Particulate Matter smaller than 10 micrograms per cubic meter (PM10), and Particulate Matter smaller than 2.5 micrograms per cubic meter (PM2.5). It turns out that Thailand's PM2.5 standard value is not protecting people's health compared with that of the World Health Organization (WHO). WHO's standard value of PM2.5 in the atmosphere is 10 micrograms per cubic meter annual mean, while Thailand's is 25 micrograms per cubic meter annual mean. For Thailand's standard value in the atmosphere by 24-hour mean, PM2.5 is 50 micrograms per cubic meter 24-hour mean, while WHO's is 25 micrograms per cubic meter 24-hour mean. (Pollution Control Department, 2011) (Wanida,2000)

		PM2.5 (Micrograms per cubic meter)
Thailand	Annual mean	25
	24-hour mean	50
WHO	Annual mean	10
	24-hour mean	25

Source: Greenpeace Southeast Asia (2015)

2.1.3 Air Quality Index: AQI

Air Quality Index of Thailand is divided into 5 levels. First, when AQI is between 0-50, the level of pollution is Good, and the color is in green. Second, when AQI is between 51-100, the level of pollution is Moderate, and the color is in yellow. Third, when AQI is between 101-150, the level of pollution is Unhealthy for Sensitive Groups, and the color is in orange. Fourth, when AQI is between 151-200, the level of pollution is Unhealthy, and the color is in red. Fourth, when AQI is between 201-300, the level of pollution is Very Unhealthy, and the color is in purple. Lastly, it is Hazardous when AQI is more than 300.

Air Quality Index		
AQI Category and Color	**Index Value**	**Description of Air Quality**
Good Green	0 to 50	Air quality is satisfactory, and air pollution poses little or no risk.
Moderate Yellow	51 to 100	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups Orange	101 to 150	Members of sensitive groups may experience health effects. The general public is less likely to be affected.
Unhealthy Red	151 to 200	Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy Purple	201 to 300	Health alert: The risk of health effects is increased for everyone.
Hazardous Maroon	301 and higher	Health warning of emergency conditions: everyone is more likely to be affected.

Source: The Air Quality Index includes AQI categories and colors.

2.1.4 Air pollution from industry.

Dust caused by combustion process or production process of industrial factories is 1 to 10 microns in size, or PM10 and PM2.5, especially from industrial factories that use fossil fuels or fuels that contain high sulfur in the production process. Moreover, PM2.5 originates from sulfur dioxide (SO2), oxide of nitrogen (NOx), Volatile Organic Compounds (VOCs), and ammonia (NH3) that reacts with other substances in the atmosphere. PM2.5 smog does not only consist of a single pollutant but many pollutants. That is, if the production process of an industrial factory emits high amount of sulfur dioxide (SO2) and oxide of nitrogen (NOx), it is likely to emit high amount of PM2.5 as well. (Dr.Sudjit Khruchit, 2014) (Pornwithu Ritthinon, 2018)

1) Sulfur Dioxide (SO2) is a non-flammable, and colorless gas. If it is concentrated to an extent of 0.3-1 ppm, it becomes irritant, pungent, and

toxic gas with low boiling point at -10 degree Celsius. It reacts easily with other substances to form harmful compounds, such as sulfuric acid, sulfurous acid, and sulfate particles. About 99% of the sulfur dioxide in the air is man-made. The main source of sulfur dioxide in the air is from industrial activities that produces sulfur-containing materials, such as the production of electricity from coal, oil, or sulfur-containing gas. Some minerals contain sulfur, and sulfur dioxide is released when they are processed. In addition, industrial activities that burn fossil fuels containing sulfur can be an important source of sulfur dioxide. Sulfur dioxide is also present in motor vehicles emitted from fuel combustion. In the past, automobile exhaust pipe was important. But not the main source of sulfur dioxide in the air. However, this is now not the case anymore.

2) Oxide of Nitrogen (NO2) is one of the groups of highly reactive gases known as oxides of nitrogen or nitrogen oxides (NOx). Other nitrogen oxides include nitrous acid and nitric acid. NO2 is used as the indicator for the larger group of nitrogen oxides. NO2 primarily gets in the air from the burning of fuels. NO2 originates from emissions from cars, trucks and buses, power plants, and off-road equipment.

2.1.5 Types of industrial plants

The standard of industrial dust emission is not more than 240 mg/m3 (Fuel oil) and 320 mg/m3 (coal). Types of factories that emit dust are divided into 3 groups, which are:

1) General factories is a group of factories that may cause pollution, especially smog, which have installed 4 air treatment systems, viz., 1) Wet Scrubber that uses the water or liquid sprayed down from the top in the opposite direction of the air flow, 2) Bag Filter, 3) Dust Collector Cyclone, and 4) Electrostatic Precipitator; ESP.

2) Factories that affects environment is a group of factories that installs various treatment systems. There are also specific controllers registered with the Department of Industrial Works, which must be qualified and have experiences in controlling treatment systems. Currently, there are about 2,000 of these types. From results of dust measurement of this group, it was found that the total average of dust emission is approximately 50 milligrams per cubic meter of air.

3) Factories that cause high pollution is a group of factories with 10 types of origin such as power plants with a capacity of 29 megawatts or

more, factories that have a 30-ton steam boiler per hour or more, cement and lime plants, and etc. According to the Notification of the Ministry of Industry, Re: Requirement for Installation of an Automatic Instrument or Equipment to Measure Quality of Air Emissions from Stacks B.E. 2544 (2001), it requires that these factories must install Continuous Emission Monitoring Systems (CEMs) with a 24-hour inspection. (Phasu Lohanchun, 2019) (Federation of Thai Industries, 2019)

2.1.6 Legal measures

Due to the continuous PM 2.5 smog, it requires the government to have measures to control and solve air pollution. The Minister of Industry has commanded all bureaus under the ministry to design measures and improve work processes to prevent or reduce smog problems caused by industrial processes. He has also requested cooperation from industrial entrepreneurs for reducing production capacity. Initially, he ordered ministerial bureaus to issue mitigation measures as follows:

1.) Requesting cooperation from industrial entrepreneurs to reduce production capacity and control emission of pollution and requiring that a factory must install CEMs that is located outside of the law enforcement area to transfer the air quality reports to the Department of Industrial Works.
2.) Inspecting and monitoring factories to prevent dust and air pollution emission by the 2020 annual plant inspection plan focusing mainly on factories that once had a p dust emission complaint in the past few years.
3.) Requiring factories to inspect their air treatment systems to be more efficient.
4.) Promoting green technology usage in factories and supporting them technically to reduce pollution from the manufacturing processes.
5.) Coordinating with the Royal Thai Air Force to explore PM2.5 situation.

In order to solve the problem, it is necessary to have a thorough study and help ensure that these measures are proficient and practically effective. However, many measures in Thailand have never have academic proof, e.g. the case of the government considering using odd-even rule for cars if the air pollution reaches a critical stage. This measure has not yet been

proven efficient by any academic research. In foreign countries, this measure cannot always reduce air pollution but may make it even worse. Whereas, the policy that promotes public transportation can solve air pollution better than odd-even rule measure. Other measures are worth for consideration at the same time such as toll collection in traffic congestion areas, parking fee, energy tax, free of charges for private parking to urge using public transportation. (Office of the National Economic and Social Development Council, 2019)

2.1.7 Other factors that affect the industrial factories

1) COVID-19 or the Novel Coronavirus Disease

In addition to PM2.5 smog, there are other factors affecting industry. During early 2020, there has been an outbreak of the virus species named Coronavirus (later known as COVID-19) emerging from the city of "Wuhan" in Mainland China where it is the center of the outbreak. It has been found that the mortality rate there is between 2-4%, while the rate in other areas is only 0.7%. The Novel Coronavirus has been spreading to many cities in China and many countries such as Thailand, South Korea, Japan, the United States, and etc. (Rapee Phanratanawongnara, 2020)

From the evaluation of Kasikorn Thai Research Center, it was found that if considering 3 main ways that Chinese economy has effects on ASEAN economy, China’s investment in the area will be directly affected by its own economy recession at the highest ratio, since the direct investment is often highly fluctuating in accordance with the country's economy. If China's GDP growth rate decreases by 1 percent, the investment from China in ASEAN countries will fall to around 2.8 percent, while incomes from Chinese tourists and export values to China of ASEAN countries will decrease by approximately 1.5 percent and 1.2 percent respectively. Therefore, from the evaluation of the 3 main ways by Kasikorn Research Center, it has been predicted that if Chinese economic growth rate decreased by 1.0 percent, it will directly affect ASEAN economy around 2.4-3.4 billion US dollars or 0.07-0.11 percent of total ASEAN GDP. In the case of Thailand, Kasikorn Research Center predicted that if Chinese economic growth rate decreased by 1 percent, it will damage Thai economy for approximately 500-700 million US dollars or 0.09-0.13 percent of Thai GDP. Thai export sector will be affected up to 300-400 million US dollars.

From the Agenda 5.3 of the strategic conference on 19 February 2020, it was found that there were 35 confirmed cases of COVID-19 infection in Thailand; 15 cases having returned home, and 20 cases being hospitalized. The government has been monitoring the situation by screening 55 total cases from the airports and 782 cases hospitalizing themselves. Moreover, there were 703 cases allowed to return home, while there are still 134 cases hospitalized. The government has legislated laws for people returning from abroad to monitor their symptoms for 14 days to ensure that they have not contracted the coronavirus. Published in the Royal Gazette, the government also prohibits international flights from outside of the country including 11 countries and areas such as Mainland China, Macau, Hong Kong, Japan, Malaysia, Vietnam, Italian, and Iran. Chiang Mai Province has announced Phase 3 that requires the governor to strengthen measures to prevent the outbreak by screening all arrivals from China airlines together with Taiwan, Hong Kong, and Macau, requiring the airport authority to renovate screening rooms and quarantines, along with screening passengers at 3 bus stations (Chang Phueak, Arcade 1, and Arcade 2) and Chiang Mai Railway Station.

2.1.8 Related Theories

1) Externalities mean the impacts to third parties that come from business transactions, trades, exchanges, and operations of any person. In other words, it is an activity of some economic units that makes an impact on other people rather than the unit itself, where the market price does not reflect this impact at all, and it causes economy to function inefficiently. There are 2 types of externalities which are Positive externality and Negative externality.

1.1) Positive externality is benefits or things caused by upturns of economic activities rather than the direct benefits that occur. This will benefit the third parties who are not related. It is an advantage of such economic activities because they benefit others. For example, the direct benefit of the 15-year free education by Thai government is that Thai students receive more opportunities to study and acquire knowledge. On the other hand, its indirect benefit is that when the society is full of educated citizens, developments will be done much easier, and they will be effective labors. All of these will eventually benefit the society from this positive externality. Prices of such activities do not include this positive externality. It also causes underproduction than it should be

because it is useful both directly and indirectly. We should promote or support such activities, where that indirect benefit is called External Benefit or Spillover Benefit.

1.2) Negative externality is an external cost or a spillover cost for third parties from economic activities. It is a personal activity affected by indirect externality and resulting in increased costs, with the market price does not include the cost that occurs to other parties as well. It makes economy overproduce goods and services. Taking environment perspective as an example, factories located upstream emits polluted water without any treatment, while the other factories located downstream cannot use the polluted water for production. Factories upstream does not usually pay attention to such effects, so it causes the high amount of chemicals in the water than it should be because that cost will be ignored. Therefore, we should stop or reduce these kinds of activities. (Wannaphong Durongkhawot, 2011)

2.2 Related research

Jirachaya Singmanee (2017) studied about the PM2.5 smog problem and analyzed by using SWOT analysis. It was found that the industrial sector did not strictly abide by the law and lacked proper environmental-friendly management. Some parts of the problem were caused by the government sector, which lacked improvement and modernization of the law because it was found that there were legal gaps that allowed law offenders to emit air pollution. They exploited both in a practical way and provision of inaccurate information in air pollution emission reports. It was affecting local people living nearby and cause environment deterioration.

Asst. Prof. Dr.Sudjit Khruchit (2018) stated that ther research aimed to develop guidelines for air quality management in medium and small industrial factories. According the green industry concept, the researcher selected three factories in Mueang district, Nakhon Ratchasima province to have them followed the guidelines and evaluate the results. It was found that the important factors that affected the operation were executives of the factories, who were interested in and support the guidelines. As for the level of operational details, step 1-4 and 7 should be taken such as collecting the data, surveying community opnion, creating pollution emission records, conducting pollution measurement, and creating air quality management plans. In step 5 and 6, they are estimating pollution

with simulation and assessing health risk in which it should only be done by operating environment inspectors and related personnel.

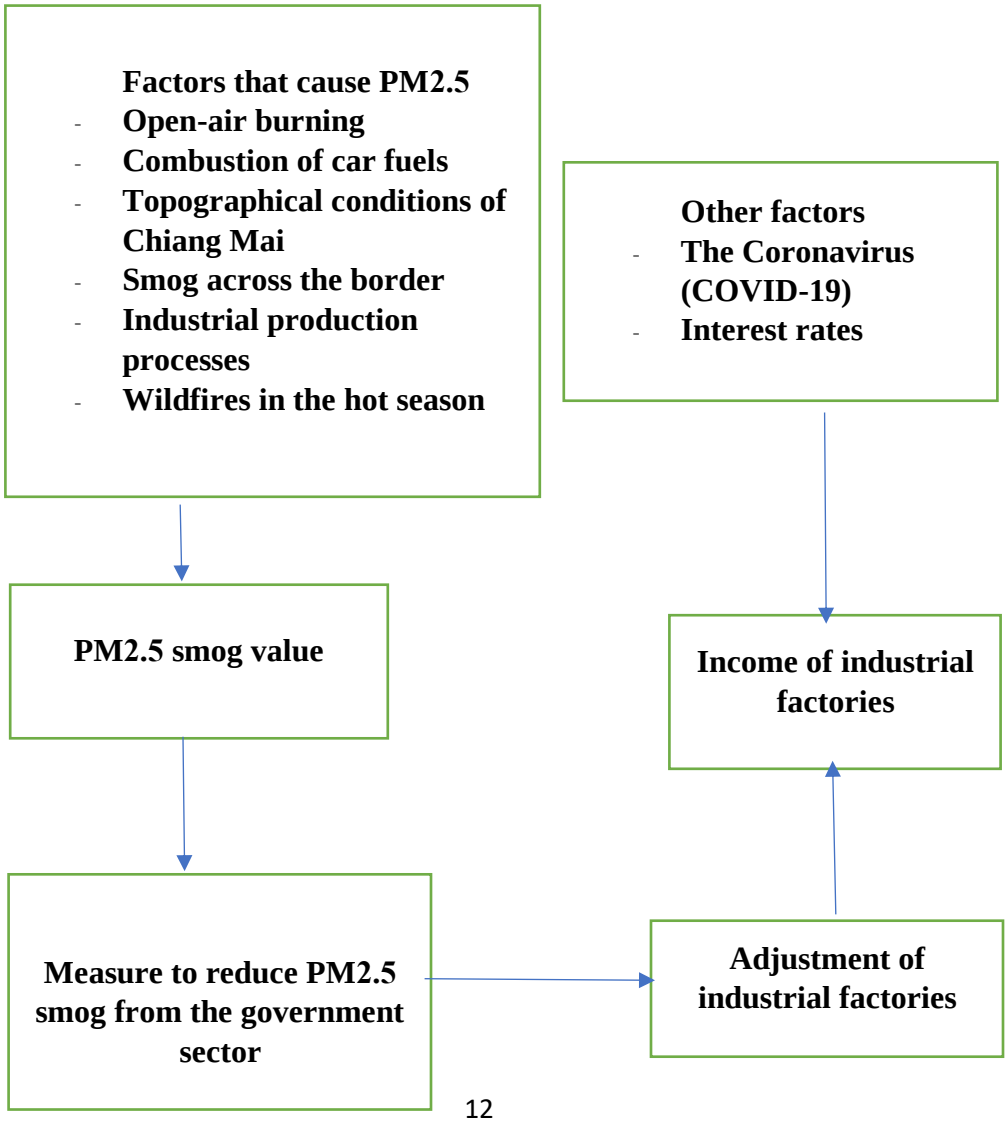
According to a qualitative research by Pasin Yothachan (2019), it was found that the problem and related obstacles to promote cooperation of industrial factories in natural resource and environment conservation was that there was no specific law to do so. Therefore, it is necessary to have a specific law that sets out the details and clear rules to promote conservation of natural resources and the environment and specifies clear rules to solve problems. In addition, it was found that industrial factories should study about the effect to the environment and public health living in the surrounding area to find preventive measures and solve problems that can occur later on. Moreover, there should be a center to receive complaints from the surrounding communities as well as disseminate information about dangers caused by industrial pollution.

Mr. Pongpat Sukkasem's research (2015) developed industrial air quality management guidelines by using air quality models together with clean technology guidelines. The researcher studied the suitability of using 2 air quality models, which are SCREEN3 and AERMOD models, used these two tools for air quality management of a small cassava flour mill in Nakhon Ratchasima, and chose the clean technology for reducing dust, which are: (1) Spraying water on piles of materials, (2) Planting a tree wall, (3) Categorizing specific piles of materials, (4) Using cyclones, and (5) Using filter bags. From the model, it was shown that the maximum dust concentration at the ground level can be reduced by 12%, 28%, 34%, 18%, and 18% respectively. Therefore, it could be concluded that this study demonstrates the performance of the guideline that can help decision-making process of industrial plants.

CHAPTER 3
RESEARCH METHODOLOGY

The objectives of this study are to study effects PM2.5 smog that affect the industrial factories in Chiang Mai province, and to find the external externalities that can be the factors affecting the industrial factories and causing PM2.5 smog in order to know the occurring problems.

3.1 Conceptual Framework



3.2 Population and Sample

This research identified the population and divided the sample groups as follows: factory entrepreneurs, business owners, managers, and relevant divisional directors. For the types of industrial factories, there are agricultural processing, textiles/leather/jewelry, pottery/handicrafts, automobile, electronics/electricity, packaging, printing, construction, furniture/home décor, health/beauty and service, and etc. For the members of the Federation of Thai industries, Chiang Mai Chapter, they can be categorized into different types which are ordinary-factories (owning factory), ordinary-trade association (without factory) and associate-legal entity (business entrepreneurs). In 2020, it consists of 421 membership and the researcher gathered data from several questionnaires.

3.3 Research instruments

This research study uses 2 types of research instruments which are a questionnaire and telephone interview

3.3.1 Questionnaire

The questionnaire is divided into 6 parts.

Section 1 This section asks about general information of respondents and their types of industries. It is a checklist that contains 7 questions.

Section 2 This section asks about respondents' background knowledge on the PM2.5 smog. It is a true-false test that contains 6 questions.

Section 3 This section asks about the factors that contribute the increase of PM2.5 values. This part surveys understanding in industrial perspectives. It is a checklist that contains 6 questions.

Section 4 This section asks divided into 3 measures as follows:

Measure 1: Management measures in the production process, 2 items

Measure 2: Measures to inspect and monitor factories to prevent dust and air pollution, 2 items

Measure 3: Measures to promote using clean technology in factories and provide technical assistance to improve processes for reducing pollution at the source, 2 items

Section 5 This section asks about how the industrial factories adjust to decrease the PM2.5 smog. It is a checklist that contains 4 questions.

Section 6 This section asks about the other factors that affect industrial factories. It can be divided in to 3 parts.

Part 1: This part asks that between the outbreak of the COVID-19 virus and interest rates which one has more effects and to what extent it is, 1 item

Part 2: This part asks about the effect from PM2.5 smog, the COVID-19 virus, and interest rate that how much they affect their incomes.

Part 3: This part asks that which factors are affecting their incomes the most by ranking from the most to the least.

3.3.2 Telephone interview

Telephone interview will help acquire information faster when there are not so many questions and they are not too complicated. However, there are some disadvantages because the researcher can interview only with samples that have telephones. In some cases, respondents may be inconsiderate and unhappy to answer, or even hang up the phone.

3.4 Data collection

To collect data to use in this research study, there are 2 parts as follows:

1. Primary data

   Data collection is divided into 2 parts. First, data is collected from the questionnaire, and the second part is telephone interview. For the telephone interview, the interviewer will delve directly into the issues. The data collection and information presentation from the interviewee are divided into 2 parts, which are the group that have factories and the group that does not have factories. both are membership in the Federation of Thai Industries in Chiang Mai chapter.
2. Secondary data

   Data will be collected from documents such as academic information from articles, journals, theses, and other related academic reports.

3.5 Data analysis

3.5.1 Quantitative data analysis from the questionnaire

To analyze data, the researcher will use the descriptive statistics by distributing the frequency and showing the results of the statistical analysis, which we will analyze the results as:

1) The mean
2) The percentage
3) The standard deviation
4) The rating scales
5) Rank Rating Scale, which is to specify more than 1 answer, then let the respondents prioritize them.

In the evaluation, the questionnaire responses will be interpreted by the Likert Scale which uses 5-level criteria which are Highest, High, Average, Low, and Lowest. The interpretation criteria are for rating the mean score in each range by using mean according to the principle of Class Interval. Then, use the formula to find the class interval as follows: (Kalaya Wanich Bancha, 2007)

$$\textbf{Interval} = \frac{\textbf{Rage®}}{\textbf{Class©}}$$

$$= \frac{\mathbf{5-1}}{\mathbf{5}}$$

$$= \mathbf{0.8}$$

After that, find the mean of the questionnaire responses by considering the evaluation criteria as follows:

Mean 4.21-5.00 means the highest impact

Mean 3.41-4.20 means the high impact

Mean 2.61-3.40 means the average impact

Mean 1.81-2.60 means the low impact

Mean 1.00-1.80 means the lowest impact

3.5.2 Qualitative data analysis

From the interview, it is a summary about the issues which is a content analysis by collecting data from the telephone interview with the sample group. The researcher also sends E-mail based on the content and subject of the interview and replies in text form. Then, classify the data in accordance with the objectives of the study, and analysis the data.

CHAPTER 4
RESULTS

To analyze data regarding the PM2.5 impact on industries in Chiang Mai. The objectives of this research are to study about the PM2.5 dust value, solve the PM2.5 smog by the government measures, and study how those measures affect to the industrial factories. The researcher had collected data from the sample group that is members of the Federation of Thai Industries, Chiang Mai chapter. However, with the temporary closures of many facilities due to the Coronavirus (COVID-2019) outbreak in Chiang Mai. The researcher could consequently collect data from only 38 samples. Collected data, the researcher use Descriptive statistics to perform analysis. From the results, the researcher presented analyzed data by dividing them into 2 parts which are:

4.1: Quantitative data results

Table 4.1.1: General information of respondents

General information of respondents	quantity	percentage
Sex		
- Male	14	50.00
- Female	14	50.00
Total	38	100.00
Age		
- 20-30	17	44.70
- 30-40	16	42.10
- More than 40	5	13.20
Total	38	100.00
Education background		
- Undergraduate	6	15.80
- Bachelor's degree	28	73.70
- Graduate	4	10.50
Total	38	100.00
Position		
- Factory entrepreneurs	2 14	5.30 36.80
- Business owner	10	36.30
- Manager	6	15.80

- Division chief - Other	6	15.80
Total	38	100.00
Type of Industry		
1. Agricultural Processing	10	26.30
2. Textiles, Leather, Jewelry	1	2.60
3. Pottery, Handicrafts	-	-
4. Automobile	2	5.30
5. Electronic, Electricity	4	10.50
6. Packaging, Printing	2	5.30
7. Construction	-	-
8. Furniture, Home décor	1	2.60
9. Health, Beauty	3	7.90
10. Service, Etc.	15	39.50
Total	38	100.00
Types of membership of the Federation of Industries		
- Ordinary factories (owning factory)	16	42.10
- Ordinary-trade association (without factory)	6	15.80
- Associate-legal entity (Business entrepreneurs)	14	36.80
- other	2	5.20
Total	38	100.00
Work experience		
- Less than 5years	19	50.00
- 5-10 years	4	10.50
- More than 10 years	15	39.50
Total	38	100.00

From table 4.1, it was found that male and female respondents are at the same size which is 50 percent. The average age of respondent is not more

than 40 years. The average of education background is bachelor's degree which is 73.70 percent. Most of the respondents' position are business owners and managers, who are responsible for overseeing the business, mapping out marketing strategies, supervising the production process of the factory, and controlling the factory production. Most of the types of industries are Service, Etc. which is hotel, tourism business, and metal parts for construction by 39.50 percent. Next, it is Agricultural Processing such as dried fruits, spices, various herbs, packaged rice, and pork slaughterhouses by 26.30 percent. Most of the membership types of the Federation of Industries is ordinary factories (owning factory) that have knowledge of the production process of the factory by 42.1 percent. As for the ordinary-trade association, they are enterprises established to promote enterprise without factory production. For the associate-legal entity, they are business entrepreneurs without factory production. Most of the work experience is less than 5 years which mean that the factory is small and has just been established. However, the medium and large factories have work experience more than 10 years.

Table 4.1.2 The understanding and knowledge about PM2.5 dust

Question: Understanding PM2.5 dust	**Percentage**
1. PM2.5 dust is a dust pollution that is smaller than 1 part per 25 of the diameter of human hair.	86.84
2. If we inhale PM2.5 too much, we will receive the risk of cancer.	92.11
3. PM 2.5 dust cannot be seen with the eyes.	76.32
4. PM 2.5 dust equals in length to hair diameter.	52.63
5. The Air Quality Index (AQI) is used to tell the quality of air.	97.37
6. N95 facemask can help prevent PM 2.5 dust.	92.11
Total average	82.89

From table 4.2, it shows respondents' knowledge about PM2.5 dust. From the question 1, it says "PM2.5 dust is a dust pollution that is smaller than 1 part per 25 of the diameter of human hair." In this question, most of the respondents are ordinary-factories that have good knowledge about dust

by 86.64 percent. In question 2, it says "If we inhale PM2.5 too much, we will receive the risk of cancer." According to the World Health Organization's research, PM2.5 dust is classified as a group 1 carcinogen that causes lung cancer. The respondents have a well-informed knowledge in this question by 92.11 percent. In question 3, it says "PM 2.5 dust cannot be seen with the eyes." Respondents can have different opinions in this question. First, they can say that they cannot totally see PM2.5. Second, they can say that if observed at a distance more than 800 meters, it will be seen as smog that obscures visibility. Most of the respondents agreed with first one by 76.32 percent. In question 4, it says "PM 2.5 dust equals in length to hair diameter." which is similar to the question 1. However, this question measures respondents' knowledge about PM2.5 in depth. The result is 52.63 percent, so the respondents have medium knowledge in this question. In question 5, it says "The Air Quality Index (AQI) is used to tell the quality of air." The respondents have high knowledge in this question by 97.37 percent because most of the respondents used AQI application on their smart phone. Lastly, question 6 says "N95 facemask can help prevent PM 2.5 dust." Most of the respondents have good understanding by 92.11 because they are in ordinary-factories and know about the production process of the factory that emits smog and pollution. Also, most of the respondents are business owners and managers of the factories. Therefore, they use N95 mask every time when they go monitor the production process of the factory to protect themselves from dust.

Table 4.1.3: The factors that cause PM2.5 smog from industrial perspective.

The factors that affect to PM2.5 dust.	**Mean ($\bar{x}$)**	**SD**	**Interpretation**	**Rating**
1. Open-air burning, e.g. burning fields for cultivation	4.39	0.70	highest	2
2. Combustion of fuels from cars	4.00	0.91	high	4
3. Topographical conditions,	4.07	0.89	high	3

e.g. the characteristics of Chiang Mai city where it shapes like a basin resulting in high atmospheric pressure and preventing PM2.5 smog from rising higher				
4. Smog across the border that comes from neighboring countries including Myanmar, Lao, Cambodia, and Vietnam.	3.92	0.92	high	5
5. The PM2.5 dust from industrial production process	3.71	1.07	high	6
6. Smog from the wildfires in the hot season.	4.52	0.75	highest	1

Table 4.1.3: the questionnaire is about factors that cause PM2.5 dust from industrial perspective. Most of the respondents have work experience more than 5 years. They are business owners and managers with well-informed knowledge about PM2.5 dust, and also own a factory in Chiang

Mai. During the course of the beginning of February to April every year, Chiang Mai had always been facing the smog problem from wildfires in hot season. Therefore, the respondents thought that the factor that increases PM2.5 smog is from the smoke of hot-season wildfires. It causes dust values in Chiang Mai to increase to 200-300, which is hazardous level. The respondents agreed with an opinion that it is the most contributing factor ($\overline{x}$ = 4.52, SD = 0.75). At the same time, there were open-air burnings in Chiang Mai burning fields to prepare the topsoil for cultivation in the upcoming hot season. Chiang Mai province therefore has measures to ban burning for a period and let them burn at another time. The respondents agreed that it has the second-to-most great impact ($\overline{x}$ = 4.39, SD = 0.70). The characteristics of Chiang Mai topography is that it shapes like a basin that prevents PM2.5 smog from rising to higher level. Simultaneously, together with smog from open-air burning, they causes dust concentration in Chiang Mai's atmosphere. The respondents agreed with this opinion that it is the third highest impact ($\overline{x}$ = 4.07, SD = 0.89). However, most of Chiang Mai people use cars and motorcycles that cause traffic congestion in some places such as in the heart of Chiang Mai city. The respondents agreed that this factor about combustion of car fuels is the fourth highest impact ($\overline{x}$ = 4.00, SD = 0.91). Sometimes, there are wind currents that blow from neighboring countries into Chiang Mai, Because of open-air burning for cultivation in the nearest neighboring country like the Republic of the Union of Myanmar, Chiang Mai receives more smog. The respondents agreed that this factor has the fifth highest impact ($\overline{x}$ = 3.92, SD = 0.92). Moreover, there is still dust emitted from the production process of factory. The respondents agreed with this factor at sixth highest ($\overline{x}$ = 3.71, SD = 1.07) because industrial factories can control and manage dust values by increasing the air pollution treatment machines, checking and cleaning the machine.

Table 4.1.4: Satisfaction for the measures from the Ministry of Industry to reduce and control PM2.5 smog in industrial factories.

Measures from the Ministry of Industry	**Mean ($\overline{x}$)**	**SD**	**interpretation**	**Rating**
Management measures in the				

production process				
- Requesting cooperation from industrial factories to reduce production capacity during smog incidences.	3.10	1.04	Medium	6
-Improve the combustion system of the radiator (Boiler) by suggesting following the principles from the Ministry of Industry.	3.21	1.05	Medium	5
Measures to inspect and monitor factories to prevent dust and air pollution				
-Checking the efficiency of the vacuum system in the factory building regularly	3.36	1.22	Medium	3
-Monitoring air pollution treatment	3.55	1.20	high	1

systems to be effective.				
Measures to promote using clean technology in factories and providing technical assistance				
-Changing equipment that is used for trapping dust in factories such as Filter, Electrostatic Precipitator: ESP)	3.34	1.32	Medium	4
-Changing fuels that is used in combustion machine such as Natural Gas (NG)	3.55	1.22	high	2

Table 4.1.4: Satisfaction for the measures from the Ministry of Industry.

From the increasing value of PM2.5 smog, the Ministry of Industry mapped out measures to control it by dividing into 3 measures which are: 1) Management measures in the production process, 2) Measures to inspect and monitor factories to prevent dust and air pollution, and 3) Measures to promote using clean technology in factories and providing technical assistance. Collected data from questionnaire, most of the respondents have work experience more than 5 years. They are business owners and managers that own small to medium factories. It means that they have knowledge about the factory production process and are well-informed about PM2.5 smog. The

most agreed measures by the respondents is the second measure which is monitoring of air pollution treatment systems to be effective ($\bar{x}$ = 3.55, SD = 1.20). Because in this part, the factory must check it regularly. The second highest most agreed measure ($\bar{x}$ = 3.55, SD = 1.20) is the third measure which is changing the fuel that is used in combustion machine such as Natural Gas (NG) to reduce PM2.5 dust from production process of factory. Next, the third highest agreed measure ($\bar{x}$ = 3.36, SD = 1.22) is the second measure which is checking the efficiency of the vacuum system in the factory building regularly. The respondents agreed to medium extent because the efficiency of vacuum system of each factory are different. Some of the factory structures and equipment used to trap dust are different such as Filter, Electrostatic Precipitator: ESP, while some do not have. If using a dust collector, there may have additional charge. Therefore, the respondents agreed to medium extent, which is the fourth highest ($\bar{x}$ = 3.34, SD = 1.32), in the first measure which is Management measures in the production process. The respondents agreed to medium extent, which is number 5 ($\bar{x}$ = 3.34, SD = 1.32), to improve the combustion system of the radiator because factories will require more costs to improve and may have to even adjust the factory structure. Lastly, it is requesting cooperation from factory industrial to reduce production. The respondents agreed to medium extent because the reduction of production capacity affects the industry's revenue, which is the sixth highest6 ($\bar{x}$ = 3.10, SD = 1.04).

Table 4.1.5 The adjustment of industrial factories to help reduce PM2.5 smog.

The adjustment of industrial factories	**Mean ($\bar{x}$)**	**SD**	**Interpretation**	**Rating**
1. Reducing production capacity factory to decrease PM2.5 dust value caused by production process.	3.36	1.30	Medium	4
2. Changing the fuel that is used in	4.00	0.88	high	2

	combustion machine such as Natural Gas (NG)				
3.	Changing equipment that is used for trapping dust in factories such as Filter, Electrostatic Precipitator: ESP	3.84	0.93	high	3
4.	Cleaning and checking the condition of the machine to reduce PM2.5 dust value.	4.10	0.91	high	1

From Table 4.1.5 The adjustment of industrial factories, to analyze the questionnaire about satisfaction for the measures from the Ministry of Industry, it was found that most of the respondents that own Agricultural Processing and Manufacture of metal parts factories had been adjusting in accordance with measures set by the Ministry of Industry. The most agreed measure is cleaning and checking the condition of the machine to reduce PM2.5 dust value ($\bar{x}$ = 4.10, SD = 0.91), as factories have done it regularly without additional fees. It is also beneficial to industrial factories for preserving machineries and working efficiency. The second highest ($\bar{x}$ = 4.00, SD = 0.88) is that the respondents agreed to changing the fuel that is used in combustion machine such as Natural Gas (NG) or changing light bulbs to LED lightings to save energy and reduce unnecessary expenses. Because factories did not agree to reduce production capacity, so they spend expense on dust trap equipment such as Filter, Electrostatic Precipitator: ESP to help reduce the PM2.5 smog. Thus, the respondents adjusted this way as the third highest ($\bar{x}$ = 3.84, SD = 0.9). In the part of reducing production capacity, the respondents agreed to medium extent as the fourth highest ($\bar{x}$ = 3.36, SD = 1.30) because the respondents thought that spending more

expenses to increase efficiency of air pollution treatment and dust trap is better than reducing the production capacity of the factory.

Table 4.1.6 The other factors affecting the industrial factory divided into 3 parts

Part 1: The other factors affecting the industrial factories.

The other factors	Mean ($\bar{x}$)	SD	Interpretation	Rating
1. COVID-19 (The outbreak of the coronavirus)	4.26	1.31	highest	1
2. Interest rates	3.55	1.18	high	2

During early 2020, there had been an outbreak of the new virus species named Coronavirus (COVID-19) that from the city of "Wuhan" which is its emerging center. Most of the respondents that own Agricultural Processing and metal parts Manufacturing factories agreed that the novel Coronavirus has the highest impact ($\bar{x}$ = 4.26, SD = 1.31). Including the result from telephone interviews about effects of the coronavirus, it impacted the agricultural processing by decreasing product sales for 30-50%. Also, metal part manufacturers had been affected in terms of obligations to import materials from abroad and employees lacking face masks. Most of the respondents are small to medium industrial factories. They have to apply for loans to circulate the money capital in the enterprises. Furthermore, with the impacts of the Coronavirus outbreak causing economic recession, small and medium industrial factories lost high amount of revenues. At the same time, these industrial factories must have pending interest that must be paid to the bank they borrowed. Therefore, the respondents believed that the interest rate had a high impact ($\bar{x}$ = 3.55, SD = 1.18).

Part 2: Factors of PM2.5, COVID-19, and interest rates that affects the industrial factory revenues.

1. **The impact of PM 2.5 smog on industrial revenues, "increasing" or "decreasing", represented as percentage.**

The impact of PM 2.5 smog on industrial factories	**Percentage**
- Revenue "increased"	23.70
- Revenue "decreased"	60.50
- Does not affect	15.80
Total	100.00
The impact of PM 2.5 smog on industrial revenues as percentage	**Percentage**
- 0-20%	55.30
- 20%-40%	26.30
- 40%-60%	10.50
- 60%-80%	7.90
- 80%-100%	-
Total	100.00

Most of the respondents have work experience more than 5 years. They are business owners and managers who own small to medium factories. From the PM2.5 smog, it has affected revenues of services and other industries such as tourism, hotels, and event organizers by 60.50 percent. Therefore, it caused people to spend fewer money and decreased the industrial revenue. However, at the same time there are still some industrial factories that have their income increased such as a face mask and an air purifier manufacturer. Their incomes increased by 23.70 percent because people need to use them to protect themselves from PM2.5 smog. They consequently received a high number of orders. For the respondents who own large industrial factories are not exactly affected by PM2.5 smog because they are factories that mainly produce for export. Overall, from the impact of PM2.5 smog on industrial factories, their incomes are between 0-20%.

2. **The impact of the COVID-1 9 virus on industrial revenue, "increasing" or "decreasing", represented as percentage.**

The impact of the COVID-19 virus on industrial	**Percentage**
- Revenue "increased"	18.80
- Revenue "decreased"	78.90
- Does not affect	5.30
Total	100.00

The impact of COVID-19 virus on industrial revenue as percentage	Percentage
- 0-20%	18.40
- 20%-40%	26.30
- 40%-60%	26.30
- 60%-80%	18.40
- 80%-100%	10.50
Total	100.00

Most of the respondents have work experience more than 5 years. They are business owners and managers who own small to medium factories. They have opinions that the COVID-19 highly contributed decrease of the revenue by 78.90 percent because this coronavirus was spreading fast and highly infectious. Moreover, from the telephone interviews, their revenue decreased sharply because of event bans, so it is impossible to sell the products and services. There are also warning for people to avoid events and crowded area, so people cannot come out for purchases and services. Furthermore, with concerns of factory employees, business owners or managers must provide protective equipment from the COVID-19 virus such as face masks and hand-washing alcohol gels. Then, factories have to spend more costs to spend in this part. Some industrial factories struggled to import materials. Therefore, their production capacity decreased. Most of the respondents had opinions that the COVID-19 affected industrial revenue by more than 40%.

3. **The impact of interest rates on industrial revenue, "increasing" or "decreasing", represented as percentage.**

The impact of interest rates on industrial	Percentage
- Revenue "increased"	31.60
- Revenue "decreased"	52.60
- Does not affect	15.80
Total	100.00
The impact of interest rates on industrial revenue as percentage	**Percentage**
- 0-20%	55.30
- 20%-40%	34.20
- 40%-60%	5.30

- 60%-80% - 80%-100%	2.60 2.60
Total	100.00

Most of the respondents have work experience more than 5 years. They are business owners and managers who own small to medium factories. Most of the respondents have opinions that interest rates impact industrial factories by 52.60 percent. From the effects of PM2.5 smog and the COVID-19 outbreak, their revenues decreased because they are small to medium factories with low money capital. Then, they had to pay loans with the same interest rate when they applied for the loan. Therefore, their revenues decreased. However, large-sized industries were least affected or even not affected at all. Most of the respondents had opinion that interest rates affected industrial revenues by less than 40%.

Part 3: Comparing among "PM2.5 smog", "COVID-19 virus", and "Interest rates", which one is the most affecting factor.

The other factors	**Mean ($\bar{x}$)**	**SD**	**Interpretation**	**Rating**
1. PM2.5 smog	4.02	0.58	high	2
2. COVID-19 (The outbreak of the coronavirus)	4.34	0.92	highest	1
3. Interest rates	3.71	0.82	high	3

From part 3, to compare among "PM2.5 smog", "COVID-19 corona virus", and "interest rate", which one had the highest effect to the industrial factories. Most of the respondents are business owners and managers with good background knowledge of PM 2.5 dust. Moreover, their factories are classified as small and medium factories. From the telephone interviews, most of them talked about the effects of the outbreak of the COVID-19 virus which has the highest impact ($\bar{x}$ = 4.34, SD = 0.92) because industrial factories cannot find solution by themselves. Next, PM2.5 smog had the

second highest impact ($\bar{x}$ = 4.02, SD = 0.58), which had high impact, but industrial factories could follow the measures of the Ministry of Industry to reduce PM2.5 smog. At the same time, the impact from interest rates was caused by PM2.5 smog and the COVID-19 that decreased their revenues. Furthermore, they had to pay loans with the same interest rate when they applied for the loan. The respondents have opinions that interest rate had the third highest impact ($\bar{x}$ = 3.71, SD = 0.82).

4.2: Qualitative data analysis results.

The result from telephone interviews with members of The Federation of Thai Industries, Chiang Mai Chapter about the effects of PM2.5, COVID-19, and interest rates to industry.

	Type of Industries	**The issues and request for help**
1.	**Agricultural Processing**	- Sales/orders reduced by 30-50%. - Customers delayed purchases. - Request the government support for money capital/low interest loans for entrepreneurs because there is no revolving loan for business and need to apply for more loans increasing liabilities. - Being unable to sell products due to event and crowd ban. - Products cannot be sold at tourist attractions because there are no tourists. - Employee's health problems like lacking a mask.

2.	**Textiles, Leather, Jewelry**	- Request the government support for money capital/low interest loans for entrepreneurs - Being unable to export products to the importer countries like European countries which is affected by the COVID-19.
3.	**Pottery, Handicrafts**	- Request the government support for money capital/low interest loans for entrepreneurs. - Being unable to export products to the importer countries like European countries which is affected by the COVID-19. - Employers have to reduce employment because of the loss in revenue.
4.	**Automobile**	- Purchases were cancelled and delayed from the economic recession. - Request the government support for money capital/low interest loans for entrepreneurs. - New purchase orders decreased.
5.	**Electronics, Electricity**	- Sales/orders are reduced. - Importing/ Transporting materials

		and parts from foreign countries was difficult and slow. - Employee's health problems like lacking a mask.
6.	**Packaging, Printing**	- A number of employments or service requests are reduced.
7.	**Construction**	- Request the government support for money capital/low interest loans for entrepreneurs. - No orders from customers
8.	**Furniture, Home décor**	- No order from customers. - Requesting the government to support working capital.
9.	**Healthy, Beauty**	- Medical device manufacturers lack materials to produce face masks and alcohol gels because some materials or accessories must be imported from foreign countries resulting in not being able to produce as needed on time.

10.	**Service, Etc.** **1.1 Tourism**	- Customers cancelled departure flights traveling overseas, so it affected tour agencies/ travel agencies that they had to allow refunding for customers. - The situation cannot be predicted that when it will end, so all trips that customers reserved might be canceled until the end of the year
	1.2 Hotel	- Number of guests and service uses decreased because there were no tourists.
	1.3 Laundry service	- Revenue decreased by more than 50% because most of them were laundry services for various hotels. When there were no guests staying, the employment decreased.
	1.4 Organizer / Event	- A number of employments decreased because all events were suspended.

From telephone interviews, the researcher had 5 to 10 minutes to interview by aiming for the objectives, which are impacts that industry received from PM2.5 smog, COVID-19, and interest rate. The researcher interviewed 100 members of The Federation of Thai Industries, Chiang Mai where the interviewees own small to medium factories that are categorized in Agricultural Processing and other services such as Dried Fruit Factory, metal part manufacturer, and Tourism and Hotels. Most of the interviewees have opinions that COVID-19 had the highest impact because sales and orders from customers decreased causing their revenues to decrease too. In addition, they were unable to sell products because of event and crowd bans from the

outbreak of virus COVID-19. The Tourism and Hotels industries were affected in terms of customers canceling flights traveling overseas and travel agencies having to allow refunding for customers. For hotels, the number of guests and service uses decreased because there were no tourists. As for the effects of PM2.5 smog, the interviewees' revenues were decreased slightly, but they could still continue to operate their factories and businesses because there are always performance checking of the machineries to reduce PM2.5 dust. For the effect of interest rates, it was caused by the COVID-19 outbreak because it reduced their revenues. Moreover, had to pay loans with the same interest rate when they applied for the loan. Therefore, their industrial revenues decreased. Some of the interviewees would like to have the government help solve the problem in this part by supporting for money capital/ low interest loans for entrepreneurs because most of the industrial factories lack incomes due to the impact of the COVID-19 outbreak.

CHAPTER 5

CONCLUSION AND SUGGESTIONS

The study on impacts of PM2.5 dust values to sample factories that are members of The Federation of Thai Industries, Chiang Mai Chapter from their perspectives together with their adjustments to apply measures from the Ministry of Industry to reduce the PM2.5 smog. Then, study about the other factors that affect their revenues.

This research used descriptive statistical analysis such as table of frequency distribution, percentage, mean, and standard deviation by collecting data into 2 categories. For the questionnaire, it had been responded by only 38 people, so the researcher used telephone to interview approximately 100 people. After the researcher had reviewed some relevant literatures, data collections, and research analyses, the findings of this research were summarized as follows:

5.1 Conclusion

From the research, it was found the respondents are not more than 40 years old on average. Their education backgrounds are bachelor's degree, which is 73.70 percent. Most of the positions of respondents are business owners and managers, which are responsible for overseeing the business and mapping out marketing strategies. The highest number of industry types is Agricultural Processing such as dried fruits and packaged rice. They usually have work experience less than 5 years, which means that the factory is small and medium size including with the types of Industries without factory, which are hotels, tourist agencies, and event organizers.

From the measurement of background knowledge and understanding about PM2.5 dust, it was found that both of the respondents who own a factory and do not own any factory have a good knowledge and understanding about PM2.5 dust. Moreover, for the questionnaire collection about factors contributing to PM 2.5 smog from industrial perspectives, most of them share the same opinions that the most impactful factor that increase the PM2.5 smog ($\bar{x} = 4.52$, SD = 0.75) is wildfires in the hot season. It caused the dust values in Chiang Mai rising to 200 to 300 on average.

The increase of PM2.5 smog caused the Ministry of Industry to find measures to solve the problem. From the results, the respondents who own

factories will also have good knowledge of the production process, but the respondents who do not own factories have medium knowledge about the production process. From the part of the satisfaction with the measures from the Ministry of Industry. The most agreed measures by the respondents are the second measure which is monitoring of air pollution treatment systems to be effective ($\bar{x}$ = 3.55, SD = 1.20). The second highest ($\bar{x}$ = 3.55, SD = 1.20) is the third measure which is changing the fuel that is used in combustion machine such as Natural Gas (NG) to reduce PM2.5 dust from production process. To collect data in this part, the respondents who owns factories had been adjusted according to the measures set by the Ministry of Industry to reduce PM2.5 dust value by cleaning and checking the condition of the machine and changing the fuel that used in combustion factory machine such as Natural Gas (NG) because the adjustment of the factory in this part has small additional charge and was beneficial for machinery and working efficiency.

In addition to having PM2.5 smog problem, it had other factors that affected industrial factories too. During early 2020, there has been an outbreak of the new virus species named Coronavirus (COVID-19). Most of the respondents who own factories, do not own factories, and who were the interviewed through telephone. They have opinions that the COVID-19 was the most has the most impact because it decreased their revenue by 78.90 percent. Most respondents who own factories had problems importing and transporting materials which caused their revenues to drop. At the same time, the respondents who own service industries or others were affected too such as tourism and hotels because the customers cancelled flights traveling overseas and travel agencies had to allow refunding for the customers. Therefore, these industrial factories need money capital and although their revenue decreased, they still had to pay loan debts to the bank. Most of the respondents share opinions that interest rates effect was caused by the COVID-19 and PM2.5 smog.

To conclude the PM2.5 smog and other factors, it was found that most of the industrial factories were most affected by the COVID-19 outbreak because they could not be able to do any business, service, merchandising, including with regular production. The PM2.5 smog had impacts to the industries that have factories. However, it had least impacted to them because the industrial factories followed the measures of the Ministry of Industry and adjustment to the PM2.5 smog. Therefore, they could continue their

businesses. From these problems, the respondents would like to have the government help solve problems by supporting policies or measures that can solve the COVID-19 outbreak.

5.2 Suggestion

For those interested in studying this research, for instance, industrial entrepreneurs or governmental policy planners. From the information mentioned earlier, the study is the data collection from the representative samples who are members of the Industrial Council of Chiang Mai. The researcher concludes and suggests as follows.

PM 2.5 factors

1. The government should have a long-term solution, especially the preventive measure of PM 2.5. For example, set the regulations for releasing pollution or PM 2.5 dust from the manufacturing process of the factories to maintain the PM 2.5 level to normal.
2. Industrial or factorial entrepreneurs should improve or fix the factory treatment system to reach standards or at least the standards set by the government.
3. Government should have immediate response to emergency events such as forest fire during the summer. The government should be able to react to these situations as soon as possible.
4. There should be a law about asking for permission to burn biomass items and burn garbage in general, as well as abort getting rid of garbage by burning.

COVID – 19 factors

From the effects of the outbreak of Corona Virus, it can be said that this virus affected everyone entirely. The researcher suggests that the government should have obvious laws to prevent the spread of the virus. Collaboration with private sectors should also be considered. This is to solve the problem together thoroughly and effectively. Moreover, the government should have the measures to help people who are affected from this pandemic.

Interest rate factors.

The effects from the interest rates, according to the study, came mainly from the loss of income, or from lower income. From this reason, the business

owners were not capable of paying the interest in time. The researcher suggests that the government should reduce the interest rates or pause the debt payment as well as set up economic stimulus policies

5.3 Suggestions for the future research

In the questionnaire collection section, it should have more preparation and collection time. It should be collected from more samples than this because the researcher has encountered the problem collecting questionnaires from the COVID-19 outbreak that made it impossible to collect data according to the objectives.

To collect data regarding smog reduction measures, it should have questionnaire for background knowledge about factory production processes in order to find more information and increase the quality of the research.

APPENDIX

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แบบสอบถาม วิเคราะห์ค่าฝุ่น PM2.5 ต่ออุตสาหกรรมโรงงาน

ของอุตสาหกรรมที่เป็นสมาชิกสภาอุตสาหกรรม

*Required

ส่วนที่ 1

ข้อมูลทั่วไป (ให้ทำเครื่องหมาย"√")

1. เพศ *

Mark only one oval.

- ชาย
- หญิง
- Other: _____

2. อายุ *

Mark only one oval.

- 20-30
- 30-40
- 40 ปีขึ้นไป

3. ระดับการศึกษา *

Mark only one oval.

- ต่ำกว่าปริญญาตรี
- ระดับปริญญาตรี
- สูงกว่าปริญญตรี

4. ตำแหน่งงานที่รับผิดชอบ *

Mark only one oval.

- ผู้ประกอบการโรงงาน
- เจ้าของกิจการ
- ผู้จัดการ
- หัวหน้าแผนก
- Other: _____

5. ประเภทของอุตสาหกรรม *

Mark only one oval.

- เกษตรแปรรูป/Agricultural Processing
- สิ่งทอ,เครื่องหนัง,เครื่องประดับ/Textiles,Leather,Jewelry
- เครื่องปั้น,หัตถกรรม/Pottery,Handicrafts
- ยานยนต์/Automotive
- อิเล็กทรอนิกส์,ไฟฟ้า/Electronic,Electricity
- บรรจุภัณฑ์,การพิมพ์/Packaging,Printing
- รับเหมาก่อสร้าง/Construction
- ไม้,ฟอร์นิเจอร์,ตกแต่งบ้าน/Furniture,Home decor
- สุขภาพและความงาม/Healthy,Beauty
- บริการและอื่นๆ/Service,Etc.

6. ประเภทของสมาชิกของสภาอุตสาหกรรม *

Mark only one oval.

- สามัญ-โรงงาน (มีโรงงานผลิต)
- สามัญ-สมาคมการค้า (ไม่มีโรงงานผลิต)
- สมทบ-นิติบุคคล (ผู้ประกอบการธุรกิจ)
- Other: _____

7. ประสบการณ์ในการทำงาน *

Mark only one oval.

- ต่ำกว่า 5 ปี
- 5 - 10 ปี
- 10 ปีขึ้นไป

คำถามวัดความรู้ความเข้าใจเกี่ยวกับฝุ่น PM2.5

เพื่อวัดระดับความรู้เกี่ยวกับฝุ่น PM2.5 ของผู้ตอบแบบสอบถาม

8. (ให้ทำเครื่องหมาย"√") *

Mark only one oval per row.

	ใช่	ไม่ใช่
ฝุ่น PM2.5 คือ มลพิษฝุ่นที่มีขนาดเล็กกว่า 1 ใน 25 ส่วนของเส้นผ่าศูนย์กลางของเส้นผมมนุษย์	◯	◯
ถ้าเราสูดฝุ่นละอองขนาด pm2.5เข้าไปมากๆเราจะสุ่มเสี่ยงเป็นโรคมะเร็ง	◯	◯
ฝุ่น pm 2.5 มองด้วยตาเปล่าไม่เห็น	◯	◯
ฝุ่นpm 2.5 มีขนาดเส้นผ่านศูนย์กลางขนาดเท่าเส้นผม	◯	◯
ดัชนีคุณภาพอากาศ AQI (Air Quality Index) ใช้บอกคุณภาพของอากาศ	◯	◯
หน้ากากอนามัย N95 สามารถช่วยกันฝุ่น pm2.5 ได้	◯	◯

ปัจจัยที่ส่งผลกระทบต่อค่าฝุ่น PM2.5

นอกจากการปล่อยควันของมลพิษจากอุตสาหกรรมโรงงานก็ยังมีปัจจัยอื่นๆ ที่ทำให้ค่าฝุ่น PM2.5 เพิ่มขึ้น แบบสอบถามนี้สอบถามเพื่อทราบในมุมมองของภาคอุตสาหกรรมว่ามีความคิดเห็นอย่างไรต่อฝุ่น PM2.5?

9. 1 = น้อยมาก, 2 = น้อย, 3 = ปานกลาง, 4 = มาก และ 5 = มากที่สุด (ให้ทำเครื่องหมาย"√") *

Mark only one oval per row.

	1	2	3	4	5
การเผาไหม้ในที่โล่ง เช่น มีการเผาเพื่อเตรียมการเกษตร	◯	◯	◯	◯	◯
การเผาไหม้เชื้อเพลิงจากรถยนต์	◯	◯	◯	◯	◯
สภาพภูมิประเทศ เช่น ตัวเมืองเชียงใหม่ที่มีลักษณะเป็นแอ่งกระทะ ทำให้มีความกดอากาศสูงและฝุ่นละออง PM2.5 ไม่สามารถลอยขึ้นไปสู่ชั้นที่สูงกว่าได้	◯	◯	◯	◯	◯
ฝุ่นควันข้ามแดนมาจากประเทศเพื่อนบ้าน ได้แก่ สาธารณรัฐเมียนม่าร์ สาธารณรัฐประชาธิปไตยประชาชนลาว ราชอาณาจักรกัมพูชา และสาธารณรัฐสังคมนิยมเวียดนาม	◯	◯	◯	◯	◯
ฝุ่นควันจากกระบวนการผลิตของอุตสาหกรรมโรงงาน	◯	◯	◯	◯	◯
ฝุ่นควันจากไฟป่าในช่วงฤดูร้อน	◯	◯	◯	◯	◯

มาตรการจากกระทรวงอุตสาหกรรมในการลดและควบคุมฝุ่น PM2.5 ต่ออุตสาหกรรมโรงงาน

จากปัญหาฝุ่นควัน PM2.5 ที่เป็นปัญหาต่อเนื่องมายาวนานซึ่งส่งผลกระทบไปทุกภาคส่วน นอกจากนี้กระทรวงอุตสาหกรรมได้ออกมาตรการลดฝุ่น PM2.5 จึงได้สอบถามถึงอุตสาหกรรมโรงงานว่ามีความเห็นชอบอย่างไรกับมาตรการเหล่านี้ส่งผลกระทบอย่างไรต่ออุตสาหกรรมโรงงานในการช่วยลดปัญหาของฝุ่น PM2.5?

1 = ไม่ส่งผลกระทบ, 2 = ส่งผลกระทบเล็กน้อย, 3 = ส่งผลกระทบปานกลาง, 4 = ส่งผลกระทบมาก และ 5 = ส่งผลกระทบมากที่สุด(ให้ทำเครื่องหมาย"√")

10. 1. มาตรการด้านการจัดการในกระบวนการผลิต *

Mark only one oval per row.

	1	2	3	4	5
ขอความร่วมมือโรงงานอุตสาหกรรมลดกำลังการผลิตในช่วงวิกฤตสถานการณ์ฝุ่นละออง	◯	◯	◯	◯	◯
ปรับปรุงระบบการเผาไหม้ของหม้อน้ำ (Boiler) โดยแนะนำให้ทำตามหลักการปรับแต่งการเผาไหม้เชื้อเพลิงแข็งของกรมโรงงานอุตสาหกรรม	◯	◯	◯	◯	◯

11. 2. มาตรการตรวจสอบและเฝ้าระวังโรงงานเพื่อป้องกันการเกิดฝุ่นและมลพิษทางอากาศ *

Mark only one oval per row.

	1	2	3	4	5
ตรวจสอบประสิทธิภาพระบบดูดฝุ่นภายในอาคารโรงงานอย่างสม่ำเสมอ	◯	◯	◯	◯	◯
ติดตามตรวจสอบระบบบำบัดมลพิษทางอากาศให้มีประสิทธิภาพเป็นระยะๆ	◯	◯	◯	◯	◯

12. 3. มาตรการส่งเสริมให้โรงงานใช้เทคโนโลยีสะอาด ให้ความช่วยเหลือด้านเทคนิคในการปรับปรุงกระบวนการเพื่อการลดมลพิษที่ต้นทาง *

Mark only one oval per row.

	1	2	3	4	5
การเปลี่ยนอุปกรณ์ที่ใช้ในการดักจับฝุ่นที่เกิดจากกระบวนการผลิตในโรงงาน เช่น ถุงกรอง (Bag Filter), เครื่องดักฝุ่นแบบไฟฟ้าสถิตย์ (Electrostatic Precipitator: ESP)	◯	◯	◯	◯	◯
การปรับเปลี่ยนเชื้อเพลิงที่ใช้ในการเผาไหม้เป็นเชื้อเพลิงสะอาด เช่น ก๊าซธรรมชาติ(NG)	◯	◯	◯	◯	◯

การปรับตัวของอุตสาหกรรมโรงงานเพื่อช่วยลดค่าฝุ่น PM2.5

แบบสอบถามนี้ถามความคิดเห็นจากมาตรการของกระทรวงอุตสาหกรรมที่ทำให้อุตสาหกรรมโรงงานให้ความสำคัญในการปรับตัวช่วยลดค่าฝุ่น PM2.5 มากน้อยเพียงใด?

13. 1 = น้อยมาก, 2 = น้อย, 3 = ปานกลาง, 4 = มาก และ 5 = มากที่สุด (ให้ทำเครื่องหมาย"√") *

Mark only one oval per row.

	1	2	3	4	5
ด้านกำลังการผลิต โดยลดกำลังการผลิตเพื่อช่วยลดค่าฝุ่น PM2.5 ที่เกิดจากกระบวนการผลิตของโรงงาน					
การปรับเปลี่ยนเชื้อเพลิงที่ใช้ในการเผาไหม้เป็นเชื้อเพลิงสะอาด เช่น ก๊าซธรรมชาติ (NG) หรือการใช้ พลังงานทดแทนเพื่อลดค่าฝุ่น PM2.5					
การใช้อุปกรณ์จับฝุ่น เช่น ไซโคลน (Cyclone) เครื่องดักฝุ่นแบบ ไฟฟ้าสถิตย์ เพื่อะช่วยบำบัดมลพิษทางอากาศ					
การทำความสะอาดและตรวจเช็คสภาพของเครื่องจักรเพื่อลดมลพิษในกระบวนการผลิต					

ปัจจัยอื่น ๆ ที่ส่งผลกระทบต่ออุตสาหกรรมโรงงาน

เนื่องจากในปัจจุบันนอกจากมีปัญหาฝุ่น PM 2.5 แล้ว ยังมีปัจจัยอื่น ๆที่ส่งผลกระทบต่ออุตสาหกรรมโรงงานรวมทั้งยังมีการระบาดของโรคไวรัสโคโรน่า COVID-19 จึงได้สอบถามถึงปัจจัยเหล่านี้ได้ส่งผลกระทบต่ออุตสาหกรรมมากน้อยเพียงใด?

14. 1 = น้อยมาก, 2 = น้อย, 3 = ปานกลาง, 4 = มาก และ 5 = มากที่สุด *

Mark only one oval per row.

	1	2	3	4	5
COVID-19 (การระบาดของโคโรน่าไวรัส)					
อัตราดอกเบี้ย					

15. ผลกระทบจากค่าฝุ่น PM 2.5 ต่อรายได้อุตสาหกรรม "เพิ่มขึ้น" หรือ "ลดลง" *

Mark only one oval.

- รายได้ "เพิ่มขึ้น"
- รายได้ "ลดลง"
- ไม่ส่งผลกระทบ

16. ผลกระทบจากค่าฝุ่น PM 2.5 ต่อรายได้อุตสาหกรรม คิดเป็นร้อยละ หรือ % *

Mark only one oval.

- 0-20%
- 20%-40%
- 40%-60%
- 60%-80%
- 80%-100%

17. ผลกระทบจากไวรัสโคโรน่า COVID-19 ต่อรายได้อุตสาหกรรม "เพิ่มขึ้น" หรือ "ลดลง" *

Mark only one oval.

- รายได้ "เพิ่มขึ้น"
- รายได้ "ลดลง"
- ไม่ส่งผลกระทบ

18. ผลกระทบจากไวรัสโคโรน่า COVID-19 ต่อรายได้อุตสาหกรรม คิดเป็นร้อยละ หรือ % *

Mark only one oval.

- 0-20%
- 20%-40%
- 40%-60%
- 60%-80%
- 80%-100%

19. ผลกระทบจากอัตราดอกเบี้ย ต่อรายได้อุตสาหกรรม "เพิ่มขึ้น" หรือ "ลดลง" *

Mark only one oval.

- รายได้ "เพิ่มขึ้น"
- รายได้ "ลดลง"
- ไม่ส่งผลกระทบ

20. ผลกระทบจากอัตราดอกเบี้ยต่อรายได้อุตสาหกรรม คิดเป็นร้อยละ หรือ % *

Mark only one oval.

- 0-20%
- 20%-40%
- 40%-60%
- 60%-80%
- 80%-100%

21. เรียงลำดับจากปัจจัย "ฝุ่นPM2.5", "COVID-19 โคโรน่าไวรัส", และ "อัตราดอกเบี้ย" ที่ทำให้ส่งผลระทบมากที่สุด *

Mark only one oval per row.

	อันดับ 1 (ส่งผลกระทบมาก)	อันดับ 2 (ส่งผลกระทบปานกลาง)	อันดับ 3 (ส่งผลกระทบน้อย)
"ฝุ่นPM2.5"			
"COVID-19 โคโรน่าไวรัส 2			
"อัตราดอกเบี้ย"			

751409: Research Exercise in Current Economics Issues

Title **The analysis of PM2.5 dust and other factors' effects on factory industries**

Name of student **Mister Amnart Charoenkosonthan**

Student code **591615094**

The second semester of the Academic year 2019
Faculty of Economics, Chiang Mai University

Mister Amnart Charoenkosonthan

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