Tax Policy and Food Security*

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September 17, 2014

Abstract

We build a two sector (agriculture and manufacturing) heterogenous agent model to analyze the effects of a food subsidy programme on output and employment. The government may finance this subsidy by levying a distortionary income tax or through a tax on manufacturing consumption. We find that in the long run, the subsidy programme increases the output of the food sector but lowers the manufacturing output, independent of the method of its financing. While the price of food crop relative to the price of manufacturing good falls under an income tax regime, it increases under the consumption tax regime. We also determine the welfare effects on the farmer and the entrepreneur under both tax regimes. The programme may have long-run welfare gains for *both* agents only for a certain range of subsidies. However, we find that financing this programme using an indirect consumption tax regime is Pareto superior to a direct income tax regime.

Keywords : Endogenous Growth, Fiscal Policy, Food Security, Welfare

JEL Codes: E2, E62, H29, O00

*We thank Chetan Ghate, Satya P. Das, Bharat Ramaswami, Pulapre Balakrishnan, Amartya Lahiri, Dilip Mookherjee, and participants from the 14th PET Meetings (Seattle) and the Second IGC Summer School 2014 (ISI Delhi) for insightful comments. An earlier version of this paper was titled "On Food Security".

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1 Introduction

Post 2008 world food price shocks, food security concerns have come to the forefront of developmental policy. Policy makers are trying to improve all three aspects of food security – availability of food, access to food and nutritional content of food.

In the period 2000–12, the world population has expanded by 15% (World Development Indicators), which has led to an increase in demand for food. According to FAO database FAOSTAT, during this period, the world production of wheat has grown by 14%, rice by 20%, and meat by 35%. In spite of the world food production outpacing the world population growth, in 2013, about 842 million people (or 12% of the world population) were undernourished (FAO, IFAD, and WFP (2013)). Even though food is available, it seems that either food is not available in a consistent manner or there is lack of access to food.[1]

FAO highlights the status of food security problems in its 2013 report (FAO, IFAD, and WFP (2013)). Between 2000-12, world food prices have risen by 134% (FAOSTAT), which means that economic access to food would not be available to all. Other factors like decline in agricultural investment, higher volatilities in short-run supply and demand, rapidly increasing oil prices, diversions of maize to ethanol production and middlemen hoarding have contributed to people's lack of access to food. Even when there is access to food, the nutritional content of food is a worrisome issue. On one hand the developing world is facing widely prevalent undernourishment and on the other hand the developed nations are fighting obesity problems.

The world economy has laid concrete measures in their millennium development goals (MDGs) to fight food insecurity. For instance, in South Africa, right to food is a constitutional provision and comes under the Bill of Rights. In order to address the issue of food insecurity, the South African government has implemented a number of steps. For instance, since 1999, under the National School Nutrition program (NSNP) the South African government provides meals to children in schools. The government has also instituted a number of social grants that directly target food insecurity, e.g., old age pension funds, disability grants, foster care grants, care dependency grants, and child support grants. Labadarios et al. (2011) finds that though these programs have significantly increased food security in South Africa, many who are eligible for food under the above schemes, are still deviod of access to food due to problems like intra-departmental corruption. As a result, many people in South Africa, especially children, are still unable to meet their minimum nutritional

[1] Around one in eight people in the world are likely to have suffered from chronic hunger, not having enough food for an active and healthy life. The vast majority of hungry people – 827~million of them – live in developing regions, where the prevalence of undernourishment is now estimated at 14.3~percent in 2011-13.(See FAO, IFAD, and WFP (2013))

requirement.

In another case, recently, the Government of India has passed a seminal law named the Right to Food Act. This law aims to provide subsidized food grains to approximately two thirds of India's 1.2 billion people. Under the provisions of the bill, beneficiaries are to be able to purchase 5 kilograms of cereal per month per eligible person. This would significantly improve the nutritional status of the beneficiaries of the program. Pregnant women, lactating mothers, and certain categories of children are eligible for daily free meals. In a country where 40% of children below 5 years of age are undernourished, the intent of this law is to 'meet the domestic demand as well as access, at the individual level, to adequate quantities of food at affordable prices'. This law is probably one of the biggest experiments in the world to provide subsidized food (see The Gazette of India, September, 2013).

On one hand, the Right to Food Act will provide nutrition to the poorer sections of the society who in turn can work more efficiently and contribute positively to the country's GDP. On the other hand, the wealthier sections of the society would be taxed to finance this bill, which may curb investment and long run growth of the economy. The effects of the bill on sectoral outputs are not evident. The effect on prices and welfare of agents is also not very clear.

To analyze this, we build a model of two households and two final goods. The two agents are farmer and entrepreneur who produce crops and machines respectively. We analyze two different tax regimes – a direct tax regime and an indirect tax regime – to finance such a program. Under the direct tax regime, an income tax is levied on the entrepreneur. In India agricultural income is exempted from taxation.[2] So in this model, income tax is levied only on the entrepreneur. Under the indirect tax regime, a consumption tax is imposed on both the farmer and the entrepreneur for consuming the manufacturing goods. In both tax structures, the government fixes a tax rate which balances its budget. The government uses the tax revenue to provide subsidy to both farmer and entrepreneur on their food consumptions. The aim of this paper is to see how this program affects the economy.

We find that in both tax regimes, the subsidy program increases the agriculture output but lowers the manufacturing output in the steady state. Further, while the long run price of food crop relative to the price of manufacturing good declines under an income tax regime, it increases under the consumption tax system.

We also determine the law's welfare effects on the farmer and the entrepreneur. The program has long run welfare gains for both the agents only for a certain range of subsidies.

[2] China abolished agricultural taxes in 2006. In other developing countries like South Africa, Brazil, etc. farmers are subjected to proportional income taxes. However, in these countries taxation of entrepreneurs is a larger and a more significant source of the government's income (see China Internet Information Centre (2005)).

We find that financing this program using an indirect consumption tax regime compared to a direct income tax regime is Pareto improving. On normative grounds, our paper therefore suggests that while such a subsidy program may only have limited gains in a heterogenous agent economy, sharing the tax burden between the two agents – by imposing an indirect tax – to finance the food subsidy program, is Pareto superior.

2 The Baseline Model

We construct a heterogenous agent economy. There are two types of agents – a farmer and an entrepreneur. As in Jiny and Zengz (2007) these agents are household producers. The farmer produces two agricultural goods – food crop and cash crop, while the entrepreneur produces manufacturing goods only. Consumption of manufacturing goods, food, and also leisure provides utility to the agents. Food consumption has an additional role of nutrition and hence is the source of generating labor endowment. This is a novel feature of this paper. Through this, we capture the effect of food subsidy on the production sectors. As food is essential for labor endowment, it affects labor supply and hence sectoral outputs. The cash crop is used only as an intermediate input in the manufacturing goods production. Introduction of cash crop is to highlight the effects of the subsidy program within agriculture sector – it promotes food crop production, but depresses cash crop production.

2.1 The Representative Farmer

The farmer produces – a food crop Q_{at} and a cash crop Q_{ct}. The two crops are produced using fully labor intensive CRS technologies, such that

$$\begin{aligned} Q_{at} &= AL_{at} \\ Q_{ct} &= CL_{ct} \end{aligned} \tag{1}$$

where L_{at} is labor employed in food production and L_{ct} is labor employed in cash crop production. A and C are total factor productivities (TFPs) that augment the production of the two crops. A and C are assumed to be constants.

Labor endowment is endogenous. We assume the following simple function which captures metabolism, i.e., conversion of food to labor units,

$$L_t^F = \begin{cases} 0 & \text{for} \quad X_{at} < 1 \\ 1 - \frac{1}{X_{at}} & \text{for} \quad X_{at} \geq 1 \end{cases} \tag{2}$$

where X_{at} denotes farmer's consumption of food crop.

The labor endowment function, L_t^F, is plotted in Figure (1). L_t^F is a continuous function in X_{at}. For $X_{at} > 1$, labor supply is a strictly increasing and concave in food consumption. $X_{at} = 1$ captures subsistence consumption, below which the agent has no energy to supply labor.

[INSERT FIGURE (1)]

The parametrization of endogenous labor endowment in our model is techncically similar to the functional relationship between food consumption and labor productivity in Bliss and Stern (1978). A similar function for labor productivity is also assumed in Dasgupta and Ray (1986) and Dasgupta (1997). In these paper, the authors assume that all households are endowed with a fixed number of labor hours, however the productivity of these labor hours depends on food consumption. Unlike in this literature, we do not differentiate between labor hours and labor productivity. In this paper the metabolism function is the 'effective' labor hours. An analogous way of interpreting it is as if the agent (in this economy) is endowed with one unit of labor hours and the labor productivity function is of the form L_t^F.

As mentioned before, food consumption has dual purposes, as an input in the labor endowment function and as a utility providing good. In all, the farmer derives utility from three goods: consumption of food, consumption of manufacturing good, and leisure. His utility function is

$$U_t^F = \phi_1 \ln X_{mt} + \phi_2 \ln X_{lt} + (1 - \phi_1 - \phi_2) \ln X_{at}, \quad 0 < \phi_1, \phi_2 < 1 \tag{3}$$

where X_{mt} is his manufacturing good consumption and X_{lt} is units of the labor endowment spent in leisure. His budget is

$$(1 - f_1) p_{at} X_{at} + X_{mt} = p_{at} A L_{at} + p_{ct} C \left(1 - \frac{1}{X_{at}} - L_{at} - X_{lt}\right) \tag{4}$$

where we have assumed that the manufacturing good is the numeraire. p_{at} and p_{ct} denote the price of the food crop and the cash crop respectively. Note we have already used the farmer's full employment condition in the budget constraint by substituting it for employment in cash crop production (L_{ct}) as

$$L_{ct} = L_t^F - L_{at} - X_{lt}.$$

The government extends a per-unit subsidy of f_1 on the farmer's consumption of the food crop. The farmer maximizes his utility (3) subject to its budget (4) by choosing X_{mt}, X_{at}, X_{lt} and L_{at}. The optimization yields

$$X_{at} = \frac{(1-\phi_1-\phi_2)A \pm \sqrt{(1-\phi_1-\phi_2)^2A^2 + 4(1-f_1)(2\phi_1+2\phi_2-1)A}}{2(1-f_1)}, \tag{5}$$

$$X_{mt} = \left(\frac{\phi_1}{1-\phi_1-\phi_2}\right) p_{at}A\left[\frac{X_{at}(1-f_1)}{A} - \frac{1}{X_{at}}\right], \tag{6}$$

$$X_{lt} = \left(\frac{\phi_2}{1-\phi_1-\phi_2}\right)\left[\frac{X_{at}(1-f_1)}{A} - \frac{1}{X_{at}}\right], \tag{7}$$

$$\frac{p_{at}}{p_{ct}} = \frac{C}{A}. \tag{8}$$

From (5), it can be derived that for any positive A, i.e., $A > 0$, the sufficient condition for a real solution of X_{at} is

$$\phi_1 + \phi_2 > \frac{1}{2}. \tag{9}$$

Further, this condition also ensures that there is only one positive solution of X_{at} and hence ensures a unique solution of X_{at}. With this condition we find that the consumption of manufacturing good and leisure are strictly positive (from (6), and (7)). Henceforwards, we assume (9) always holds true.

Proposition 1 *The farmer's food consumption (and hence his total labor) is constant and positively related to his entitled food subsidy.*

We can easily see from (5) that higher the farmer's subsidy, higher would be his food consumption. A greater subsidy provided to the farmer increases his food consumption and hence his labor endowment. This explains why the per-unit subsidy of f_1 on food consumption also acts as 'food security'. To understand this, suppose $f_1 = 0$ and $A = 1/(\phi_1 + \phi_2)$. For these values, $X_{at} = 1$ which implies $L^F_{at} = 0$. Thus at this level of productivity A, the farmer is not eating sufficiently and hence has no labor endowment. Now suppose if the government provides this farmer food subsidy, i.e. $f_1 > 0$. In this case, $X_{at} > 1$ and now the farmer can work in the crops production. By providing subsidy, the farmer can now work as opposed to in the case of no-subsidy when the farmer would not even have existed for the given A. By this logic we say that food subsidy provides food security as the marginalized farmer now gets sufficient food to live and work. In a similar manner, we shall see that food subsidy to the entrepreneur also provides him food security.

2.2 The Representative Entrepreneur

The entrepreneur has the same labor endowment function as the farmer, which is denoted by L_t^E. He employs labor L_{mt}, capital K_t, and the cash crop q_{ct} to produce manufactures using a CRS Cobb-Douglas production function

$$Q_{mt} = ML_{mt}^{\alpha} q_{ct}^{\beta} K_t^{1-\alpha-\beta}. \tag{10}$$

where Q_{mt} is manufacturing output and M is TFP of the manufacturing production. Note, the manufacturing good is the numeraire.

Like the farmer, the entrepreneur is also assumed to be self employed. His felicity function is same as that of the farmer

$$U_t^E = \phi_1 \ln Y_{mt} + \phi_2 \ln Y_{lt}, + (1-\phi_1-\phi_2)\ln Y_{at}, \quad 0 < \phi_1, \phi_2 < 1$$

where Y_{mt} is his manufacturing goods consumption, Y_{lt} denotes the entrepreneur's leisure units, and Y_{at} is the entrepreneur's consumption of the food crop. The entrepreneur spends his after-tax income from sale of manufacturing good on consumption of goods, purchase of cash crops and capital investment. Thus, his budget constraint is

$$\begin{aligned}(1-f_2)p_{at}Y_{at} + Y_{mt} + p_{ct}q_{ct} + K_{t+1} - (1-\delta)K_t = \\ (1-\tau_t) M \left(1 - \frac{1}{Y_{at}} - Y_{lt}\right)^{\alpha} q_{ct}^{\beta} K_t^{1-\alpha-\beta},\end{aligned}$$

where f_2 is the food subsidy given by the government to the entrepreneur. He also pays a proportional tax of τ_t on his income from selling manufactures. We have already used the entrepreneur's full employment condition, i.e. $L_{mt} = L_t^E - Y_{lt}$.

Conditional on this budget, the entrepreneur maximizes his lifetime discounted utility by choosing $\{Y_{at}, Y_{mt}, Y_{lt}, q_{ct}\}_{t=0}^{\infty}$ and $\{K_t\}_{t=1}^{\infty}$. The initial capital stock K_0 is given. The first order conditions yield

$$Y_{lt} = \frac{1 - \frac{1}{Y_{at}}}{1 + \frac{\phi_1 \alpha}{\phi_2} \frac{(1-\tau_t)Q_{mt}}{Y_{mt}}}, \tag{11}$$

$$(Y_{at}-1)\left[Y_{at} - \frac{(1-\phi_1-\phi_2)}{\phi_1(1-f_2)} \frac{Y_{mt}}{p_{at}}\right] = \frac{1}{1-f_2}\left[\frac{\phi_2}{\phi_1}\frac{Y_{mt}}{p_{at}} + \alpha \frac{(1-\tau_t)Q_{mt}}{p_{at}}\right], \tag{12}$$

$$q_{ct} = \frac{\beta(1-\tau_t)Q_{mt}}{p_{ct}}, \tag{13}$$

and the Euler equation

$$\frac{Y_{mt+1}}{Y_{mt}} = \rho\left[1-\delta+(1-\alpha-\beta)\frac{(1-\tau_{t+1})Q_{mt+1}}{K_{t+1}}\right] \tag{14}$$

where ρ is the discount factor.

2.3 Market clearing conditions

The manufacturing and agricultural (i.e., food crop and cash crop) goods market clearing conditions respectively are

$$\begin{aligned} Q_{mt} &= K_{t+1}-(1-\delta)K_t+X_{mt}+Y_{mt} && (15)\\ AL_{at} &= X_{at}+Y_{at} && (16)\\ C\left(1-\frac{1}{X_{at}}-X_{lt}-L_{at}\right) &= q_{ct}. && (17)\end{aligned}$$

Finally, the government balances budget in every time period

$$f_1 p_{at} X_{at} + f_2 p_{at} Y_{at} = \tau_t Q_{mt}. \tag{18}$$

We assume that the beneficiaries are fixed. So f_1 and f_2 are given and the government fixes taxes τ_t to balance its budget.[3]

2.4 Static System

The static system is reduced to the following four equations.

$$\beta(1-\tau_t)\frac{Q_{mt}}{p_{at}} = \left[A\left\{1-\frac{1}{X_{at}}\left(\frac{1-2\phi_2-\phi_1}{1-\phi_1-\phi_2}\right)\right\}-X_{at}\left(\frac{1-\phi_1-\phi_2 f_1}{1-\phi_1-\phi_2}\right)\right]-Y_{at} \tag{19}$$

$$Q_{mt} = M\left[\left(1-\frac{1}{Y_{at}}\right)\frac{\frac{\phi_1\alpha}{\phi_2}\frac{(1-\tau_t)Q_{mt}}{Y_{mt}}}{1+\frac{\phi_1\alpha}{\phi_2}\frac{(1-\tau_t)Q_{mt}}{Y_{mt}}}\right]^{\alpha}\left[\frac{\beta C}{A}\frac{(1-\tau_t)Q_{mt}}{p_{at}}\right]^{\beta}K_t^{1-\alpha-\beta} \tag{20}$$

$$(Y_{at}-1)\left[Y_{at}-\frac{(1-\phi_1-\phi_2)}{\phi_1(1-f_2)}\frac{Y_{mt}}{p_{at}}\right] = \frac{1}{1-f_2}\left[\frac{\phi_2}{\phi_1}\frac{Y_{mt}}{p_{at}}+\alpha\frac{(1-\tau_t)Q_{mt}}{p_{at}}\right]$$

$$\tau_t = \frac{1}{Q_{mt}/p_{at}}\cdot(f_1 X_a + f_2 Y_{at}).$$

[3] In an another extension, we may analyze the case when taxes of the government are predetermined and here the government has the liberty to set the subsidies f_1 or f_2.

We get the first equation from (7), (8),(13), (16) and (17). It is the reduced form of agents food consumption optimization condition and the agricultural goods market clearing conditions. The next equation is derived on substituting the entrepreneur's optimization conditions (11)-(13) into manufacturing production function (10). The last two equations are from entrepreneur's optimization (12) and from government budget (18) respectively. The static system yields

$$Q_{mt} = Q_m(Y_{mt}, K_t), \quad Y_{at} = Y_a(Y_{mt}, K_t), \quad p_{at} = p_a(Y_{mt}, K_t), \quad \tau_t = \tau(Y_{mt}, K_t).$$

There are a couple of points to note here.

1. The explicit form of the aforementioned functions can not be determined.

2. For positive income after-tax income from manufacturing production, i.e. $(1-\tau_t)Q_{mt} > 0$, it is necessary for the $[\cdot]$ term in (19) to be positive. This implies that there is an upper-limit to the food subsidy offered to the farmer.

3. Even though subsidies are fixed in the economy, taxes vary over time.

2.5 Dynamic System

The dynamics of the economy is spelled by Euler equation (14) and the capital accumulation equation (15).

2.6 Steady State

There is no long run growth in our economy. At steady state,

$$Y_{mt} = Y_m^*, \quad K_t = K^*$$

Using this in the dynamic equations (14) and (15), we get

$$Q_{mt} = Y_m^* + \delta K^* + X_{mt} \tag{21a}$$

$$\frac{(1-\tau_t)Q_{mt}}{K^*} = \frac{{}^1/_\rho - 1 + \delta}{1-\alpha-\beta}. \tag{21b}$$

The above equations with the static system solves for the steady state. Closed form solution does not exist. We therefore simulate the model for analyzing the change in macroeconomic variables with change in agents' subsidies.

3 Simulation

3.1 Parameter values

We choose the parameters for our simulation from the Indian economy. We use MOSPI's annual data to calculate the share of employment, α. The average compensation of employees to aggregate GDP ratio for the of period 1999-2008 is used as a proxy for α. This way, we get $\alpha = 0.245$. We assume the share of capital in the manufacturing sector for India $(1 - \alpha - \beta)$ is equal to 0.4 (Ghate et al. (2012)). We therefore get the remainder share of cash crop in the manufacturing sector $\beta = 0.355$. We fix the discount factor for India at $\rho = 0.98$ (see Verma (2012)), and the depreciation rate at $\delta = 0.1$ We calculate ϕ_1, the weightage on utility from consumption of the manufactured output as follows

$$\phi_1 = \left(\frac{S_M}{S_M + S_A}\right) \times \frac{C}{Y},$$

where S_M is the average manufacturing output share of total GDP, S_A is the average agricultural output share of total GDP, and C/Y is the average aggregate consumption to output ratio. We obtain S_M, and S_A from MOSPI's annual data for the of period 1999-2008, and for C/Y we use the quarterly data from the RBI handbook of statistics available from 1998 to 2013 to get $\phi_1 = 0.228$.[4] For ϕ_2,

$$\phi_2 = 1 - \frac{C}{Y}$$

is chosen as a proxy and we find $\phi_2 = 0.43$. As $\sum_{i=1}^{3} \phi_i = 1$, the parameter ϕ_3 is obtained from the residual.

Finally, the productivity parameters are arbitrarily fixed at $A = 100$, $C = 100$, and $M = 100$. Since we are interested in analyzing and comparing the effect of the subsidies f_1 and f_2 with the no food subsidy case, we conduct our numerical experiments in steady state for different values of f_1 and $f_2 \in [0, 1)$.

3.2 Subsidy Effects

Compared to the no food subsidy case, the steady state income tax is positively related to both the subsidies. This is because the government fixes the tax rate for a given pair of farmer's and entrepreneur's subsidies. Hence, higher the subsidies, the government would have to set a higher tax rate $\tau^* = \tau^*(\underset{+}{f_1}, \underset{+}{f_2})$. This is shown in Figure (2).

[4] See Table 164A, Handbook of Statistics on Indian Economy, RBI

[INSERT FIGURE (2)]

3.2.1 Effects on Food Consumption

We know from Proposition (1) that the farmer's consumption of food (X_{at}) is positively related to f_1 and independent of f_2. Further, as shown in Figure (3), X_a^* is strictly higher in the presence of the food subsidy program.

[INSERT FIGURE (3)]

However, for the entrepreneur we observe that in steady state, Y_a^*, i.e., the amount of food consumed by the entrepreneur, is positively related to the subsidy he himself gets and negatively related to the farmer's subsidy. The entrepreneur's food consumption is affected by the subsidy program through two channels. On one hand, a high f_1 and f_2 implies that the entrepreneur has to pay higher taxes. This reduces his after-tax income and hence lowers his consumption of food. On the other hand, a higher f_2 also lowers the effective price the entrepreneur has to pay for consuming the food crop. Our simulations suggest that in the steady state, for the entrepreneur, the latter effect of f_2 dominates the former effect, i.e., $Y_a^* = Y_a^*(\underset{-}{f_1}, \underset{+}{f_2})$. We find for a low f_1 and high f_2 the entrepreneur's food consumption may be higher than the case of no food subsidy program.[5] This is shown in Figure (4).

[INSERT FIGURE (4)]

3.2.2 Effects on Farmer's Production

Since food consumption is one-to-one related with total labor endowment of agents, we find that under this program, the farmer's labor endowment increases unequivocally, while the entrepreneur's labor units increases only for low f_1 and high f_2.

The farmer uses his total labor endowment in production of food crops, cash crops and in leisure. We have already seen from eq. (7) that farmer's leisure is increasing in his subsidy and independent of the entrepreneur's subsidy. We see the same trends in the steady state values of farmer's as shown in Figure (7).

[INSERT FIGURE (7)]

[5] In the case of equal subsidies, i.e. $f_1 = f_2$, the the entrepreneur's food consumption is decreasing in food subsidy. So it is the negative effect of higher taxes which dominates the positive food price effect and the net result is that this program adversely effects Y_a^*. It is important to highlight that if equal subsidies are offered to both agents, then the farmer's food consumption increase but it reduces the entrepreneur's food consumption. In this case, the program provides food security only to the farmer.

We present the food and cash crop employment in figures (5) and (6).

[INSERT FIGURE (5)]
[INSERT FIGURE (6)]

We find that food employment is increasing in both subsidies (Figure 5). We have already seen that farmer's subsidy boosts farmer's food consumption and the entrepreneur's food subsidy has the same effect on the entrepreneur's food consumption. Hence both subsidies raise demand for food and which leads to an increase in the food sector employment, $L_a^* = L_a^*(\underset{+}{f_1}, \underset{+}{f_2})$. In fact, this implies that the employment in the food production is always higher in the presence of food subsidy program.

In terms of cash crop employment, we find that it is decreasing in both subsidies (Figure 6). This is because with higher subsidies, the farmer shifts his productive labor (total labor minus leisure) into food production and away from cash crop production. As a result, $L_c^* = L_c^*(\underset{-}{f_1}, \underset{-}{f_2})$. Our simulations suggest that the food subsidy program adversely affects cash crop employment. Since the food and the cash crop are fully labor intensive, the effect of the food subsidy program on Q_a^* and Q_c^* follow.

3.2.3 Effects on Entrepreneur's Production

The entrepreneur spends his total labor endowment in manufacturing production and leisure. The following Figure (8) shows the effect of the food subsidy program on the entrepreneur's supply of labor towards manufacturing production.

[INSERT FIGURE (8)]

In steady state, we find that $L_m^* = L_m^*(\underset{-}{f_1}, \underset{+}{f_2})$. Our simulations suggest that compared to the no food subsidy case, a higher subsidy to the entrepreneur along with a low subsidy to the farmer could actually increase L_m^*. As implied from Figure (4), the food subsidy program has two effects on the entrepreneur's total labor endowment. A higher f_2 increases the entrepreneur's labor endowment while higher f_1 decreases it because a higher f_1 means higher taxes which lower the entrepreneur's income and therefore the incentive to spend on food. This effect on the total labor endowment extends to the allocation of labor towards L_m^*. The effect is identical for the entrepreneur's leisure (see Figure (9)). In steady state, we get $Y_l^* = Y_l^*(\underset{-}{f_1}, \underset{+}{f_2})$. In steady state, For low subsidies, the entrepreneur's leisure may be higher in the presence of food subsidy.

[INSERT FIGURE (9)]

As stated earlier, higher f_1 and f_2 imply a higher tax, which reduce after-tax income and hence capital accumulation. Thus $K^* = K^*(\underset{-}{f_1}, \underset{-}{f_2})$. The steady state capital in the presence of this food subsidy program is shown in Figure (10).

[INSERT FIGURE (10)]

Hence, the negative effect of the food subsidy program on capital accumulation and the production of cash crops in steady state dominates the possibility of a higher L_m^*, and the net effect is that the subsidy program negatively affects Q_m^*, such that $Q_m^* = Q_m^*(\underset{-}{f_1}, \underset{-}{f_2})$. This is shown in Figure (11).

[INSERT FIGURE (11)]

3.2.4 Effects on Prices

The relative prices of food and cash crop is negatively related to the two subsidies. As we can see from figures (12) and (13), compared to the no food subsidy case, $p_a^* = p_a^*(\underset{-}{f_1}, \underset{-}{f_2})$ and $p_c^* = p_c^*(\underset{-}{f_1}, \underset{-}{f_2})$.

[INSERT FIGURE (12)]
[INSERT FIGURE (13)]

This is because, in steady state, the subsidy program has an overall negative effect on the production of the manufacturing output. On one hand, higher f_1 and f_2 increases income tax on the entrepreneur, which lowers supply of manufacturing good, lowers demand for the cash crop and lowers capital accumulation. On the other hand, the subsidy program increases demand for food crop. Both effects translate into a higher allocation of labor towards food production, which implies higher supply of food crops and price of food relative to price of manufacturing good falls. Thus, both susidies lower p_a^*. Finally, from equation (8), we know that the p_a^* and p_c^* are one-to-one linked. As a result, price of the cash crop also falls in steady state.

3.2.5 Effects on Welfare

The representative farmer and the entrepreneur derive utility from consuming manufacturing good, leisure, and food. In steady state, the representative farmer's per-period utility is given by

$$\Gamma^F = \phi_1 \ln X_m^*(\underset{-}{f_1}, \underset{-}{f_2}) + \phi_2 \ln X_l^*(\underset{+}{f_1}, \underset{0}{f_2}) + (1 - \phi_1 - \phi_2) \ln X_a^*(\underset{+}{f_1}, \underset{0}{f_2}).$$

The effect of the subsidy program on X_m^* is derived from the simulations and shown in Figure (14) . Intuitively, both subsidies adversely affect manufacturing output and also makes manufacturing consumption more expensive as compared to food consumption (as p_a^* falls). Thus, the farmer's demand for manufacturing good declines with higher subsidies.

It is easy to see that f_1 has two opposing effects on farmer's welfare. On one hand, it reduces the manufacturing goods consumption and on the other hand it increases consumption of agricultural good and leisure. We thus find that for any given f_2, there exists an interior value of $f_1 = \hat{f}_1$ where the farmer's welfare is maximized. Further, the farmer's welfare is strictly decreasing in f_2. The farmer's per-period welfare is shown in Figure(16).

[INSERT FIGURE (16)]

Our simulations suggest that low levels of f_2 may actually have a positive effect on the farmer's welfare, compared to the no-subsidy case.

The representative entrepreneur's steady state per-period utility is given by

$$\Gamma^E = \phi_1 \ln Y_m^*(\underset{-}{f_1}, \underset{-}{f_2}) + \phi_2 \ln Y_l^*(\underset{-}{f_1}, \underset{+}{f_2}) + (1 - \phi_1 - \phi_2) \ln Y_a^*(\underset{-}{f_1}, \underset{+}{f_2}).$$

We have derived the effects of the two subsidies on Y_m^* from the simulations as shown in Figure (15). As in the farmer's case, due to increase in relative price of manufacturing good as compared to agricultural good, the entrepreneur reduces manufacturing consumption as subsidies increase. It is clear that f_1 has a negative effect on the entrepreneur's welfare. The entrepreneur's food subsidy f_2 has an adverse effect in the consumption of manufacturing good but it increases leisure and agricultural good consumption. The trend suggests that for any given f_1, there exists an interior value of $f_2 = \hat{f}_2$ where the farmer's welfare is maximized. This is shown in Figure (18). The effect of the subsidy program with respect to f_1 for a given f_2 on the entrepreneur's per-period welfare is shown in Figure (17).

[INSERT FIGURE (17)]
[INSERT FIGURE (18)]

Taking the two agents together, our simulations suggest that low f_1 and f_2 may have a positive effect on the aggregate welfare of the economy, compared to the no-subsidy case. This is shown in Figure(19).

[INSERT FIGURE (19)]

3.3 Economy With Consumption Tax

In this section, we investigate an alternate form of financing the food subsidy program, namely tax on manufacturing consumption. The government taxes the two agents' manufacturing good consumption at a uniform rates τ_{st}. The farmer's utility maximization problem is unchanged, except for the budget constraint. The new budget is

$$(1-f_1)p_{at}^s X_{at}^s + (1+\tau_{st})X_{mt}^s = p_{at}^s A L_{at}^s + p_{ct}^s C\left(1 - \frac{1}{X_{at}^s} - L_{at}^s - X_{lt}^s\right). \tag{22}$$

It is evident that the optimization condition changes only for manufacturing consumption

$$X_{mt}^s = \left(\frac{\phi_1}{1-\phi_1-\phi_2}\right)\frac{p_{at}^s A}{1+\tau_{st}}\left[\frac{X_{at}^s\,(1-f_1)}{A} - \frac{1}{X_{at}^s}\right] \tag{23}$$

and the other conditions remain as in the income tax regime, i.e., (5), (7) and (8). Therefore

$$X_{at} = X_{at}^s, \tag{24}$$

i.e., the farmer's food consumption remains unchanged in both the income tax and the consumption tax regime remain unchanged. As a result, the farmer's total labor endowment L_t^{Fs} and his allocation for leisure, X_{lt}^s, also remains unchanged under both tax regimes, i.e.,

$$L_t^F = 1 - \frac{1}{X_{at}} = 1 - \frac{1}{X_{at}^s} = L_t^{Fs}, \tag{25}$$

$$X_{lt} = X_{lt}^s. \tag{26}$$

Thus,

Proposition 2 *The farmer's food consumption, his total labor endowment and his leisure are unchanged in the income tax and manufacturing consumption tax regime.*

The entrepreneur's problem has been similarly altered in the consumption tax regime. His utility is same but now his manufacturing consumption, instead of income, is taxed. The entrepreneur's new budget is

$$\begin{aligned}(1-f_2)p_{at}^s Y_{at}^s + (1+\tau_{st})\,Y_{mt}^s + p_{ct}^s q_{ct}^s + K_{t+1}^s - (1-\delta)\,K_t^s = \\ M\left(1 - \frac{1}{Y_{at}^s} - Y_{lt}^s\right)^{\alpha}(q_{ct}^s)^{\beta}\,(K_t^s)^{1-\alpha-\beta}.\end{aligned}$$

The first order conditions are

$$
\begin{aligned}
Y_{lt}^{s} &= \frac{1-\frac{1}{Y_{at}^{s}}}{1+\frac{\phi_1\alpha}{\phi_2}\frac{Q_{mt}^{s}}{(1+\tau_{st})Y_{mt}^{s}}}, && (27)\\
\left(Y_{at}^{s}-1\right)\left[Y_{at}^{s}-\frac{(1-\phi_1-\phi_2)}{\phi_1(1-f_2)}\frac{(1+\tau_{st})Y_{mt}^{s}}{p_{at}^{s}}\right] &= \frac{1}{1-f_2}\left[\frac{\phi_2}{\phi_1}\frac{(1+\tau_{st})Y_{mt}^{s}}{p_{at}^{s}}+\alpha\frac{Q_{mt}^{s}}{p_{at}^{s}}\right], && (28)\\
q_{ct}^{s} &= \frac{\beta Q_{mt}^{s}}{p_{ct}^{s}}, && (29)
\end{aligned}
$$

and the Euler equation is

$$
\frac{(1+\tau_{st+1})Y_{mt+1}^{s}}{(1+\tau_{st})Y_{mt}^{s}} = \rho\left[1-\delta+(1-\alpha-\beta)\frac{Q_{mt+1}^{s}}{K_{t+1}^{s}}\right]. \tag{30}
$$

The goods market clearing conditions are unchanged as (15), (16) and (17). Finally, the new government balances budget is

$$
f_1 p_{at}^{s} X_{at}^{s} + f_2 p_{at}^{s} Y_{at}^{s} = \tau_{st}(X_{mt}^{s}+Y_{mt}^{s}). \tag{31}
$$

As before, f_1 and f_2 are given and the government fixes taxes.

3.4 Static System

The economy can be expressed in four equations, which constitute the static system

$$
\begin{aligned}
\beta\frac{Q_{mt}^{s}}{p_{at}^{s}} &= \left[A\left\{1-\frac{1}{X_{at}^{s}}\left(\frac{1-2\phi_2-\phi_1}{1-\phi_1-\phi_2}\right)\right\}-X_{at}^{s}\left(\frac{1-\phi_1-\phi_2 f_1}{1-\phi_1-\phi_2}\right)\right]-Y_{at}^{s} && (32)\\
Q_{mt}^{s} &= M\left[\left(1-\frac{1}{Y_{at}^{s}}\right)\frac{\frac{\phi_1\alpha}{\phi_2}\frac{Q_{mt}^{s}}{(1+\tau_{st})Y_{mt}^{s}}}{1+\frac{\phi_1\alpha}{\phi_2}\frac{Q_{mt}^{s}}{(1+\tau_{st})Y_{mt}^{s}}}\right]^{\alpha}\left[\frac{\beta C}{A}\frac{Q_{mt}^{s}}{p_{at}^{s}}\right]^{\beta}\left[K_t^{s}\right]^{1-\alpha-\beta} && (33)\\
\left(Y_{at}^{s}-1\right)\left[Y_{at}^{s}-\frac{(1-\phi_1-\phi_2)}{\phi_1(1-f_2)}\frac{(1+\tau_{st})Y_{mt}^{s}}{p_{at}^{s}}\right] &= \frac{1}{1-f_2}\left[\frac{\phi_2}{\phi_1}\frac{(1+\tau_{st})Y_{mt}^{s}}{p_{at}^{s}}+\alpha\frac{Q_{mt}^{s}}{p_{at}^{s}}\right]\\
\tau_{st}\left[\left(\frac{\phi_1}{1-\phi_1-\phi_2}\right)\frac{A}{1+\tau_{st}}\left\{\frac{X_{at}^{s}(1-f_1)}{A}-\frac{1}{X_{at}^{s}}\right\}+\frac{Y_{mt}^{s}}{p_{at}^{s}}\right] &= f_1 X_{at}^{s}+f_2 Y_{at}^{s}. && (34)
\end{aligned}
$$

The first equation is the reduced form of the food and cash crop optimization and market clearing conditions. The next equation is derived on substituting the entrepreneur's optimization conditions (27)-(29) into manufacturing production function (10). The last two equations are from entrepreneur's optimization (12) and from government budget (18) respectively. The last equation gives a unique positive consumption tax rate. Note, we already know the value of X_{at}^s from (5). Hence, the static system yields

$$Q_{mt}^s = Q_m^s(Y_{mt}^s, K_t^s), \quad Y_{at}^s = Y_a^s(Y_{mt}^s, K_t^s), \quad p_{at}^s = p_a^s(Y_{mt}^s, K_t^s), \quad \tau_{st} = \tau_s(Y_{mt}^s, K_t^s).$$

3.5 Steady State

The capital accumulation equation (15) and the Euler equation (30) constitute the dynamic equations of the economy. At steady state, the dynamic variables are constant so

$$Y_{mt}^s = Y_m^{s*}, \quad K_t^s = K^{s*}$$

and from the dynamic equations we get

$$Q_m^s = \delta K^{s*} + Y_m^{s*} + X_m^s \tag{35}$$

$$\frac{Q_m^s}{K^{s*}} = \frac{1/\rho - 1 + \delta}{1 - \alpha - \beta}. \tag{36}$$

The above equations with the static system can solve for the steady state. Again, closed form solutions do not exist. However, in steady state, we find that the entrepreneur's consumption of food remains unchanged. This is shown in Lemma (1).

Lemma 1 ***Proposition 3*** *In steady state,* $Y_a^{s*} = Y_a^*$.

Proof. See Appendix ■

Lemma (1) along (24) in steady state implies the farmer's allocation of labor for food production and production of cash crops will be equal. That is,

$$L_a^{s*} = L_a^*, \quad L_c^{s*} = L_c^*.$$

Further, from Lemma (1), eqs. (11) and (27) we get that the entrepreneur's steady state total labor endowment and his allocation towards manufacturing labor and leisure remain unchanged in the two tax regimes. That is,

$$1 - \frac{1}{Y_a^{s*}} = 1 - \frac{1}{Y_a^{s*}}, \quad L_m^{s*} = L_m^*, \quad Y_l^{s*} = Y_l^*.$$

Proposition 4 *In steady state, the sectoral employments (in food crop, cash crop and manufacturing output production) are unchanged in the two tax regimes. Further, the steady state entrepreneur's leisure is unaffected by the tax structures.*

Proof. Discussed above. ■

3.6 Simulation

Using the same parameter values in the income tax regime, we simulate the model to determine long run effects on the economy.

3.6.1 Production Effects

The steady state tax on consumption is positively related to both the subsidies. As shown in Figure (20), compared to the no-subsidy case, the tax on consumption is now much higher. Since the government fixes the tax rate for a given pair of farmer's and entrepreneur's subsidies, higher the subsidies, the government would have to set a higher tax rate $\tau_s^* = \tau_s^*(\underset{+}{f_1}, \underset{+}{f_2})$.

[INSERT FIGURE (20)]

We also find that the tax on consumption is higher in comparison to the income tax, in other words, $\tau_s^* > \tau^*$.

We have already shown that $X_a^{s*} = X_a^*$ and $Y_a^* = Y_a^{s*}$. Hence the food consumption plots are the same as in figures (3) and (4). As discussed, the employments in food crop, cash crop and manufacturing are same as were in the income tax regime. The plots are depicted in figures (5), (6) and (8).

The tax structure affects the manufacturing market. Regarding the steady state levels of capital, the indirect consumption tax regime has two effects. First, it lowers the effective income of the farmer as well as the entrepreneur and this income effect has a negative impact on steady state capital. This effect is also present in the income tax regime. Second, the manufacturing consumption tax makes the consumption of this good more expensive than food consumption and there is an substitution effect away from manufacturing to food consumption. This further depresses steady state capital, as a result

$$K^{s*} = K^{s*}(\underset{-}{f_1}, \underset{-}{f_2}) < K^*.$$

Accumulation of capital in steady state is lower in the consumption tax regime compared to the income tax regime.The steady state capital in the presence of this food subsidy program is shown in Figure (21).

[INSERT FIGURE (21)]

Due to lower capital stock in consumption tax regimes, it follows that $Q_m^{s*} = Q_m^{s*}(\underset{-}{f_1}, \underset{-}{f_2}) < Q_m^*$.[6] This is shown in Figure (22).

[6] $K^{s*} < K^* \Longrightarrow Q_m^{s*} < Q_m^*$ because we know that $L_m^{s*} = L_m^*$ and $q_c^{s*} = q_c^*$

[INSERT FIGURE (22)]

Finally, the other important difference between the income and consumption tax regime is that the relative price of the food crop p_a^* increases for higher f_1 and f_2, i.e., $p_a^{s*} = p_a^{s*}(\underset{+}{f_1}, \underset{+}{f_2})$. This is unlike the income tax regime where $p_a^* = p_a^*(\underset{-}{f_1}, \underset{-}{f_2})$. Since p_c^{s*} is proportional to p_a^{s*}, $p_c^{s*} = p_c^{s*}(\underset{+}{f_1}, \underset{+}{f_2})$. This is shown in figures (23) and (24).

[INSERT FIGURE (23)]
[INSERT FIGURE (24)]

3.6.2 Welfare Effects

As in the income tax regime, the the representative farmer's per-period steady state utility is given by

$$\Gamma^{Fs*} = \phi_1 \ln X_m^{s*}(\underset{-}{f_1}, \underset{-}{f_2}) + \phi_2 \ln X_l^{s*}(\underset{+}{f_1}, \underset{0}{f_2}) + (1 - \phi_1 - \phi_2) \ln X_a^{s*}(\underset{+}{f_1}, \underset{0}{f_2}),$$

and similarly, the representative entrepreneur's steady state per-period utility is given by

$$\Gamma^{Es*} = \phi_1 \ln Y_m^{s*}(\underset{-}{f_1}, \underset{-}{f_2}) + \phi_2 \ln Y_l^{s*}(\underset{+}{f_1}, \underset{0}{f_2}) + (1 - \phi_1 - \phi_2) \ln Y_a^{s*}(\underset{+}{f_1}, \underset{0}{f_2}).$$

Financing the subsidy program using tax on consumption does not qualitatively change the trends of the farmer's and the entrepreneur's welfare. The channels of effects of subsidies are still the same, only the magnitude of the effects have altered. The welfare for farmer and entrepreneur for different subsidies is shown in respective figures (27) and (28). Figure (29) shows that as in the income tax regime, there exists an interior maximum $\widehat{f_2}$ for a given f_1 that maximizes the entrepreneur's welfare.

[INSERT FIGURE (27)]
[INSERT FIGURE (28)]
[INSERT FIGURE (29)]

While the program has long-run welfare gains for the two agents only for a certain range of subsidies, financing this program using an indirect consumption tax regime compared to a direct income tax regime is Pareto improving. As a result, sharing the tax burden, by imposing an indirect tax, is Pareto superior. An interesting normative insight we get from this experiment is that sharing the tax burden – between the farmer and the entrepreneur – via manufacturing consumption tax is beneficial in terms of aggregate welfare. We present the aggregate welfare in Figure (30).

[INSERT FIGURE (30)]

4 Conclusion

Our work is motivated by the recent food security schemes announced across several developing and middle income economies to fulfill their millenium developmental goals. Several economies like India and South Africa have made "Right to Food" as a constitutional act. The objective of our paper was to analyze the effects of a food subsidy program on output and employment. To do this, we build a two sector heterogenous agent model of a famer and an entrepreneur, both of whom are elibigle for a subsidy on food consumption. The novelty of our paper is that food consumption augments the labor endowmment of a representative agent who then decides how to allocate this endowment towards work and leisure.

We then assume two different tax regimes The government may finance this subsidy by levying a distortionary income tax or through a tax on manufacturing consumption. In the long run, the subsidy program increases the output of the food sector but lowers the manufacturing output, independent of the method of its financing. While the price of food crop relative to the price of manufacturing good falls under an income tax regime, it increases under the consumption tax regime.

We also determine the welfare effects of the food subsidy program on the farmer and the entrepreneur under both tax regimes. The program may have long-run welfare gains for the two agents only for a certain range of subsidies. However, financing this program using an indirect consumption tax regime is Pareto superior to a direct income tax regime.

This is work in progress. Future work can extend this framework by adding public debt as an alternative source of financing the subsidy program. We may also extend our model by allowing for international trade.

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Appendix

Proof of Lemma (1)

As the tax regimes does not differentially affect the farmer's optimization conditions, so from eqs. (19) and (32) we get that if $Y_{at} = Y_{at}^{s}$, then $(1-\tau_t)Q_{mt}/p_{at} = Q_{mt}^{s}/p_{at}^{s}$. This implies that the respective implicit functions are equal

$$[1-\tau(Y_{at})]\cdot Q_{mt}(Y_{at})/p_{at}(Y_{at}) = Q_{mt}^{s}(Y_{at}^{s})/p_{at}^{s}(Y_{at}^{s}). \tag{37}$$

In steady state of the income tax regime, using (18), (21a) and (21b) we get

$$\begin{aligned}\frac{Y_m^*}{p_a^*} &= f_1 X_a^* + f_2 Y_a^* + \left(\frac{{}^1\!/_\rho - 1 + \delta}{1-\alpha-\beta} - \delta\right)\left(\frac{1-\alpha-\beta}{{}^1\!/_\rho - 1+\delta}\right)\frac{(1-\tau^*)\,Q_m^{s*}}{p_a^{s*}} \\ &\quad - \left(\frac{\phi_1}{1-\phi_1-\phi_2}\right) A\left\{\frac{X_a^{s*}(1-f_1)}{A} - \frac{1}{X_a^{s*}}\right\},\end{aligned} \tag{38}$$

and similarly in the consumption tax regime using (34) , (36), and (35), we get

$$\begin{aligned}(1+\tau_s^*)\,\frac{Y_m^{s*}}{p_a^{s*}} &= f_1 X_a^{s*} + f_2 Y_a^{s*} + \left(\frac{{}^1\!/_\rho - 1 + \delta}{1-\alpha-\beta} - \delta\right)\left(\frac{1-\alpha-\beta}{{}^1\!/_\rho - 1+\delta}\right)\frac{Q_m^{s*}}{p_a^{s*}} \\ &\quad - \left(\frac{\phi_1}{1-\phi_1-\phi_2}\right) A\left\{\frac{X_a^{s*}(1-f_1)}{A} - \frac{1}{X_a^{s*}}\right\}.\end{aligned} \tag{39}$$

As $X_a^* = X_a^{s*}$ and together with (37), (38) and (**??**) we get

$$Y_m(Y_a^*)/p_a(Y_a^*) = [1+\tau^s(Y_a^{s*})]\cdot Y_m^s(Y_a^{s*})/p_a^s(Y_a^{s*}). \tag{40}$$

Substituting (37), (40) in the entrepreneur's food optimization condition (12) and (28) we get that in steady state

$$Y_a^* = Y_a^{s*}.$$

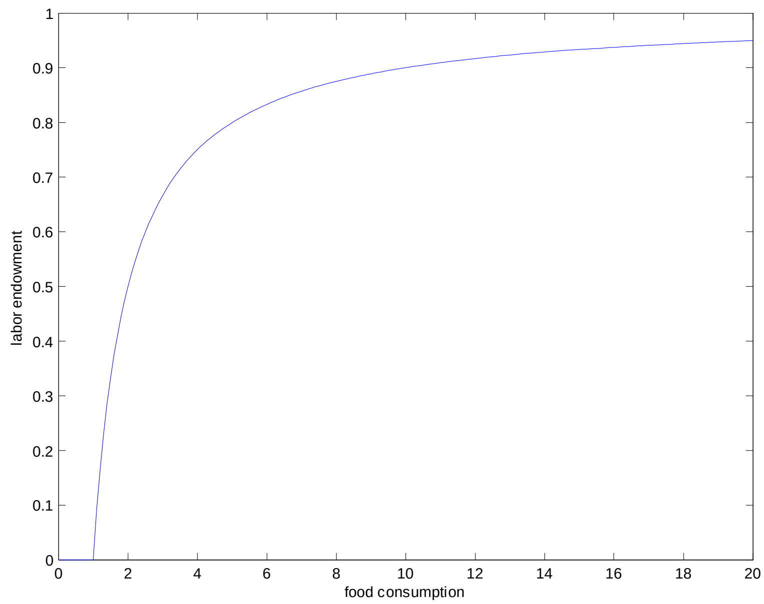

Figure 1: Metabolism Function

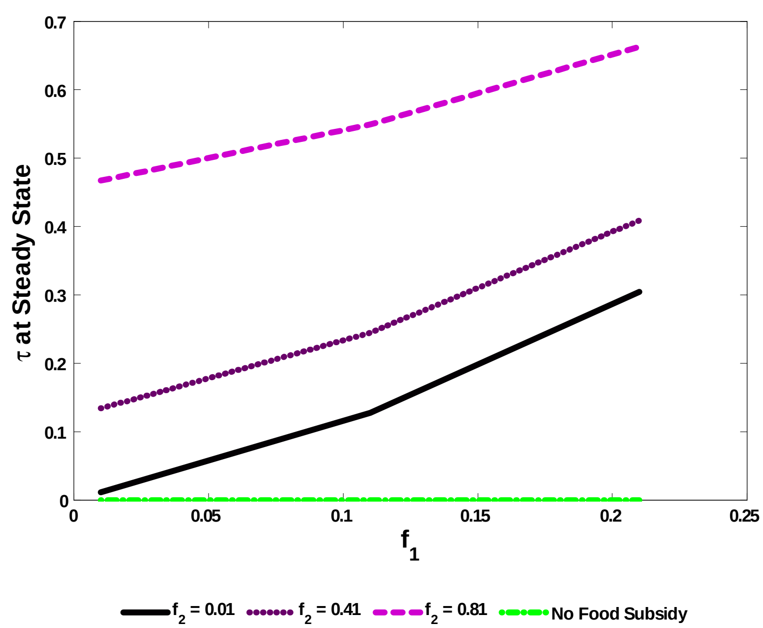

Figure 2: The effect of the food subsidy program on τ^*

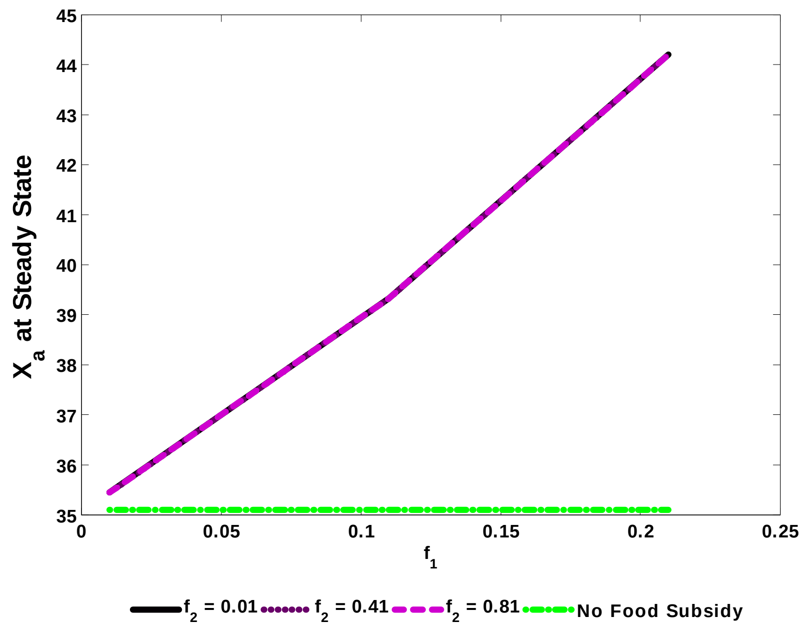

Figure 3: The effect of the food subsidy program on X_a^*

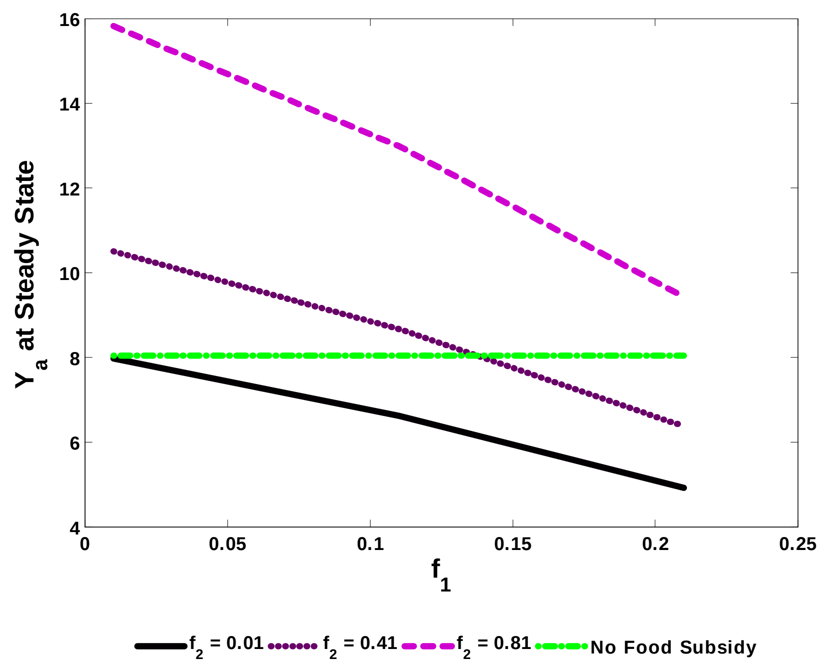

Figure 4: The effect of the food subsidy program on Y_a^*

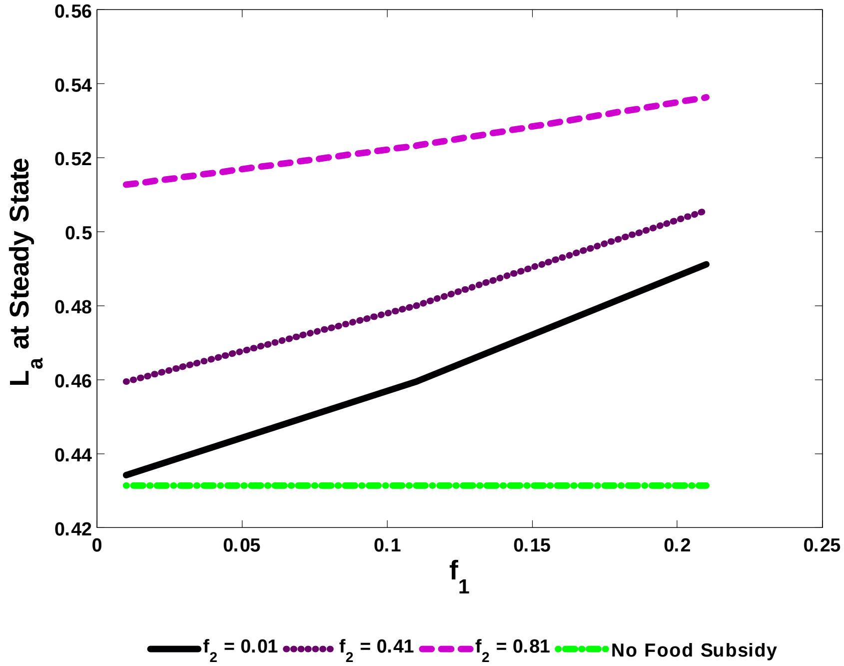

Figure 5: The effect of the food subsidy program on L_a^*

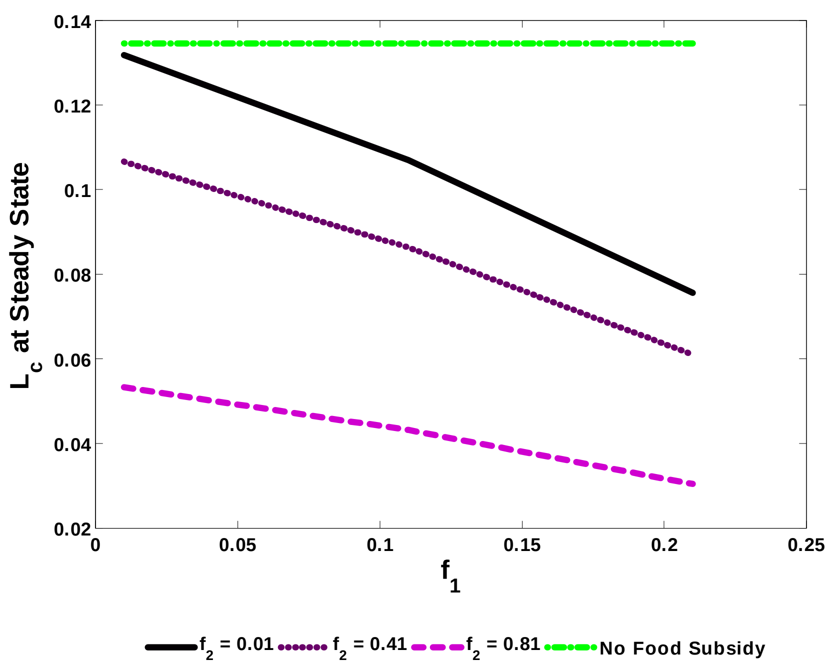

Figure 6: The effect of the food subsidy program on L_c^*

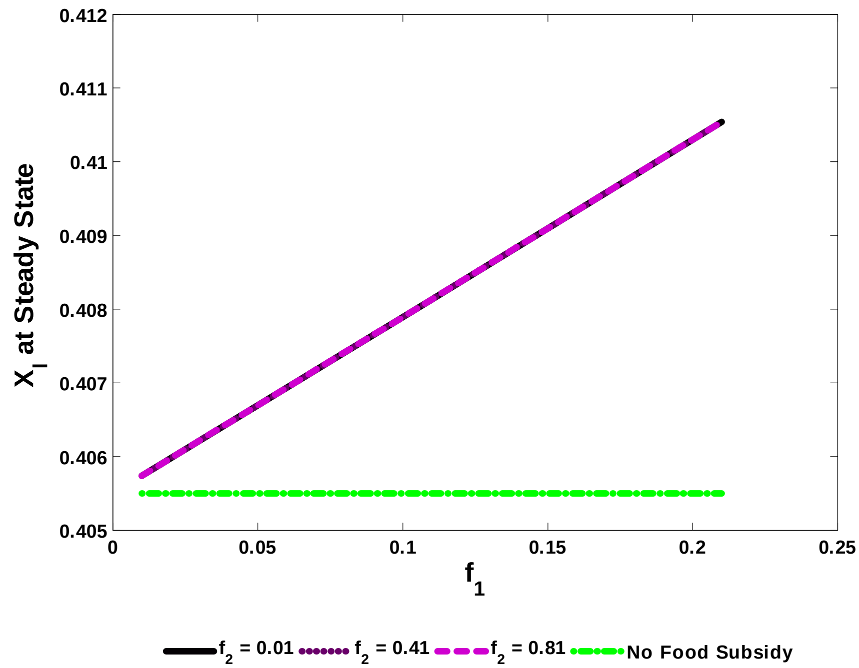

Figure 7: The effect of the food subsidy program on X_l^*

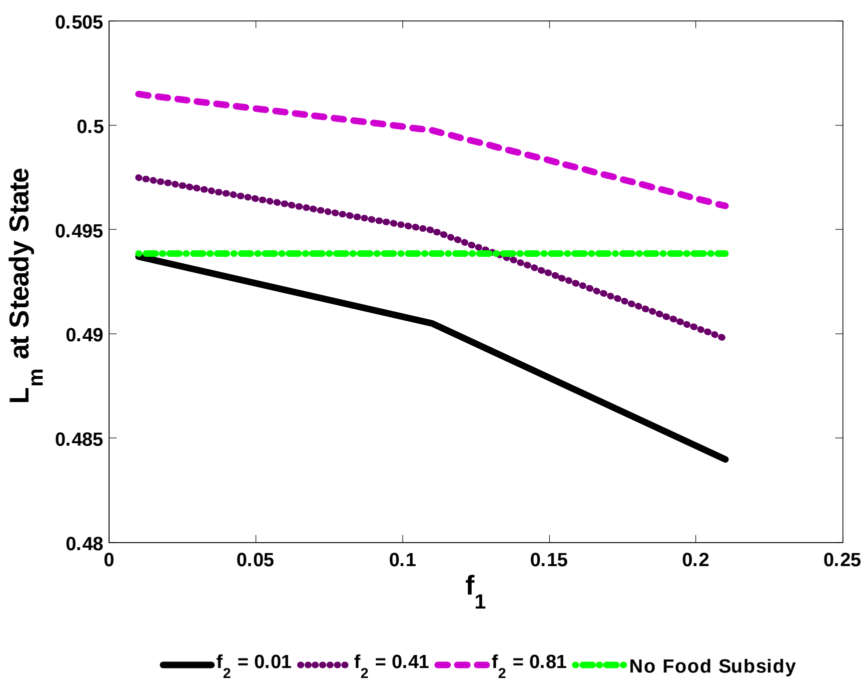

Figure 8: The effect of the food subsidy program on L_m^*

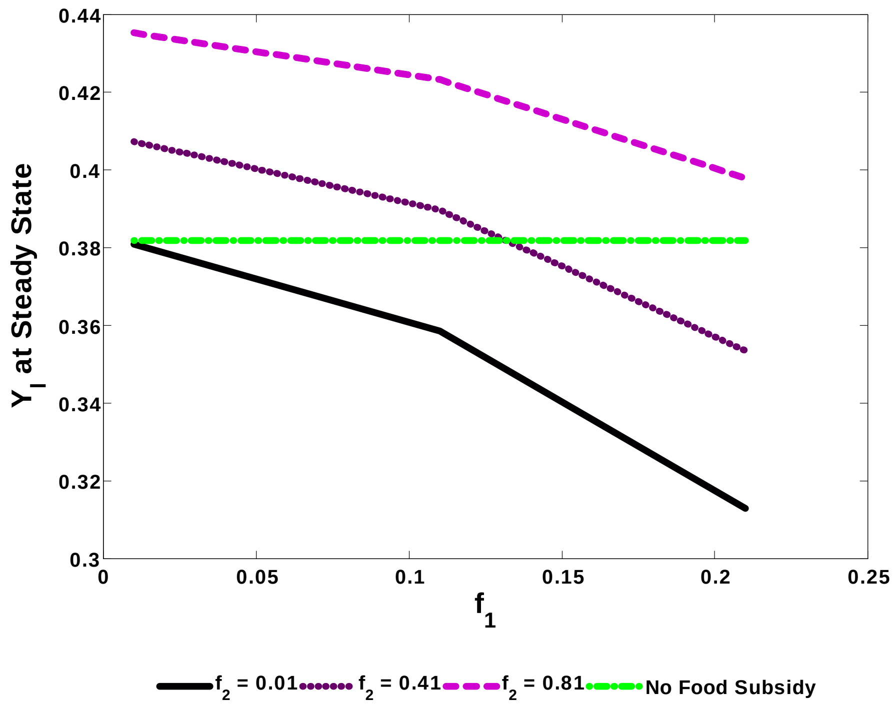

Figure 9: The effect of the food subsidy program on Y_l^*

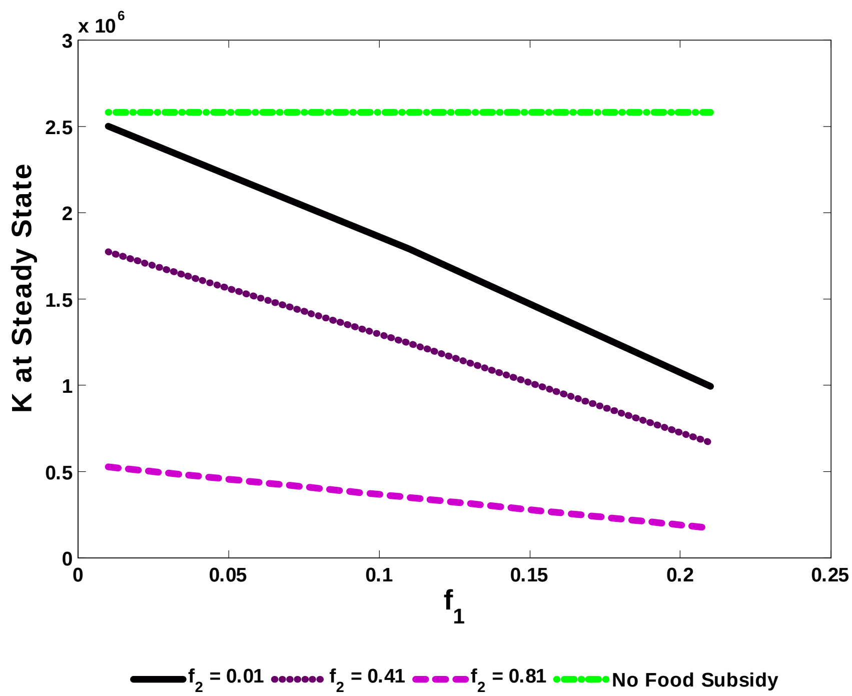

Figure 10: The effect of the food subsidy program on K^*

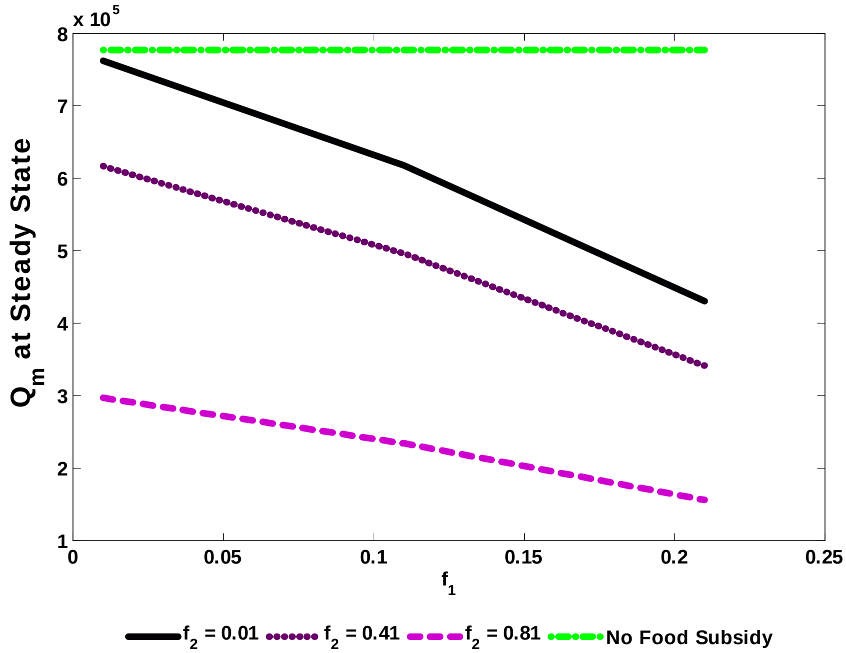

Figure 11: The effect of the food subsidy program on Q_m^*

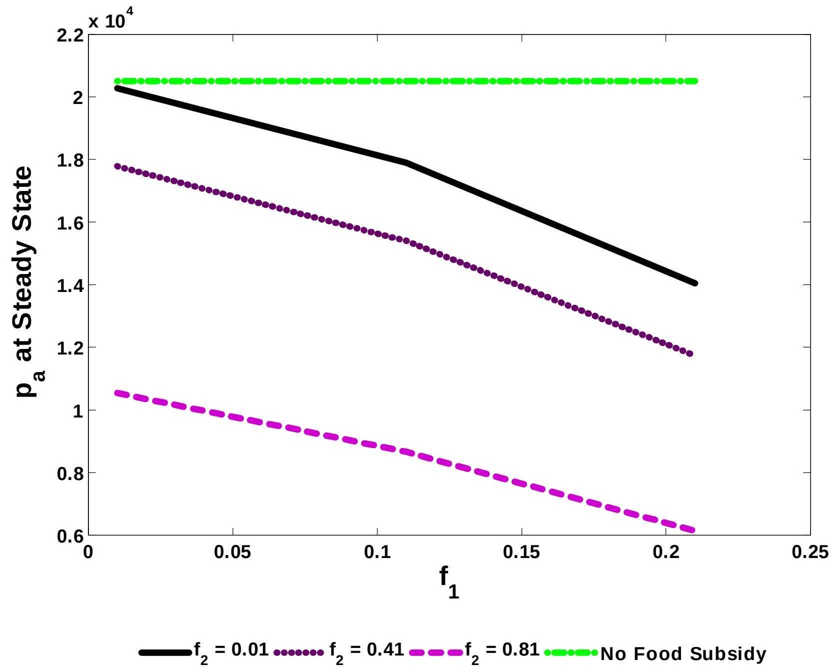

Figure 12: The effect of the food subsidy program on p_a^*

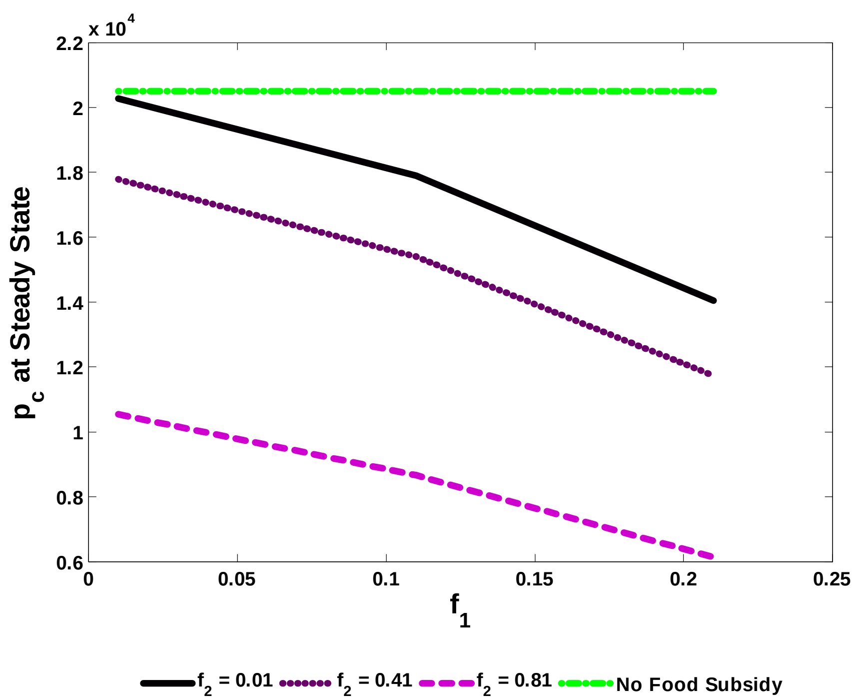

Figure 13: The effect of the food subsidy program on p_c^*

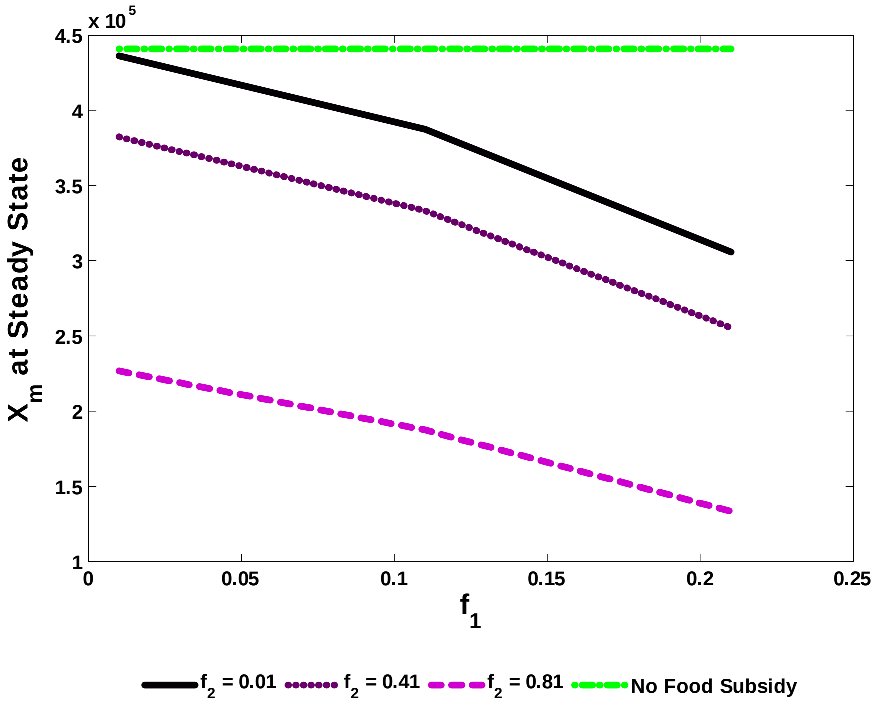

Figure 14: The effect of the food subsidy program on X_m^*

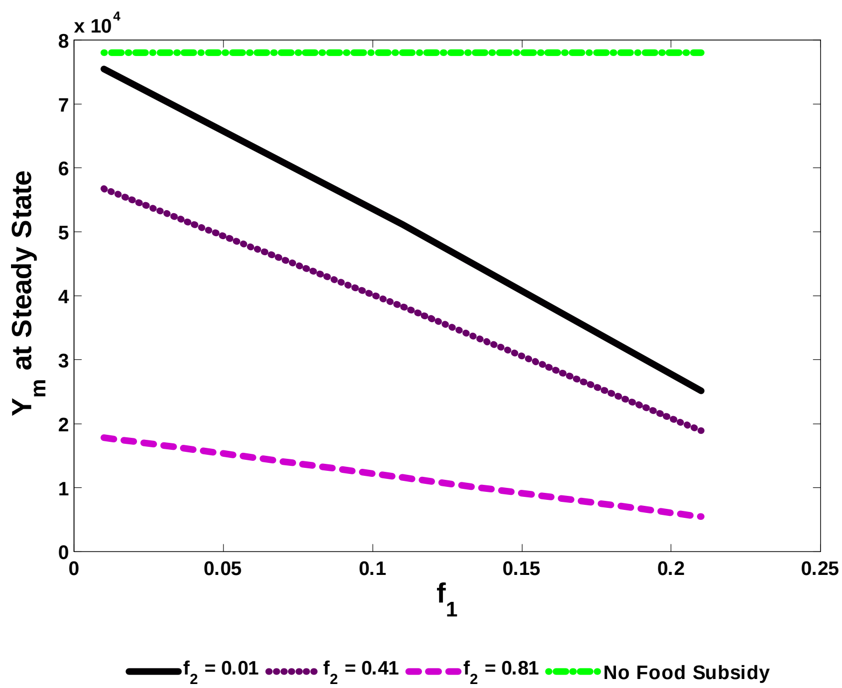

Figure 15: The effect of the food subsidy program on Y_m^*

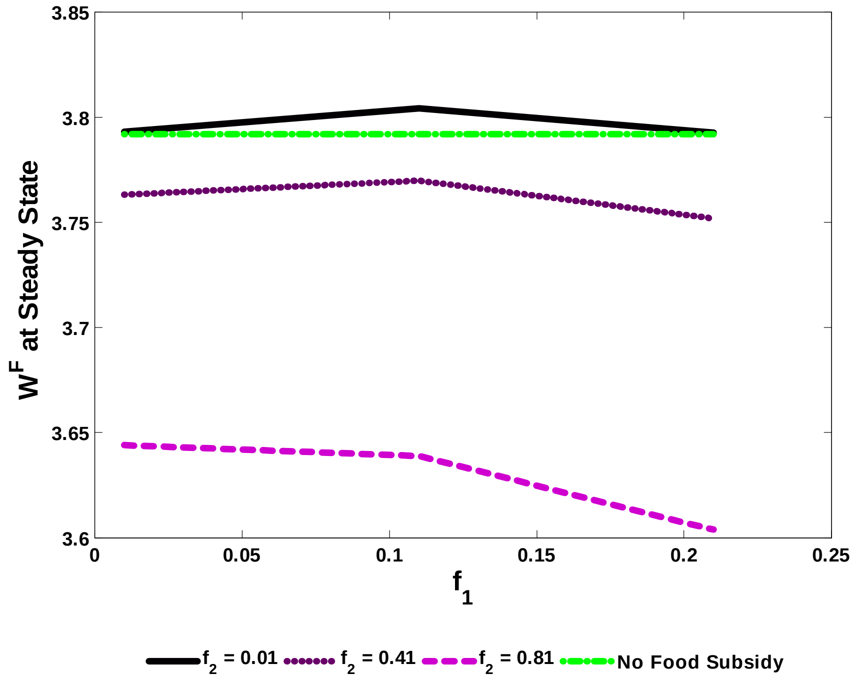

Figure 16: The effect of the food subsidy program on W^{F*}

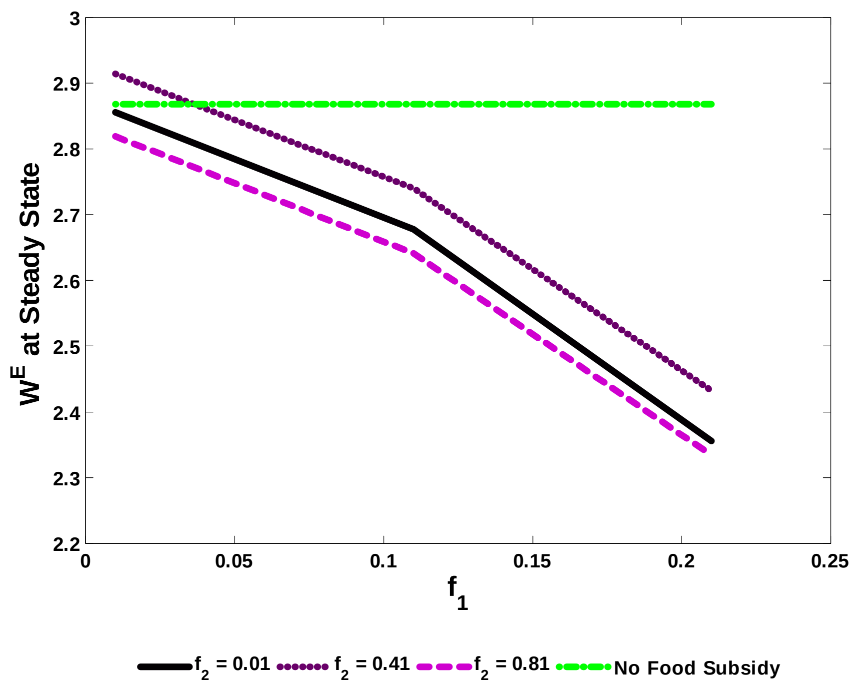

Figure 17: The effect of the food subsidy program on W^{E*}

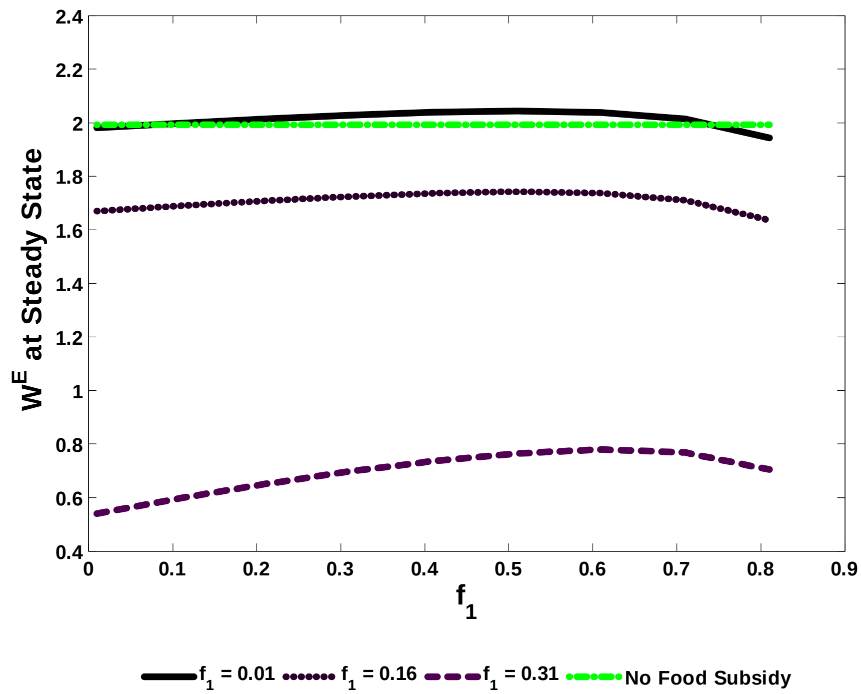

Figure 18: The effect of changing f_2 for a given f_1 on W^{E*}

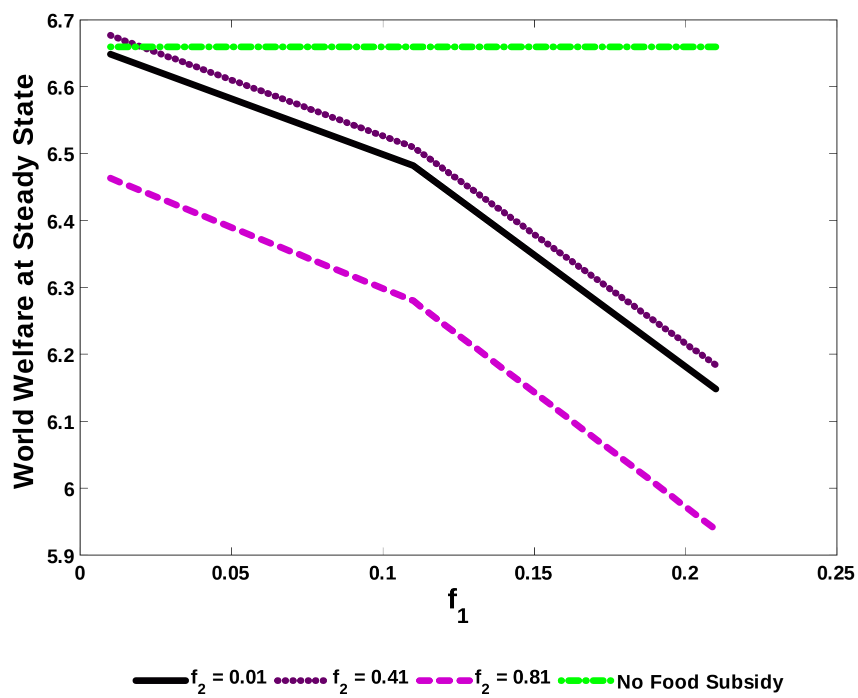

Figure 19: The effect of the subsidy program on W^{O*}

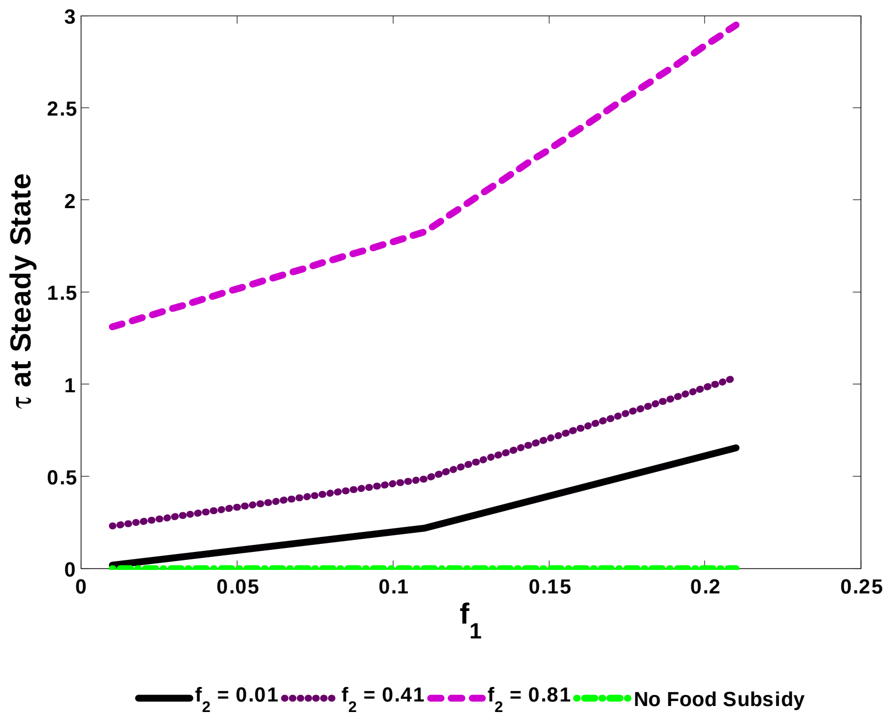

Figure 20: The effect of the subsidy programme on τ_s^*

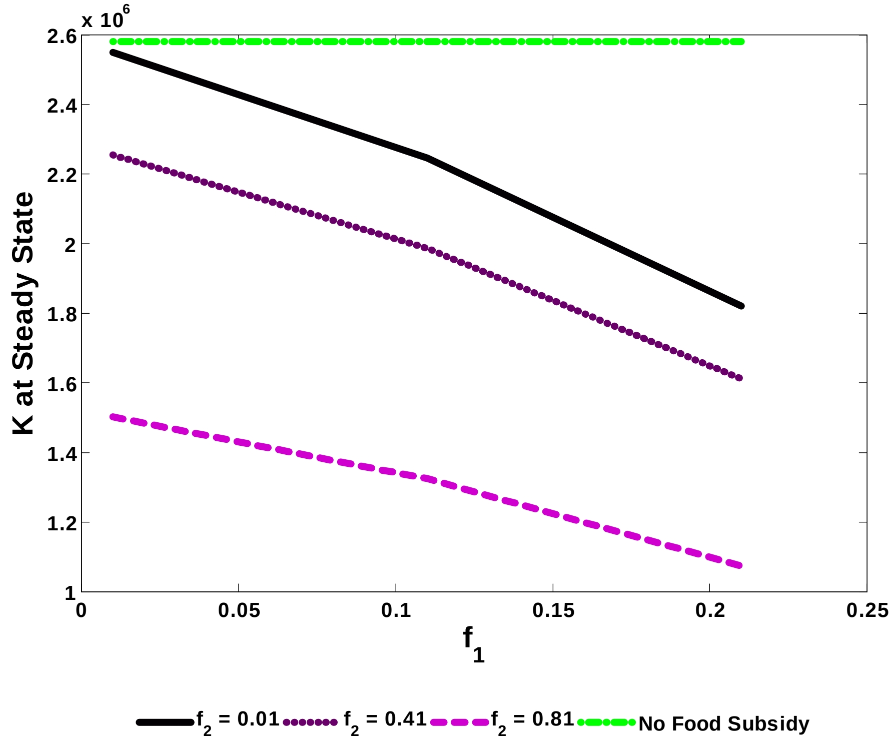

Figure 21: The effect of the subsidy programme on K^{s*}

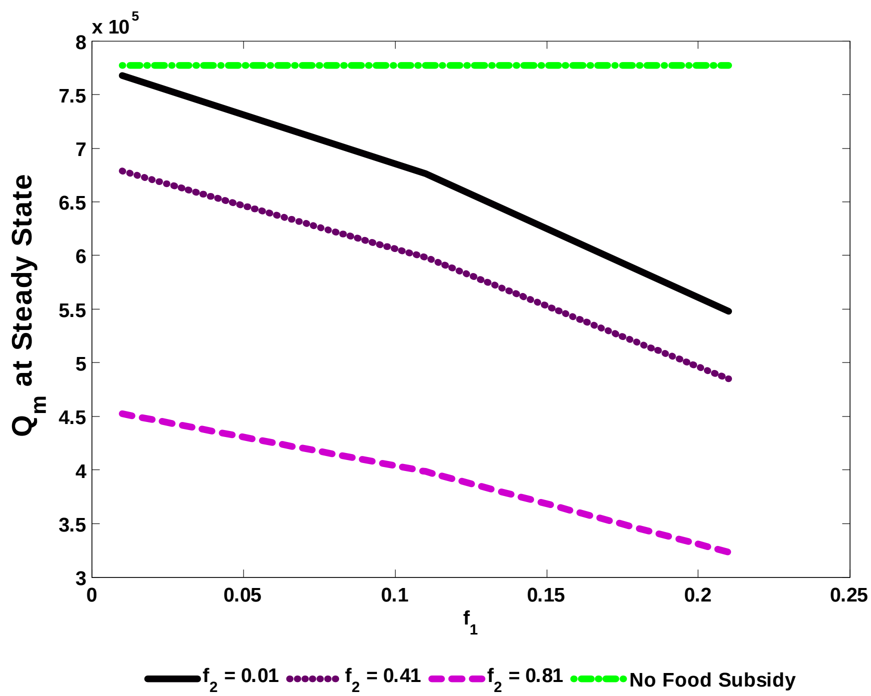

Figure 22: The effect of the subsidy programme on Q_m^{s*}

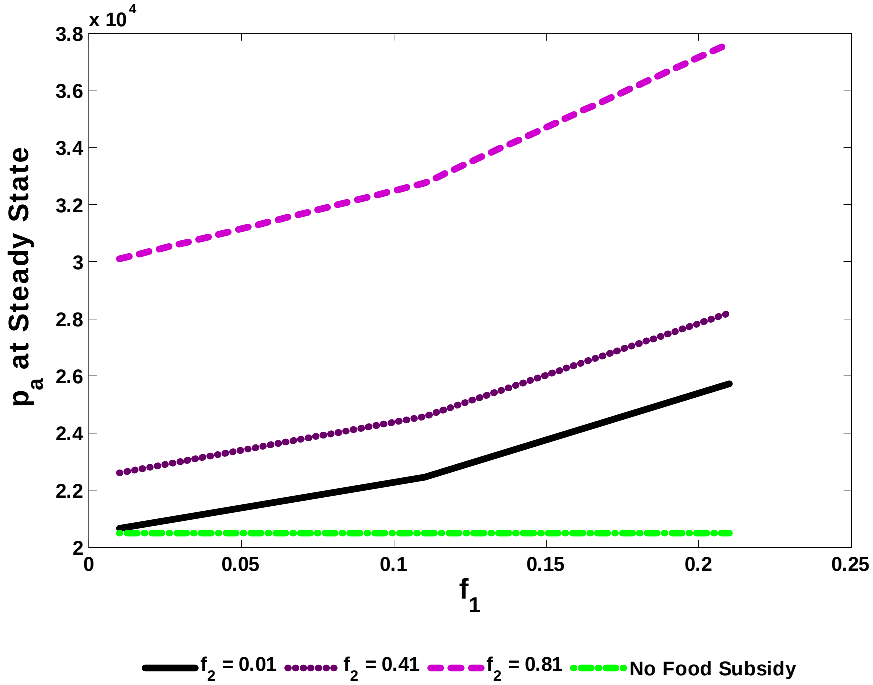

Figure 23: The effect of the subsidy programme on p_a^{s*}

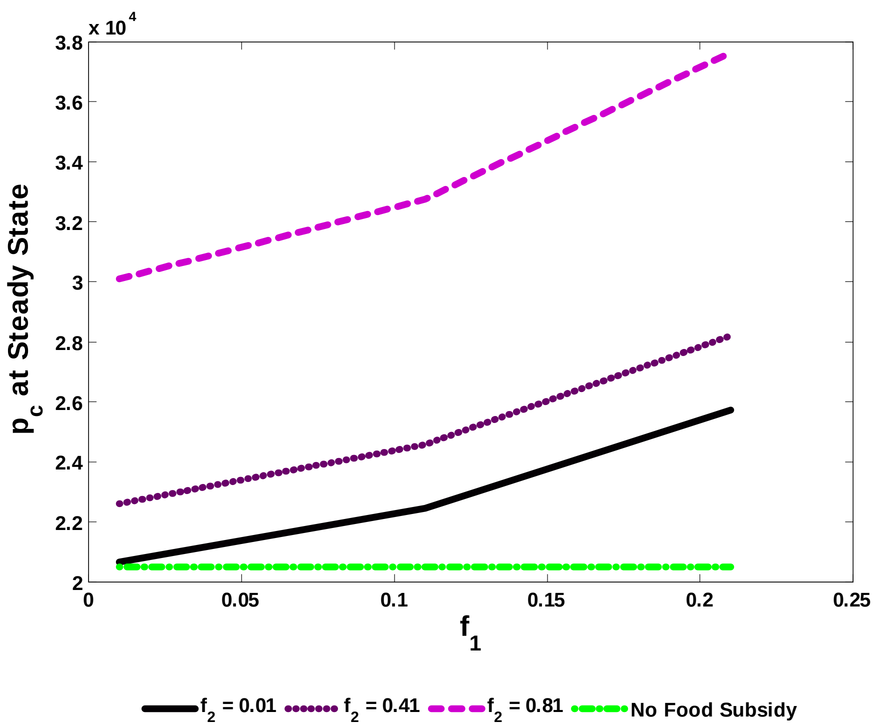

Figure 24: The effect of the subsidy programme on p_c^{s*}

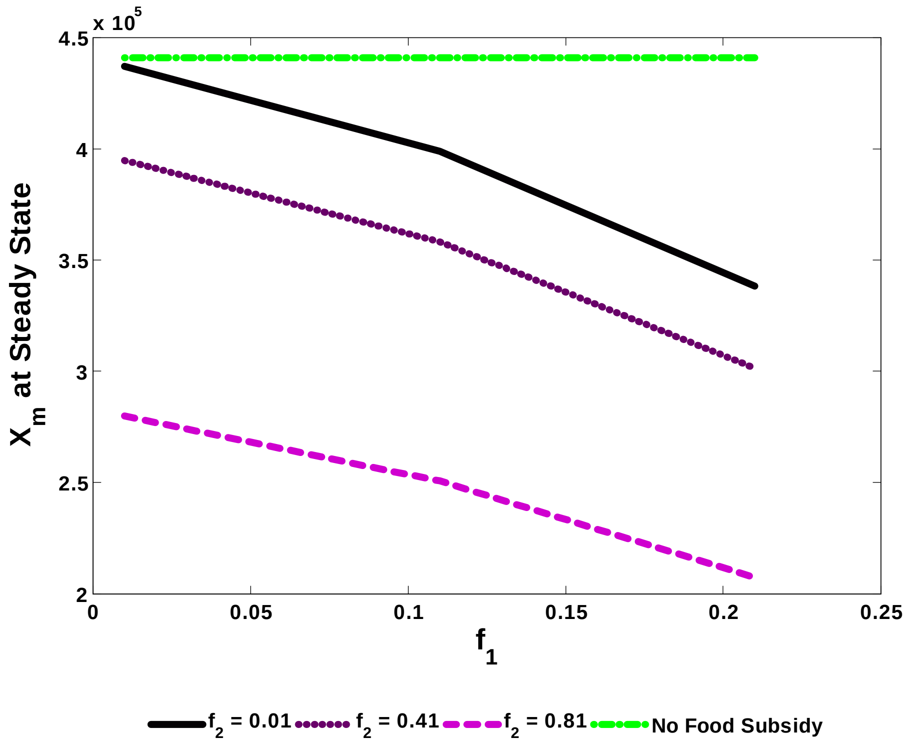

Figure 25: The effect of the subsidy programme on X_m^{s*}

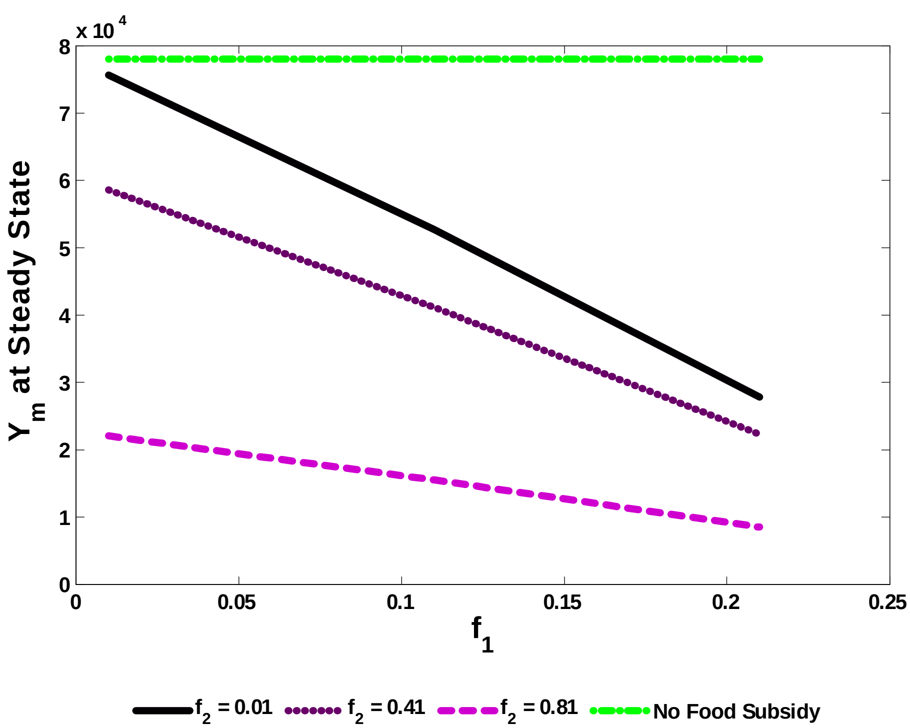

Figure 26: The effect of the subsidy programme on Y_m^{s*}

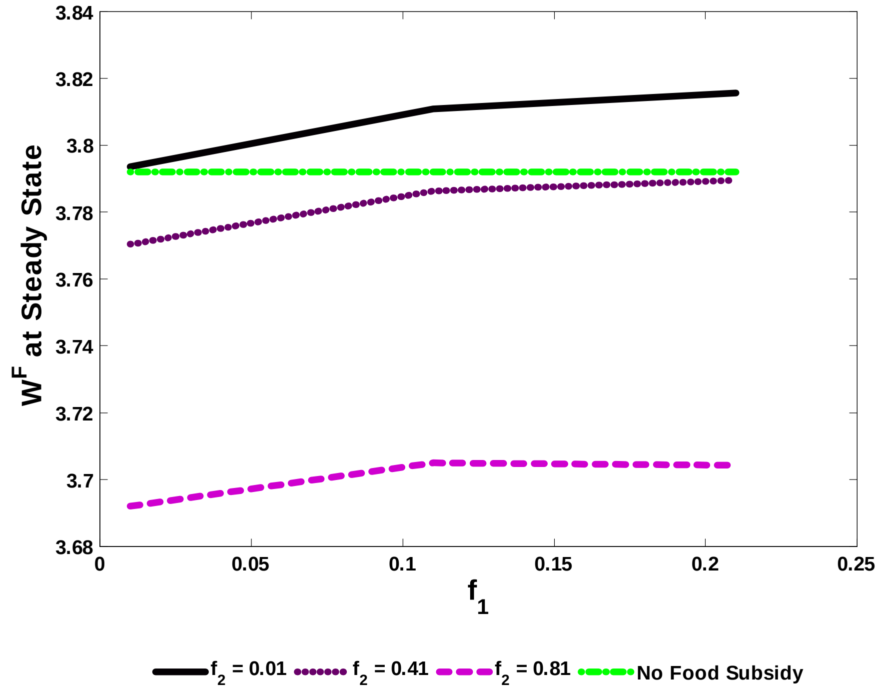

Figure 27: The effect of the subsidy programme on W^{sF*}

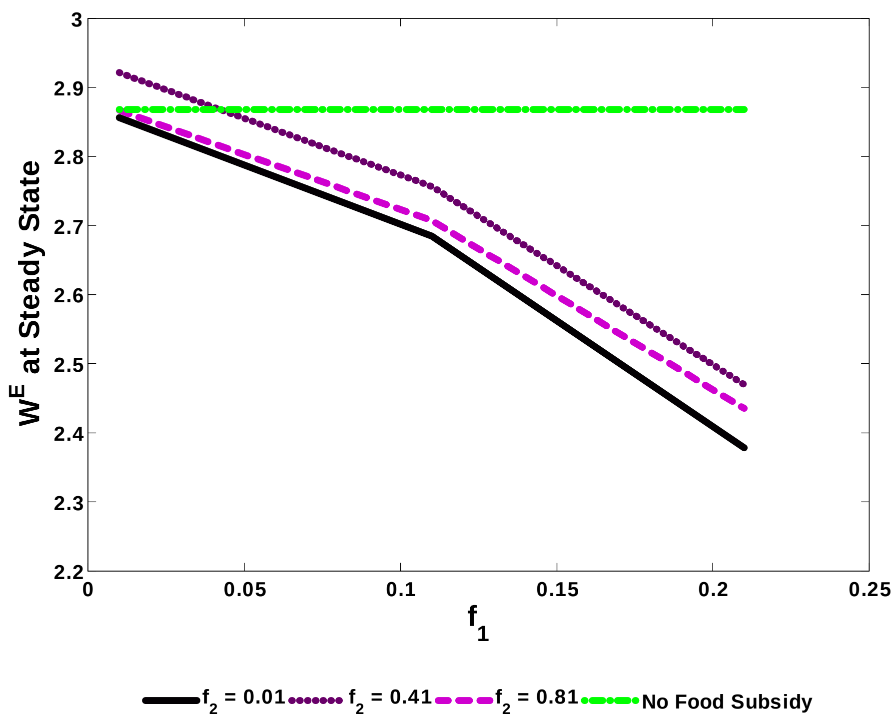

Figure 28: The effect of the subsidy programme on W^{sE*}

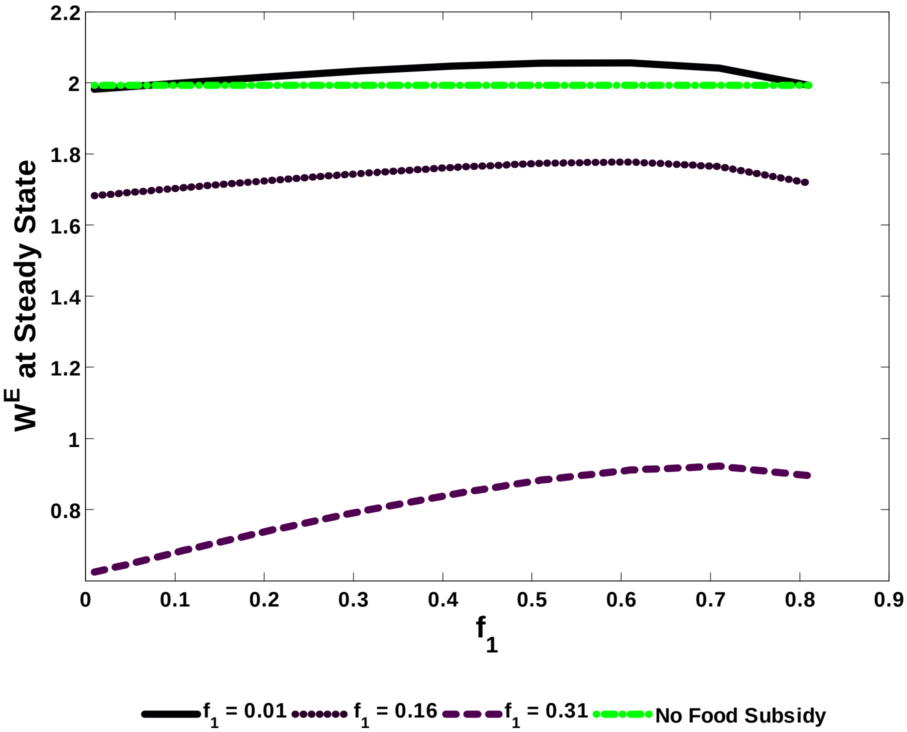

Figure 29: The effect of changing f_2 for a given f_1 on W^{sE*}

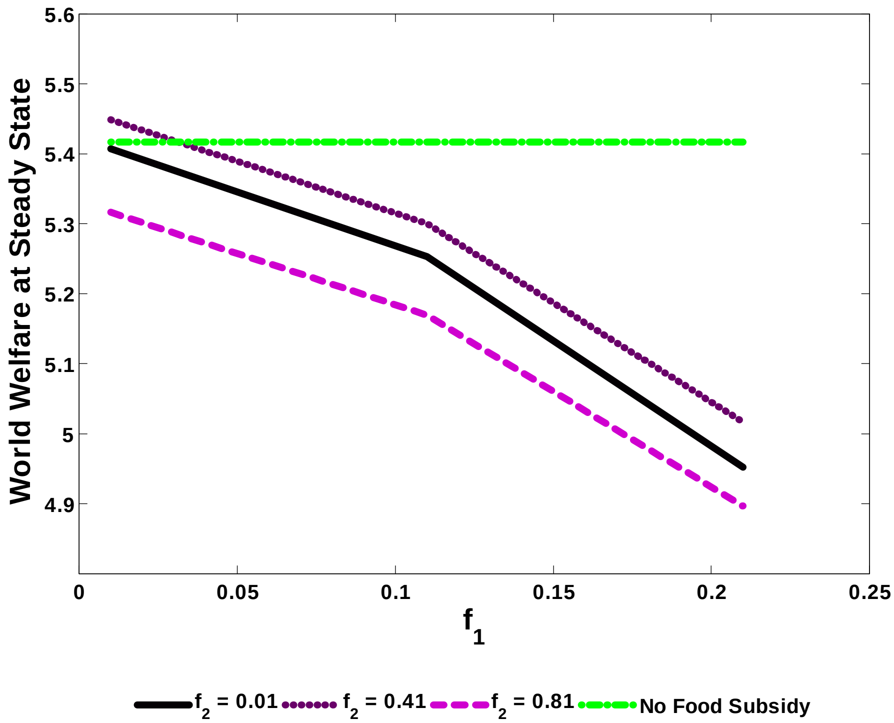

Figure 30: The effect of the subsidy programme on W^{sO*}

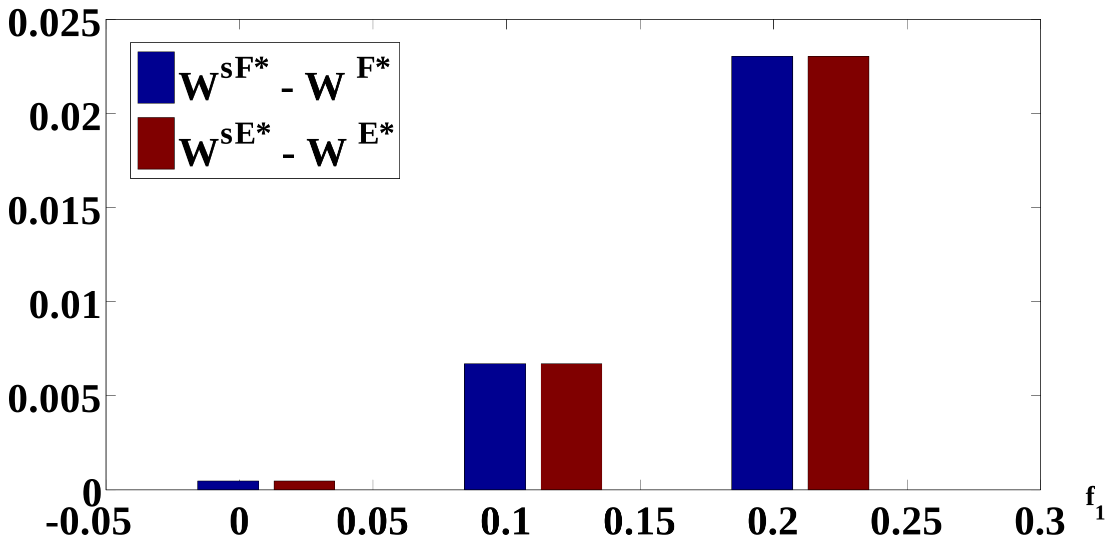

Figure 31: Welfare gains between the two tax regimes ($f_2 = 0.01$)

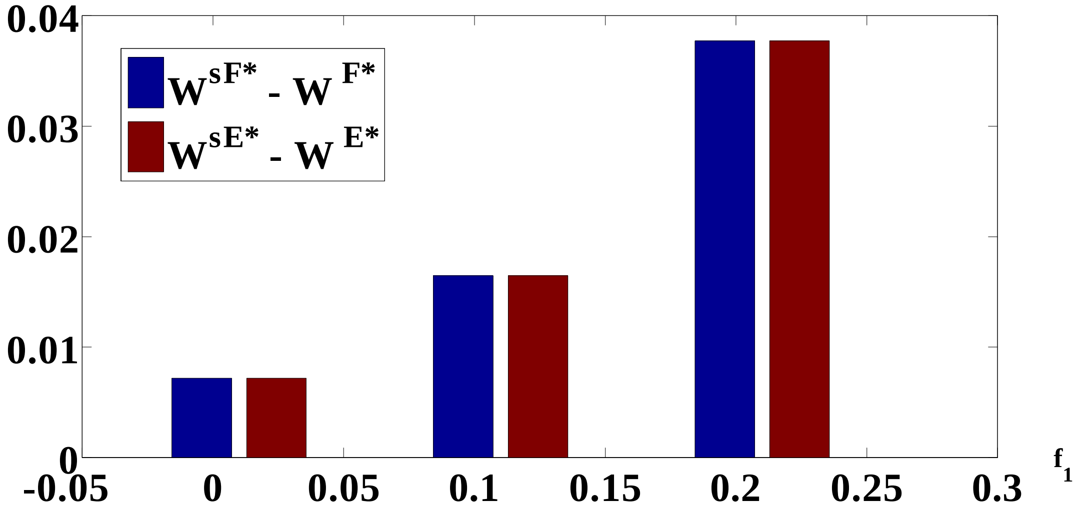

Figure 32: Welfare gains between the two tax regimes ($f_2 = 0.41$)

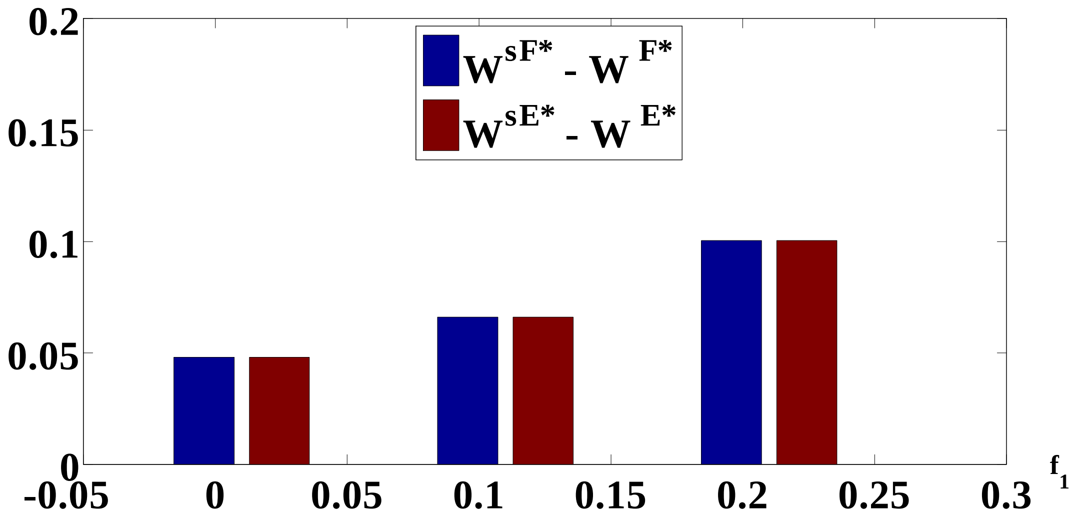

Figure 33: Welfare gains between the two tax regimes ($f_2 = 0.81$)