Exploring the decline in fertility rates with system Dynamics: The case of Thailand

Master's thesis

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Abstract

Since 1950, the changes in fertility behavior in the Thai population have proved to be very interesting. Between the years of 1950 to 1957, the government invoked a pro-natalist policy and created the Married organization where the fertility rate has increased in that period. In 1960, the government concerned about the increasing in fertility rate, which led to the introduction to the National Family Planning Program, under the Ministry of Public Health, which promoted the voluntary use of contraception. Since then the fertility pattern has entered "controlled fertility". To date, fertility continues to decline and is currently below replacement level.

The changes in fertility rates, and the shifts in government policy, require research into the causes of the factors influencing the total fertility rate (TFR). In this study, a Thai TFR model is constructed by using *"system dynamics modelling concept",* to investigate TFR behavior, including the effects of government policy. This system dynamics model has been examined and analyzed, which leads to the conclusion that the increase in fertility rates in 1950s were caused by the government pro-natalist policy. On the other hand, the later decline in fertility was influenced by the intensity of the support for the government's anti-natalist policy (National Economic and Social Development Plan [NESDP], 1970).

Finally, this research provides the policy recommendation, which aims to support child bearing cost. This policy leads couple to perceive the decline in cost, they will then prefer more children. However, the government should also focus on the promotion of population quality, ensure that all births are desirable and safe, mothers and babies are provided with quality services.

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Abbreviations/Acronyms

TFR   = total fertility rate

NFPP   = National Family Planning Program

CPR   = contraceptive prevalence rate

IUD   = Intrauterine Device

NESDP   = National Economic and Social Development Plan

PDA   = Population and Community Development Association

CPS   = Contraceptive Prevalence Survey

1. Introduction

Pre-census Population (Before 1900)

The Thai people have had a very long existence. The furthest land to which they can be traced to was the south of China. Later they were forced to move further south. Their first kingdom, known as Siam, was established in the mid-thirteenth century. Although many contemporary records were kept, data on population numbers are available only from scattered and disparate sources. As fighting with neighboring countries was almost continuous, it is possible that population records might have been kept for conscription or other military purposes, but have not survived to the present. In the absence of reliable records, knowledge of early Thai populations is very limited and uncertain. However, from the few available sources, we can assume that the birth rate in this period was high because of the lack of contraception. In contrast, population growth in this period was low because of the balance between high birth and death rates. This observation is supported by the fact that it took approximately seven centuries for the total Thai population to reach 8 million (counted at the first census) (The Institute of population studies, Chulalongkron University, 1974), while the addition of a further 8 million took much less time. In addition, historical populations may be assessed through estimation as shown in Table 1:1

Date	Total population (million)	Increase since the previous census	Year/months Since the previous census	Annual % inter-censal increase
1911	8.3	-	-	-
1919	9.2	940,447	8.0	1.4
1929	11.5	2,298,952	10.3	2.2
1937	14.4	2,957,898	7.8	3.0
1947	17.4	2978584	10.0	1.9
1960	26.2	11,467,727	12.1	3.2
1970	34.3	11,860,542	9.9	2.7

Table 1:1 Census Counts of population and Inter-Censal Increases, 1911-1970

Source: The Institute of population studies, Chulalongkron University, 1974

Table 1:1assembles educated conjectures and sketched-in trend lines to form a consensus of these historical informed guesses; most of these have been derived from local registers kept by district officials, generally for purposes of military conscription, taxation, or administrative utility. From these figures, it can be estimated that number of people living inside the present borders would have been approximately 4 million in 1700, rising to 7 million by 1900, with most of this growth probably occurring in the nineteenth-century. Acceleration in the rate of growth apparently began at some time between 1850 and 1875 (The Institute of population studies, Chulalongkron University, 1974). It is obvious that the fighting with neighboring countries and the lack of population knowledge prevented the government focusing on population policy. Therefore; there were no population policies provided.

Current population situation

The data from the United Nations indicate that the total fertility rate in Thailand has been decreasing since 1960, from about 7 births per women to about 1.5 (present). In addition, the data from the Thai government indicate that the TFR prior to 1960 was lower than the TFR in 1960. In 1950, the TFR was approximately 6, and it increased exponentially to about 7 in 1960, probably the highest TFR in Thailand's history. As the TFR changed, the population changed. Population changes have a fundamental impact on economic development. Changes in family size, the structure of households and the age composition of the population affect health costs, education, labor force participation, consumer demand, wages, and even a country's comparative advantage wealth (Bell, 1995, Warakamin et al., 2004).

The conclusions of this data allow us to divide TFR behavior into roughly four periods: fertility increase (from 1950 to 1965), fertility decline (from 1965 to 1990), low fertility (from 1991 to 1996), and below replacement fertility (from 1997 to present) (Jones et al., 2011). Examination of TFR behavior therefore brings up the following research questions:

- Could the increase in fertility rates in Thailand, from 1950 to 1965, be explained by a pro-natalist policy?
- Could the decline in fertility rates in Thailand, in the period 1960 to present, be explained by an anti-natalist policy (family planning program)?
- If not, which other factors might contribute to these patterns?

This research aimed to answer these questions by using the method of system dynamics. The model specification section will briefly illustrate the dynamics of TFR, including the dynamics of government policy intervention. Finally, the comparison between the TFR behavior, with and without government policy, will provide the answers to the research questions, which will be explained in the conclusion.

2. <u>Literature review</u>

There is a large amount of literature on the dynamics of fertility rates, which is relevant to the decline in fertility rates in Thailand. A study of this literature is given below:

The fertility rate is affected by many variables. Conclusively, the theories clearly explain that the proximate variables directly affect the fertility rate. Meanwhile, the social variables, economic variables and environmental variables indirectly affect the fertility rate through those proximate variables.

One of first publications on the subject of fertility was *"Social Structure and Fertility: An Analytic Framework"* by Davis and Blake ,in which they examined the proximate determinants of fertility(Davis and Blake, 1956). They described differentials in fertility through their investigation of population biology. Their work covers the three stages of human reproduction, which are intercourse, conception and gestation. According to this framework, fertility rates can be simplified in a flow chart as shown in Figure 2:1
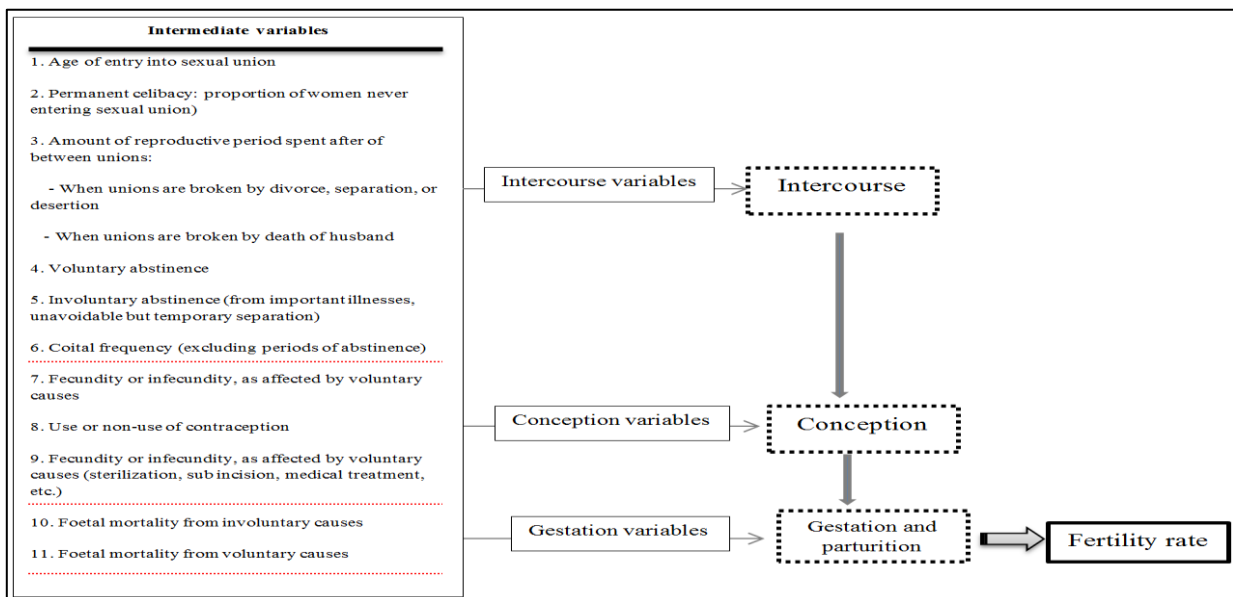
Figure 2:1 Davis and Blake's proximate Determinants of Fertility

Source: Davis and Blake's 1956

Even though eleven factors were initially listed, only a few were important in affecting the levels of fertility. In *"A framework for Analyzing the Proximate Determinants of Fertility"* by John Bongaarts (1978), the author reclassified these eleven variables into eight variables that directly affect the fertility rate, as demonstrated in Figure 2:2.
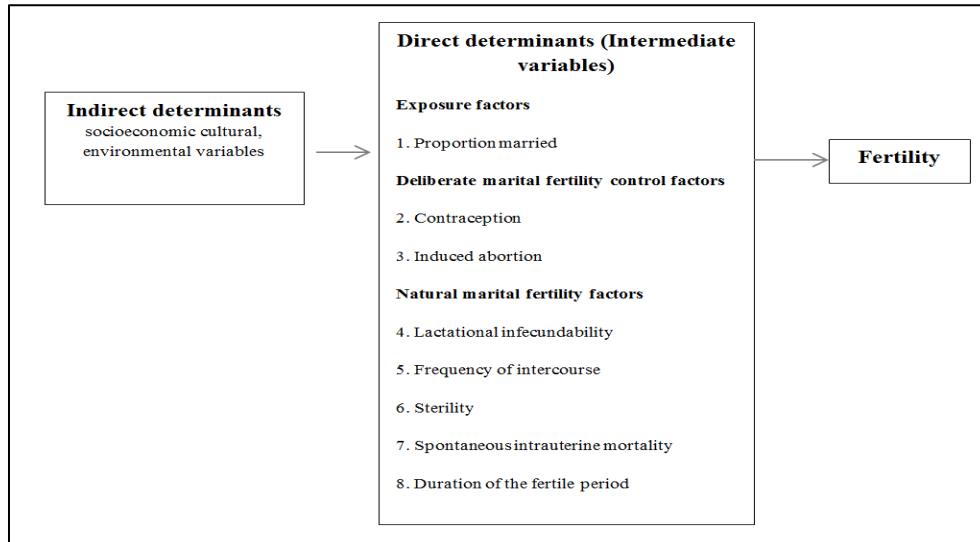
Figure 2:2 John Bongaarts' Intermediate Determinants of Fertility

Source: A framework for Analyzing the Proximate Determinants of Fertility (Bongaarts, 1978)

From his final analysis, the factors can be summarized as an equation:

$$TFR = C_m * C_c * C_a * C_i * TF \qquad\qquad 2:1$$

Given;   TFR= total fertility rate

C_m = the proportion of women married

C_c = index of non-contraception

C_a = index of abortion

C_i = index of lactational infecundability

TF = total fecundity rate

This equation indicates that the majority of fertility variation is affected by four key proximate causes, which consist of:

- *The proportion of women married (C_m)*

The proportion of women married is defined by Bongaarts as the proportion of childbearing women who are sexually active, are at a reproductive age, and are living in stable sexual unions (Bongaarts, 1978). Throughout his assessment, Bongaarts uses the calculation of three indexes, which are TFR, total marital fertility rate (TM) and the index of proportion married (C_m) in 59 countries for the period 1970–75. Bongaarts found that countries with a higher fertility (TFR > 5) typically have a high proportion of married women, and countries with TFR below 5 typically have lower values for the index of proportion married (Bongaarts, 1978) .

-Contraception

Bongaarts refers to contraception as any deliberate parity-dependent practice, including abstention and sterilization, undertaken to reduce the risk of conception (Bongaarts, 1978). Bongaarts calculated values for total marital fertility (TM), total natural marital fertility and induced abortion, and index of non-contraception in 30 countries around 1970 (among developed countries and developing countries). From the calculation, he noted that the highest natural fertility levels are found in the developed countries, where the index of non-contraception is lowest. This indicates that contraception can reduce marital fertility, in the countries where contraception is commonly practiced. According to his conclusion, the contraceptive prevalence in Thailand has been increasing since 1968, while marital fertility and total fertility have been decreasing, as shown in Table 2:1

Survey	Total fertility rate	Contraceptive prevalence rate
SPC1(1963-1964)	6. 30	-
LS1(1968-1969)	6. 10	14. 8
LS2(1971-1972)	5. 35	26. 4
SPC2(1974-1976)	4. 90	36. 7
CPS1(1978-1979)	3. 70	53. 4
CPS2(1981)	3. 68	59. 0
CPS3(1984)	3. 47	64. 6
CUPS(1987)	2. 60	67. 5
TDHS(1987)	2. 32	70. 5
CPS96(1996)	1. 98	72. 2

Table 2:1 Total fertility rate and contraceptive prevalence index of married women aged 15-44 in Thailand from 1963-1996

Source: Contraceptive use patterns of Thai women (WONGSANSRI, 2002)

The results of the surveys indicated that as the contraceptive prevalence rate increases, the TFR decreases. Furthermore, in cases where the contraceptive practiced has failed, women would try to induce abortion to serve their desire (desire to be non-pregnant).

-Induced abortion

Induced abortion is defined by Bongaarts as any practice that deliberately interrupts the normal course of gestation (Bongaarts, 1978). However, since abortion is against the law in Thailand, except in cases of a risk to a woman's health or if the pregnancy is the result of rape or other sexual crime, it is quite difficult to investigate the induced abortion rate. However, though the data are fragmentary, there are a few survey regarding abortion in Thailand, such as; *"Induced Abortion in Thailand: Current Situation in Public Hospitals and Legal Perspectives"* by **Warakamin, Boonthai, and Tangcharoensathienb (Warakamin et al., 2004).** Their study was carried out in 1999 in 787 government hospitals in 76 provinces. They found that the induced abortion ratio =19.5 to 1,000 live births (Warakamin et al., 2004). This survey was unable to collect data from private

hospitals and clinics (which are illegal), however, so their figures are likely to underestimate the extent of abortion in Thailand. Since it is illegal to induce abortion, illegal abortions have been widely reported (common knownledge in Thai society), particularly in the rural areas of the country (United Nations). One survey, *"Abortion in Rural Thailand: A Survey of Practitioners"* by **Tongplaew Narkavonnakit(Narkavonnakit, 1979)** , found that at least 300,000 illegal abortions were performed annually in rural Thailand (1978). Narkavonnakit based his survey on the population sizes of a total of 60 districts in 48 provinces. (There are 643 districts and 72 provinces in Thailand.) He noted that most illegal abortions are performed by non-medical personnel, such as self-trained practitioners, and the most frequently used procedures in rural areas is the traditional massage abortion, followed by uterine injections. Some studies have shown that for a majority of women in rural areas, the stated reason for obtaining an abortion was to limit family size (Narkavonnakit, 1979).

Lactational infecundability

Lactational infecundability, or duration of breastfeeding, refers to the period of infecundity after the gestation period that exists until the normal patterns of ovulation and menstruation are restored, and is influenced by the duration and intensity of lactation. The primary determinant of postpartum infecundability is the duration of breastfeeding. Bongaarts has estimated the mean duration of breastfeeding among developing and developed countries. He found that countries with low levels of contraceptive practice had an average mean duration of breastfeeding of 16 months, while countries with high levels of contraceptive had an average mean duration of breastfeeding of about 3 months. However, there are limited data on the duration of breastfeeding in Thailand. In *" The Fertility of Thai women"* by **Knodel and Prachuabmoh,(Board, 1974).** the authors mention that it is clear that the vast majority of Thai women breastfeed their children, although there are rural-urban differences in this respect (Knodel, 1970). According to their survey, the longest women in rural areas breastfeed their children for is 12–23 months, the longest women in urban area breastfeed their children for is 1 year or less. In *"The Effects of Nuptiality, Contraception and Breastfeeding on Fertility in Developing Countries"* by

Cleland, Casterline, Singh and Ashurst (1984) the authors discuss that the effect of lactational infecundability declines with increasing education. They estimated that the potential increase in fertility represented by these differences amounts to an average of 15–16 per cent between the lowest and highest educational strata, the Americas and Asia (including Thailand).

Bongaarts also mentions that these key proximate determinants are influenced by other factors that exist in the societies studied, namely the indirect variables. The influence of these variables on fertility can only exist if it is conducted through the proximate determinants. But his framework did not provide an explanation of them.

Using Bongaarts' proximate determinants framework, **Wheat (2012)** created fertility model to investigate the fertility decline in Lithuania, as shown in Figure 2:3
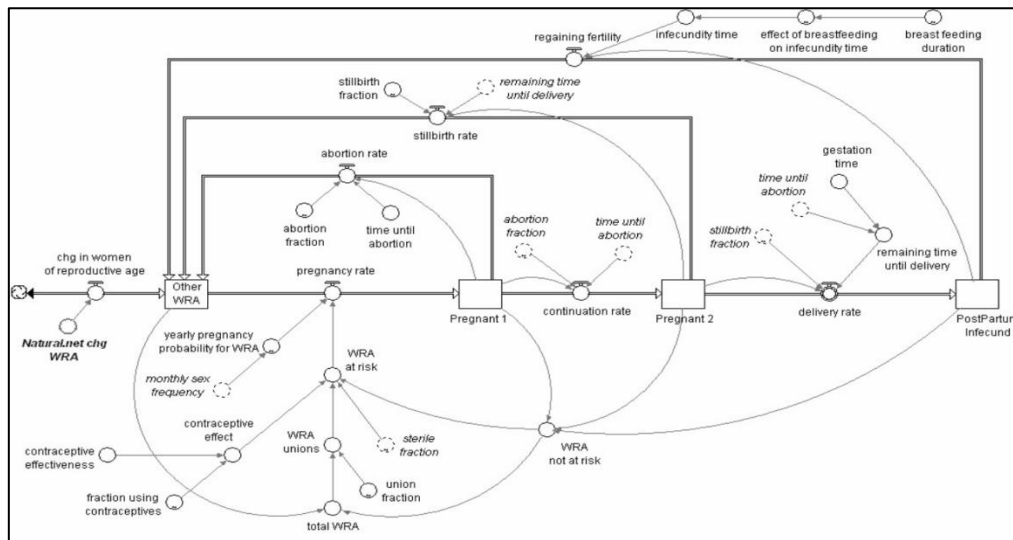
Figure 2:3Wheat's Fertility Model

Source: Wheat (2012)

Wheat's model demonstrates the fertility process among fertile women (women between 15 and 49 years old), by dividing these women into four groups (other WRA,

Pregnant1, Pregnant2 and Post-Partum infecund). Firstly, the **other WRA** represented the women who are not pregnant and not in the postpartum period; they, thus, can be pregnant. The women in this group will be pregnant with some probability if they: are married, have intercourse, are not using contraceptives (or the contraceptives that they are using are not effective). The women that became pregnant would move to the Pregnant 1 group. The **Pregnant 1** group are the women who are at risk of induced abortion. Those who induced abortion revert to the **other WRA** group and the rest (who did not induce abortion) would continue to the next period of pregnancy, which is **Pregnant 2.** Women in this condition could lose their unborn child (stillbirth), if so, they would revert to **other WRA.** Otherwise, those who have gone through the whole process will give birth, which results in the **delivery rate.** After they have given birth, the women remain in the **postpartum infecund** condition for some time (longer if they breastfeed their babies)

Wheat's fertility model is the first system dynamic adaptation of Bongaarts' framework fertility (Wheat, 2012) , which succeeds to explain the dynamic of proximate determinants conclusively. Therefore, it suitable for this research, and it will be adapted as a part of the research model.

The theory regarding indirect variables

In addition to the proximate variables, there are several discussions in the literature regarding indirect variables that should be taken into account. *"Beginning Population Studies" by* **Lucas, David, Meyer and Paul (Gefen et al., 2003)** states that socioeconomic structure; socioeconomic and cultural characteristics; attitudes relating to family size, structure and formation; environment; biosocial characteristics; and knowledge of contraception and attitudes toward contraception, are all variables included in the explanatory or indirect variables which affect fertility through the proximate determinants of fertility.

Lucas also constructed a simple framework, based on the framework developed by Jones (1977) and Freedman (1975). This simple framework represents the relationships among these determinants, as shown in Figure 2:4
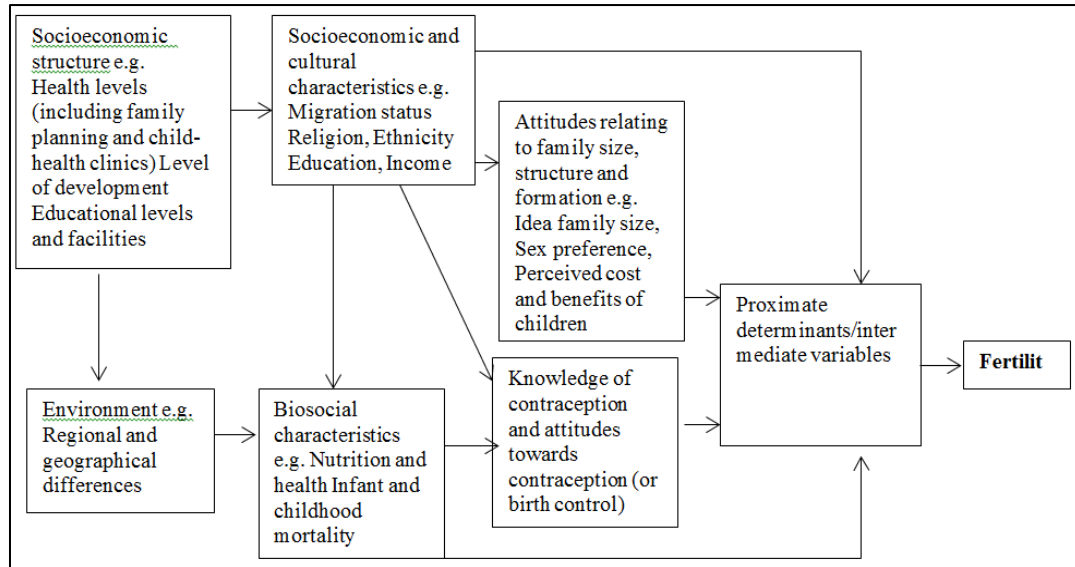
Figure 2:4 Simple Framework for Fertility Analysis

Among the indirect variables mentioned in the Simple Framework for Fertility Analysis, some could be relevant for Thai society. Family planning programs were carried out in many developing countries from the1950s through to the 1980s. It is therefore the National Family Planning Program (NFPP) that should be included in the Thai fertility framework, since the Thai government has integrated it as a part of the five-year National Economic and Social Development Plan (NESDPs; since 1970 when the TFRs began to decrease). However, it does not mean that the NFPP was the factor that affected the TFR and lead to the decline in TFR. Thus, this is the key factor that this study will investigate, and it will be discussed further later. In *"Thailand's Family Planning Program Achieved Sustainability: A System Dynamics Perspective"* by **Wongthanavasu and Kamnuansilpa, (Supawatanakorn Wongthanavasu 2000)**. The authors stated that the NFPP is well recognized as one of the World's most successful family planning program, and is highly effective in moving contraceptive information, services and supplies throughout the country. The contraceptive prevalence rate (CPR) rose rapidly after the

program was launched in 1970, and fertility fell dramatically (Supawatanakorn Wongthanavasu 2000). The success is attributed   to cooperation between the government and the private sector, and the inclusion of international assistance which provided more than two-thirds of the program's budget through the 1980s'. **Wongthanavasu and Kamnuansilpa (2000)** have also created a system dynamic model of the Thai family planning which explain how the government decision regarding the family planning program affects TFR in Thailand.

The model includes five subsystems, which consist of demographic, political, economic, organizational capacity and social benefits (Supawatanakorn Wongthanavasu 2000). They explained that the political system is the main mover of the family planning program in which the basic decision was made to make the radical change from a pro-natalist to an anti-natalist population policy. The change occurred in 1970, when the government adopted a formal policy to slow population growth by reducing fertility, and led to the development of a specific political commitment to family planning. This commitment led to the development of organizational capacity, the creation of a family planning unit and to resource allocation into the NFPP. As mentioned, the international assistance has provided a budget, and is thus included in the model. These political and economic inputs helped build organizational capacity in the family planning program. Accordingly, the capacity for family planning program also fed back into the international assistance system to increase the flow of funds to the program. Program capacity led to increased use of contraceptives, and a consequent decline in fertility and population growth. **Wongthanavasu and Kamnuansilpa** concluded that family planning led to benefits at the individual and collective levels. On an individual level, it reduced the costs of raising children. On a collective level, it put less pressure of population on society welfare provisions, such as health, education, housing infrastructure and other development projects. It thus yielded a cost-benefit ratio that fed back into the political system, which, in turn, increased political support, and "sustained" the program. However, I believe that this model does not cover the impact of family planning in the long run, such as the overall

economic(workforce) and social system. Nevertheless, the model could be used as a reference to develop more valid models that include all importance sectors.

This research will use Wongthanavasu and Kamnuansilpa 's model as a part of the research model in order to formulate the government decision making system which affects directly to TFR pattern.

According to **Lucas's framework** (Simple Framework for Fertility Analysis)(Gefen et al., 2003), education level is the one factor that indirectly influenced fertility. In *"Impact of Demographic Change in Thailand"* (**Hoffman et al., 1999**) state that educational achievement by gender is used as an indicator to reflect the fertility rate. Thus, it is interesting to investigate the improvement of education (status) among Thai women.

Year	Men	Women
1960	1. 6	1. 1
1970	1. 7	1. 6
1980	6. 1	6. 6
1990	8. 8	10. 8
2000	15. 3	20. 7
2010	17. 1	22. 7

Table 2:2 Percentage of population aged 20-24 years old who have bachelor degrees, by sex, 1960-2010

Source: Impact of demographic change in Thailand (Hoffman et al., 1999)

In 1960, fewer than 2 per cent of the population, aged 20-24 years old, had a bachelor's degree, and the percentage of men who had a bachelor's degree was slightly higher than the percentage of women. As time passed, the trend shows a rise in the proportion of people who have a bachelor's degree, and a remarkable increase in the ratio of women to men. By the year 2000, the proportion of women with a bachelor's degree was larger than the proportion of men by five percentage points and increased to six percentage

points in 2010. The increase in women's education leads to female participation in the labor force. The increase in education level and women's labor force participation has had a few negative effects on fertility; firstly, for the proportion married, which indicates women in sexual unions. **Prasartkul, Vapattanawong and Thongthai** explained that the increase in women's education level has reduced the proportion ever married among Thai's women and had some negative effects on fertility, which decreased from 71 per cent in 1960 to 68 per cent in 2000, and to 67 per cent in 2010. Another perspective on marital status is provided by looking at the proportion of women who remain never married at the end of their reproductive life (Prasartkul, Vapattanawong and Thongthai, 2011). The proportion of single women aged 50-54 years old was only 2 per cent in 1960. It had increased three fold to 6 per cent in 2000 and, to increase to 8 per cent in 2010.

Secondly, the increase in women's education has affected the age at first marriage, which had also some negative effect on fertility (the higher the age at first marriage, the shorter the time spent in a married state during the reproductive period, which will reduce fertility). As **Nowrozy Kamar Jahan (2008)** discusses in ***"Teenage Marriage and Educational Continuation in Thailand",*** (Bellman et al., 1999) female teenagers, who were in school and who could successfully continue their education beyond lower secondary level, tended to remain unmarried(Bellman et al., 1999). Those who did so realized the benefit of education for their future, and were therefore likely to postpone marriage. Hence, early marriage is more likely among those who are socially disadvantaged and who are unable to complete their education.

Based on those literatures that studied the education trend in Thailand, it is obvious that the education variable is the one variable among indirect variable that affected TFR pattern in Thailand for the past 50 years.

In addition , ***"An Economic Framework for Fertility Analysis"*** Becker (Easterlin, 1975) uses an economic framework to analyze the factors that determine fertility. Becker states that fertility is determined by income, child costs, knowledge, uncertainty, and tastes of the couple. Typically, an increase in income and a decline in costs would increase the demand for children (Easterlin, 1975), because of the budget available for children.

The theories from literatures could be used to formulate the model framework for this research, as shown in Figure 2:5
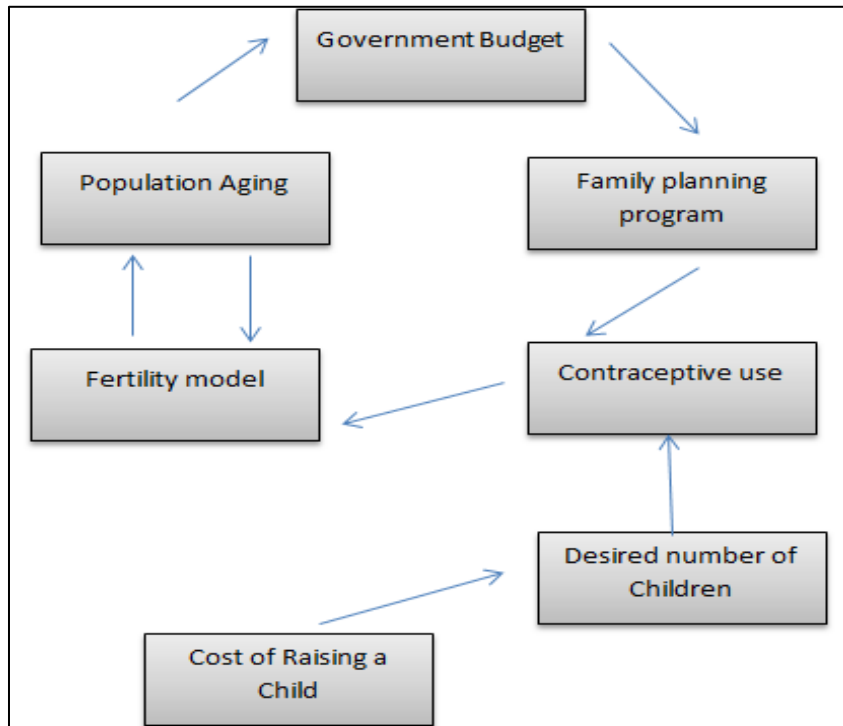
Figure 2:5 model 's framwork

Figure 2:5 indicates the conclusion of literatures where Bongaarts'concept together with Wheat's fertility model can be used to model Thai fertility model based proximate determinants of fertility in Thailand (as presented in literature review). Moreover, the article by Wongthanavasu and Kamnuansilpa (2000) can be used to model the government decision making system in family planning program, which is affected by government budget. Since Easterlin (1975) mentioned the effect of costs of rising a child on the demand for children, these variables are then included in the model.

3. <u>Dynamic problem</u>

<u>Data adjustment</u>

There are several data sources that could be used to estimate the Thais TFR. One source is the data from the Thai government (The Bureau of Policy and Strategy, Ministry of Public Health). The Institute for Population and Social Research (Mahidol University) used the data from the government to calculate TFR from 1965 to 2010; the results are presented below (Figure 3:1):
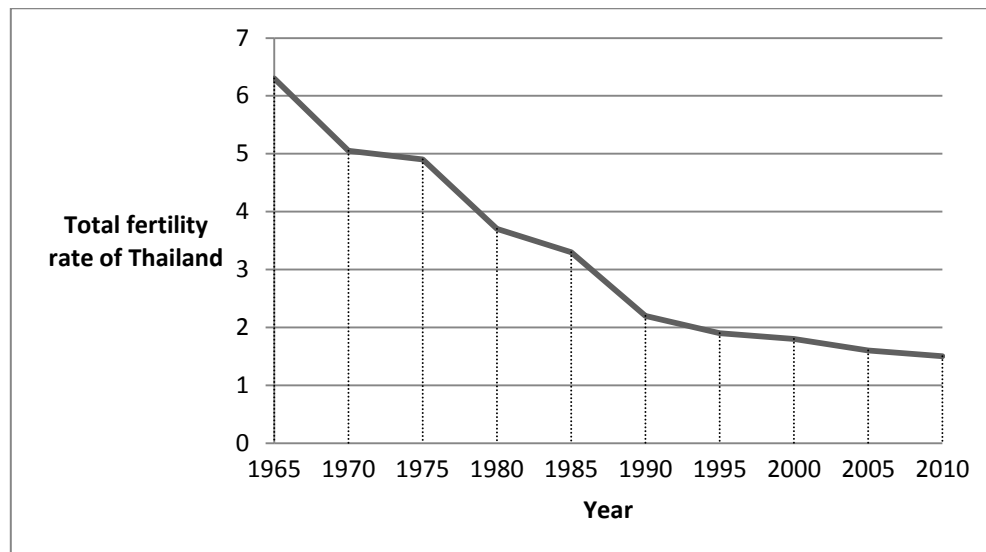
Figure 3:1 Estimated TFR by Institute for Population and Social Research

Source: Mahidol University (2013)

However, there was no TFR calculated prior to1965 from the Thai government, which brings up several hypotheses: *the TFR prior to 1965 is higher than 6; the TFR prior 1965 is lower than 6 and the TFR prior to 1965 is equal to 6.*

Since Thai government implemented pro-natalist policies in 1950, it is then essential to estimate the TFR trend since 1950. In order to estimate the TFR prior 1965, an additional data source is required. Fortunately, there is data from the Bureau of Policy and

Strategy, Ministry of Public Health, regarding age-specific fertility rates in Thailand from 1950 to 1985. In order to identify the actual fertility rate, the age-specific fertility rate data from in the Ministry of Public Health needs to be transformed to TFRs, by using the equation:

TFR = (Σ Age-specific fertility rates)*5/1000 **3:1**

The results of the calculation presented in Figure 3:2.
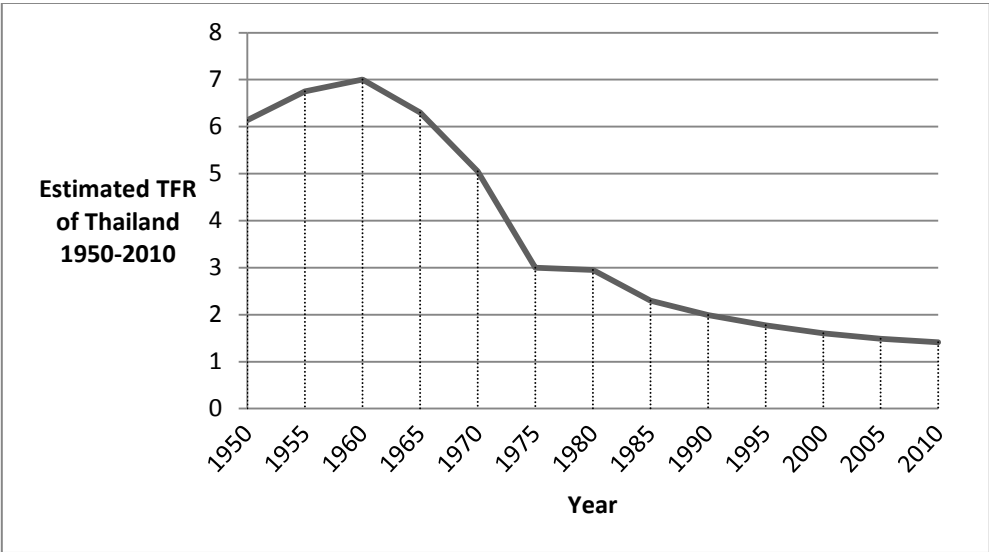
Figure 3:2 Estimated TFR of Thailand 1950-2010 (reference mode)

Source: the Bureau of Policy and Strategy, Ministry of Public Health (2013)

As expected, the initial TFR in 1950 was lower than the TFR in 1965. In 1950, the TFR was about 6, and then increased exponentially to about 7 in 1960, which is the highest measured TFR in Thailand.

Overview of the decline in fertility

The fertility transition in Thailand has been one of the most rapid among Asian countries that are yet to attain the newly industrialized country status. Most evidence suggests that there was little or no fertility decline at the national level prior to the 1960s (Slesinger, Sweet and Taeuber, 1987). According to the data from the Bureau of Policy and Strategy, Ministry of Public Health (Figure 3:2), the TFR increased from 1950 to 1960. In

another words, the TFR was approximately 6 in 1950, and then dramatically increased until year 1965 to about 7.

As shown in Figure 3:2, the TFR exceeded six births per woman in 1960 and it has since been decreasing. TFR began to decline sharply in the 1960s, reaching a level of 5.4 to 5.8 in 1970, and 4.5 to 4.9 by 1975. As the data illustrates, the fertility transition in Thailand can be divided roughly into four periods (Figure 3:3) ; fertility increase (from 1950 to 1960), fertility decrease (from 1960 to 1990), low fertility (from 1991 to 1996), and below replacement fertility (from 1997-present)(Jones et al., 2011). The increase in fertility in the first period is interesting, since existing comparable increase was not seen in other Southeast Asia countries (in 1950 to 1960). Furthermore, Thailand took only 10 years to increase the TFR from about 6 to 7. Thus, the fertility rate behavior in this period was unusual.
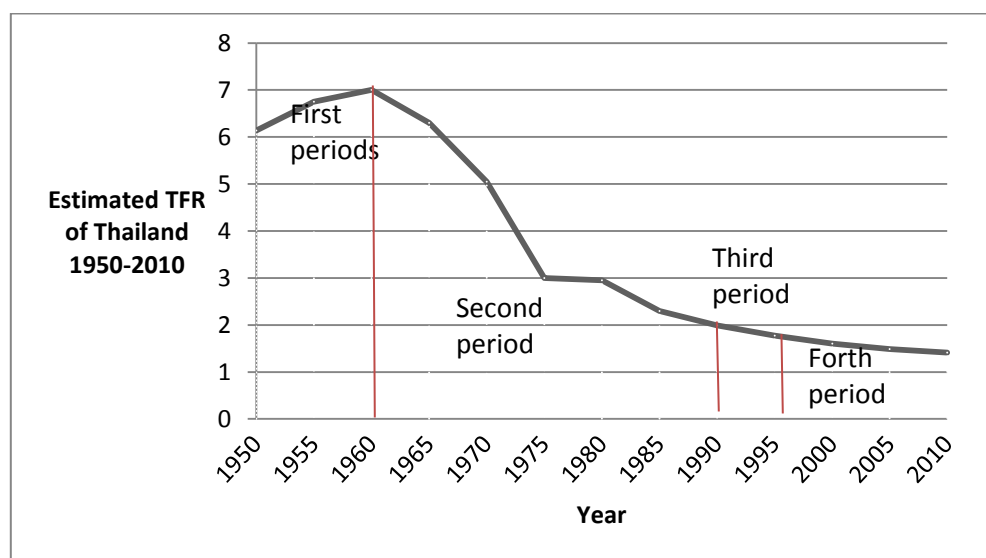
Figure 3:3 The fertility transition in Thailand

Source: the Bureau of Policy and Strategy, Ministry of Public Health (2013)

On the other hand, the decline in fertility seen in the second period is common among countries throughout the world. Nevertheless, if we focus on the length of time

taken for the TFR to decline from about 5.5 to 2.2 (from high levels almost to replacement level), Thailand achieved this decline in a short period of approximately 20 years (between 1970 and 1990). It is sometimes claimed that Thailand had the most rapid decline in fertility in the world (Jones et al., 2011) . In order to demonstrate the rapid in fertility decline in Thailand, it is useful to compare it with other developing countries in Southeast Asia. As shown in Table 3:1, Thailand had the most rapid decline in fertility (61. 6 %) from a TFR of 5.9 in 1970, to 2.3 in 1990.

Countries ▼	1970 ▼	1990 ▼	Percent change from 1970 to 1990 ⌄↑
Thailand	5,99	2,30	-61,60
Vietnam	7,25	4,02	-44,55
Indonesia	5,57	3,40	-38,96
Myanmar	6,10	3,80	-37,70
Malaysia	5,94	4,00	-32,66
Philippines	6,50	4,55	-30,00
Cambodia	6,22	6,00	-3,54
Lao	6,00	6,20	3,33

Table 3:1 Per cent of TFR change

Source: Source: Impact of Demographic Change in Thailand (Jones et al., 2011)

As shown above(Table 3:1), the fertility rate has now declined to approximately 1.5, and if it maintained without any policy change, will eventually result in a population structure as shown in the population pyramids of Thailand from 1960-2030 (Figure 3:4). As mentioned above, the fertility rate has now declined to 1.5 (year 2012), and because of this, the United Nations low projection (which assumes that the TFR in Thailand will decline to 1.60 in 2005–2010,and to 1.28 in 2010–2015) seems to be reasonably accurate (Jones et al., 2011). Thus, the low projection (of fertility rates) will be used to estimate the population structure (population pyramid in Figure 3:4).

Estimating population structure and key issue

According to the data from *"Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects"* (Hoffman et al., 1999), the population pyramids can be seen in Figure 3:4.The population pyramids show that Thailand's population structure has changed from a broad-based pyramid (1960), which indicates a high proportion of children, a rapid rate of population growth and a low proportion of older people, to a low proportion of children and slow rate of population growth. As estimated, by 2020, the "undercutting" in the age pyramid will be even more pronounced for the childhood ages, and numbers will be swell at ages 50 and above (Jones et al., 2011).
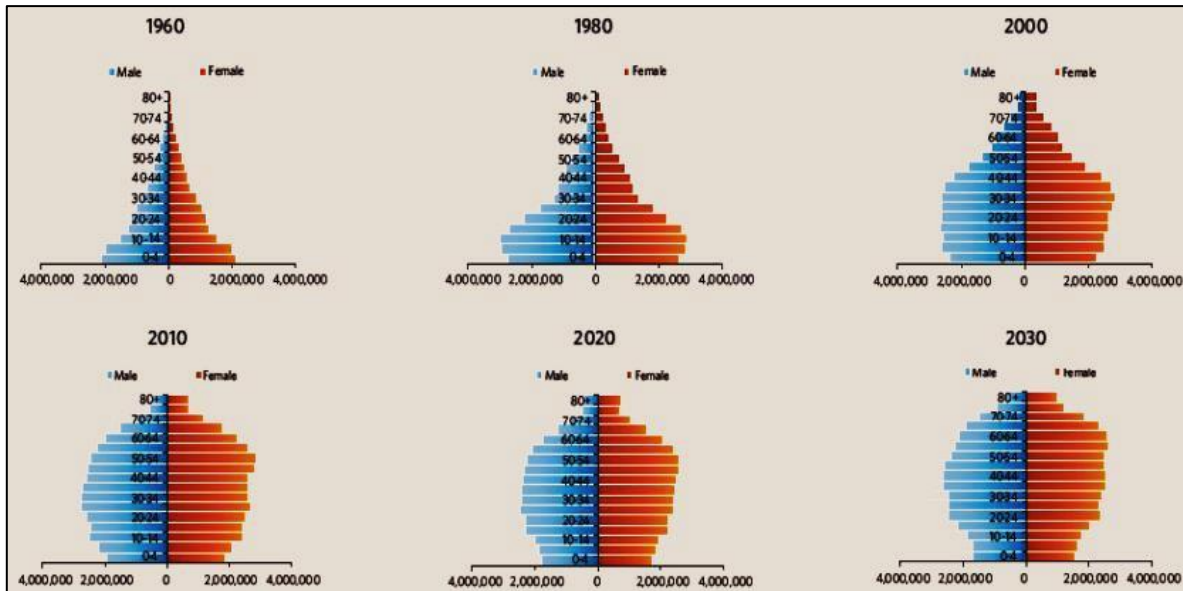
Figure 3:4 Population pyramids of Thailand 1960-2030

Source: Impact of Demographic Change in Thailand (Jones et al., 2011)

As mentioned earlier, the fertility decline changes the age structure in Thai society. As age structure changes, many sectors that exist in society change (private sector, government sector). It then affects several parts of the country, predominantly, labor force participation and its relation to economic growth. The conditions become less beneficial for

economic growth as the working-age groups begin to decline relative to the old age cohorts, and will consequently result in lower rates of saving and investment (Mohamed Abdel-Ghany, 2008). These impacts can be explained as follows:

Increase in the elderly population

As estimated, the population structure will change, resulting in a decline in the numbers of children and of the young working-age population, whereas the numbers of the mature working ages will slowly increase. At the same time, the elderly population will increase very rapidly. As it can be seen in Figure 3:5 , the old-aged dependency ratio has been increasing since 1985, which means a shrinking support base of adults on whom the old age population can depend (Knodel, Chayovan and Prachuabmoh 2011).
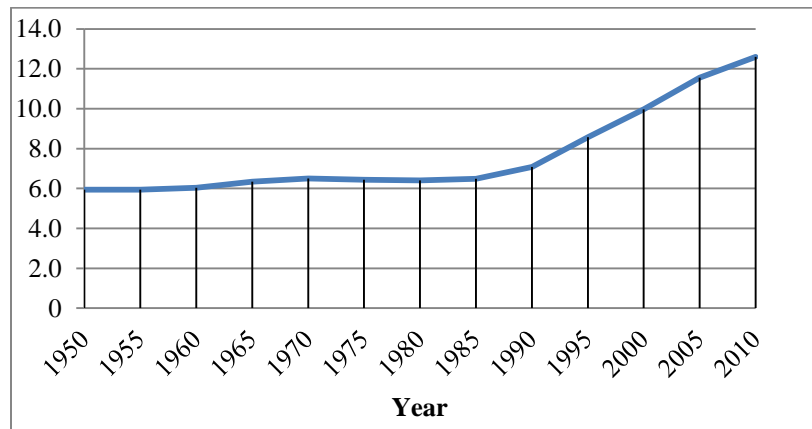
Figure 3:5 Old-aged dependency ratios (ratio of 65+ populations per 100 populations 15-64)

Source: Population Division of the United Nations Secretariat (2012)

The rapid growth is a legacy of the high levels of fertility that prevailed at the time when the cohorts, now entering older age, were born. In the case of Thailand, this would be the time, before 1950, that the government launched its pro-natalist policies to force economic growth. Another reason is the subsequent improvements in mortality rates over the lifetime of this elderly cohort.
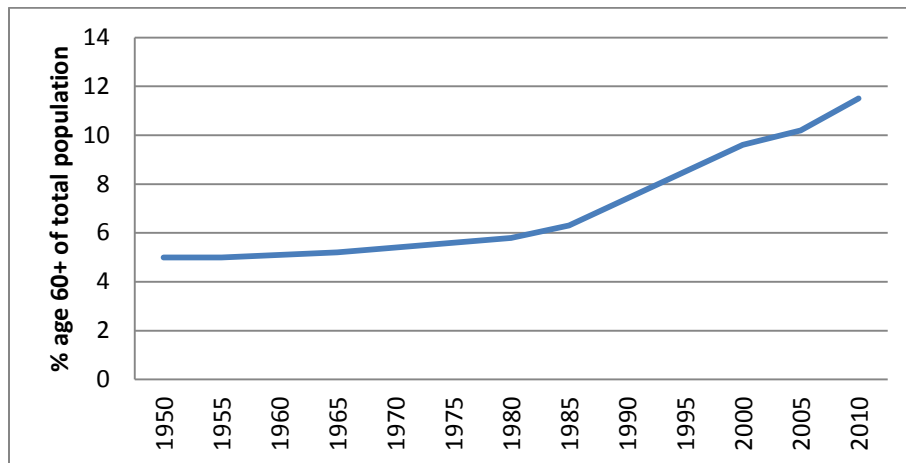
Figure 3:6 Percentage age 60+ of the total population

Source: Population Division of the United Nations Secretariat (2012)

According to UN data from, the Thai population age 60 and over, more than doubled between 1950 and 1975. However, their share of the total population increased only very modestly from 5.0 to 5.6 per cent as it can be seen in Figure 3:6. This was because the overall population growth rate was also high during 1950 to 1975. Since then, fertility has begun to decline, and has slowed overall population growth, while the population growth rate at the older ages remained high, and even accelerated. As a result of population aging, the size of the older population rose. As people get older, demand for health care grows. Rising demand for treatment of the illnesses associated with old age affects long term government expenditure. In addition, when the elderly population increases the demands for government welfare increases, whereas the supply of revenue to the government remains constant. Hence, this may also negatively affect the well-being of elderly.

Economic growth

As discussed above, the rapid decline in fertility has led to a smaller proportion of the population being young, which indicates the smaller proportion of working-age population and a larger proportion of the population being elderly. Since the age structures have potentially important implications for economic growth, the aging changes could deter economic growth. In order to understand the impact of the demographic on economic growth, Mason (2005) then introduced the concept of the "*economic support ratio*". The economic support ratio is computed as the ratio between the effective number of producers (calculated from the age-specific profile of labor income) and the effective number of consumers (calculated from the age-specific profile of consumption) (Jones et al., 2011). In this ratio the variations in the labor market, such as income received for part-time, full-time or self-employed workers, among the population in different age groups are taken into consideration (Jones et al., 2011). Since the economic support ratio is calculated by the number of the population in each group, the economic support ratio may rise or fall, depending on the changes in age structure during the period of the demographic transition.
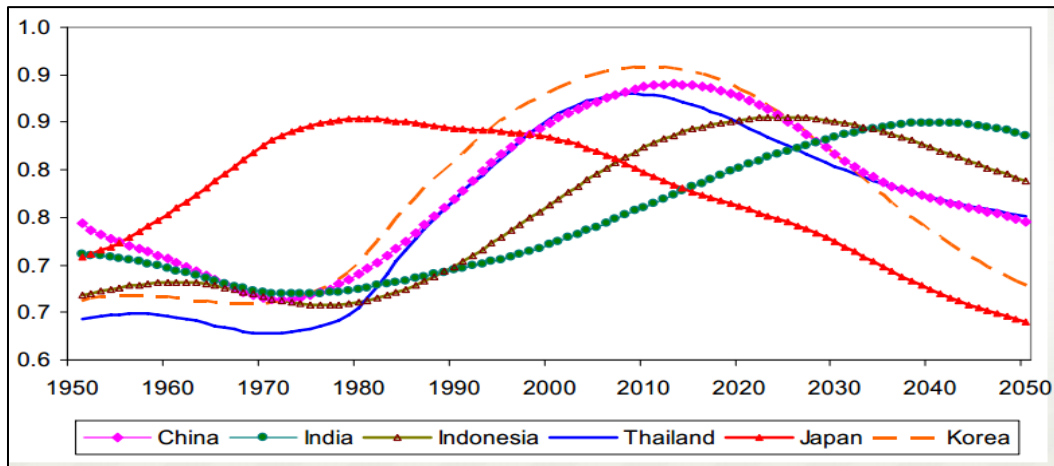
Figure 3:7 The Economic Support Ratio for Selected Asian Countries

Source: Impact of demographic change in Thailand (Chandoevwit and Chawla, 2011)

The results for the economic support ratios of selected Asian countries are shown in Figure 3:7. The economic support ratio for Thailand was lower than that of other countries before 1980, but then rises steeply, due to a rapid increase in the proportion of working-age adults, when the population born in the baby boom period began to enter the labor market, and this rising affected positively to Thai economic. The economic support ratio for Thailand reached its peak in 2009 and began to decline in 2010. The period in which the growth of the economic support ratio increases refers to the demographic dividend where the economics gain benefits from the age structure. On the other hand, if fertility continues to decline, then the working-age population (labor force) declines, and the proportion of the population that is made up by the labor force gradually declines, whereas the relative proportion of the elderly increases (as happening in Thailand), and the economic support ratio decreases. If that happens, the demographic dividend will decline and eventually will become negative, which means that the demographics negatively affects the economics. The economic support ratio increases at a decreasing rate indicating the gradual decline in the demographic dividend that occurred in Thailand in the beginning of 2000. Thailand enjoyed the positive effects of demographic transition on economic growth until 2010, when the positive demographic dividend for Thailand ended. Unfortunately, the current trend of fertility rates in Thailand indicates that population aging will eventually have a negative result on economic growth.

Obviously, the declining in fertility rate is a new issue for Thailand. The most serious part of the issue is its impacts on the economic, since Thailand is a developing country, and still need the work force to support the development. Unfortunately, the total fertility rate now has reached 1.4, which means Thailand may lack of workforce in the future. Thus, Thai government need to aware of the effects of fertility decline, and should to apply some policy in order to raise the total fertility rate.

However, the total fertility in Thailand was increasing from 1950 to 1965, unlike other developing countries where the TFR decreasing dramatically. It is then interesting to investigate the TFR trend, which can be used to explain and address the factors that contribute to the increasing and the declining over the past 60 years. The understanding of

the TFR trend enables the government to design right policies at the right time. The government may consider the policy that has been implemented prior 1950, if it really increases the fertility rate, which will be answered in this research.

4. History of family planning in Thailand.

Population policies

From 1948 to 1957

The first time that Thailand can be said to have had a population policy was in the periods 1938 to 1944 and 1948 to 1957, when Field Marshal Plaek Phibunsongkhram was prime minister, and virtual military dictator, of Thailand. At that time, the government believed that it was necessary to have a large population to build a strong nation. Accordingly, Field Marshal Plaek Phibunsongkhram stated that "Thailand will be saved if we have enormous population and Thailand will be as powerful a kingdom as we all expected if we have enormous population". The statement had been written in a marriage manual, which was distributed to the population. At that time, the Thai population was only 14,464,105, but Field Marshal Plaek Phibunsongkhram aimed to increase the population to 40 million.

The mission to increase the population was transferred to many policies. One of them was to maintain good population health and help the population live for a long time(Phouksoom, 2007). The government believed in Eugenics, which focuses on the improvement of human hereditary traits through the promotion of higher reproduction rates of the more desirable people and traits, and reduced reproduction in less desirable people. In other words, a healthy baby should be delivered by healthy parents (physical and mental). Eugenics encouraged the selection of people to become husband and wife.

Eugenics led the government to build Marriage organizations. These married organizations aimed to encourage healthy men and women to marry. The married organizations also promoted the idea of marriage, by organizing competitions for Able-bodied men and Miss Thailand. These competitions were held in Bangkok on the first of April 1938. The contestants had to be Thai citizens, who were between 20 and 30 years old, and healthy. These competitions aimed to reflect the ideals of beautiful, healthy people, as shown in the competition rules: the minimum height is 156 cm, weight about 50 to 53 kg,

have a body in peak condition, and the contestants needed to pass health checks (including teeth). The government also convinced the population to marry at specific ages (aged 20 to 30 for men and 15 to 29 for women).

The Marriage organizations encouraged the population to marry, by accommodating people who wanted to get married. The organizations accommodated people by providing consultations and health examination before marriage. In addition, the organization organized the "Thai National marriage" in 29th March 1943, and there were the marriage festivals in every province in January 1944. The married organizations also organized the "Married agency" which had the motto: *"Everyone has duties to build the nation. Marriage at a young age creates national prosperity, marriage registration stabilizes the nation, and a healthy spouse results the strong nation"*.

The married organizations motivated to get married by many means, such as: they could borrow money from government, a school fees exemption for the first child of the married couple for whom the government held their wedding ceremony, free bus and train rides for pregnant women, etc. At the same time, the government legislated a tax for people who were single (1944). There was an additional tax for men who were over 25 years old and remained single. The government discouraged contraception at this time. The government controlled contraceptive medicines and equipment in the same manner as it controlled narcotics; the purchase of contraceptive medicine needed to be permitted by the government and prescribed by a doctor.

From 1957 to 2010

In 1959, a World Bank economic mission described the adverse consequences that Thailand's marked high rate of population growth would have on economic development. Even though the government paid little attention to the population problem, the interest of key health officials and academics eventually prompted a series of seminars on the issue beginning in 1963 (Robinson and Ross, 2007). The First National Population Seminar, sponsored by the National Research Council of Thailand and funded by the Population

Council, discussed the high rate of population growth and recommended that the matter be studied more closely (Gille and Balfour,1964). National population seminars were held again in 1965 and in 1968. After the first seminar, in 1964, the Ministry of Public Health and the National Research Council did not immediately use the family planning program as they had suggested. At first, the Ministry of Public Health and the National Research Council decided to begin a small demonstration project in Potharam (a rural district outside Bangkok). Family planning services were provided at a small number of health centers. Government health staff members were responsible for client education and motivation. After an 18-month period, the survey found that fewer than 5 per cent of married women knew of any modern contraceptive methods; fewer than 3 per cent of couples were using contraceptives, including sterilization; and yet 70 per cent of the women did not want additional children. During the action phase of this project, more than 30 per cent of married women accepted contraception, the majority electing to use an IUD, with sterilization as the second place choice. A follow-up survey in 1965, found that more than 80 per cent of women in the district knew about one or more modern methods of contraception. This project indicated that rural couples were interested in limiting their childbearing and would make use of family planning services if they were available. It therefore encouraged a few hospitals in Bangkok to open family planning clinics in 1965 and four Bangkok hospitals joined the International Postpartum Program sponsored by the Population Council in 1966. By the mid-1970s, some 350 family planning clinics had been established in hospitals and health centers (Hemachudha and Rosenfield 1975). Public information activities were prevented during this time, and the project relied on word of mouth (between potential clients and satisfied clients as the main means of promoting family planning).

In 1970, the pro-natalist policy was officially reversed since the NESDP was formed in order to slow the fertility rate. The government targeted a population growth of 2.5% by the end of the 1976. In fact, by the end of 1976, population growth was 2.7%. Hence, the government continued to target decreases in the rate of population growth, as part of the NESDPs, for more than two decades. What happened over the period covered by

the 3rd (1972-1976) to 6th (1987-1991) of the five-year plans was one of the most rapid declines in fertility in the history of the world and was the fastest decline over that period among all countries in Southeast Asia – a decline from a TFR of 5.5 in 1970 to 2.2 in just 20 years (Gavin Jones and Worawan Chandoevwit, 2011). At that time, private and public sectors worked together in family planning. Most of the population recognized the slogan "Having many children leads to poverty", which was widely advertised. The Ministry of Public Health ensured that family planning services were widely available and took radical steps to ensure that women needing contraceptive protection were able to obtain it, including allowing midwives to insert IUDs (contraceptive coils).

In 1979, a private non-profit organization, the Population and Community Development Association (PDA) was established, and is the largest non-governmental agency in Thailand, led by Mechai Viravaidya. PDA offers loans that are linked to people's use of contraception. Mechai Viravaidya, who was nicknamed *Mr. Condom*, emphasized that having many children did not only lead to poverty but also adversely affected the health of fathers, mothers, and newborns (Veravaidya, 1979). Mechai's private sector activities were an effective complement to the efforts of the Ministry of Public Health.

Figure 4:1 Thailand's condom king Mechai Viravaidya hands out condoms

Although condoms – now commonly called "mechais" in Thailand – became the natural trademark of his publicity campaign, Mechai used a variety of other family planning tools as well. Under his direction, birth-control carts sporting pills, IUDs, spermicidal foam, and condoms appeared at bus stations and public events. The Thai government supported Mechai's efforts by making a wide range of new contraceptive technologies available to the public. Thailand was among the first countries to allow the use of the intravenous, injectable contraceptive DMPA, and remains one of its largest users. Thai physicians have also developed simplified methods of female sterilization, and now operating room nurses are trained to perform these procedures. Non-scalpel vasectomies are available at festivals and other public events, and, in a characteristically celebratory manner, PDA offers free vasectomies on the King's birthday. Sterilization has now become the most widely used form of contraception in the country.

By the time of the 7th plan (1992-1996), the number of children per family was steadily decreasing, and the aim of fertility reduction was targeted more to controlling population growth in certain regions, such as northeast Thailand and the mountainous areas, where the birth rate remained relatively high, causing imbalances in allocation of resources to education and health (Gavin Jones and Worawan Chandoevwit, 2011).

In the 8th plan (1997-2001), the government goal (NESDP) was not to target a reduction in the population growth rate, but was focused on maintaining an appropriate family size. Accordingly, in the 9th plan (2002-2006), the government stated its goal of maintaining fertility at around replacement level. It also noted the need to improve accessibility and quality of reproductive health and family planning programs. Unfortunately, when these plans were prepared, the fertility rate was already below that needed for population replacement.

Currently, the 10th plan is concerned with the aging population and is focused on issues of preparing for aging, improvement of labor productivity and social services relating to the elderly. It also notes that aging populations in developed countries might cause tremendous labor movements from developing to developed countries where job opportunities are better. Such movements could cause more labor shortages in Thailand. However, present policies at the ministry level are responsive policies, intended to cope

with the changing population structure. No attention has been paid to the issue of raising the fertility rate, but there is some emphasis on controlling the deaths of newborns and mothers. (Gavin Jones and Worawan Chandoevwit, 2011)

5. Research approach and methodology

Research approach

As explained in the last chapter, the history of population policy shifted between pro-natalist and anti-natalist policies. Hence, it is interesting to investigate the effectiveness of these policies. Thus, this research begins with the questions:

- Could the increase in fertility rate in Thailand, from 1950 to 1965, be explained by the pro-natalist policy?
- Could the decline in the fertility rate in Thailand, in the period 1960–present, be explained by the anti-natalist policy (the family planning program)?
- If so, another question is "Why do overshoots and undershoots occur?"

Methodology

As we know, this research is involved with demographic analyses and interconnected sectors of society, such as the government budget, government existing policies, marriage, and contraceptive use. This, therefore, creates a huge number of feedback and complexities. In order to understand complex systems, it requires mastery of concepts such as feedback, stocks and flows, time delays, and nonlinearity. System dynamics is useful methodology to study and manage complex systems that change over time (Andrew Ford, 2010). Since it is aimed to study and manage complex systems, it is therefore well suited to modeling social problems like demographic.

The methods of system dynamics provide us with tools to understand difficult management problems. Moreover, these methods have been used for over 50 years (Forrester 1961), and are now established in well-known softwares[1]. In demographic analyses, the population must be divided into different age groups for investigation. In this

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[1] such as ithink, Vensim, Stella and Powersim

case, the analysis can be performed with the system dynamic theory regarding co-flows and aging chains. Moreover, there are several system dynamic concepts that are useful for this research, such as material delay, information delay or feedback loops. In order to deal with such complexities, this research uses ithink software. ithink software was used to model the TFR dynamic of Thailand, which contributes to the TFR behavior, as is shown in the reference mode. The modeling process is explained below. The result from this modeling method will enables the government to understand the demographic issue in Thailand more clearly and closely. In addition it allows decision maker (or government) to test the policies before actually implement them. This policy testing helps decision maker to understand policy effectiveness in order to make better decision (save cost and time).

Analytical process

This research aims to answer the questions of how government population policy (both pro-natalist and anti-natalist) affected TFR behavior in Thailand (from 1950 – present). To do this, the research processes were ordered as follows:

Firstly, we need to focus on reference mode modeling. The TFR behavior from 1950 to 2010 is the reference mode in this research, and then we need to work out its causes. There are many studies that refer to TFR's factors, and the best known of these is *"A Framework for Analyzing the Proximate Determinants of Fertility"* by John Bongaarts (1978), as discussed earlier. Hence, the equation described in this report will be used to model "*the initial model*" (explained in depth in the next section). The initial model is the TFR model that uses the proximate determinants described by Bongaarts and modeled by Wheat (2012)

Since the government policies have been implemented, we then will extend the model to get the bigger view of the TFR's factors and to connect with the government policy structure. The two proximate variables that have been chosen to be extended are: the index of proportion married, and the contraceptive prevalence. The main reason to choose

these two variables is their connection with government population policy. In other words, from 1950 to 1957, the government population policy was aimed at the increase of the married rate (see the detail in the historical sector), and from 1970 to the present day, the government population policy has been aimed to increase the contraceptive prevalence. The process of modeling government population policy involves the selected variables, which are the index of proportion married and the contraceptive prevalence. The pro-natalist policy modeling part (1950 to 1957) will focus on the *Married organizations,* and the anti-natalist policy modeling part (1970 to present) will focus on the *National Family Planning Program.*

In order to answer the research questions, we now need to run the model with and without government intervention. That means there will be two initial base runs: for the first run the policy will be switched on (Ithink software allows us to do this), and for the second run, the policy will be switched off. The differences between these two behaviors indicate how government population policy (both pro-natalist and anti-natalist) affected TFR behavior in Thailand

6. <u>Hypotheses</u>

<u>First hypothesis</u>

According to the fertility transition graph (Figure 3:3), the Thai fertility transition path can be divided into four periods. The first period is from 1950 to 1960, which represents the increase in TFR from six to seven births per women. The second period is from 1960 to 1990, in which the fertility rate declined rapidly .The third period is (from 1991 to 1996) where the TFR is in the low level and declined slowly. The fourth period is from the end of 1997 – to the present, in which the fertility rate gradually declined and stabilized.

This first hypothesis will support the impacts of government policies on fertility rate. It can be hypothesized that the increase in fertility rate in the first period was affected by the pro-natalist policy from the government at that time, as mentioned above. On the other hand, the decline in fertility could be explained by the intense anti-natalist policy from the government (NESDP from 1970 to 1991). This hypothesis believes that government policy is the major factor in the increasing and decreasing fertility rates. In this case, the fertility transition (Figure 3:3) can be divided into three periods, by using the history of government policies prior to 1960, and NFPP after 1970.

The first period (1950 to 1960) is the period that Thai fertility rapidly increased (from 6 to 7), when the family planning program was not yet practiced, even though, in 1959, a World Bank economic mission suggested the damaging consequences that Thailand's markedly high rate of population growth would have on economic development. However, the effects of the pro-natalist policy still existed as the TFR was still increasing. This could be explained by "information delay", as it takes time to remove old information and it takes time to gain new information (information regarding population policy). Even though, the government was aware of the population problem (high fertility), they did not implement any new policies. The interest of key health officials and academics in the

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problem, eventually prompted a series of seminars on the subject, beginning in 1963 (Kulczycki, 2008). The First National Population Seminar, sponsored by the National Research Council of Thailand and funded by the Population Council, discussed the high rate of population growth and recommended that the matter be studied more closely (Gille and Balfour 1964). Hence, the first period can be thought of as a prepared period of National Family planning, but no fertility decline was seen in this period.

The second period (1960 to 1990) is the longest period in which Thailand's fertility rate decreased dramatically. In 1965, a few hospitals in Bangkok opened family planning clinics. These hospitals included Chulalongkorn Hospital, whose clinic only offered intrauterine devices (IUDs). This resulted in the beginning of the decline in fertility, in late 1965. Additionally, in 1966, four Bangkok hospitals joined the "International Postpartum Program", sponsored by the Population Council (Zatuchni 1970). These hospitals provided family planning education to maternity patients in the prenatal and postpartum wards and offered contraception, primarily the IUDs and sterilization, to women prior to discharge or in the months thereafter (Robinson and Ross, 2007). As shown in Figure 3:2, the rapid declining in fertility began in 1970. In the mid-1970s, the Thai postpartum program had expanded outside Bangkok to eight provincial hospitals and three maternal and child health centers of the Ministry of Public Health. In the period of 1966 to 1971, nearly 100,000 women accepted family planning services and the family planning clinic at Chulalongkorn Hospital, which became one of the world's largest IUD clinics at the time, even though the hospital did not advertise its services. Rather, women learned about the services through word of mouth communication (Robinson and Ross, 2007). In 1972 the government developed a five-year plan (1972–76), with the goal of reducing the rate of population growth from more than 3.0 per cent per year to 2.5 per cent per year by the end of 1976. The informal family planning then became the NFPP, and family planning activities continued to be integrated within the existing health care infrastructure that covered the whole country, expanded the range of available contraceptive methods and advertised its services. After the government began to advertise the NFPP, knowledge of contraceptive expanded to rural or provincial areas. The demand for contraception increased, and the

government expanded the role of auxiliary midwives to meet this increasing demand (increase capacities). In other words, the government allowed auxiliary midwives to insert IUDs and distribute the pill. Hence, contraceptive use increased along with the decrease in total fertility. According to "Contraceptive prevalence survey" (CPS), the percentage of ever married women who were aware of a specific contraceptive method had increased dramatically, as shown in Table 6:1

Method	CPS1 1978	CPS2 1981	CPS3 1984
Pill	99	98	100
Female sterilization	96	97	99
IUD	92	93	97
Contraceptive Injection	90	95	99
Male sterilization	87	93	98
Condom	82	83	94
Vaginal method	19	22	25
Induced abortion	62	75	89
Rhythm method	-	43	52
Withdrawal	-	29	38

Table 6:1 Percentage of ever married women aware of specific contraceptive methods

Source : Contraceptive prevalence survey (1984)

Method	LI1 1969-1970	LI2 1972-1973	1975 SOFT	CPS1 1978	CPS2 1981	CPS3 1984
Any method	14. 8	26. 4	36. 7	69	75	82
Pill	3. 8	10. 6	15. 2	47	51	57
Condom	0. 8	0. 1	0. 5	10	11	13
Vaginal method	-	-	-	2	2	1
Contraceptive Injection	0. 4	0. 9	2. 1	12	18	24
IUD	2. 2	4. 6	6. 5	10	12	13
Female sterilization	5. 5	6. 8	7. 5	13	18	23
Male sterilization	2. 1	2. 9	2. 2	4	4	4
Abortion	-	-	-	3	2	3
Rhythm method	-	-	-	8	10	8
Withdrawal	-	-	-	8	7	7
Other	-	-	2. 8	1	1	1

Table 6:2 Percentage of ever married women aged 15-49 who had ever used contraception

Source : Contraceptive prevalence survey (1984)

The other factor that influenced the use of contraception in the 1970s is the private sector, such as the privately operated organization, Community-Based Family Planning Services, later renamed the PDA. This organization, one of the developing world's most successful non-governmental organizations for community development and family planning, introduced the first contraceptive program in 1974. The PDA is headed by Mechai Viravaidya, who was well-known as Mr. Condom, at that time. Mechai Viravaidya

announced also slogan that "Having many children leads to poverty", which was broadly posted. This slogan affected Thai's women's attitudes to the desired quantity of children.

The third period is from 1990 to the present day, in which the fertility rate declined gradually and stabilized. This situation was also caused by the family planning policies. In other words, the government began to slow down its support of the anti-natalist policy. In the 7th plan of national family planning (1992-1996), the number of children per family was steadily decreasing, and the aim of reducing fertility was increasingly targeted to controlling the population growth in particular regions, such as northeast Thailand and the mountainous areas, where the birth rate remained relatively high, causing imbalances in the allocation of education and health resources. (Jones and Chandoevwit, 2011). In the 8th plan (1997-2001), the national family planning goal was not targeted to reducing the population growth rate, but was focused on maintaining appropriate family sizes. Accordingly, for the 9th plan (2002-2006), the government had a goal of maintaining fertility at around the replacement level. Unfortunately, by the time that these plans were prepared, the fertility rate was already below replacement level. Currently, the 10th plan is concerned with the aging population, and notes that aging populations in developed countries might cause a notable labor movement from developing to developed countries, where job opportunities are better. Such movements could cause more labor shortage in Thailand. However, the present ministerial policies are responsive, in order to cope with the changing population structure. There are no new policies aimed at raising the fertility rate, but there is some emphasis on reducing deaths of newborns and mothers. (Jones and Chandoevwit, 2011)

Alternative hypothesis

 The alternative hypothesis:

- The increase in the fertility rate in Thailand between 1950 to 1965 could not be explained by the pro-natalist policy;
- The decline in fertility rate in Thailand in the period 1960–present could not be explained by the anti-natalist policy (family planning program);
- There were other factors that contributed to the changes in fertility rates. These factors could be industrialization, the economic situation and education. In other words, the growth of industrialization and growth in the economy increased the desires of the workforce. Educational background is of great importance when the stage of life involving marriage is reached, and the decision of whether to have children or not becomes relevant, and this is directly reflected in the declining birth rate.

In this research the alternative hypothesis would be supported if TFR behavior from the first modeling run and the second run are the same; this would mean that the government policies do not affect the TFR.

7. <u>Model specifications</u>

<u>Initial model</u>

In this case, the initial model is the fertility model. This fertility model was adapted from the model developed by Wheat (2012) in *"Modeling fertility in Lithuania: A preliminary Report"*. The aim of this section is to illustrate the dynamic of fertility in Thailand, which was drove by the proximate determinants. Several proximate determinants included in Thai fertility model such as contraception, stillbirths, infant death, sex frequency, bread-feeding duration and number of marriage women. The dynamic of the model shows in Figure 7:1 (presenting the simplified version of the model in order to avoid complexity).
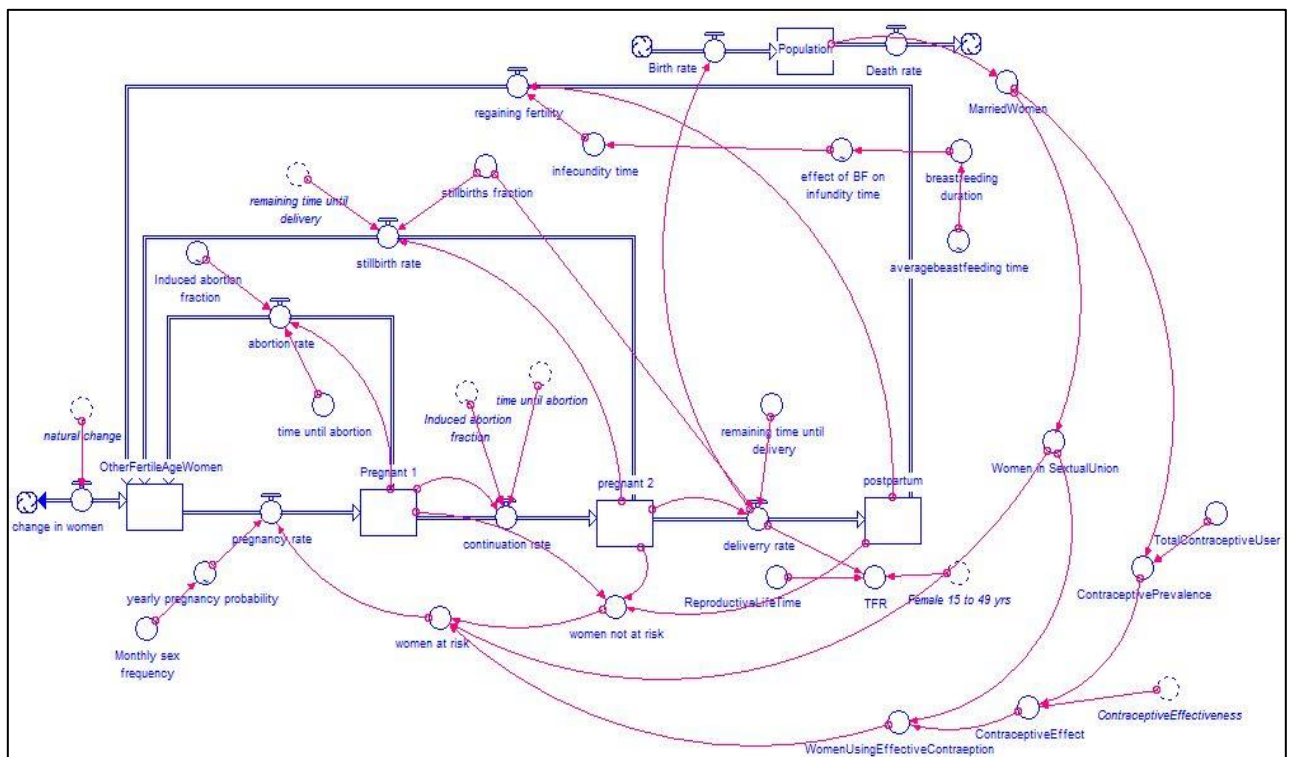

Figure 7:1 Simplified fertility model, adapted from Wheat (2012)

We divided fertile women (women between 15 and 49 years old) into four groups, which are other fertile age women, Pregnant1, Pregnant2 and Post-Partum. The **other fertile age women** represented the women who are not pregnant and not in the postpartum period; they thus can be pregnant. The women in this group will be pregnant with some probability if they are married, having intercourse, and not using contraceptives. The women who are married, not using contraceptives, or the contraceptives that they are using are not effective are the **women at risk**. The equation for **women at risk** is ;

women at risk=Women in sexual union- women using effective contraception

$$-\text{women not at risk} \qquad (7{:}1)$$

Given the **women in sexual union** are married women .Since the dynamic of marriage is the important part, we will discuss it deeply in the next section.

The **women not at risk** is the women who are remain pregnant (they are not able to get pregnant in this period).Therefore the **women not at risk** are the sum of 3 stocks, which are the stock of **Pregnant1**, the stock of **Pregnan** and the stock of Post-**Partum**.

The **Women using effective contraception** is the women in sexual union who are using effective contraception, as equation;

Women using effective contraception = women is sexual union *contraceptive effect.

$$(7{:}2)$$

The **contraceptive effect** depends on two variables, which are the **contraceptive prevalence** and **contraceptive effectiveness**, as equation;

The contraceptive effect= contraceptive prevalence*contraceptive effectiveness   (7:3)

The **contraceptive effectiveness** in the model is the average effectiveness of all contraceptive methods that have been used in Thailand, which is about 95 % affective (Ministry of public health, 2013). In this case , the **contraceptive prevalence** is measured by the percentage of currently married women who are presently using a contraceptive method(Chamratrithirong et al., 1986). Thus, the equation for contraceptive prevalence is ;

Contraceptive prevalence= Total contraceptive user / married women (7:4)

Since the contraceptive part is the important part in this model, we will discuss it deeply in the next section.

When the **women at risk** are having intercourse**,** there is a probability they will get pregnant. The women that became pregnant would move to the **pregnant 1** group, through the **pregnancy rate**. However, it depends on sex frequency as well. In another words, if the **women at risk** are never have sex, the pregnancy rate would be 0. The **yearly pregnancy probability**(Figure 7:2) is calculated by Wheat (2012) , he based his calculation on Fairley's equation [2](Wheat, 2012).
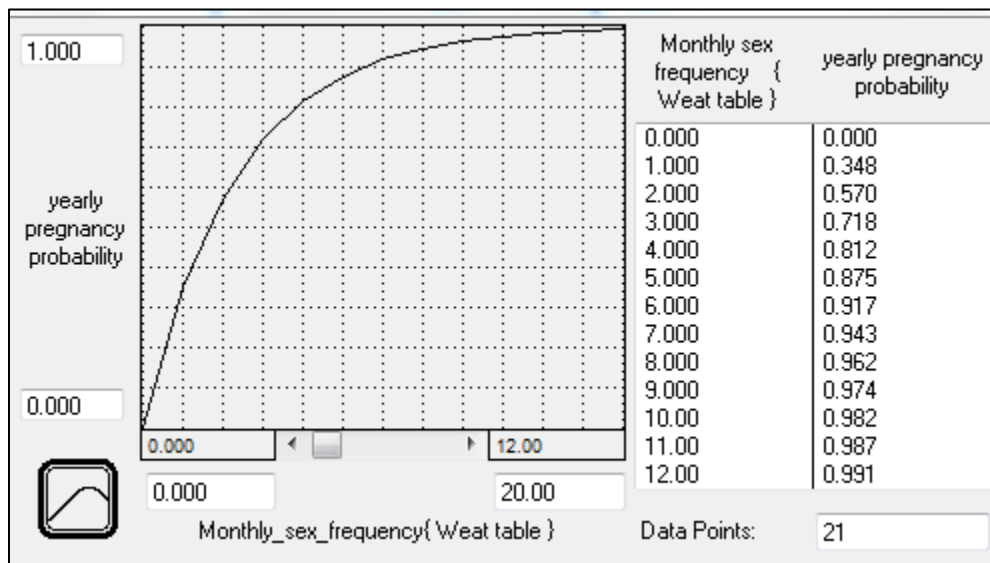

Figure 7:2 Yearly pregnancy probability calculated by Wheat (2012)

The equation for pregnancy rate is;

Pregnancy rate = Women at risk*Yearly pregnancy probability (7:5)

The **pregnant 1** group is the women who are at risk of induced abortion. Those who induced abortion will revert to the **other fertile age women** group through the **abortion rate,** as equation**;**

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[2] $12*M*P*(1-P)_{12*(M-1)} / (12*M*P*(1-P)_{12*(M-1)} + (1-P)_{12*M})$ where M is the monthly frequency of sexual intercourse and P is the probability of pregnancy each time

Abortion rate= (Pregnant_1*Induced abortion fraction)/time until abortion) (7:6)

Since abortion is illegal in Thailand, data and measurements of the total abortion rate is lacking. However, there was a publication that studies the abortion situation in Thailand: "Induced *Abortion in Thailand: Current Situation in Public Hospitals and Legal Perspective"* (Warakamin et al., 2004) The study estimated the induced abortion rate from public hospitals and legal organizations[3]. Their estimation for the induced abortion rate was about 0.02% among pregnant women, and it has been used as a constant variable in the model. The rest (who did not induce abortion) would continue to the next period of pregnancy, which is **pregnant 2.** Women in this condition could lose their unborn child (stillbirth), if so, they would revert to **other fertile age women.** There was a data from Ministry of public health, Thailand (2013) regarding stillbirths rate in Thailand (Figure 7:3), which have been used in this model.

Otherwise, those who have gone through the whole process will give birth, which results in the **delivery rate.** After they have given birth, the women remain in the **postpartum** infecund condition for some time. The time that they remain in **postpartum** infecund is called **infecundity time** in this model. The **infecundity time** is affected by the **breastfeeding duration .**In another words, the women who are in postpartum will remain infecund longer if they have longer duration of breastfeeding**.**

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[3] Abortion is illegal in Thailand unless the woman's health is at risk or pregnancy is due to rape.
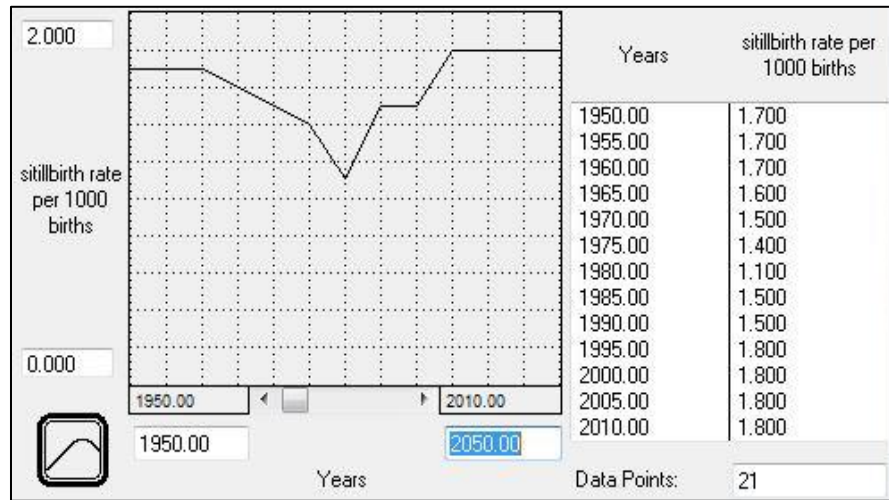
Figure 7:3 Stillbirth rate in Thailand 1950 -2010

Sources ; Public health statistic , Ministry of public health (2013)

In *"Modeling fertility in Lithuania: A preliminary Report"*(Wheat, 2012) ,Wheat calculated the effect of breastfeeding duration on infecundity time (Figure 7:4) ,which has been used in this model. Wheat based his calculation on a tight-fitting (R2 = 0.96) regression[4] estimate of the effect of breastfeeding on infecundity time(Wheat, 2012) provided in Bongaarts and Potter (1983).
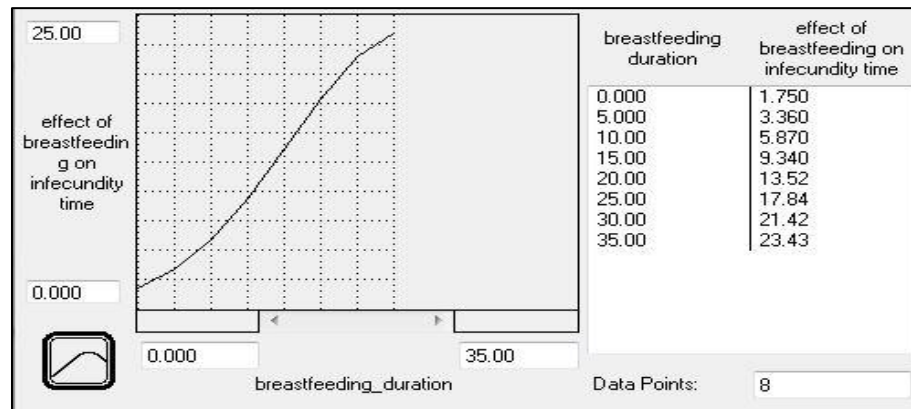

Figure 7:4 The effect of breastfeeding duration on infecundity time(Wheat, 2012)

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[4] $T = 1.753e^{0.1396*B-0.001872*B^2}$ Where T is infecundity time and B the breastfeeding duration, both measured in months

In "*Breastfeeding in Thailand: Data from the 1981 Contraceptive Prevalence Survey*"(Knodel et al., 1982) found the average total duration of breastfeeding in Thailand has decreased over time. The results from the survey indicate that Thai mothers introduce supplemental food into the diet of the children within the first few months of life. Thus the duration of full breastfeeding is quite short. The preference for breastfeeding is influenced by a variety of nutritional factors, work conditions, health/medical factors, social, economic, cultural conditions, and by psychological reasons (Knodel et al., 1982).The average breastfeeding in Thaind is shown in Figure 7:5
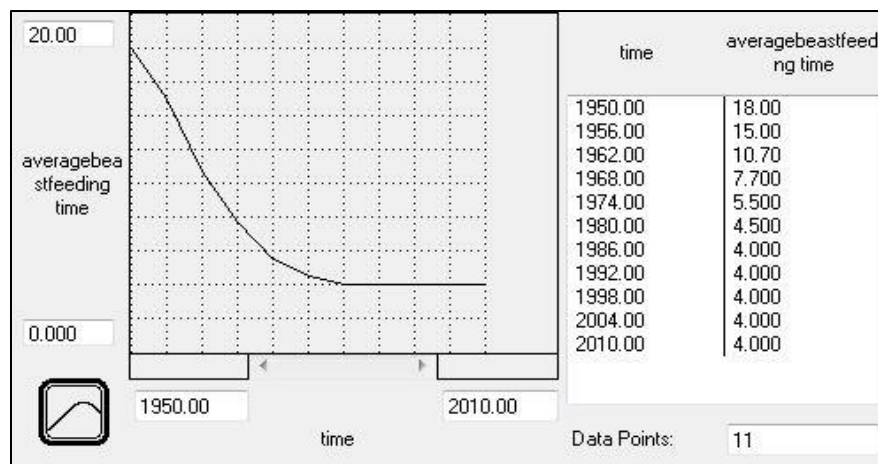

Figure 7:5 The average breastfeeding in Thailand(Knodel et al., 1982)

As mentioned that those who have gone through the whole process will give birth, and results in the **delivery rate,** which is the number of live birth per year. This **delivery rate** is the **birth rate** that is accumulated in the **population** stock. The **delivery rate** is also illustrate the total fertility rate (**TFR**) ,as equation ;

TFR = (Delivery rate *Reproductive life time)/Female 15_to 49 yrs.   (7:7)

Given the **Reproductive life** time equals 35 year, and **the Female 15_to 49 yrs.** is the fertile women who are aged 15 to 49, which is the result from the population section (it will be discussed in the next section) . Figure 7:6 shows the dynamics of this initial model, by using a causal loop diagram (CLD). The CLD shows how these interrelated variables affect each other, and the relationships between variables, represented by arrows, can be

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labeled as positive or negative. A positive causal link means that the two variables change in the same direction, if a variable in the link starts to increases, the other variable also increases. A negative causal link means that the two variables change in opposite directions, if a variable in the link starts to increases, then the other variable decreases. Other labels are B and R, which represent balancing loops and reinforcing loops respectively. Reinforcing loops are loops that have an even number of negative links, and balancing loops means loops that have uneven numbers of negative links.

As shown in Figure 7:6 , loop **R1** is the loop that reinforces TFR to increase, as the population increase, the married women and pregnancies increase, and then force back to birth rate which increase the population. However, TFR could be decreased by the power of contraceptive use, which is the exogenous variable. The contraceptive prevalence depends on the number of contraceptive user. These contraceptive users divided in to 2 groups, which are the private clinic users and the NFPP users. The number of contraceptive users will increase if the desired TFR increase. This desired TFR depends on perceived cost of raising a child. Moreover, the Loop B1 aims to balance the population as the death rate increased, the population decreased.
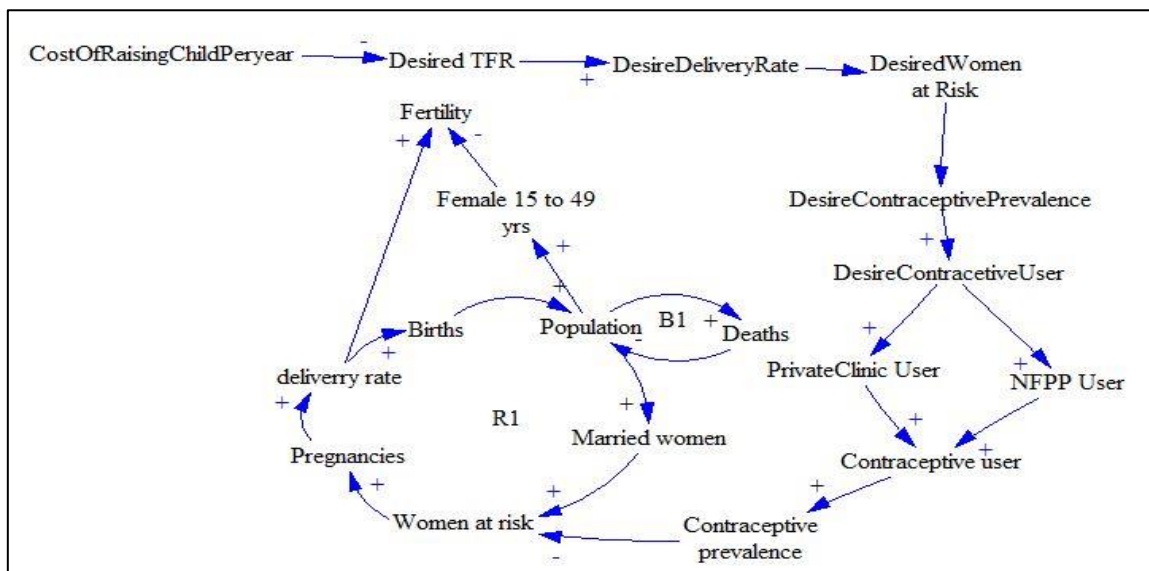

Figure 7:6 CLD for initial model

Extended model

Since this research aims to investigate the impact of government policies, the model needs to focus on the variables that relate to government policies. As mentioned earlier, from 1950 to 1957 Field Marshal Plaek Phibunsongkhram was the prime minister of Thailand, who believed in a pro-natalist policy, and the increasing in numbers of married women. It is therefore appropriate to include an extension on the marriage dynamic in this model. Figure 7:7 shows the dynamic of this model, including the marriage process, which illustrates the effects of marriage on TFR.
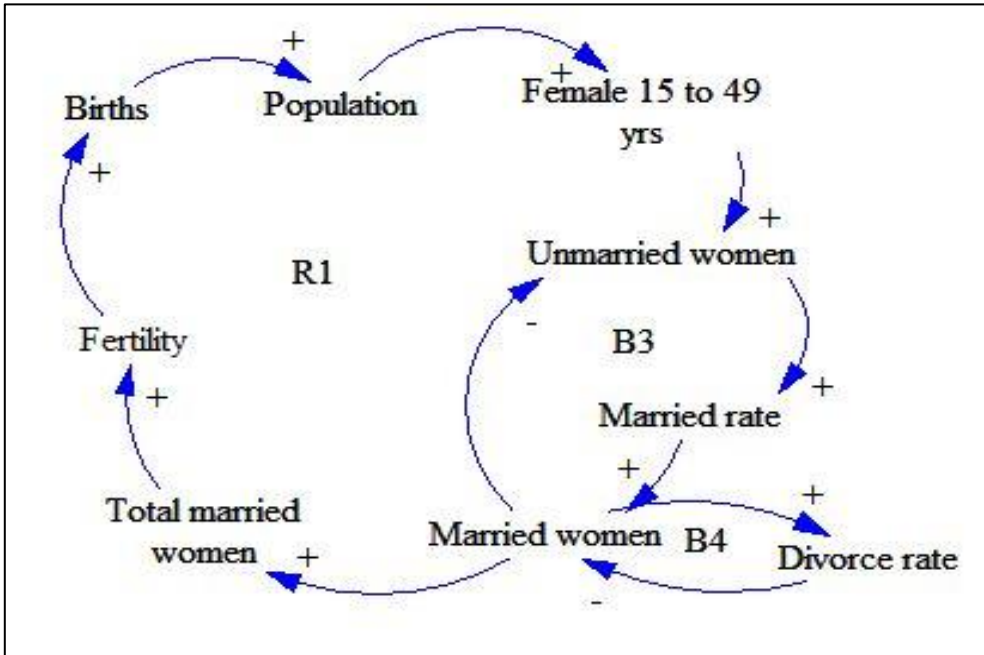

Figure 7:7 CLD of the married model

This CLD makes it easier to understand the whole system by summarizing the dynamics of the model. However, to be more specific, the stock and flow diagram (simplified version) need to be presented (Figure 7:8), along with an explanation of each variable.
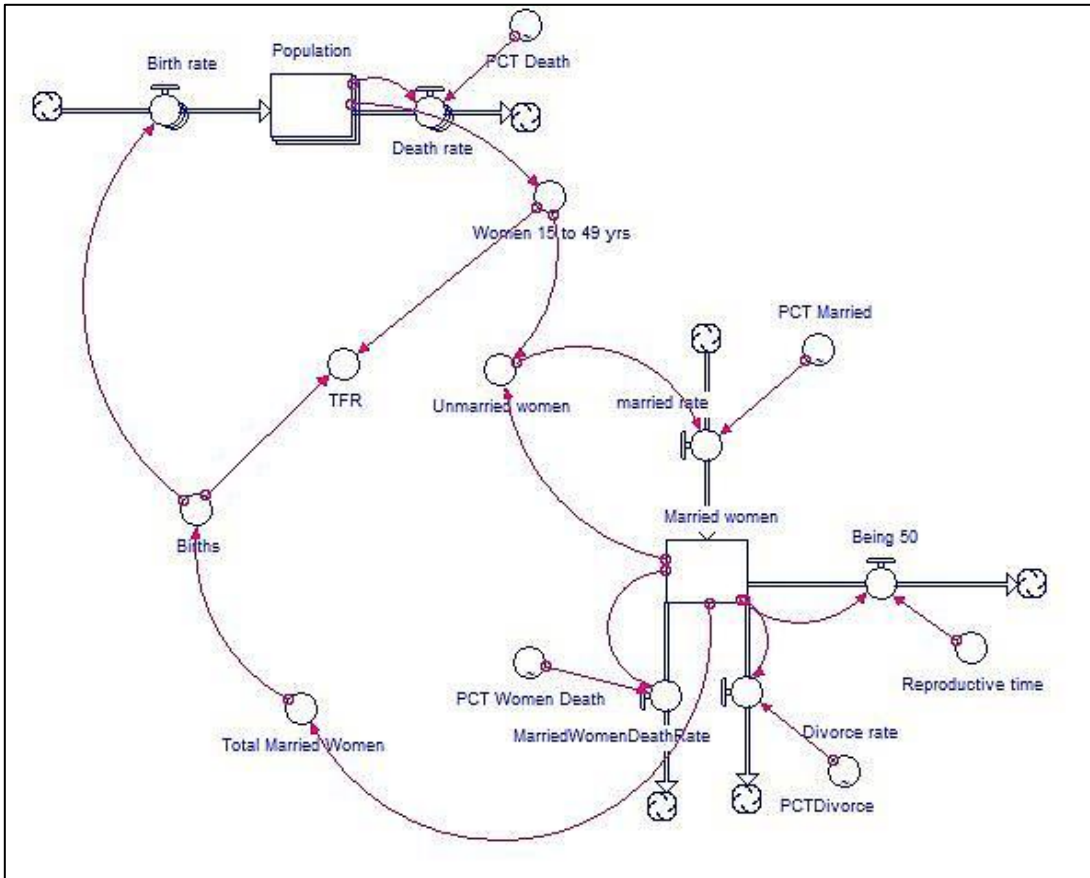
Figure 7:8 simplified version of married model

As seen in the CLD, there are several loops in the married system. It is important to understand the dynamics of each loop, and to do so, an explanation of each loop is needed:

Loop R$_1$ is the reinforcing loop, which means the bigger the initial push, the bigger the consequential push. This reinforcing loops increase the TFR, as shown in Figure 7:7. The first variable of the loop that is important, and needs to be investigated in this part, is the population.

The population, in the simplified version of the stock and flow diagram below (Figure 7:9), the population sector is shown as one stock. Actually , the population stock is divided into 13 age groups: $0 - 4, 5 - 9, 10 - 14, 15 - 19, 20 - 24, 25 - 29, 30 - 34, 35 - 39, 40 - 44, 45 - 49, 50 - 44, 55 - 59$ and over 60s (co-flow) as shown below (Figure 7:9):
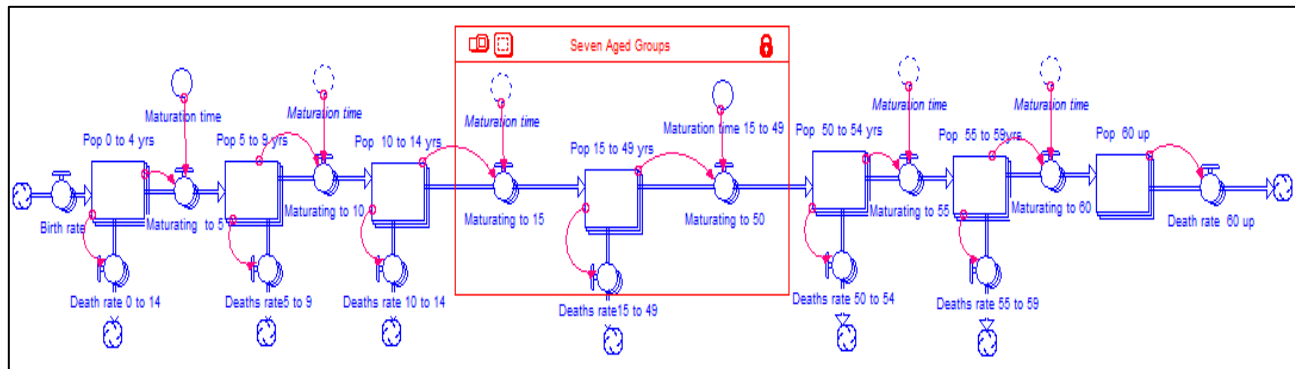
Figure 7:9 Simplified Population stocks

The red box in Figure 7:9 indicates that there are seven stocks of population in the original model. Moreover, each population stock is also divided into two-dimensional arrays, which indicates the gender of the population (male, female).

Total women aged 15 to 49 are the fertile females who are able to become pregnant. As with the total number of married women, the total women aged 15 to 49 is a part of the population model, and is thus calculated from the population stocks (population ages 15 to 19, population ages 20 to 24, population ages 25 to 29, population ages 30 to 34, population ages 35 to 39, population ages 40 to 44 and population ages 45 to 49). Since the total women aged 15 to 49 is part of population, it creates a positive relationship between these two variables (as the population increases, the total women aged 15 to 49 increases).

Unmarried women are the number of women who are single at that time, and are able to marry. From the concept of the unmarried women, the equation below was created:

Unmarried women=fertile women (specific age group) - married women (in that age group)   (7:8)

Since unmarried women is the group that are able to get married, this group, therefore, positively effects the married rate, as shown in Figure 7:7

Married rate represents the number of women who get married each year, which accumulate in married women stocks. The married rate is influenced by unmarried women,

and the percentage of marriage in each age group which is an exogenous variable, and their relationship is shown as an equation:

Married rate =Unmarried women *percentage of marriage (7:9)

Data on the percentage of marriage is calculated from the number of registered marriages and the number of unmarried women each year from the Department of the Interior, Ministry of Interior Thailand. The equation is :

Percentage of marriage= registered marriages/number of unmarried women (7:10)

Years	15 to 19 yrs	20 to 24	25 to 29 yrs	30 to 34 yrs	35 to 39 yrs	40 to 44 yrs	45 to 49 yrs
1950	1.44%	20.32%	49.86%	60.48%	49.11%	13.14%	12.97%
1955	1.42%	21.26%	52.48%	66.12%	49.58%	14.19%	12.74%
1960	1.41%	22.22%	55.40%	72.71%	51.16%	15.43%	12.71%
1965	1.12%	20.58%	50.08%	58.58%	37.85%	11.91%	10.70%
1970	0.94%	19.14%	45.60%	48.41%	29.32%	9.53%	9.16%
1975	0.77%	13.43%	31.21%	35.03%	23.86%	7.29%	6.89%
1980	0.65%	10.08%	22.89%	26.49%	19.78%	5.82%	5.50%
1985	0.61%	8.53%	16.87%	18.44%	12.03%	3.83%	4.01%
1990	0.58%	7.32%	12.97%	13.79%	8.25%	2.76%	3.17%
1995	0.56%	6.67%	12.09%	13.13%	7.80%	2.67%	2.99%
2000	0.54%	6.11%	11.29%	12.51%	7.38%	2.57%	2.82%
2005	0.53%	6.05%	10.30%	9.48%	6.00%	1.97%	2.14%
2010	0.51%	6.01%	9.37%	7.32%	4.89%	1.53%	1.66%

Table 7:1Percentage of marriage

The result is shown in Table 7:1, which indicates that the percentage of marriages increased from 1950 to 1955 in some age groups: 20 to 24 , 25 to 29, 30 to 34, 35 to 39 and 40 to 44. Regarding the contemporary of population policy, this is the period that the pro-natalist policy was implemented. In another words, it is possible that the increase in percentage of marriage was caused by the pro-natalist policy of the government of Field Marshal Plaek Phibunsongkhram. After 1957, the pro-natalist policy was cancelled, and the percentage of marriage has decreased to its present rate.

The married rate is the inflow of married women's stock, the married rate therefore effects positively to married women (as the inflow increase, the stock increase).

Total number of married women is the sum of the number of married women in each age group, (since the married women in the original model were divided into seven age groups (co-flow); aged 15 to 19, aged 20 to 24, aged 25 to 29, aged 30 to 34, aged 35 to 39, aged 40 to 44 and aged 45 to 49, as shown in Figure 7:10.
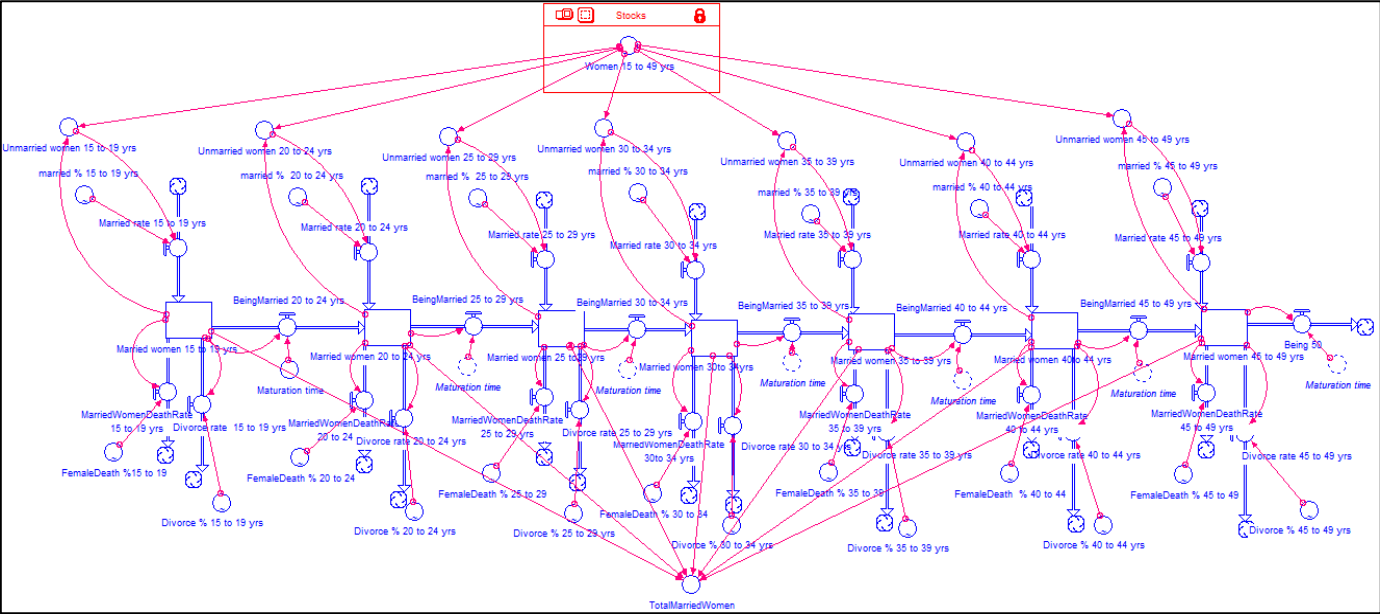

Figure 7:10 stock and flow marriage model

In addition, there are some important balancing loops as shown in Figure 7:7, which are loops B3 and B4.The first big loop is **loop B3**, which indicates that as women get married, fewer women are available to get married, as shown in equation (7:8. **Loop B4** includes a new variable that has not been mention before, which is **divorce rate**.

Divorce rate represents the outflow of married women's stock. Its concept is as women get divorced, there are fewer married women in the stock. This could be written as an equation:

Divorce rate =Married women *the percentage of divorce   (7:11)

Unlike the percentage of marriage, the percentage of divorce is the proportion of women getting divorced each year over the total number married women each year.

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The other variable that needs to be extended in this research is the married women who are using contraception, since this relates to the government anti-natalist policy. This section will demonstrate the dynamic between contraception and TFR, as shown in the simplified version in Figure 7:11 (CLD).
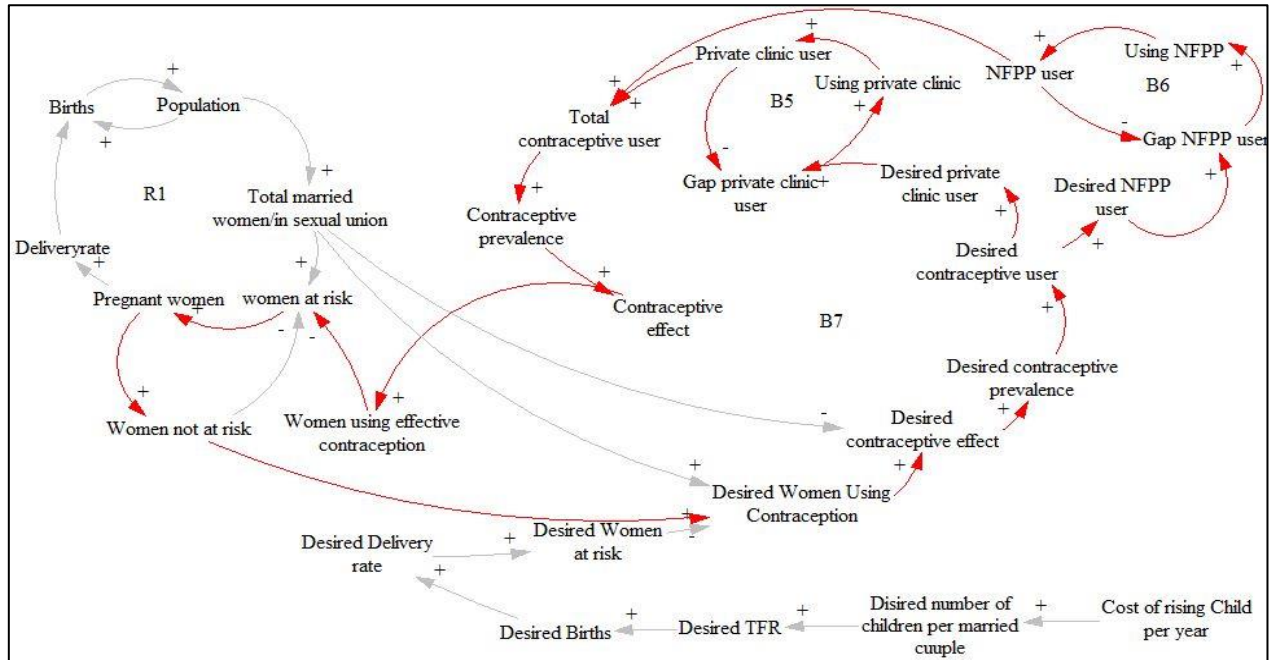

Figure 7:11 CLD of the contraceptive dynamic

In Figure 7:11, the dynamic of the proportion of married women who are using contraception (from now it will be called the contraceptive prevalence) is affected by the endogenous variables and exogenous variable. The dynamics of this section of the model creates three main, important loops, which are loops B5, B6 and B7 (Figure 7:11). Loop B5 and loop B6 are the loops that balance the gap between the desired contraceptive users and the actual contraceptive users. Loop B7 is the loop that indicates how the desired TFR affects the desired contraceptive prevalence, and then affects the fertility part.

However, to be more specific, the stock and flow diagram (simplified version) is required (Figure 7:12), and the important variables will be explained in detail.
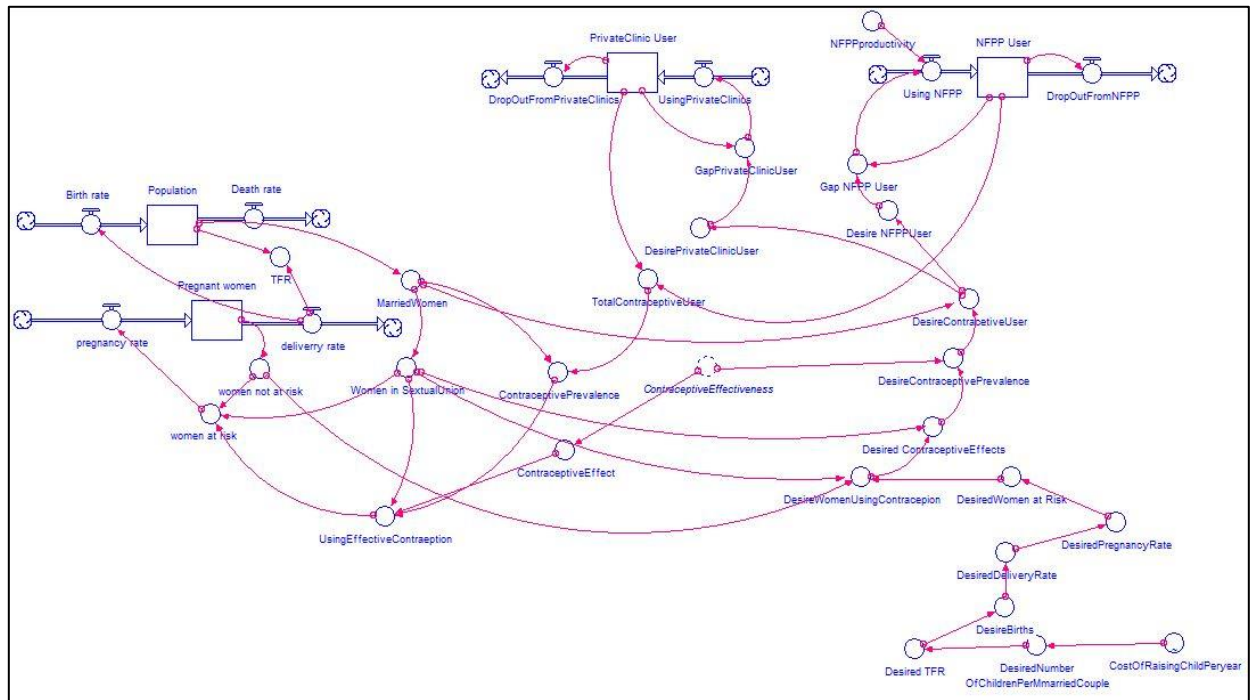
Figure 7:12 simplified version of the contraceptive model in stock and flow diagram

This section of the model attempts to calculate **the desired contraceptive prevalence,** which is affected by **the desired TFR.** As shown in the CLD, the Desired TFR is identified as an exogenous variable in this model. The concept of the Desired TFR is the number of births (children) that a woman desires at the end of her reproductive years, it refers to the desired number of children per married couple in Thailand. The data of the average desired number of children per married couple from the Contraceptive prevalence survey is shown below (Figure 7:13).
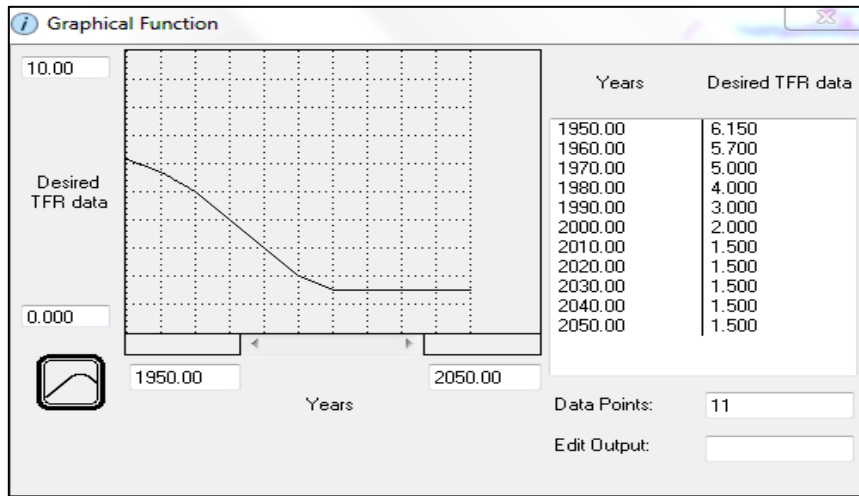
Figure 7:13 Desired number of children per couple data

Source : (Chamratrithirong et al., 1986)

In the book called **"Thailand's Reproductive Revolution"** mentioned that the desired number of children per a married couple in Thailand has been affected by the **cost of raising a child per year** (John Knodel et al., 1987). In addition, the National Statistical Office did the survey on the desired number of children per a married couple; the data is shown in Figure 7:13. Since, there is a relation between the demand of children and the cost of raising a child as mentioned by John Knodel (1987) , the average cost of raising a child in Thailand need to be investigated. Accordingly, the National Statistical Office has also survey the cost of raising a child per year as shown in
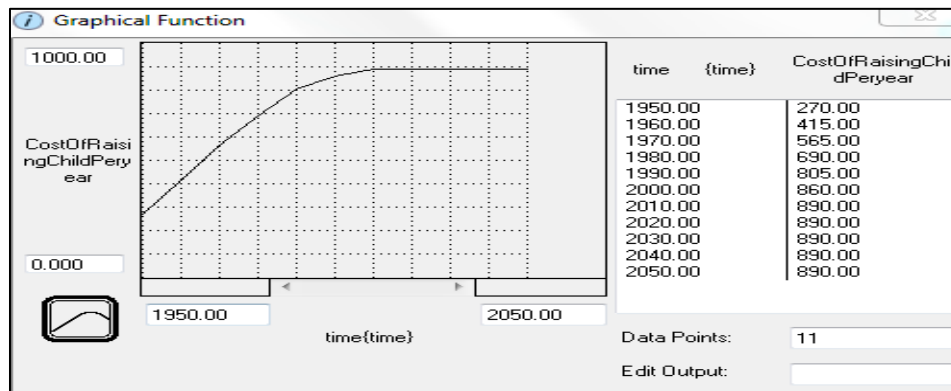
Figure 7:**14** .

As shown in the graphs (Figure 7:13 and Figure 7:14) , the relationship between the cost of raising a child per year and the average desired number of children per married couple is a negative relationship (as the costs of raising a child increase, the desired number of children decreases). Considering the relation between these two graphs, graphical function that indicates the effect of cost of raising a child to the desired number of children is then can be drawn as in Figure 7:15.
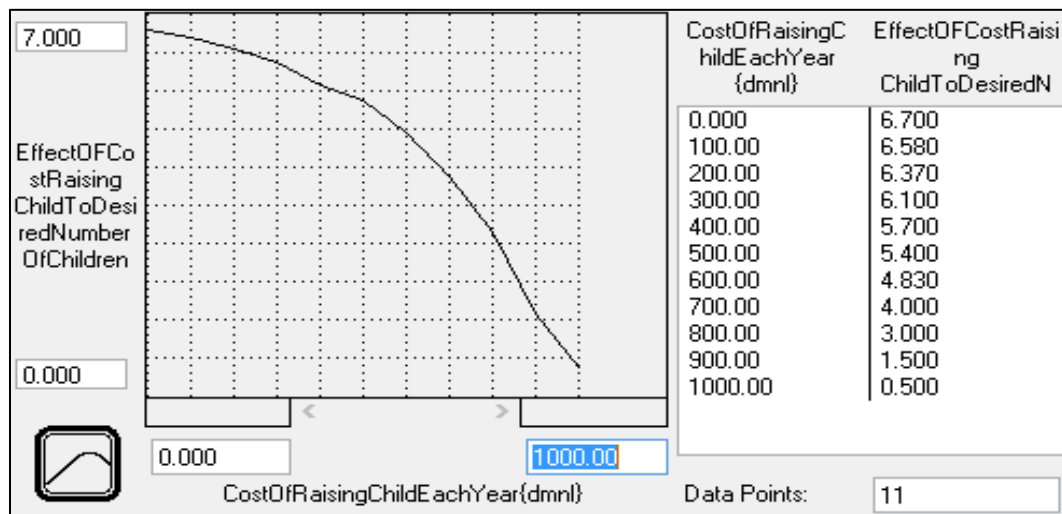
Figure 7:15 The effect of cost of raising a child to the desired number of children

This graphical function is indicate the **Desired number children per married couple** (for their whole life), which is the **Desired TFR.** The Desired TFR, could then give us the **Desired delivery rate**, by using equation;

Desired delivery rate=(Desired TFR*Female 15 to 49 yrs)/Reproductive life time   (7:12)

This desired delivery rate indicates the **desired pregnancy rate**, as shows in equation;

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Desired pregnancy rate = DesireDeliveryRate+Stillbirth rate+Abortion rate   (7:13)

Referring the equation 7:5, this desired pregnancy rate then implies the **desired women at risk**, as in equation;

Desired women at risk = Desired pregnancy rate/Yearly pregnancy probability   (7:14)

This gives the opportunity to calculate **Desire women using effective contraception.** The Desire women using contraception is found by method of reverse calculating;

since

Women at risk=Women in sexual union- using effective contraception–women not at risk

Then;

Desire women using effective contraception= desire women at risk +Women in sexual union-women not at risk   (7:15)

The desire women using effective contraception could be used to calculate the **Desired contraceptive effects, and** then Desired contraceptive effects could be used to calculate the **Desired contraceptive prevalence ,** since **;**

The contraceptive effect= contraceptive prevalence*contraceptive effectiveness

Then ;

Desired contraceptive prevalence=Desired contraceptive effect/contraceptive effectiveness   (7:16)

With the value of the desired contraceptive prevalence, it is possible to calculate the desired contraceptive users, which have a positive relationship to each other, as indicated in:

Desire contraceptive user =desired contraceptive prevalence*total married women   (7:17)

The desired contraceptive users indicate the number of married women who will be using contraception, from one of the contraceptive resources. As seen in the stock and flow diagram (Figure 7:12) users choose between the private organizations (drugstores, private hospitals or private clinics) and the government organizations (NFPP). The CPS, by Mahidol University (associated with the government), is provides data on the percentage of contraceptive resources among contraceptive users. The desire of total contraceptive users can be divided into two groups: users of private clinic, and users of the NFPP. Each contraceptive resource gives its own contraceptive prevalence. And, the sum of the contraceptive users from both resources is the total contraceptive users that indicate the level of contraceptive prevalence, which then fully affects the TFR. To be more specific, the equations are:

Total contraceptive user = NFPP user+ Private Clinic user   (7:18)

Result:

Contraceptive prevalence= Total contraceptive user /Married women   (7:19)

As we can see in Figure 7:11, there were positive effects from the desired contraceptive prevalence until the real contraceptive prevalence (it is increases as its desire increases). Since the relationships from the real contraceptive prevalence to the TFR have been explained in the last section, they will not be discussed further here.

Pro-natalist policy model (1950 to 1957)

This section discusses the process of the pro-natalist policy modeling, which occurred in 1950 to 1957 in the Thai population policy history. As mentioned earlier, in this period the government aimed to bring up the marriage rate within women aged 15 to 29. The model in this section will feed into the previous marriage rate (increase the index of proportion married). Accordingly, in this section we will investigate the dynamics of the

Married organization (government policy) and its effect on the TFR, shown in Figure 7:16 ;
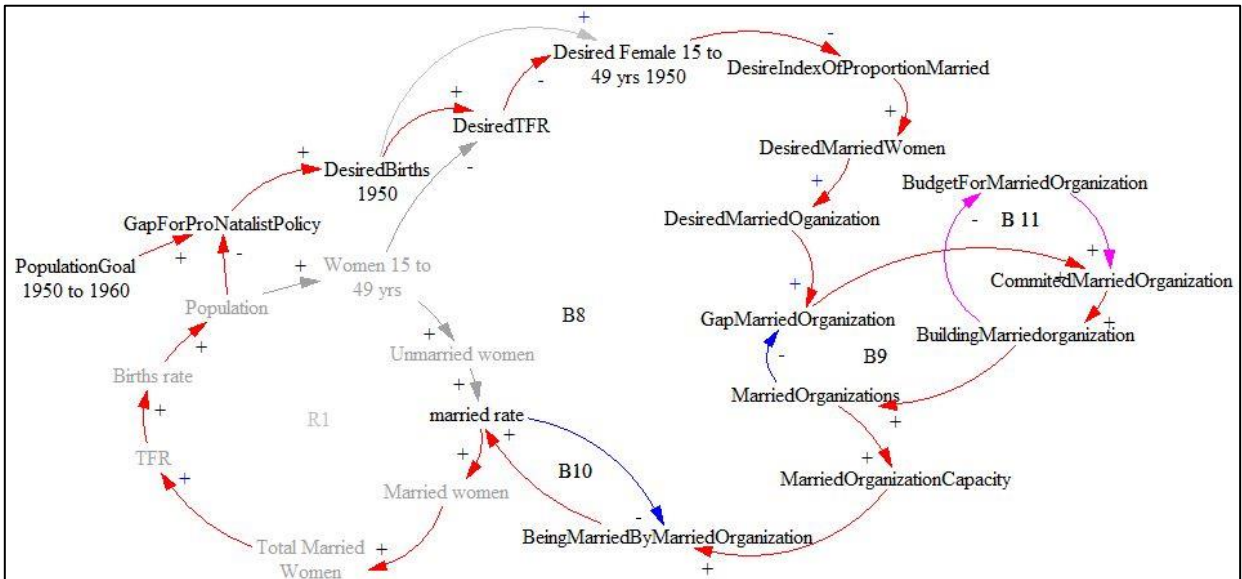
Figure 7:16 CLD for Pro-natalist policy

Loop B7 is the main loop that serves the desire of government (to increase population and balance the goal), through the married organizations, which aimed to increase the marriage rate. Loops B9 and B11 are the balancing loops that balance the stock within the Married organization system, which are the Married organization's stock, and being married by Married organization's stock, and budget for organization's stock. The simplified version of the stock and flow diagram (Figure 7:17) shows that the outflows of the married organizations feed into the inflows of married women stocks.

However, those outflows do not flow into all stocks of married women. The main reason for this is that the government was focusing only on women aged 15 to 29, as mentioned in the history of the government policy. Therefore, other stocks of married women were not affected by the government policy.
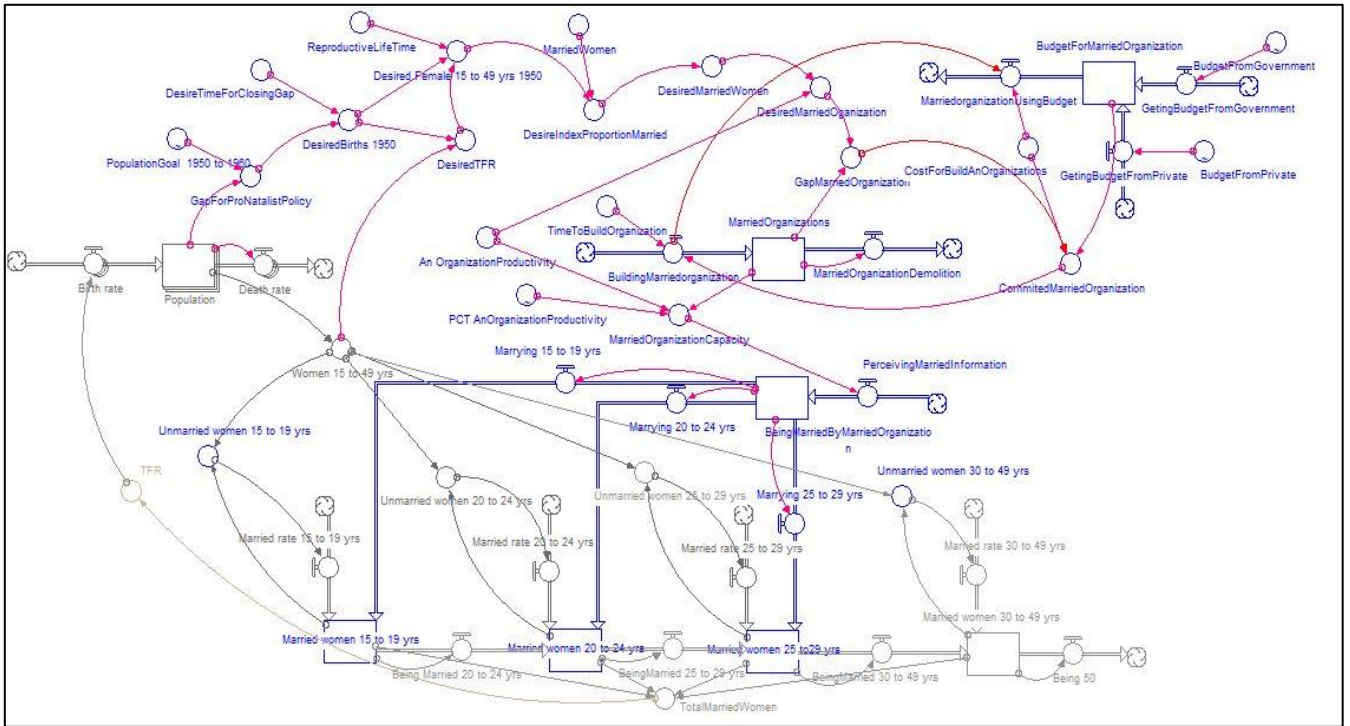
Figure 7:17 Pro-natalist policy Stock and flow

The main idea of this policy sector is the process to increase the marriage rate, which means it will force loop R1 to increase (Figure 7:6), and was controlled by the goal of government in 1950. As mentioned in the historical section, Field Marshal Plaek Phibunsongkhram was rebuilding the nation after World War 2, and expected to increase the population to 40 million (the Thai population was only 14,464,105 at that time). Thus, the goal for this section was 40 million populations, and that goal has been set from 1950 to 1957, as his position was terminated in 1957. The gap between the population goal and the real population can be used to calculate the **Desired birth** each year based on the time for closing the gap (10 years). The desired birth can be then used to calculate the **Desired TFR (1950 to 1960),** by using the equation:

Desired TFR(1950 to 1960)= Desired Births/women aged 15 to 49)*35   (7:20)

And if we refer to equation 7:6 with respect to the calculation of TFR, we can calculate the **Desired Female 15 to 49 yrs 1950;**

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Desired Female 15 to 49 yrs 1950= Desired Births 1950 to 1960/Desired TFR 1950 to 1960)*Reproductive life Time (7:21)

It would seem that the desired index of proportion married should be able to be used to calculate the number of **desired married women**. The government will decide to formulate married organizations, based on the number of desired married women and the productivity per an organization, as indicated in ;

Desired married organization=Desired married women/An organization productivity (7:22)

From the study of literature regarding married organizations, the government decided to build four married organizations at that time (located in the main cities of Thailand). The goal to increase the population to 40 million ensures that the desire of married women exceeds 0, and brings up a new goal to formulate four married organizations. To build the married organizations, the government needed a budget. Since this occurred in the period after World War 2, when the country was recovering, the government had a limited budget to provide for the married organizations (approximately 500,000 to 1,000,000 million baht per year). And, because the married organizations had been built prior 1950 (in 1947), the initial value of the married organizations equals 1. As seen in Figure 7:17, the gap between the desired Married organization and the real married organizations affects governmental approval (**Committed Married Organizations**). However, the government also took the budget availability into account. In other words, the government would approve the desired gap, if there were available finance.

After the gap has been committed, it then flows into the building process. The building process begins with the building rate (**Building Married organization**), with a time delay (1 year), and the equation is:

Building Married organization= DELAY3 (committed married organization, time to build organization) (7:23)

As organizations are built, the lesser budget there is in the stock. This cycle is indicated in loop B11 (Figure 7:16). The quantity of Married organization and its productivity indicates the organization's capacity, as in the equation:

Organization's capacity= MarriedOrganizations*An Organization Productivity*PCT An

Organization Productivity   (7:24)

The percentage of organization productivity means the proportion of fertile women who are convinced to marry by a Married organization. The details regarding how the married organizations convince women to marry has been discussed in the historical section. The organization's capacity means that women who have been convinced by the married organizations will be moved to a stock of women who are being married (**being married by Married organization**) through the information delay (which is time taken to decide). And finally, being **married by Married organization** will flow to the married women's stocks (for each age group). This means that the outflows of the **being married by Married organization's stock** are the additional inflows for the married women's stocks.

Anti-natalist policy model (from 1970 to present)

This section describes the process of anti-natalist policy modeling, which occurred from 1970 to the present day. This policy change occurred somewhat gradually from about 1958 to 1970, but it takes time for the population to perceive the change. Therefore, the actual implementation was practiced officially in 1970, when economics and education were also related to the program (NFPP). As mentioned, the objective of the program was to increase contraceptive use (contraceptive prevalence), so we then connected this part of the model to the contraceptive part. Basically, the model was developed by interviewing leaders and workers in the NFPP program, by extensive reading of other studies, and from consideration of theories of development administration.

The dynamics of the connections to the contraceptive part (simplified stock and flow diagram), shown below in Figure 7:18 ;
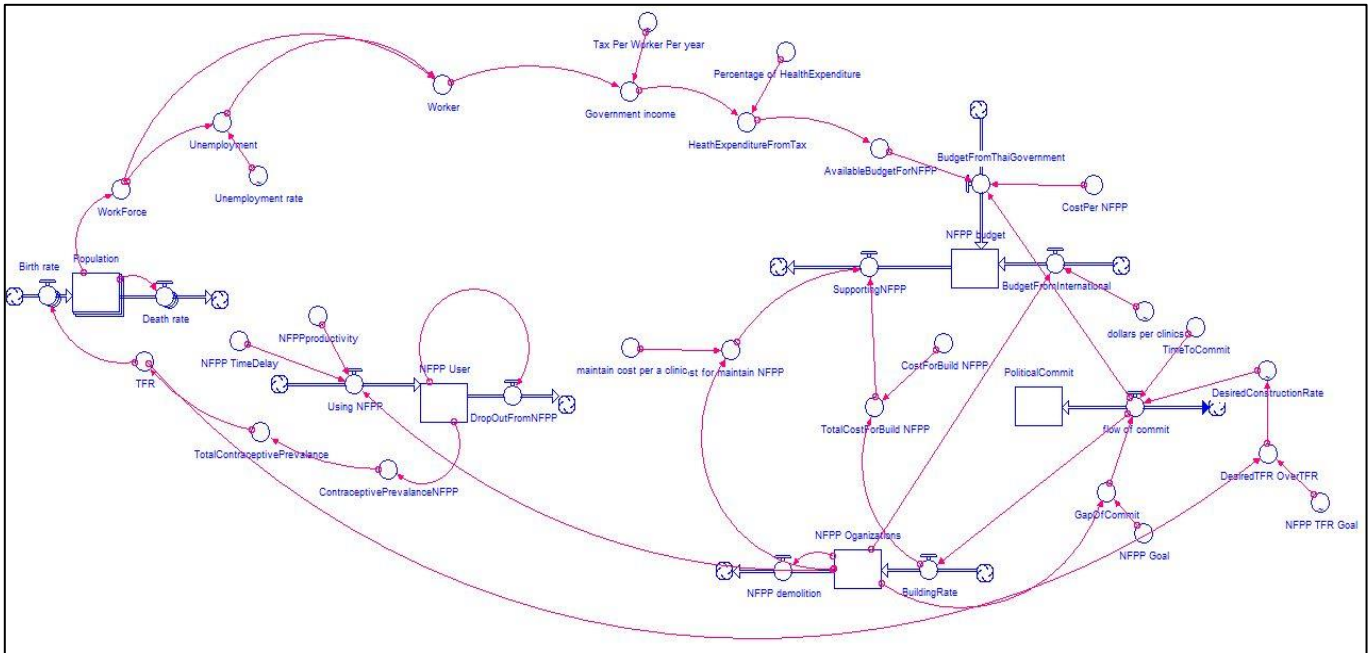
Figure 7:18 Simplified NFPP stock and flow diagram

In 1970, the NFPP was officially practiced, and the goal was set. The goal for NESDP was decided on a five yearly basis. The goal was to decrease TFR, as shown in Figure 7:19 ;
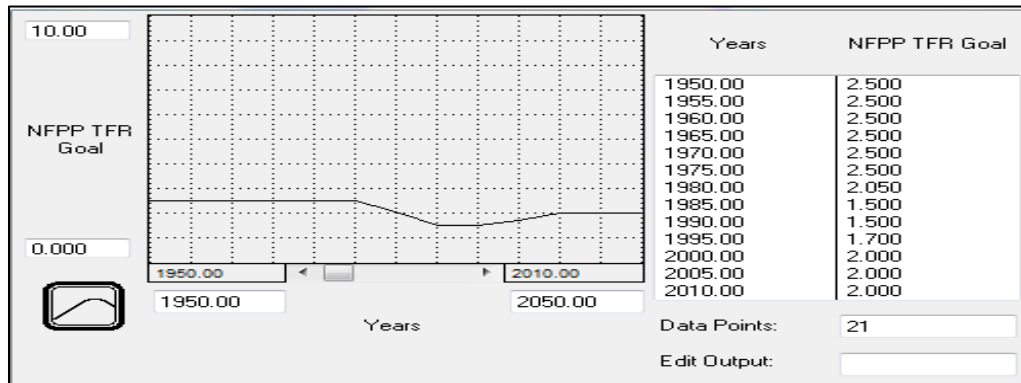
Figure 7:19 NFPP goal

Source : Impact of demographic change in Thailand (Jones et al., 2011)

The dynamics in this section begin with the gap between the TFR goal and the real TFR. In this case the gap will be measured in term of a proportion, which is called **Desired TFR over TFR.** This value will indicate the possibility (Mebrate) of building the NFPP organization. The equation of the Desired TFR over TFR is:

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Desired TFR over TFR =NFPP TFR goal/TFR   (7:25)

Since it is a fraction, it ranges from 0 to 1, which means there are no gaps between the goal TFR and the real TFR if it equals 1. This proportion will negatively affect the **Desired Construction Rate.** In another words, if the Desired TFR over TFR equals 1, this means that the gap is equal to the real TFR, and the government will not approve the building of the NFPP. The relationship of the Desired TFR over TFR and the **Desired Construction Rate** has been transferred to a graph, as follows:


DesiredTFR OverTFR {%}	DesiredConstruction Rate
0.000	1.000
0.100	0.775
0.200	0.620
0.300	0.430
0.400	0.300
0.500	0.200
0.600	0.145
0.700	0.115
0.800	0.070
0.900	0.030
1.000	0.000

DesiredTFR_OverTFR{ %}   Data Points: 11
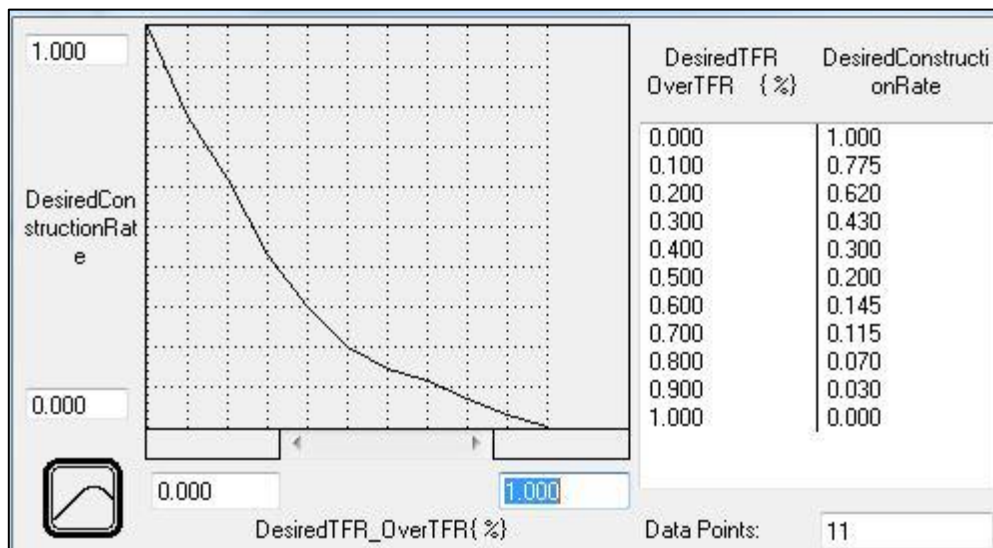
Figure 7:20 Desired Construction Rate

This part of the model indicates that the political system is the main mover of the family planning program where the basic decision was made to commit to the program. The Desired Construction Rate positively affects the **flow of commit,** which refers to the number of the NFPP clinics that have been committed to be built each year. The flow of commit also depends on the **gap between the NFPP clinics goal** and **the real NFPP clinics**. From the study and interview with the NFPP's leaders in Thailand, it can be concluded that the goal was 124 clinics, at that time. (1970). However, there is some delay in political commitment, and the model, therefore, uses the information delay in the **flow of commit.** The commitment leads to the increase of the building of the NFPP organization rate, since the **flow of commit equals** the **building rate. The Quantity of** NFPP

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organization positively affects the international support, which is the inflow of the NFPP's budget. Another inflow for the NFPP's budget stock is from the Thai government (budget from Thai government), which is based on the flow of commit's cost and available budget. As shown in the stock and flow diagram, the budget's stock had an outflow, which depended on the total cost for build NFPP clinics and the cost for maintaining NFPP clinics.

The result of this section of the model is the NFPP capacity, which refers to how many people NFPP could handle per year. The NFPP capacity is then fed in to **NFPP user** as explained in the last section. The inflow to the NFPP user was called **Using NFPP,** which based on the gap between its actual stock and its desired user, and NFPP's capacity (NFPP's organizations*NFPP's productivity), leads to the equation:

Using NFPP = min (Gap NFPP User / NFPP time Delay, NFPP organizations*NFPP
productivity)   (7:26)

This equation indicates that the NFPP program could not cope if the desired user exceeds its capacity, and there are some time delays to use contraception via NFPP's organizations.

8. <u>Validation and model testing</u>

Model validation is an important aspect of any model-based methodology, including system dynamics methodology. Model validation is the process by confidence in the usefulness and robustness of the model is established. Accordingly, there are a range of specific tests that can be used to uncover flaws and improve models. The tests that have been chosen for this research are:

<u>Behavior validity</u>

The first variable that needs to be investigated is the reference mode, which is TFR. The data prior to 1965 does not exist, and therefore age-specific fertility rates from 1950 to 1965 were used to calculate the actual TFR in that period (refer to equation 3:1). The simulated TFR pattern should resemble match with the data pattern.

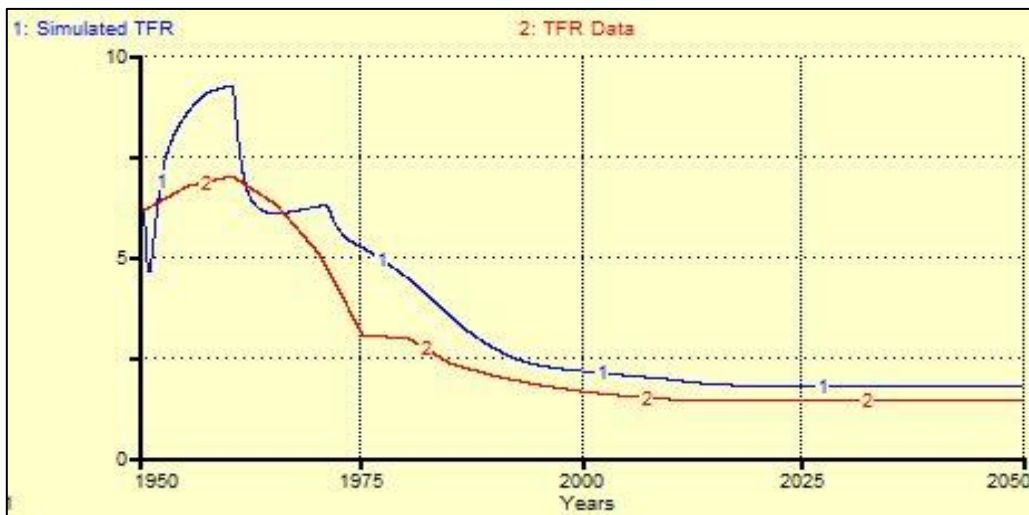**Figure 8:1 TFR comparison between simulated behavior (Blue line) and estimated data (Red line).**

The simulated result shows a different value at the beginning of the curve, and the wide gap between blue simulated result line and red data line between 1950 and 1960.This might be caused by data uncertainty as some data prior to 1960 in Thailand is uncertain and the data collection was not cover the whole kingdom.

Extreme conditions tests

Under these tests, the expected behavior of three variables of interest, namely Total abortion rate, cost of raising a child per year and married women, in each condition is compared with simulated behavior in the following sections. These variables are chosen because they are important indicators of the validity of the model and the TFR values.

- **Set the Total abortion rate to 3**
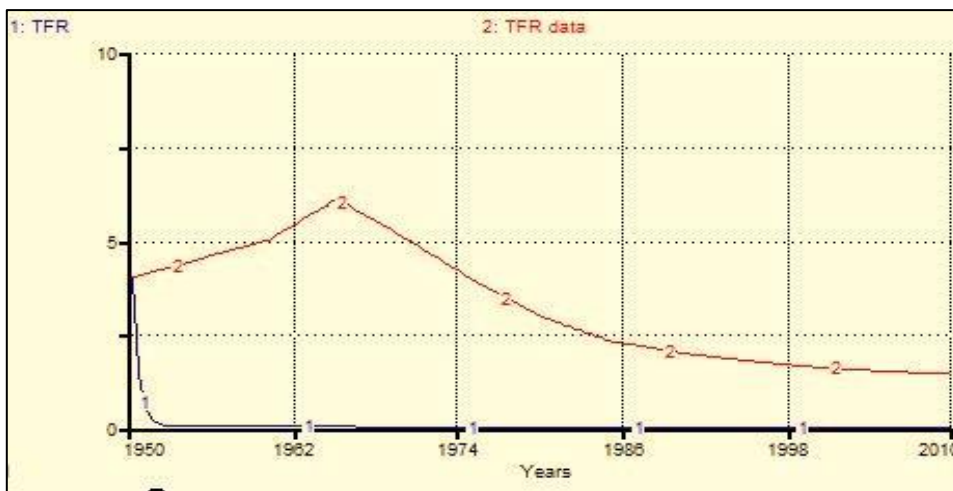
Figure 8:2 Extreme condition test result with Induced abortion fraction set to 1

In the original value the **Induced abortion fraction** was equal to 0.02, which meant there was only 2 % of women in **Pregnant 1**, would induced abortion in Thailand. In Figure 8:2, the simulated TFR behavior is shown along with the actual data of TFR behavior, when the induced abortion fraction has been increased to 100 per cent (all the women in **Pregnant 1** were induced abortion. As in equation **Abortion rate=** (Pregnant_1*Induced abortion fraction)/time until abortion)   (7:6, with regard to the relationship between **Pregnant 1** and **Induced abortion fraction**, the increase in induced abortion fraction would decrease with the pregnant women. The TFR then dropped to zero because there were no births delivered.

- **Set the cost of raising child per year to 100,000 dollars**

Since, the cost of raising a child per year directly affected the Desired TFR, it is interesting to calculate whether or not it will affect the real TFR in a short period. In this case, the cost of raising a child was set to 100,000 dollars in 1980, as it was, in fact, 865 dollars in 1980. Figure 8:3 shows that the TFR suddenly decreased to almost 0 (with delay time about 1 year), and then gradually increased. The gradual increase after 1980 was due to people beginning to adjust to the high cost of child raising.
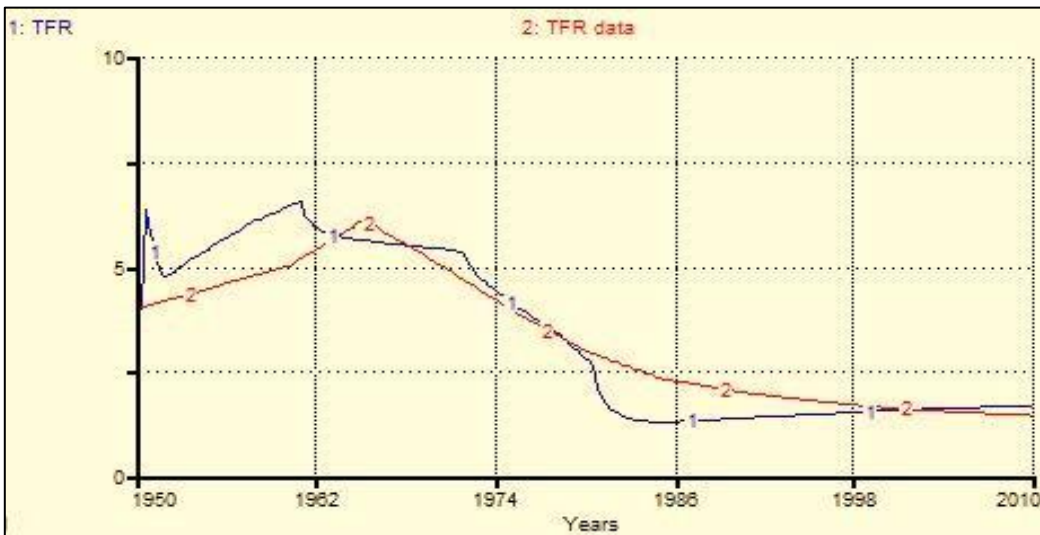

Figure 8:3 Extreme condition test result with cost of raising a child per year set to 100,000 dollars

- **Married women is increased 2,000,000 in year 1980**

Figure 8:4 Extreme condition test result with added 2,000,000 married women

This extreme condition can be called a shock condition. This test attempted to investigate the dynamics of the number of married women and TFR. What would happen if the number of married women suddenly increased dramatically in 1980? It would make sense that the TFR would also show a dramatic increase, as can been seen in Figure 8:4:

Parameter sensitivity analysis

This purpose of this test is to check if the model behavior is sensitive to parameter value permutation. The parameters that should be taken into account are the cost of raising a child per year, since it affects contraceptive prevalence, which is the main variable in this research.

Year	Base Run	Increased 50 %
1950	270	405
1960	415	622.5
1970	605	907.5
1980	865	1297.5
1990	935	1402.5
2000	955	1432.5
2010	980	1470

Table 8:1 cost of raising a child per year (dollar)

In Table 8:1 shows the values of two situations, the first row are the values for the base run, as used in the original model and the second row are the values with an increase

of 50 %. The purpose of this test is to observe the effects of an increase in cost of raising a child on the TFR.

Figure 8:5 TFR with parameter sensitive test

As shown in the graph, we can conclude that the TFR is sensitive to this variable. In addition, this test confirms the negative relationship between these two variables (as cost of raising a child increases, TFR decreases).
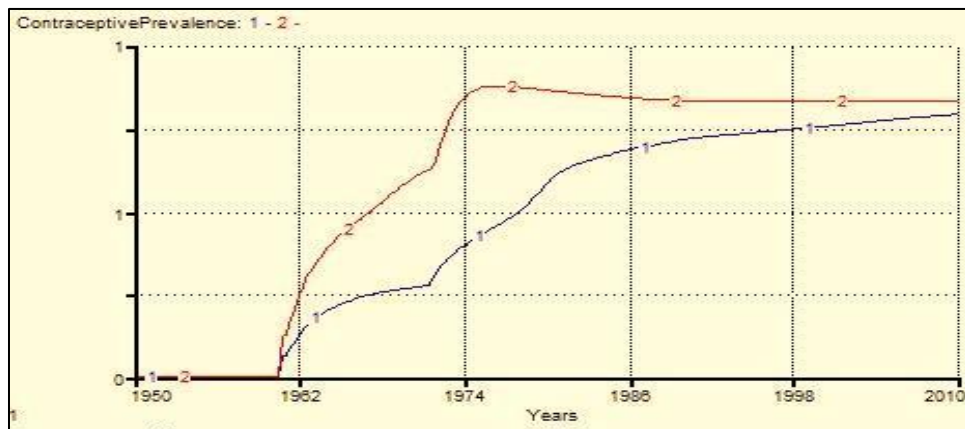
Figure 8:6 Contraceptive prevalence with parameter sensitivity test

Another variable that will surely be affected by the change in cost of raising a child is contraceptive use, which decreases TFR. When the cost increases, the desire of children decreases, and the desire to use contraception significantly increases. Since we can see a

large difference between the blue line and red line in both graphs, we would say that the cost of raising a child is sensitive to TFR in this model.

9. Model results and conclusion

This section will show the results of the two base runs (with and without government policy intervention):

First run

The first run, which had the pro-natalist policy from 1950 -1957 switched on, and the anti-natalist policy from 1970- present switched on, is shown in Figure 9:1,

Figure 9:1 Both policies were switched on

Second run

The second run had both policies switched off, as shown in Figure 9:2,

Figure 9:2 Both policies have been switched off

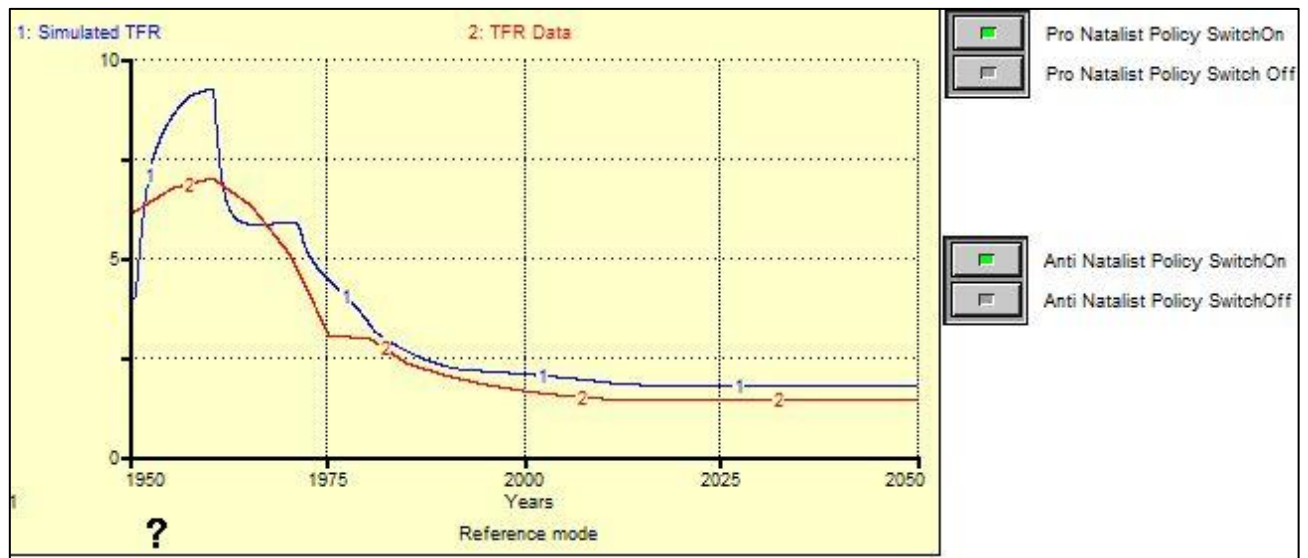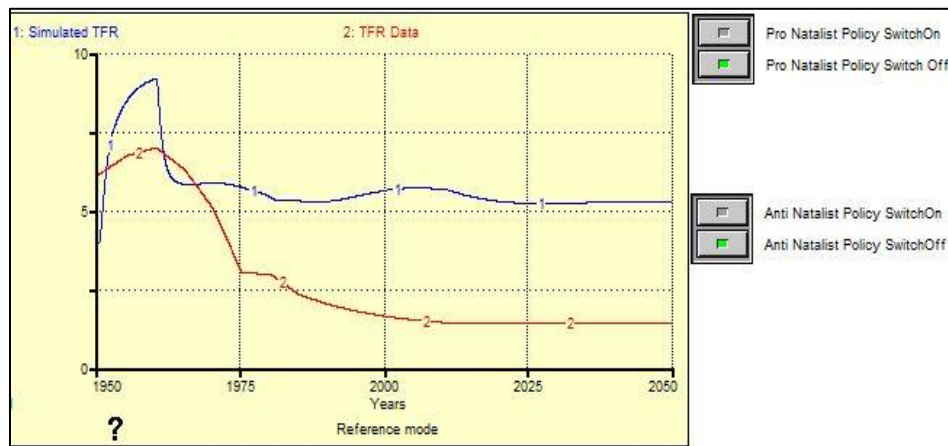From the comparison of both runs, the TFR behaviors are different; that means the government policies have some effects on the increases and decreases in TFR. Hence, this research supports the first hypothesis, which explains the fertility behavior by historical government policies (both anti-natalist and pronatalist policies).Since the simulated TFR pattern resemble with the data pattern when we include both policies with the fertility model, the historical policy parts of model are then plausible.

Policy recommendations

The decline in fertility to below replacement level may raise the issue of whether Thailand should have a **pro-natalist policy** to avoid depopulation and labor force shortages in the near future. A promotion to bring up the birth rate, however, has not been discussed in Thai politics so far, even though it appears certain that fertility in Thailand will decline further. The fertility rate of Thai women may become lower than 1.5, which is as low as the fertility rates in Singapore, Japan and South Korea (which are developed countries, while, in contrast, Thailand is still a developing country). This alarming trend indicates that Thailand needs policies to deal with the decline in fertility. It would be possible to reconsider the pro-natalist policy that was used in 1950, since it was effective among Thais.

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However, the pro-natalist policy that was used in 1950 aimed to increasing in married women, by convincing people to get married. This kind of policy may difficult to implement in this generation who are more independent and high educated. Base on the parameter sensitivity analysis, the cost of raising a child per year is pretty sensitive for the model. Therefore, it appropriate to focus on this parameter in order to increase TFR.As mentioned that the decreasing in cost, will lead TFR to increase. Government should then support the child bearing cost, such as free child care, free medicine and milk for children aged 0 to 5 .When the couple perceived the decline in cost, they will then prefer more children. The dynamic of the policy shown in Figure 9:3, the dynamic begin with goal setting, as TFR = 2. According to the effect of cost of raising a child on the desire TFR, TFR goal could be then indicate the cost preference (cost that a couple prefers at a certain level of TFR goal). The difference between the cost preferences and the actual cost (cost that used in the initial model), is the gap that government must fulfill.

As mentioned that the fulfillment could be done by supporting child bearing cost, such as free child care, free medicine and milk for children. Moreover, the government need budget for policy implementation. In the model (Figure 9:3) the government imposes tax on single people (population aged 25 to 49 who remain single) and this single person tax may somehow increase the married rate as well.
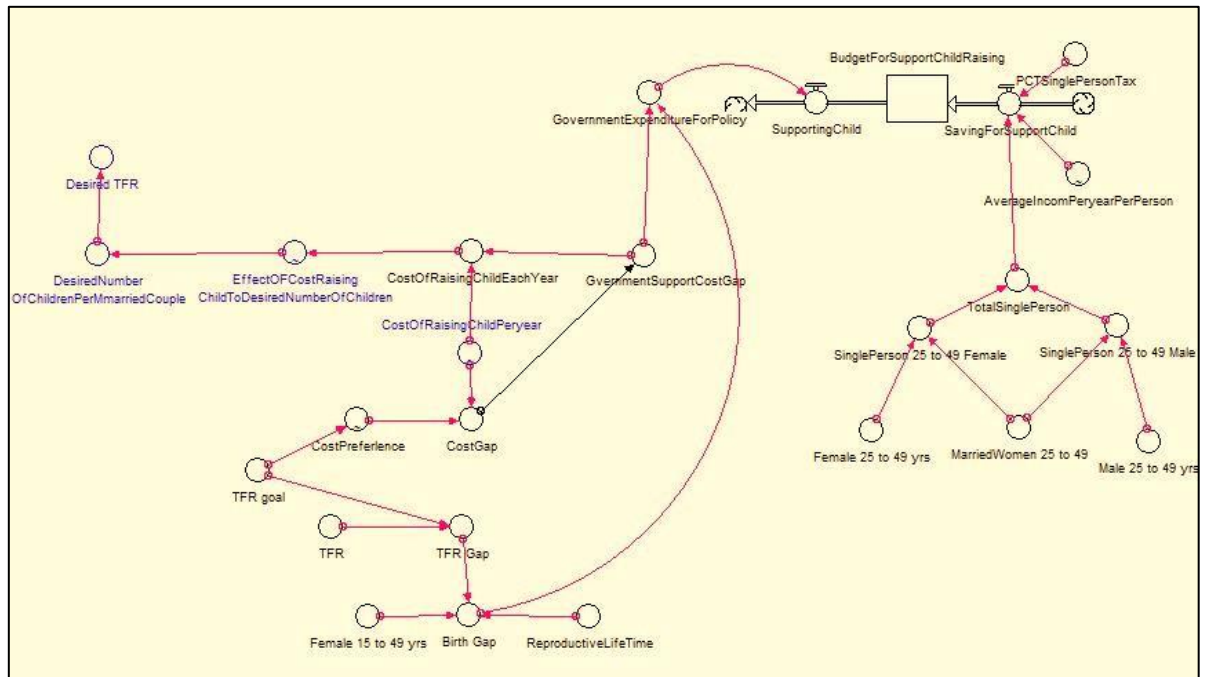
Figure 9:3 Policy recommendation

The result of policy implementation from 2014 illustrates in Figure 9:4
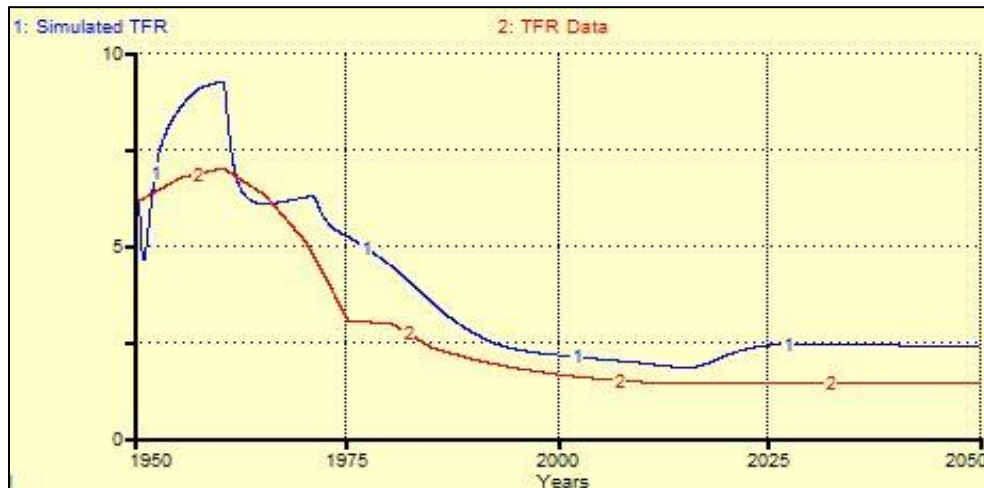
Figure 9:4 Policy implementation from 2014

In addition, quality births should begin from intended pregnancies at appropriate ages. All pregnancies should have good maternal care and be delivered by medical

personnel. This policy should ensure that every birth is wanted, safe and healthy. However, there are some implementation difficulties such as budget sources for child support as Thailand has many issues associated with national budget likely. As recommended in the model that the budged may gain from imposing tax on single people, this may causes dissatisfaction among single people, and then leads to protestation as it happen occasionally in Thailand. Thus the government needs a proper budget plan that fit all parties needs.

In conclusion, this research aimed to investigate the mysterious behavior of Thai TFR. The hypothesis focused on the shift of population policies, which might produce the sudden increasing and decreasing in Thai TFR since 1950. The Thai fertility model model was formulated initially by using Bongaarts'concept together with Wheat's fertility model, and then extended by adding the government policy parts (Anti-natalist and pro-natalist). The simulated TFR pattern from the model that includes both policies resemble the TFR data pattern, this indicates that the government policies appear to have influenced the TFR behavior in Thailand.

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Appendix A: Model Equations

BeingMarriedByMarriedOrganization(t) = BeingMarriedByMarriedOrganization(t - dt) + (PerceivingMarriedInformation - Marrying_15_to_19_yrs - Marrying_20_to_24_yrs - Marrying_25_to_29_yrs) * dt

INIT BeingMarriedByMarriedOrganization = 1000

INFLOWS:

PerceivingMarriedInformation = if(time>Pro_Natalist_Start_time)and(Pro_Natalist_Policy_SwitchOn=1)then(MarriedOrganizationCapacity/TimeToPerceive)else(0)

OUTFLOWS:

Marrying_15_to_19_yrs = If(time<1957)then(BeingMarriedByMarriedOrganization*0.01)else(0)

Marrying_20_to_24_yrs = If(time<1957)then(BeingMarriedByMarriedOrganization*0.02)else(0)

Marrying_25_to_29_yrs = If(time<1957)then(BeingMarriedByMarriedOrganization*0.01)else(0)

BudgetForMarriedOrganization(t) = BudgetForMarriedOrganization(t - dt) + (GetingBudgetFromGovernment + GetingBudgetFromPrivate - MarriedorganizationUsingBudget) * dt

INIT BudgetForMarriedOrganization = 1000000

INFLOWS:

GetingBudgetFromGovernment = If(time<1960)then(BudgetFromGovernment)else(0)

GetingBudgetFromPrivate = If(time<1960)then(BudgetFromPrivate)else(0)

OUTFLOWS:

MarriedorganizationUsingBudget = BuildingMarriedorganization*CostForBuildAnOrganizations

MarriedOrganizations(t) = MarriedOrganizations(t - dt) + (BuildingMarriedorganization - MarriedOrganizationDemolition) * dt

INIT MarriedOrganizations = 1

INFLOWS:

BuildingMarriedorganization = DELAY3(CommitedMarriedOrganization,TimeToBuildOrganization)

OUTFLOWS:

MarriedOrganizationDemolition = If(time<1960)then(MarriedOrganizations*0.01)else(1)

Married_women_15_to_19_yrs_2(t) = Married_women_15_to_19_yrs_2(t - dt) + (married_rate_15_to_19_yrs + Marrying_15_to_19_yrs - Divorce_rate__15_to_19_yrs - BeingMarried_20_to_24_yrs - MarriedWomenDeathRate_15_to_19_yrs) * dt

INIT Married_women_15_to_19_yrs_2 = 8200

INFLOWS:

married_rate_15_to_19_yrs = Unmarried_women_15_to_19_yrs*married_%_15_to_19_yrs{ women/year }

Marrying_15_to_19_yrs = If(time<1957)then(BeingMarriedByMarriedOrganization*0.01)else(0)

OUTFLOWS:

Divorce_rate__15_to_19_yrs = Married_women_15_to_19_yrs_2*Divorce_%_15_to_19_yrs{ women / year }

BeingMarried_20_to_24_yrs = Married_women_15_to_19_yrs_2/Maturation_time

MarriedWomenDeathRate_15_to_19_yrs = (FemaleDeath_%15_to_19/100)*Married_women_15_to_19_yrs_2

Married_women_20_to_24_yrs_2(t) = Married_women_20_to_24_yrs_2(t - dt) + (married_rate_20_to_24_yrs + BeingMarried_20_to_24_yrs + Marrying_20_to_24_yrs - Divorce_rate_20_to_24_yrs - BeingMarried_25_to_29_yrs - MarriedWomenDeathRate_20_to_24_yrs) * dt

INIT Married_women_20_to_24_yrs_2 = 107231{person}

INFLOWS:

married_rate_20_to_24_yrs =
Unmarried_women_20_to_24_yrs*married_%__20_to_24_yrs{ women /year }

BeingMarried_20_to_24_yrs = Married_women_15_to_19_yrs_2/Maturation_time

Marrying_20_to_24_yrs =
If(time<1957)then(BeingMarriedByMarriedOrganization*0.02)else(0)

OUTFLOWS:

Divorce_rate_20_to_24_yrs =
Married_women_20_to_24_yrs_2*Divorce_%_20_to_24_yrs{ women / year }

BeingMarried_25_to_29_yrs = Married_women_20_to_24_yrs_2/Maturation_time

MarriedWomenDeathRate_20_to_24_yrs =
(FemaleDeath_%_20_to_24/100)*Married_women_20_to_24_yrs_2

Married_women_25_to29_yrs(t) = Married_women_25_to29_yrs(t - dt) +
(Married_rate_25_to_29_yrs + BeingMarried_25_to_29_yrs + Marrying_25_to_29_yrs -
Divorce_rate_25_to_29_yrs - BeingMarried_30_to_34_yrs -
MarriedWomenDeathRate_25_to_29_yrs) * dt

INIT Married_women_25_to29_yrs = 209109{person}

INFLOWS:

Married_rate_25_to_29_yrs =
Unmarried_women_25_to_29_yrs*married_%__25_to_29_yrs{ women / year }

BeingMarried_25_to_29_yrs = Married_women_20_to_24_yrs_2/Maturation_time

Marrying_25_to_29_yrs =
If(time<1957)then(BeingMarriedByMarriedOrganization*0.01)else(0)

OUTFLOWS:

Divorce_rate_25_to_29_yrs =

Married_women_25_to29_yrs*Divorce_%_25_to_29_yrs{ women / year }

BeingMarried_30_to_34_yrs = Married_women_25_to29_yrs/Maturation_time

MarriedWomenDeathRate_25_to_29_yrs =
(FemaleDeath_%_25_to_29/100)*Married_women_25_to29_yrs

Married_women_30to_34yrs(t) = Married_women_30to_34yrs(t - dt) +
(Married_rate_30_to_34_yrs + BeingMarried_30_to_34_yrs - Divorce_rate_30_to_34_yrs
- MarriedWomenDeathRate_30to34_yrs - BeingMarried_35_to_39_yrs) * dt

INIT Married_women_30to_34yrs = 448090

INFLOWS:

Married_rate_30_to_34_yrs =
Unmarried_women_30_to_34_yrs*married_%_30_to_34_yrs{ women / year }

BeingMarried_30_to_34_yrs = Married_women_25_to29_yrs/Maturation_time

OUTFLOWS:

Divorce_rate_30_to_34_yrs = Married_women_30to_34yrs*Divorce_%_30_to_34_yrs

{ women / year }

MarriedWomenDeathRate_30to_34_yrs =
(FemaleDeath_%_30_to_34/100)*Married_women_30to_34yrs

BeingMarried_35_to_39_yrs = Married_women_30to_34yrs/Maturation_time

Married_women_35_to_39_yrs_2(t) = Married_women_35_to_39_yrs_2(t - dt) +
(Married_rate_35_to_39_yrs + BeingMarried_35_to_39_yrs - Divorce_rate_35_to_39_yrs
- MarriedWomenDeathRate_35_to_39_yrs - BeingMarried_40_to_44_yrs) * dt

INIT Married_women_35_to_39_yrs_2 = 437601{person}

INFLOWS:

Married_rate_35_to_39_yrs =
Unmarried_women_35_to_39_yrs*married_%_35_to_39_yrs{ women / year }

BeingMarried_35_to_39_yrs = Married_women_30to_34yrs/Maturation_time

OUTFLOWS:

Divorce_rate_35_to_39_yrs =

Married_women_35_to_39_yrs_2*Divorce_%_35_to_39_yrs{ women / year }

MarriedWomenDeathRate_35_to_39_yrs =
(FemaleDeath_%_35_to_39/100)*Married_women_35_to_39_yrs_2

BeingMarried_40_to_44_yrs = Married_women_35_to_39_yrs_2/Maturation_time

Married_women_40to_44_yrs(t) = Married_women_40to_44_yrs(t - dt) +
(Married_rate_40_to_44_yrs + BeingMarried_40_to_44_yrs - Divorce_rate_40_to_44_yrs
- MarriedWomenDeathRate_40_to_44_yrs - BeingMarried_45_to_49_yrs) * dt

      INIT Married_women_40to_44_yrs = 500707 {person}

      INFLOWS:

Married_rate_40_to_44_yrs =
Unmarried_women_40_to_44_yrs*married_%_40_to_44_yrs{ women / year }

BeingMarried_40_to_44_yrs = Married_women_35_to_39_yrs_2/Maturation_time

      OUTFLOWS:

Divorce_rate_40_to_44_yrs = Married_women_40to_44_yrs*Divorce_%_40_to_44_yrs

{ women / year }

MarriedWomenDeathRate_40_to_44_yrs =
(FemaleDeath__%_40_to_44/100)*Married_women_40to_44_yrs

BeingMarried_45_to_49_yrs = Married_women_40to_44_yrs/Maturation_time

Married_women_45_to_49_yrs(t) = Married_women_45_to_49_yrs(t - dt) +
(Married_rate_45_to_49_yrs + BeingMarried_45_to_49_yrs - Divorce_rate_45_to_49_yrs
- MarriedWomenDeathRate_45_to_49_yrs - Being_50) * dt

      INIT Married_women_45_to_49_yrs = 531423{person}

      INFLOWS:

Married_rate_45_to_49_yrs =
Unmarried_women_45_to_49_yrs*married_%_45_to_49_yrs{ women / year }

BeingMarried_45_to_49_yrs = Married_women_40to_44_yrs/Maturation_time

      OUTFLOWS:

Divorce_rate_45_to_49_yrs = Married_women_45_to_49_yrs*Divorce_%_45_to_49_yrs

{ women / year }

MarriedWomenDeathRate_45_to_49_yrs =
(FemaleDeath_%_45_to_49/100)*Married_women_45_to_49_yrs

Being_50 = Married_women_45_to_49_yrs/Maturation_time

NFPP_budget(t) = NFPP_budget(t - dt) + (BudgetFromInternational +
BudgetFromThaiGovernment - SupportingNFPP) * dt

    INIT NFPP_budget = 0{ Dollar }

    INFLOWS:

BudgetFromInternational = NFPP_Oganizations*InternationalSupportPerClinics

{ Dollar /Year }

BudgetFromThaiGovernment =
If(time>1970)then(min(flow_of_commit*CostPer_NFPP,AvailableBudgetForNFPP))else(0
){ Dollar /Year }

    OUTFLOWS:

SupportingNFPP = cost_for_maintain_NFPP+TotalCostForBuild_NFPP

{ Dollar /Year }

NFPP_Oganizations(t) = NFPP_Oganizations(t - dt) + (BuildingRate - NFPP_demolition) *
dt

    INIT NFPP_Oganizations = 0{ clinic}

    INFLOWS:

BuildingRate =
if(time>Anti_Natalist_Start_time)and(Anti_Natalist_Policy_SwitchOn=1)then(flow_of_co
mmit)else(0){ clinics /year }

    OUTFLOWS:

NFPP_demolition = NFPP_Oganizations*0.001{ clinics /year }

NFPP_User(t) = NFPP_User(t - dt) + (Using_NFPP - DropOutFromNFPP) * dt

    INIT NFPP_User = 0{person}

INFLOWS:

Using_NFPP =
If(time>1970)then(min(Gap_NFPP_User/NFPP_TimeDelay,NFPP_Oganizations*NFPPproductivity))else(0){ Person/year }

OUTFLOWS:

DropOutFromNFPP = NFPP_User*DropOutRate{ Person/year }

NonPregnat(t) = NonPregnat(t - dt) + (stillbirth_rate + regaining_fertility + abortion_rate + change_in_women - pregnancy_rate) * dt

INIT NonPregnat = Female_15_to_49_yrs-Pregnant_1-pregnant_2-postpartum{ person }

INFLOWS:

stillbirth_rate = (pregnant_2*stillbirths_fraction)/remaining_time_until__delivery{ person / year }

regaining_fertility = if(infecundity_time=0)then(postpartum/dt)else

(postpartum/infecundity_time){ person / year }

abortion_rate = ((Pregnant_1*Induced_abortion__fraction)/time_until_abortion){ person / year }

change_in_women = natural_change{ person / year }

OUTFLOWS:

pregnancy_rate = women_at_risk*yearly_pregnancy_probability_15_to_19_yr

{ persons / year }

PoliticalCommit(t) = PoliticalCommit(t - dt) + (flow_of_commit) * dt

INIT PoliticalCommit = 1{ clinic }

INFLOWS:

flow_of_commit =
SMTH3(min(GapOfCommit*DesiredConstructionRate),TimeToCommit){ clinics /year }

Pop_0_to_4_yrs[Male](t) = Pop_0_to_4_yrs[Male](t - dt) + (Birth_rate[Male] - Maturating__to_5[Male] - Death_rate_0_to_14[Male]) * dt

INIT Pop_0_to_4_yrs[Male] = 1315780{person}

Pop_0_to_4_yrs[Female](t) = Pop_0_to_4_yrs[Female](t - dt) + (Birth_rate[Female] - Maturating__to_5[Female] - Death_rate_0_to_14[Female]) * dt

INIT Pop_0_to_4_yrs[Female] = 1315780{person}

INFLOWS:

Birth_rate[Male] = Births*Sex__ratio[Male]

Birth_rate[Female] = Births*Sex__ratio[Female]{Person / year }

OUTFLOWS:

Maturating__to_5[Male] = Pop_0_to_4_yrs[Male]/Maturation_time{persons/year }

Maturating__to_5[Female] = Pop_0_to_4_yrs[Female]/Maturation_time{ persons / year }

Death_rate_0_to_14[Male] = (Pop_0_to_4_yrs[Male]*MaleDeath_%_0_to_4)/100

{ persons /year }

Death_rate_0_to_14[Female] = (Pop_0_to_4_yrs[Female]*FemaleDeath_%_0_to_4)/100

{ persons / year }

Pop_45_to_49_yrs[Male](t) = Pop_45_to_49_yrs[Male](t - dt) + (Maturating_to_45[Male] - Maturating_to_50[Male] - Deaths_45_to_49[Male]) * dt

INIT Pop_45_to_49_yrs[Male] = 373658{person}

Pop_45_to_49_yrs[Female](t) = Pop_45_to_49_yrs[Female](t - dt) + (Maturating_to_45[Female] - Maturating_to_50[Female] - Deaths_45_to_49[Female]) * dt

INIT Pop_45_to_49_yrs[Female] = 373658{person}

INFLOWS:

Maturating_to_45[Male] = Pop__40_to_44_yrs[Male]/Maturation_time{ persons / year }

Maturating_to_45[Female] = Pop__40_to_44_yrs[Female]/Maturation_time{ person/year }

OUTFLOWS:

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Maturating_to_50[Male] = Pop_45_to_49_yrs[Male]/Maturation_time{ persons/year }

Maturating_to_50[Female] = Pop_45_to_49_yrs[Female]/Maturation_time{ persons/year }

Deaths_45_to_49[Male] = (Pop_45_to_49_yrs[Male]*MaleDeath__%_45_to_49)/100

{ persons/year }

Deaths_45_to_49[Female] = (Pop_45_to_49_yrs[Female]*FemaleDeath_%_45_to_49)/100

{ persons/year }

Pop_5_to_9_yrs[Male](t) = Pop_5_to_9_yrs[Male](t - dt) + (Maturating__to_5[Male] - Deaths_5_to_9[Male] - Maturating_to_10[Male]) * dt

INIT Pop_5_to_9_yrs[Male] = 1220829{person}

Pop_5_to_9_yrs[Female](t) = Pop_5_to_9_yrs[Female](t - dt) + (Maturating__to_5[Female] - Deaths_5_to_9[Female] - Maturating_to_10[Female]) * dt

INIT Pop_5_to_9_yrs[Female] = 1220829{person}

INFLOWS:

Maturating__to_5[Male] = Pop_0_to_4_yrs[Male]/Maturation_time{persons/year }

Maturating__to_5[Female] = Pop_0_to_4_yrs[Female]/Maturation_time{ persons / year }

OUTFLOWS:

Deaths_5_to_9[Male] = (Pop_5_to_9_yrs[Male]*MaleDeath_%_5_to_9)/100{ persons/year }

Deaths_5_to_9[Female] = (Pop_5_to_9_yrs[Female]*FemaleDeath_%_5_to_9)/100{ persons/year }

Maturating_to_10[Male] = Pop_5_to_9_yrs[Male]/Maturation_time{ Persons/year }

Maturating_to_10[Female] = Pop_5_to_9_yrs[Female]/Maturation_time{ persons/ year }

Pop__10_to_14_yrs[Male](t) = Pop__10_to_14_yrs[Male](t - dt) + (Maturating_to_10[Male] - Deaths_10_to_14[Male] - Maturating_to_15[Male]) * dt

INIT Pop__10_to_14_yrs[Male] = 1117738{person}

Pop__10_to_14_yrs[Female](t) = Pop__10_to_14_yrs[Female](t - dt) + (Maturating_to_10[Female] - Deaths_10_to_14[Female] - Maturating_to_15[Female]) * dt

INIT Pop__10_to_14_yrs[Female] = 1117738{person}

INFLOWS:

Maturating_to_10[Male] = Pop_5_to_9_yrs[Male]/Maturation_time{ Persons/year }

Maturating_to_10[Female] = Pop_5_to_9_yrs[Female]/Maturation_time{ persons/ year }

OUTFLOWS:

Deaths_10_to_14[Male] = (Pop__10_to_14_yrs[Male]*MaleDeath_%_10_to_14)/100

{ persons/year }

Deaths_10_to_14[Female] = (Pop__10_to_14_yrs[Female]*FemaleDeath_10_to_14)/100{ persons/year }

Maturating_to_15[Male] = Pop__10_to_14_yrs[Male]/Maturation_time{ Person / year }

Maturating_to_15[Female] = Pop__10_to_14_yrs[Female]/Maturation_time{ persons / year }

Pop__15_to_19_yrs[Male](t) = Pop__15_to_19_yrs[Male](t - dt) + (Maturating_to_15[Male] - Deaths_15_to_19[Male] - Maturating_to_20[Male]) * dt

INIT Pop__15_to_19_yrs[Male] = 1.04E+06{person}

Pop__15_to_19_yrs[Female](t) = Pop__15_to_19_yrs[Female](t - dt) + (Maturating_to_15[Female] - Deaths_15_to_19[Female] - Maturating_to_20[Female]) * dt

INIT Pop__15_to_19_yrs[Female] = 1.04E+06{person}

INFLOWS:

Maturating_to_15[Male] = Pop__10_to_14_yrs[Male]/Maturation_time{ Person / year }

Maturating_to_15[Female] = Pop__10_to_14_yrs[Female]/Maturation_time{ persons / year }

OUTFLOWS:

Deaths_15_to_19[Male] = (Pop__15_to_19_yrs[Male]*MaleDeath_%15_to_19)/100{ persons/year }

Deaths_15_to_19[Female] = (Pop__15_to_19_yrs[Female]*FemaleDeath_%15_to_19)/100

{ persons/year }

Maturating_to_20[Male] = Pop__15_to_19_yrs[Male]/Maturation_time{ persons / year }

Maturating_to_20[Female] = Pop__15_to_19_yrs[Female]/Maturation_time{ persons / year }

Pop__20_to_24_yrs[Male](t) = Pop__20_to_24_yrs[Male](t - dt) + (Maturating_to_20[Male] - Deaths_20_to_24[Male] - Maturating_to_25[Male]) * dt

INIT Pop__20_to_24_yrs[Male] = 1105653{person}

Pop__20_to_24_yrs[Female](t) = Pop__20_to_24_yrs[Female](t - dt) + (Maturating_to_20[Female] - Deaths_20_to_24[Female] - Maturating_to_25[Female]) * dt

INIT Pop__20_to_24_yrs[Female] = 1105653{person}

INFLOWS:

Maturating_to_20[Male] = Pop__15_to_19_yrs[Male]/Maturation_time{ persons / year }

Maturating_to_20[Female] = Pop__15_to_19_yrs[Female]/Maturation_time{ persons / year }

OUTFLOWS:

Deaths_20_to_24[Male] = (Pop__20_to_24_yrs[Male]*MaleDeath_%_20_to_24)/100

{ persons/year }

Deaths_20_to_24[Female] = (Pop__20_to_24_yrs[Female]*FemaleDeath_%_20_to_24)/100{ persons/year }

Maturating_to_25[Male] = Pop__20_to_24_yrs[Male]/Maturation_time{ persons/year }

Maturating_to_25[Female] = Pop__20_to_24_yrs[Female]/Maturation_time { persons / year }

Pop__25_to_29_yrs[Male](t) = Pop__25_to_29_yrs[Male](t - dt) + (Maturating_to_25[Male] - Deaths_25_to_29[Male] - Maturating_to_30[Male]) * dt

INIT Pop__25_to_29_yrs[Male] = 923578{person}

Pop__25_to_29_yrs[Female](t) = Pop__25_to_29_yrs[Female](t - dt) + (Maturating_to_25[Female] - Deaths_25_to_29[Female] - Maturating_to_30[Female]) * dt

INIT Pop__25_to_29_yrs[Female] = 923578{person}

INFLOWS:

Maturating_to_25[Male] = Pop__20_to_24_yrs[Male]/Maturation_time{ persons/year }

Maturating_to_25[Female] = Pop__20_to_24_yrs[Female]/Maturation_time { persons / year }

OUTFLOWS:

Deaths_25_to_29[Male] = (Pop__25_to_29_yrs[Male]*MaleDeath_%_25_to_29)/100{ persons/year }

Deaths_25_to_29[Female] = (Pop__25_to_29_yrs[Female]*FemaleDeath_%_25_to_29)/100{ persons/year }

Maturating_to_30[Male] = Pop__25_to_29_yrs[Male]/Maturation_time{ persons / year }

Maturating_to_30[Female] = Pop__25_to_29_yrs[Female]/Maturation_time{ persons / year }

Pop__30_to_34_yrs[Male](t) = Pop__30_to_34_yrs[Male](t - dt) + (Maturating_to_30[Male] - Deaths_30_to_34[Male] - Maturating_to_35[Male]) * dt

INIT Pop__30_to_34_yrs[Male] = 780842{person}

Pop__30_to_34_yrs[Female](t) = Pop__30_to_34_yrs[Female](t - dt) + (Maturating_to_30[Female] - Deaths_30_to_34[Female] - Maturating_to_35[Female]) * dt

INIT Pop__30_to_34_yrs[Female] = 780842{person}

INFLOWS:

Maturating_to_30[Male] = Pop__25_to_29_yrs[Male]/Maturation_time{ persons / year }

Maturating_to_30[Female] = Pop__25_to_29_yrs[Female]/Maturation_time{ persons / year }

OUTFLOWS:

Deaths_30_to_34[Male] = (Pop__30_to_34_yrs[Male]*MaleDeath_%_30_to_34)/100

{ persons/year }

Deaths_30_to_34[Female] = Pop__30_to_34_yrs[Female]*FemaleDeath_%_30_to_34/100

{ persons/year }

Maturating_to_35[Male] = Pop__30_to_34_yrs[Male]/Maturation_time{ persons / year }

Maturating_to_35[Female] = Pop__30_to_34_yrs[Female]/Maturation_time{ persons/year }

Pop__35_to_39_yrs[Male](t) = Pop__35_to_39_yrs[Male](t - dt) + (Maturating_to_35[Male] - Deaths_35_to_39[Male] - Maturating_to_40[Male]) * dt

> INIT Pop__35_to_39_yrs[Male] = 520870{person}

Pop__35_to_39_yrs[Female](t) = Pop__35_to_39_yrs[Female](t - dt) + (Maturating_to_35[Female] - Deaths_35_to_39[Female] - Maturating_to_40[Female]) * dt

> INIT Pop__35_to_39_yrs[Female] = 520870{person}

> INFLOWS:

Maturating_to_35[Male] = Pop__30_to_34_yrs[Male]/Maturation_time{ persons / year }

Maturating_to_35[Female] = Pop__30_to_34_yrs[Female]/Maturation_time{ persons/year }

> OUTFLOWS:

Deaths_35_to_39[Male] = (Pop__35_to_39_yrs[Male]*MaleDeath_%_35_to_39)/100

{ persons/year }

Deaths_35_to_39[Female] = (Pop__35_to_39_yrs[Female]*FemaleDeath_%_35_to_39)/100{ persons/year }

Maturating_to_40[Male] = Pop__35_to_39_yrs[Male]/Maturation_time{ persons / year }

Maturating_to_40[Female] = Pop__35_to_39_yrs[Female]/Maturation_time{ persons/year }

Pop__40_to_44_yrs[Male](t) = Pop__40_to_44_yrs[Male](t - dt) + (Maturating_to_40[Male] - Maturating_to_45[Male] - Deaths_40_to_44[Male]) * dt

INIT Pop__40_to_44_yrs[Male] = 500827{person}

Pop__40_to_44_yrs[Female](t) = Pop__40_to_44_yrs[Female](t - dt) + (Maturating_to_40[Female] - Maturating_to_45[Female] - Deaths_40_to_44[Female]) * dt

INIT Pop__40_to_44_yrs[Female] = 500827{person}

INFLOWS:

Maturating_to_40[Male] = Pop__35_to_39_yrs[Male]/Maturation_time { persons / year }

Maturating_to_40[Female] = Pop__35_to_39_yrs[Female]/Maturation_time{ persons/year}

OUTFLOWS:

Maturating_to_45[Male] = Pop__40_to_44_yrs[Male]/Maturation_time{ persons / year }

Maturating_to_45[Female] = Pop__40_to_44_yrs[Female]/Maturation_time{ person/year }

Deaths_40_to_44[Male] = (Pop__40_to_44_yrs[Male]*MaleDeath_%_40_to_44)/100

{ persons/year }

Deaths_40_to_44[Female] = (Pop__40_to_44_yrs[Female]*FemaleDeath__%_40_to_44)/100{ persons/year }

Pop__50_to_54_yrs[Male](t) = Pop__50_to_54_yrs[Male](t - dt) + (Maturating_to_50[Male] - Deaths_50_to_54[Male] - Maturating_to_55[Male]) * dt

INIT Pop__50_to_54_yrs[Male] = 358889{person}

Pop__50_to_54_yrs[Female](t) = Pop__50_to_54_yrs[Female](t - dt) + (Maturating_to_50[Female] - Deaths_50_to_54[Female] - Maturating_to_55[Female]) * dt

INIT Pop__50_to_54_yrs[Female] = 358889{person}

INFLOWS:

Maturating_to_50[Male] = Pop_45_to_49_yrs[Male]/Maturation_time{ persons/year }

Maturating_to_50[Female] = Pop_45_to_49_yrs[Female]/Maturation_time{ persons/year }

OUTFLOWS:

Deaths_50_to_54[Male] = (Pop__50_to_54_yrs[Male]*MaleDeath_%_50_to_54)/100

{ persons/year }

Deaths_50_to_54[Female] =
(Pop__50_to_54_yrs[Female]*FemaleDeath_%_50_to_54)/100{ persons/year }

Maturating_to_55[Male] = Pop__50_to_54_yrs[Male]/Maturation_time{ persons/year }

Maturating_to_55[Female] = Pop__50_to_54_yrs[Female]/Maturation_time{ persons/year }

Pop__55_to_59yrs[Male](t) = Pop__55_to_59yrs[Male](t - dt) + (Maturating_to_55[Male] - Maturating_to_60[Male] - Deaths_55_to_59[Male]) * dt

INIT Pop__55_to_59yrs[Male] = 235869{person}

Pop__55_to_59yrs[Female](t) = Pop__55_to_59yrs[Female](t - dt) + (Maturating_to_55[Female] - Maturating_to_60[Female] - Deaths_55_to_59[Female]) * dt

INIT Pop__55_to_59yrs[Female] = 235869{person}

INFLOWS:

Maturating_to_55[Male] = Pop__50_to_54_yrs[Male]/Maturation_time{ persons/year }

Maturating_to_55[Female] = Pop__50_to_54_yrs[Female]/Maturation_time{ persons/year }

OUTFLOWS:

Maturating_to_60[Male] = Pop__55_to_59yrs[Male]/Maturation_time{ persons/year }

Maturating_to_60[Female] = Pop__55_to_59yrs[Female]/Maturation_time{ persons/year }

Deaths_55_to_59[Male] = (Pop__55_to_59yrs[Male]*MaleDeath_%_55_to_59)/100

{ persons/year }

Deaths_55_to_59[Female] = (Pop__55_to_59yrs[Female]*FemaleDeath_%_55_to_59)/100

{ persons/year }

Pop__60_up[Male](t) = Pop__60_up[Male](t - dt) + (Maturating_to_60[Male] - Death_60_up[Male]) * dt

INIT Pop__60_up[Male] = 372350{person}

Pop__60_up[Female](t) = Pop__60_up[Female](t - dt) + (Maturating_to_60[Female] - Death_60_up[Female]) * dt

INIT Pop__60_up[Female] = 372350{person}

INFLOWS:

Maturating_to_60[Male] = Pop__55_to_59yrs[Male]/Maturation_time{ persons/year }

Maturating_to_60[Female] = Pop__55_to_59yrs[Female]/Maturation_time{ persons/year }

OUTFLOWS:

Death_60_up[Male] = (Pop__60_up[Male]*MaleDeath_%_60_up)/100{ persons/year }

Death_60_up[Female] = (Pop__60_up[Female]*FemaleDeath_%_60_up)/100

{ persons/year }

postpartum(t) = postpartum(t - dt) + (deliverry_rate - regaining_fertility) * dt

INIT postpartum = 424282{person}

INFLOWS:

deliverry_rate = (1-stillbirths_fraction)*pregnant_2/remaining_time_until__delivery{ person / year }

OUTFLOWS:

regaining_fertility = if(infecundity_time=0)then(postpartum/dt)else

(postpartum/infecundity_time){ person / year }

Pregnant_1(t) = Pregnant_1(t - dt) + (pregnancy_rate - abortion_rate - continuation_rate) * dt

INIT Pregnant_1 = 425282{person}

INFLOWS:

pregnancy_rate = women_at_risk*yearly_pregnancy_probability_15_to_19_yr{ persons / year }

OUTFLOWS:

abortion_rate = ((Pregnant_1*Induced_abortion__fraction)/time_until_abortion)

{ person / year }

continuation_rate = (1-Induced_abortion__fraction)*Pregnant_1/time_until_abortion

{ person / year }

pregnant_2(t) = pregnant_2(t - dt) + (continuation_rate - deliverry_rate - stillbirth_rate) * dt

INIT pregnant_2 = 424282{person}

INFLOWS:

continuation_rate = (1-Induced_abortion__fraction)*Pregnant_1/time_until_abortion

{ person / year }

OUTFLOWS:

deliverry_rate = (1-stillbirths_fraction)*pregnant_2/remaining_time_until__delivery

{ person / year }

stillbirth_rate = (pregnant_2*stillbirths_fraction)/remaining_time_until__delivery

{ person / year }

PrivateClinic_User(t) = PrivateClinic_User(t - dt) + (UsingPrivateClinics - DropOutFromPrivateClinics) * dt

INIT PrivateClinic_User = 0{person}

INFLOWS:

UsingPrivateClinics =
If(time>1960)then(GapPrivateClinicUser/PrivateClinicsTimeDelay)else(0)

OUTFLOWS:

DropOutFromPrivateClinics = PrivateClinic_User*DropOutRate

An_OrganizationProductivity = 1000000{ women }

AvailableBudgetForNFPP = HeathExpenditureFromTax*0.001

{ Dollar /Year }

averagebeastfeeding_time = GRAPH(time)

(1950, 18.0), (1960, 15.0), (1970, 10.7), (1980, 7.70), (1990, 5.50), (2000, 4.50), (2010, 4.00), (2020, 4.00), (2030, 4.00), (2040, 4.00), (2050, 4.00)

Births = deliverry_rate-InfantDeaths{ person }

breastfeeding_duration = averagebeastfeeding_time{ months }

CommitedMarriedOrganization =
If(time<1957)then(Min(GapMarriedOrganization,BudgetForMarriedOrganization/CostFor BuildAnOrganizations))else(0)

Condom_effectiveness = 0.85

CondomUserNFPPData = CondomUser_data*PCT_CondomdusingNFPPData

CondomUserPrivateClinicsData = CondomUser_data*PCT_CondomUsingPrivateData

CondomUser_data = MarriedWomen_Data*PCT_Condom_using_data

ContraceptiveEffect = ContraceptivePrevalence*ContraceptiveEffectiveness

ContraceptiveEffectiveness =
(Condom_effectiveness+implant_effectiveness+injectable__effectiveness+IUD_effectiveness+pills_effectiveness+Sterilization_or_vasectomy_effectiveness)/6

ContraceptivePrevalence = TotalContraceptiveUser/MarriedWomen

CostForBuildAnOrganizations = 1000000

CostForBuild_NFPP = 40000{ dollars / clinic }

CostOfRaisingChildPeryear = GRAPH(time (1950, 270), (1960, 415), (1970, 605), (1980, 865), (1990, 935), (2000, 955), (2010, 980), (2020, 980), (2030, 980), (2040, 980), (2050, 980)

CostPer_NFPP = 50000{ dollars }

cost_for_maintain_NFPP = NFPP_Oganizations*MaintainingCostPerClinic{ dollars / year }

DesireBirths = (Desired_TFR*Female_15_to_49_yrs)/ReproductiveLifeTime{ Birth}

DesireContraceptivePrevalence =
Desired_ContraceptiveEffects/ContraceptiveEffectiveness

DesireContracetiveUser = DesireContraceptivePrevalence*MarriedWomen{ Person }

DesiredBirths_1950_to_1960 = GapForProNatalistPolicy{ person }

DesiredConstructionRate = GRAPH(DesiredTFR_OverTFR{ % })

(0.00, 1.00), (0.1, 0.775), (0.2, 0.62), (0.3, 0.43), (0.4, 0.3), (0.5, 0.2), (0.6, 0.145), (0.7, 0.115), (0.8, 0.07), (0.9, 0.03), (1, 0.00)

DesiredDeliveryRate = DesireBirths+InfantDeaths

DesiredMarriedOganization = DesiredMarriedWomen/An_OrganizationProductivity

DesiredMarriedWomen =
If(time<1957)then(MAX(DesireIndexProportionMarried*Female_15_to_49_yrs,Female_15_to_49_yrs))else(0)

DesiredNumber__OfChildrenPerMmarriedCouple =
EffectOFCostRaising_ChildToDesiredNumberOfChildren{ person/person }

DesiredTFR_1950_to_1960 = (DesiredBirths_1950_to_1960/Female_15_to_49_yrs)*35

DesiredTFR_OverTFR = NFPP_TFR_Goal/TFR

DesiredWomen_at_Risk = DesiredDeliveryRate

Desired_ContraceptiveEffects =
DesireWomenUsingEffectiveContracepion/Women_in_SexualUnion

Desired_Female_15_to_49_yrs_1950 =
If(time<1960)then((DesiredBirths_1950_to_1960/DesiredTFR_1950_to_1960)*ReproductiveLifeTime)else(0) { person }

Desired_TFR = DesiredNumber__OfChildrenPerMmarriedCouple{ person/person }

DesireIndexProportionMarried =
If(time<1960)then(MarriedWomen/Desired_Female_15_to_49_yrs_1950)else(0){ dmnl }

DesirePrivateClinicUser = DesireContracetiveUser*(1-PCT_Using_NFPP){ Person }

DesireWomenUsingEffectiveContracepion = MAX(0,-
DesiredWomen_at_Risk+Women_in_SexualUnion-women_not_at_risk){ person }

Desire_NFPPUser = DesireContracetiveUser*PCT_Using_NFPP{ Person }

GapForProNatalistPolicy = If(time<1960)then(PopulationGoal__1950_to_1960-TotalPopulation)else(0){ person }

GapMarriedOrganization = DesiredMarriedOganization-MarriedOrganizations

GapOfCommit = NFPP_Goal-NFPP_Oganizations{ clinic }

GapPrivateClinicUser = DesirePrivateClinicUser-PrivateClinic_User

Gap_NFPP_User = Desire_NFPPUser-NFPP_User

Government_income = Tax_Per_Worker_Per_year*Worker

HeathExpenditureFromTax = Government_income*(Percentage_of_HealthExpenditure/100)

implant_effectiveness = 0.99

Induced_abortion__fraction = 0.02{ percentage }

InfantDeaths = (deliverry_rate*InfantDeaths_Per_1000_LiveBiths)/1000{ person }

infecundity_time = effect_of_BF_on_infundity_time/12

inflow__of_women_15_to_49 = Maturating_to_15[Female]+Maturating_to_20[Female]+Maturating_to_25[Female]+Maturating_to_30[Female]+Maturating_to_35[Female]+Maturating_to_40[Female]+Maturating_to_45[Female]{ women / year }

inflow__of_women_15_to_50 = Maturating_to_15[Female]+Maturating_to_20[Female]+Maturating_to_25[Female]+Maturating_to_30[Female]+Maturating_to_35[Female]+Maturating_to_40[Female]+Maturating_to_45[Female]{ woemn / year }

Initial_TFR = 3.87

InternationalSupportPerClinics = GRAPH(time{ dollars })

(1950, 0.00), (1960, 0.00), (1970, 10000), (1980, 15000), (1990, 0.00), (2000, 0.00), (2010, 0.00), (2020, 0.00), (2030, 0.00), (2040, 0.00), (2050, 0.00)

MaintainingCostPerClinic = 5000{ dollar / clinic / year }

PrivateClinicsTimeDelay = 3/12{ year }

remaining_time_until__delivery = total_time_for_giving_birth-time_until_abortion{ year }

ReproductiveLifeTime = 35{ year }

Sex__ratio[Male] = 0.53{ % per year }

Sex__ratio[Female] = 0.47{ percentage }

Sterilization_or_vasectomy_effectiveness = 0.995

stillbirths_fraction = sitillbirth_rate_per_1000_births/births_1000

Tax_Per_Worker_Per_year = GRAPH(time{ dollars })

(1950, 285), (1960, 465), (1970, 630), (1980, 690), (1990, 780), (2000, 795), (2010, 800), (2020, 800), (2030, 800), (2040, 800), (2050, 800)

TFR = (Births*ReproductiveLifeTime)/Female_15_to_49_yrs{ person / person }

TimeToBuildOrganization = 1{year}

TimeToCommit = 1{ year }

TimeToPerceive = 1.2

time_until_abortion = .125{ years or 6 weeks ; this is midway during the first trimester = 1.5/12 : Wheat }

TotalContraceptiveUser = NFPP_User+PrivateClinic_User

{ person }

TotalContraceptiveUsingFractionData = MIN(ContraceptiveUsingFractionNFPPdata+ContraceptiveUsingFractionPrivateData,1)

TotalCostForBuild_NFPP = BuildingRate*CostForBuild_NFPP{ Dollar /Year }

TotalPopulation = Pop_0_to_4_yrs[Male]+Pop_0_to_4_yrs[Female]+Pop_5_to_9_yrs[Male]+Pop_5_to_9_yrs[Female]+Pop__10_to_14_yrs[Male]+Pop__10_to_14_yrs[Female]+Fertile_pop_15_to_49_yrs+Pop__50_to_54_yrs[Male]+Pop__50_to_54_yrs[Female]+Pop__55_to_59yrs[Male]+Pop__55_to_59yrs[Female]+Pop__60_up[Male]+Pop__60_up[Female]

total_time_for_giving_birth = 0.75{ year }

TotoalEmployed = TotalPopulation*EmploymentToPopulationRatio

Unemployment = WorkForce*Unemployment_rate

Unmarried_women_15_to_19_yrs = Pop__15_to_19_yrs[Female]Married_women_15_to_19_yrs_2{ women }

Unmarried_women_20_to_24_yrs = Pop__20_to_24_yrs[Female]-Married_women_20_to_24_yrs_2{ women }

Unmarried_women_25_to_29_yrs = Pop__25_to_29_yrs[Female]-Married_women_25_to29_yrs{ women }

Unmarried_women_30_to_34_yrs = Pop__30_to_34_yrs[Female]-Married_women_30to_34yrs{ women }

Unmarried_women_35_to_39_yrs = Pop__35_to_39_yrs[Female]-Married_women_35_to_39_yrs_2{ women }

Unmarried_women_40_to_44_yrs = Pop__40_to_44_yrs[Female]-Married_women_40to_44_yrs{ women }

Unmarried_women_45_to_49_yrs = Pop_45_to_49_yrs[Female]-Married_women_45_to_49_yrs{ women }

WomenUsing_Effective_Contraception = Women_in_SexualUnion*ContraceptiveEffect

women_at_risk = Women_in_SexualUnion-WomenUsing_Effective_Contraception-women_not_at_risk{ women }

Women_in_SexualUnion = MarriedWomen

women_not_at_risk = postpartum+Pregnant_1+pregnant_2

Worker = WorkForce-Unemployment

WorkForce = TotalPopulation-(Pop_0_to_4_yrs[Male]+Pop_0_to_4_yrs[Female]+Pop__10_to_14_yrs[Male]+Pop__10_to_14_yrs[Female]+Pop__15_to_19_yrs[Male]+Pop__15_to_19_yrs[Female]+Pop_5_to_9_yrs[Male]+Pop_5_to_9_yrs[Female]+Pop__60_up[Male]+Pop__60_up[Female]){people}