

# The Three-party Evolutionary Game Under "Re-familization" Family Policies

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**Abstract.** With the development of society and the change of fertility culture, the fertility rate is gradually decreasing around the world, which leads to a lot of problems, so the Chinese government is seeking effective family policies to improve fertility levels. Based on the evolutionary game theory, the article defines the three participants in the evolutionary process of fertility choice and their payoff functions, then constructs a three-party evolutionary game model among individuals, firms and local governments, and finally analyzes the strategic choices of each party under the government-led family policies. The findings suggest that economic policies that directly give cash incentives and tax benefits are more effective in increasing fertility rate and creating a fertility-friendly social environment. Thus, the author suggests that the government should mainly use economic policies to promote the increase of fertility level and solve the social problem of low fertility rate.

**Keywords:** Re-familization, Fertility Choice, Family Policy; Evolutionary Game Theory.

## 1. Introduction

With the development of society and the change of fertility culture, the fertility rate has gradually decreased around the world, which is often below the replacement level of 2.1, and the population size is on the trend of shrinking. The low fertility rate brings multiple problems such as population aging, labor shortage and lack of economic vitality, and has received wide attention from academic circles.

China has achieved low fertility level for nearly 30 years and now enters a very low fertility stage. To encourage childbirth, the Chinese government has loosened fertility restrictions, but those policies didn't work well. In that situation, an NPC deputy said in an interview that the length of maternity leave for women should be extended to three years while liberalizing the three-child birth policy and granting birth incentives. Both policies he mentioned are typical "re-familization" family policies. The term "re-familization" refers to the idea that families should bear the costs of childbirth, rather than sharing them with other welfare producers (such as the government, the market and society). Recent changes in policies suggest that the Chinese government prefers to adopt "re-familization" family policies in the short term to increase fertility rate. Thus, this paper focuses on the differences in the effects of different "re-familization" family policies. The article examines the choices of individuals, firms, and local governments in fertility issues through an evolutionary game approach, then analyzes the interests of each party and the equilibrium of the game, and finally makes suggestions about family policy choices for the Chinese government.

## 2. Literature Review

### 2.1 Factors that Influencing Fertility Behavior

The factors that influencing fertility choices have been analyzed comprehensively in the academic community and can be summarized into four main categories: Political, economic, social, and demographic factors.

Political factors have the most direct and targeted influence on fertility behavior, which include fertility policies, family policies, and welfare policies. Fertility policy refers to guidelines set by the national government to regulate the fertility behavior of people in reproductive age, and China's family planning policy is a typical fertility policy. Strictly enforced quantitative fertility restrictions

and high fines for over-births have a significant effect on fertility reduction, but the relaxation of fertility restrictions does not lead to a sustained increase in fertility [1-4]. Family policies can be divided into two types: "De-familization" family policies and "re-familization" family policies. "De-familization" family policies refer to service policies (providing childcare services). "Re-familization" family policies refer to economic policies (providing fertility bonuses and tax preferences) and time policies (extending maternity leave and paternity leave). Researches have generally shown that "de-familization" family policies are more conducive to increasing fertility rate, but they require a large investment in creating childcare service system, which is difficult to achieve in a short period of time in a country with a large population like China [5]. The social welfare and security system may affect individuals' measure of economic benefits from childbearing. The better public education, public health care, and retirement security are, the lower people's expectations of economic benefits from their children they have, and thus their willingness to have children decrease [6,7].

Economic factors affect people's fertility behavior mainly by influencing the cost of childbearing for families, and can be divided into society production methods, income levels, and the cost of childbearing. Increased female labor force participation and delayed retirement due to industrialized production methods have a negative impact on fertility levels [8-10]. The income level has a significant effect on fertility behavior, but the direction of its influence is somewhat controversial among researchers. While an increase in income may increase the ability to raise children, it also increases the opportunity cost of childbearing, which may lead to a reduction in fertility behavior [11,12]. In addition to the income per capita, the distribution of income and the stability of income sources can also influence people's fertility choices [13-15]. Fertility costs include both direct and indirect costs: Direct costs are the money spent from the mother's pregnancy to the child's self-sufficiency, including living costs, education costs, and medical costs. Indirect costs are the time and effort spent in raising a child, and the opportunity cost of income decline and potential promotion opportunity lost. Their increase has a significant inhibitory effect on fertility rate [16-18].

Social factors tend to act on fertility behavior by influencing the mental gains people derive from their children, including cultural customs and education levels. Gender-specific preferences, the importance attached to reproductive behavior in different cultures, and the social status of women can influence people's reproductive choices [11,19]. As the education level of people in childbearing ages increases, their participation in the workforce, marriage and childbearing are delayed, and both fertility intentions and fertility rates decrease [20].

Demographic factors are intermediate variables affecting fertility, covering factors such as marital status, age at childbearing, family structure, and the "low fertility trap". Since this aspect is not covered in this paper, it will not be discussed here.

## 2.2 Researches on Fertility Issues from the Game Theory Perspective

By combing through the literature related to fertility issues, it is found that most scholars currently use quantitative analysis to examine the effects of different factors on fertility. For example, Zhiqiang and Zaiping analyzed the uneven sharing of the fertility net cost among the government, firms, and families through a labor supply and demand model [21]. Zilian used a time-series and panel data vector autoregressive model to analyze the mutual shock effect between income and fertility [22]. Minja and Hyungseok used the period-child progressive total fertility rate to describe marriage and childbearing behavior, and compared the effects of factors such as women's education level and the development of childcare services on fertility through regression analysis [23].

Only a small amount of literature using game theory approach to study fertility issues. There is still some room for academic development in this area. In previous studies, Yuyin, Hanmin and Kainan have provided a comprehensive overview of the characteristics and application scope of the evolutionary game theory in their articles [24,25]. The objects of evolutionary games are often groups of people who change their strategies over time. The evolutionary game theory follows the assumption of finite rationality and assumes that participants do not possess full knowledge of the

game structure and rules, so they cannot adopt the optimal strategy at the beginning, but they would constantly modify and improve their behavior in the course of time, imitating the successful strategies. Therefore, the evolutionary game model can better reflect the complexity and diversity of participants, better simulate the behavior of people in the real society and provide a theoretical basis for policy making. These characteristics of evolutionary game theory make it very applicable to the study of fertility issues. When making a fertility decision, individuals are often not fully aware of their firm's attitudes toward childbirth and possible policies in the future. In that case, people would rely heavily on the choices made by the group in the past. Over time, some random factors emerge to influence people's fertility decisions, which is very close to the assumptions of the evolutionary game theory. Therefore, this paper chooses to apply the research method of evolutionary game to examine the fertility issues, to analyze the influence of different factors on the participants and the final evolutionary stabilization strategy, which is also the innovation of this paper.

### **3. Fertility Behavior Evolutionary Game Model**

#### **3.1 Definition of Game Participants**

In the fertility behavior evolutionary game model, there are three types of participants: Individuals, firms and local governments. It is assumed that all three parties involved in the game are not perfectly rational. Under this condition, each party is unable to find their own optimal strategy at the beginning, but they would adjust their strategies according to their experience.

Individuals are the decision makers and actual bearers of fertility costs. For individuals, the costs and benefits of childbearing are the main factors that influencing their reproductive choices. The costs of childbearing can be divided into direct and indirect costs: Direct costs include living costs, educational costs, medical costs, which are affected by the price level. Indirect costs include the time and effort spent on raising children, as well as the possible loss of job income and promotion opportunities due to childbearing. The benefits of childbirth can be divided into economic benefits and spiritual benefits: Economic benefits include the income that children bring to the family when they become adults, the insurance for retirement and the ability to resist risks, which are influenced by the production method and the economic condition of the family. Spiritual benefits include the sense of completeness and satisfaction from childbirth, as well as an increase in the couple's relationship with each other, and relief of social pressure, which are influenced by cultural customs and the education level. Individuals are influenced by many factors when making fertility choices and have different perceptions of the fertility costs and benefits, and their opinions of having a child change over time, so individuals are assumed to be imperfectly rational.

Firms are the fertility cost co-sharers. In the short term, childbirth only imposes multiple costs on the firm, including the efficiency loss due to interruption of employees' work and adjustment of employees' work schedules, and the expense of recruiting new employees or paying overtime to other employees to share the work. In the long term, childbirth brings multiple benefits to the business, including future workforce and potential consumers. Firms may only focus on short-term costs, or take long-term benefits into consideration. Firms' different perceptions towards fertility make their choices somewhat unstable, so firms are assumed to be imperfectly rational.

Local governments are the fertility policy makers and supervisors. In the short run, family policies require a large amount of funding and human resources to implement and monitor; different family policies may have different effects on the government's reputation. In the long run, fertility will bring many social benefits, such as accumulating future labor productivity, boosting domestic demand, passing on national culture, and ensuring human reproduction; at the same time, fertility will bring future tax revenue to the government and increase government revenue. A short-sighted government will only consider the short-term costs and benefits, while a forward-thinking government will take potential benefits and social gains into account. Different government attitudes may affect their policy choices and there is some instability, so local governments are assumed to be imperfectly rational.

### 3.2 Model Hypothesis and Parameters

Hypothesis 1: Individuals are participant 1, firms are participants 2, and local governments are participants 3. All three parties have imperfect rationality, and the strategy choice evolves gradually over time to their optimal strategy.

Hypothesis 2: Individuals have a strategy set of having children and not having children. Individuals choose to have children at a rate of  $x$  and choose not to have children at a rate of  $(1 - x)$ .

Hypothesis 3: Firms have a strategy set of being maternity friendly and being maternity discriminatory. Being maternity friendly means that the company treats pregnant employees normally, arranges appropriate work contents for them, allows them to take maternity leave, and gives them the wages and subsidies they deserve. Being maternity discriminatory means that firms discriminate against pregnant employees by transferring them to other jobs, reducing their salaries, or even dismissing them. Firms choose to be maternity friendly at a rate of  $y$  and choose to be maternity discriminatory at a rate of  $(1 - y)$ .

Hypothesis 4: Local governments have a strategy set of economic policy and time policy. Economic policy means that local governments offer direct childbirth bonuses and childcare subsidies for families and give tax incentives to individuals who have children and fertility-friendly firms. Time policy means that local governments extend statutory maternity leave for women and paternity leave for men. Local governments choose the economic policy at a rate of  $z$  and the time policy at a rate of  $(1 - z)$ .

Other parameters are set as shown in Table 1, and all parameters are positive.

**Table 1.** Parameter descriptions

Parameter	Description
Fertility cost for individual $C_1$	The direct and indirect costs when an individual chooses to have children.
Cost of maternity leave extension for individual $C_2$	Employment difficulties and promotion difficulties for individuals due to extended maternity leave.
Additional fertility cost for individual $C_3$	Wages and job opportunities lost for childbearers when they are in a fertility discriminatory firm.
Fertility cost for company $C_4$	Fertility friendly firms incurs efficiency losses, overtime payments and expenses from recruiting new employees when their employees choose to have children.
Cost of maternity leave extension for company $C_5$	The increase of firm costs due to the extension of statutory maternity leave.
Fertility revenue for individual $R_1$	The financial and spiritual benefits to the person who have children.
Revenue of maternity leave extension for individual $R_2$	The decline in childcare costs for individual due to the extension of maternity leave.
Fertility bonus $B$	Under the economic policy, local governments give fertility bonuses and childcare allowances to childbearers.
Tax preference for individual $T_1$	Tax benefits to individuals who have children under economic policies.
Tax preference for company $T_2$	Tax benefits to fertility-friendly firms under economic policies.
Penalty $P$	Penalties when a firm discriminates pregnant employees.
Reputation enhancement $S_1$	The increase of firm reputation when a firm is fertility friendly.
Reputation decline $S_2$	The decline of firm reputation when a firm is fertility discriminatory.
Credibility enhancement $G_1$	The increase in government credibility when a local government choose economic policies.
Credibility decline $G_2$	The decline in government credibility when a local government choose time policies.

### 3.3 Local Government-firm-individual Game Model Construction

According to the parameters set in the previous section, the payoff matrix shown in Table 2 is constructed.

**Table 2.** Payoff matrix of individuals, firms and local governments

		Local government: economic policy ( $z$ )		Local government: time policy ( $1 - z$ )	
		Firm: maternity friendly ( $y$ )	Firm: maternity discriminatory ( $1 - y$ )	Firm: maternity friendly ( $y$ )	Firm: maternity discriminator ( $1 - y$ )
Individual	have children ( $x$ )	$(-C_1 + R_1 + B + T_1, -C_4 + T_2 + S_1, -B - T_1 - T_2 + G_1)$	$(-C_1 - C_3 + R_1 + B + T_1 + P, -P - S_2, -B - T_1 + G_1)$	$(-C_1 - C_2 + R_1 + R_2, -C_4 - C_5 + S_1, -G_2)$	$(-C_1 - C_2 - C_3 + R_1 + R_2 + P, -P - S_2, -G_2)$
	not have children ( $1 - x$ )	$(0, T_2 + S_1, -T_2 + G_1)$	$(0, -S_2, G_1)$	$(-C_2, S_1, -G_2)$	$(-C_2, -S_2, -G_2)$

Here are the expected benefits  $U_{x1}$  for individuals choosing to have children,  $U_{x2}$  for not having children, and the replication dynamic equation  $F$ :

$$U_{x1} = yz(-C_1 + R_1 + B + T_1) + (1 - y)z(-C_1 - C_3 + R_1 + B + T_1 + P) + y(1 - z)(-C_1 - C_2 + R_1 + R_2) + (1 - y)(1 - z)(-C_1 - C_2 - C_3 + R_1 + R_2 + P) \quad (1)$$

$$U_{x2} = y(1 - z)(-C_2) + (1 - y)(1 - z)(-C_2) \quad (2)$$

$$F = \frac{dx}{dt} = x(1 - x)(U_{x1} - U_{x2}) = x(1 - x)[(-C_1 - C_3 + R_1 + R_2 + P) + (C_3 - P)y + (B + T_1 - R_2)z] \quad (3)$$

Here are the expected benefits  $U_{y1}$  for maternity friendly firms,  $U_{y2}$  for maternity discriminatory firms, and the replication dynamic equation  $G$ :

$$U_{y1} = xz(-C_4 + T_2 + S_1) + (1 - x)z(T_2 + S_1) + x(1 - z)(-C_4 - C_5 + S_1) + (1 - x)(1 - z)S_1 \quad (4)$$

$$U_{y2} = xz(-P - S_2) + (1 - x)z(-S_2) + x(1 - z)(-P - S_2) + (1 - x)(1 - z)(-S_2) \quad (5)$$

$$G = \frac{dy}{dt} = y(1 - y)(U_{y1} - U_{y2}) = y(1 - y)[(S_1 + S_2) - (C_4 + C_5 - P)x + T_2z + C_5xz] \quad (6)$$

Here are the expected benefits  $U_{z1}$  for local governments implementing economic policy,  $U_{z2}$  for implementing time policy, and the replication dynamic equation  $H$ :

$$U_{z1} = xy(-B - T_1 - T_2 + G_1) + x(1 - y)(-B - T_1 + G_1) + (1 - x)y(-T_2 + G_1) + (1 - x)(1 - y)G_1 \quad (7)$$

$$U_{z2} = xy(-G_2) + x(1 - y)(-G_2) + (1 - x)y(-G_2) + (1 - x)(1 - y)(-G_2) \quad (8)$$

$$H = \frac{dz}{dt} = z(1 - z)(U_{z1} - U_{z2}) = z(1 - z)[(G_1 + G_2) - (B + T_1)x - T_2y] \quad (9)$$

## 4. Model Analysis

### 4.1 Stability Analysis of Individual Strategy Choice

Let  $F(x) = 0$ , getting  $x = 0$ ,  $x = 1$ , and  $(-C_1 - C_3 + R_1 + R_2 + P) + (C_3 - P)y + (B + T_1 - R_2)z = 0$ . If  $(-C_1 - C_3 + R_1 + R_2 + P) + (C_3 - P)y + (B + T_1 - R_2)z = 0$ , then  $F(x) \equiv 0$ , which means that regardless of the proportion of individuals choosing to have or not to have children, their strategies do not change over time. If  $(-C_1 - C_3 + R_1 + R_2 + P) + (C_3 - P)y + (B + T_1 - R_2)z \neq 0$ , letting  $F(x) = 0$ ,  $x = 0$  and  $x = 1$  are the two stable points of  $x$ . This means that individuals will be stable in their strategy as long as there are no mutating factors changing the strategy choice.

Set  $a = C_3 - P$ , and  $a$  represents the gap between the additional fertility cost and the compensation. Since  $C_3$  is often greater than  $P$ ,  $a > 0$  is set here. The effect of the individuals' strategy choice rate on their stable equilibrium strategy is:

$$\frac{\partial F(x)}{\partial x} = (1 - 2x)[(-C_1 + R_1 + R_2 - a) + ay + (B + T_1 - R_2)z] \quad (10)$$

Letting  $\lambda_{y'} = \frac{(C_1 - R_1 - R_2 + a) + (R_2 - B - T_1)z}{a}$ , when  $y > \lambda_{y'}$ ,  $\left. \frac{\partial F(x)}{\partial x} \right|_{x=1} < 0$ , the individual evolutionary stabilization strategy is  $x^* = 1$ , which means that individuals tend to have children; when  $y < \lambda_{y'}$ ,  $\left. \frac{\partial F(x)}{\partial x} \right|_{x=0} < 0$ , the individual evolutionary stabilization strategy is  $x^* = 0$ , which means that individuals tend to not have children. Letting  $\lambda_{z'} = \frac{(-C_1 + R_1 + R_2 - a) + ay}{R_2 - B - T_1}$ , the value of  $(R_2 - B - T_1)$  would hugely affect the individual evolutionary stability strategy, and the relationship between  $x$  and  $z$  is not significant.

From the analysis above, it is clear that individuals are influenced by the choice of firms but is not significantly related to the choice of local governments.  $x$  increases as  $y$  rises. When firms tend to be maternity friendly, individuals tend to have children. In addition, whether individuals choose to have children is related to the fertility cost  $C_1$ , the fertility revenue  $R_1$ , the revenue of maternity leave extension  $R_2$  and the gap between the additional fertility cost and the compensation  $a$ , as well as the fertility bonus  $B$  and the tax preference  $T_1$ . When  $C_1$  is smaller, and  $R_1$ ,  $R_2$ ,  $B$ ,  $T_1$  and  $a$  are bigger,  $y > \lambda_{y'}$  exists, which means that individuals tend to have children.

### 4.2 Stability Analysis of Firm Strategy Choice

Let  $G(y) = 0$ , getting  $y = 0$ ,  $y = 1$ , and  $(S_1 + S_2) - (C_4 + C_5 - P)x + T_2z + C_5xz = 0$ . If  $(S_1 + S_2) - (C_4 + C_5 - P)x + T_2z + C_5xz = 0$ , then  $G(y) \equiv 0$ , which means that regardless of the proportion of firms choosing to be maternity friendly or maternity discriminatory, their strategies do not change over time. If  $(S_1 + S_2) - (C_4 + C_5 - P)x + T_2z + C_5xz \neq 0$ , letting  $G(y) = 0$ ,  $y = 0$  and  $y = 1$  are the two stable points of  $y$ . This means that firms will be stable in their strategy as long as there are no mutating factors changing the strategy choice.

Since  $C_4$  is often greater than  $P$ ,  $C_4 - P > 0$  is set here. The effect of the firms' strategy choice rate on their stable equilibrium strategy is:

$$\frac{\partial G(y)}{\partial y} = (1 - 2y)[(S_1 + S_2) - (C_4 + C_5 - P)x + T_2z + C_5xz] \quad (11)$$

Letting  $\lambda_{x'} = \frac{(S_1 + S_2) + T_2z}{(C_4 + C_5 - P) - C_5z}$ , when  $x > \lambda_{x'}$ ,  $\left. \frac{\partial G(y)}{\partial y} \right|_{y=0} < 0$ , the firm evolutionary stabilization strategy is  $y^* = 0$ , which means that firms tend to be maternity discriminatory; when  $x < \lambda_{x'}$ ,  $\left. \frac{\partial G(y)}{\partial y} \right|_{y=1} < 0$ , the firm evolutionary stabilization strategy is  $y^* = 1$ , which means that firms tend to

be maternity friendly. Similarly, letting  $\lambda_{z'} = \frac{(C_4 + C_5 - P)x - (S_1 + S_2)}{T_2 + C_5 x}$ , when  $z > \lambda_{z'}$ ,  $\left. \frac{\partial G(y)}{\partial y} \right|_{y=1} < 0$ , the firm evolutionary stabilization strategy is  $y^* = 1$ , which means that firms tend to be maternity friendly; when  $z < \lambda_{z'}$ ,  $\left. \frac{\partial G(y)}{\partial y} \right|_{y=0} < 0$ , the firm evolutionary stabilization strategy is  $y^* = 0$ , which means that firms tend to be maternity discriminatory.

From the analysis above, it is clear that firms are influenced by the choices of individuals and local governments.  $y$  increases as  $x$  decreases and  $z$  rises. When individuals tend not to have children and local governments tend to choose economic policy, firms tend to be maternity friendly. In addition, whether firms choose to be maternity friendly is related to the fertility cost  $C_4$ , the cost of maternity leave extension  $C_5$ , the penalty  $P$  and the tax preference  $T_2$ , as well as the reputation enhancement  $S_1$  and the reputation decline  $S_2$ . When  $C_4$  and  $C_5$  are smaller, and  $P$ ,  $T_2$  and  $(S_1 + S_2)$  are bigger,  $x < \lambda_{x'}$  exists, which means that firms tend to be maternity friendly.

### 4.3 Stability Analysis of Local Government Strategy Choice

Let  $H(z) = 0$ , getting  $z = 0$ ,  $z = 1$ , and  $(G_1 + G_2) - (B + T_1)x - T_2y = 0$ . If  $(G_1 + G_2) - (B + T_1)x - T_2y = 0$ , then  $H(z) \equiv 0$ , which means that regardless of the proportion of local governments choosing economic policy or time policy, their strategies do not change over time. If  $(G_1 + G_2) - (B + T_1)x - T_2y \neq 0$ , letting  $H(z) = 0$ ,  $z = 0$  and  $z = 1$  are the two stable points of  $z$ . This means that local governments will be stable in their strategy as long as there are no mutating factors changing the strategy choice.

The effect of the local governments' strategy choice rate on their stable equilibrium strategy is:

$$\frac{\partial H(z)}{\partial z} = (1 - 2z)[(G_1 + G_2) - (B + T_1)x - T_2y] \quad (12)$$

Letting  $\lambda_{x'} = \frac{(G_1 + G_2) - T_2y}{B + T_1}$ , when  $x > \lambda_{x'}$ ,  $\left. \frac{\partial H(z)}{\partial z} \right|_{z=0} < 0$ , the local government evolutionary stabilization strategy is  $z^* = 0$ , which means that local governments tend to choose time policy; when  $x < \lambda_{x'}$ ,  $\left. \frac{\partial H(z)}{\partial z} \right|_{z=1} < 0$ , the local government evolutionary stabilization strategy is  $z^* = 1$ , which means that local governments tend to choose economic policy. Similarly, letting  $\lambda_{y'} = \frac{(G_1 + G_2) - (B + T_1)x}{T_2}$ , when  $y > \lambda_{y'}$ ,  $\left. \frac{\partial H(z)}{\partial z} \right|_{z=0} < 0$ , the local government evolutionary stabilization strategy is  $z^* = 0$ , which means that local governments tend to choose time policy; when  $y < \lambda_{y'}$ ,  $\left. \frac{\partial H(z)}{\partial z} \right|_{z=1} < 0$ , the local government evolutionary stabilization strategy is  $z^* = 1$ , which means that local governments tend to choose economic policy.

From the analysis above, it is clear that local governments are influenced by the choices of individuals and firms.  $z$  increases as  $x$  and  $y$  decreases. When individuals tend not to have children and firms tend to be maternity discriminatory, local governments tend to choose economic policy. In addition, whether local governments choose economic policy is related to the fertility bonus  $B$ , the tax preferences  $T_1$  and  $T_2$ , as well as the credibility enhancement  $G_1$  and the credibility decline  $G_2$ . When  $B$ ,  $T_1$  and  $T_2$  are smaller, and  $(G_1 + G_2)$  is bigger,  $x < \lambda_{x'}$  exists, which means that local governments tend to choose economic policy.

### 4.4 Evolutionary Equilibrium of Fertility Behavior System

The equilibrium point derived from a single replicated dynamic equation is not necessarily an evolutionary stable strategy for the system. Therefore, the stability of the evolutionary equilibrium point of three parties will be further analyzed in this paper. Here is the Jacobi matrix obtained from the dynamic replication equations of the three parties:

$$J = \begin{bmatrix} J_{11} & J_{12} & J_{13} \\ J_{21} & J_{22} & J_{23} \\ J_{31} & J_{32} & J_{33} \end{bmatrix} = \begin{bmatrix} \frac{\partial F}{\partial x} & \frac{\partial F}{\partial y} & \frac{\partial F}{\partial z} \\ \frac{\partial G}{\partial x} & \frac{\partial G}{\partial y} & \frac{\partial G}{\partial z} \\ \frac{\partial H}{\partial x} & \frac{\partial H}{\partial y} & \frac{\partial H}{\partial z} \end{bmatrix} \quad (13)$$

$$J_{11} = \frac{\partial F}{\partial x} = (1 - 2x)[(-C_1 - C_3 + R_1 + R_2 + P) + (C_3 - P)y + (B + T_1 - R_2)z] \quad (14)$$

$$J_{12} = \frac{\partial F}{\partial y} = x(1 - x)(C_3 - P) \quad (15)$$

$$J_{13} = \frac{\partial F}{\partial z} = x(1 - x)(B + T_1 - R_2) \quad (16)$$

$$J_{21} = \frac{\partial G}{\partial x} = y(1 - y)[-C_4 - C_5 + P + C_5z] \quad (17)$$

$$J_{22} = \frac{\partial G}{\partial y} = (1 - 2y)[(S_1 + S_2) - (C_4 + C_5 - P)x + T_2z + C_5xz] \quad (18)$$

$$J_{23} = \frac{\partial G}{\partial z} = y(1 - y)(T_2 + C_5x) \quad (19)$$

$$J_{31} = \frac{\partial H}{\partial x} = z(1 - z)(-B - T_1) \quad (20)$$

$$J_{32} = \frac{\partial H}{\partial y} = z(1 - z)(-T_2) \quad (21)$$

$$J_{33} = \frac{\partial H}{\partial z} = (1 - 2z)[(G_1 + G_2) - (B + T_1)x - T_2y] \quad (22)$$

From the previous analysis, it is clear that the equilibrium points of the system are:  $E_1(0, 0, 0)$ ,  $E_2(1, 0, 0)$ ,  $E_3(0, 1, 0)$ ,  $E_4(0, 0, 1)$ ,  $E_5(1, 1, 0)$ ,  $E_6(1, 0, 1)$ ,  $E_7(0, 1, 1)$ , and  $E_8(1, 1, 1)$ . Since this paper focuses on explaining how to create a fertility-friendly social environment and promote fertility rate through appropriate family policies, the stability of  $E_5(1, 1, 0)$  and  $E_8(1, 1, 1)$  is mainly analyzed here.

Firstly, here is the situation at  $E_5(1, 1, 0)$ :

$$J = \begin{bmatrix} C_1 - R_1 - R_2 & 0 & 0 \\ 0 & -(S_1 + S_2 - C_4 - C_5 + P) & 0 \\ 0 & 0 & G_1 + G_2 - B - T_1 - T_2 \end{bmatrix} \quad (23)$$

Only when  $C_1 < R_1 + R_2$ ,  $S_1 + S_2 > C_4 + C_5 - P$ , and  $G_1 + G_2 < B + T_1 + T_2$  hold at the same time,  $E_5(1, 1, 0)$  is the evolutionary stabilization strategy of the system. Individuals choose to have children, when the fertility cost  $C_1$  is less than the sum of the fertility revenue  $R_1$  and the revenue of maternity leave extension  $R_2$ . Firms choose to be maternity friendly, when the gap in the impact of a firm's choice on reputation ( $S_1 + S_2$ ) is greater than the increase in cost it brings ( $C_4 + C_5 - P$ ). Local governments choose time policy, when the gap in the impact of a local government's choice on credibility ( $G_1 + G_2$ ) is less than the increase in cost it brings ( $B + T_1 + T_2$ ).

Then, here is the situation at  $E_8(1, 1, 1)$ :

$$J = \begin{bmatrix} C_1 - R_1 - B - T_1 & 0 & 0 \\ 0 & -(S_1 + S_2 - C_4 + P + T_2) & 0 \\ 0 & 0 & -(G_1 + G_2 - B - T_1 - T_2) \end{bmatrix} \quad (24)$$

Only when  $C_1 < R_1 + B + T_1$ ,  $S_1 + S_2 + T_2 > C_4 - P$ , and  $G_1 + G_2 > B + T_1 + T_2$  hold at the same time,  $E_8(1, 1, 1)$  is the evolutionary stabilization strategy of the system. Individuals choose to have children, when the fertility cost  $C_1$  is less than the sum of the fertility revenue  $R_1$  and the economic compensation ( $B + T_1$ ). Firms choose to be maternity friendly, when the sum of the gap in the impact of a firm's choice on reputation ( $S_1 + S_2$ ) and the tax preference  $T_2$  is greater than the increase in cost it brings ( $C_4 - P$ ). Local governments choose economic policy, when the gap in the impact of a local government's choice on credibility ( $G_1 + G_2$ ) is greater than the increase in cost it brings ( $B + T_1 + T_2$ ).

## 5. Conclusion

In the evolution of fertility behavior, there are many factors affecting participants' decisions, and any participant changing its own choice will change the costs and benefits of others, thus affecting their strategic choices. Therefore, when choosing family policies, local governments need to consider all the factors, so as to guide firms to have fertility-friendly attitudes and promote individuals to have children, and thus gradually increase the fertility rate in China.

From the replication dynamic equation of individuals, it is clear that the proportion of local governments' choice does not have a significant effect on individuals' fertility choice. Local governments can only change people's fertility choice by affect their maternity leave extension gain  $R_2$ , fertility reward  $B$  and fertility tax benefit  $T_1$ . The larger  $R_2$ ,  $B$  and  $T_1$  are, the higher proportion of individuals choosing to have children would be. Among these parameters,  $B$  and  $T_1$  can be directly decided by local governments.  $R_2$  is affected by the price level, and it is not possible for local governments to change the price level in China through a single family policy. Thus, economic policies are more feasible than time policies. Therefore, this paper suggests that the government choose economic policies, or a combination of family policies based on economic policies to increase the benefits individuals receive from childbirth and reduce the costs of childbirth by granting fertility bonuses, childcare subsidies, and providing tax benefits to childbearers, so as to promote the increase of fertility.

From the replication dynamic equation of firms, it is clear that economic policies are more helpful for firms to choose fertility-friendly attitudes and create a fertility-friendly social environment. Meanwhile, the larger reputation gap ( $S_1 + S_2$ ), penalty  $P$ , and tax preference  $T_2$  are, the higher proportion of firms choosing to be fertility friendly would be. Among these parameters,  $T_2$  can be directly determined by local governments.  $P$  is related to the probability of employees choosing labor arbitration, and the probability is related to workers' knowledge of labor law and local governments' efforts to popularize the law. The greater probability of labor arbitration is, the greater the penalties would be. ( $S_1 + S_2$ ) is related to social concern about fertility issues and women's rights, and efforts to promote corporate culture. Therefore, this paper suggests that local governments, while choosing economic policies, should strengthen the popularization of labor laws, increase workers' awareness of protecting their legal rights, and make employees dare to engage in labor arbitration, so that the cost of maternity discriminatory firms increases. Local governments can also advocate a maternity-friendly concept in society and offer recognition to maternity-friendly firms, so that making ( $S_1 + S_2$ ) increases, thus increasing the benefits of fertility-friendly firms.

From the replication dynamic equation of local governments, it is clear that when individuals tend not to have children, firms tend to be fertility discriminatory, local governments tend to choose economic policies. Such an analysis is also consistent with the current low fertility rate and negative social perceptions of fertility in China, suggesting that local governments should choose economic policies.

From the Jacobi matrix and the analysis above, it is clear that the equilibrium point  $E_8(1, 1, 1)$  is the evolutionary stabilization strategy of the replication dynamic system, only when  $C_1 < R_1 + B + T_1$ ,  $S_1 + S_2 + T_2 > C_4 - P$ , and  $G_1 + G_2 > B + T_1 + T_2$  hold at the same time. At that point, individuals choose to have children, firms choose to be fertility friendly, and local governments

choose economic policies. Meanwhile, local governments should take a longer-term view, and take social benefits of fertility and future financial resources into account, as well as calculate the benefits in a comprehensive way, so that the system eventually converges to  $E_8(1, 1, 1)$  and achieves the goal of higher fertility rate and a fertility-friendly society.

In the model analysis part, this paper didn't distinguish the gender of individuals, but generally grouping them into one category, ignoring the gender differences in the fertility costs and their effects on fertility decisions, which is a shortcoming of this paper. In future studies, scholars can further refine the groups of individuals to make their research more accurate.

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