Tax Policy and Food Security

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10 February 2015

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February 10, 2015

Abstract

We build a two sector (agriculture and manufacturing) heterogenous agent model to analyze the effects of a food subsidy program on output and prices. The government may finance this subsidy by levying a distortionary income tax or a tax on manufacturing consumption. We find that in the long run the program increases the food output but lowers the manufacturing output, in both methods of its financing. While the price of food crop relative to the price of manufacturing good falls with subsidies in the income tax regime, the effect is opposite in the consumption tax regime. We also find that the food subsidy program may have long-run welfare gains for the two agents, but only for a certain range of subsidies. However, our simulations suggest that there is no subsidies which benefit both agents at the same time. Further, financing this program using an indirect consumption tax is a Pareto improvement over the direct income tax regime.

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

JEL Codes: E2, E62, H29, O00

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*We thank Chetan Ghate, Satya P. Das, Bharat Ramaswami, Pulapre Balakrishnan, Amartya Lahiri, Dilip Mookherjee, Gopal Naik and participants from the 14th PET Meetings (Seattle), the 10th Annual Conference on Economic Growth and Development (ISI Delhi), and the 2014 IMR Doctoral Conference (IIM Bangalore) 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. In the period 2000–12, even though the world food production outpaced the world population growth (wheat grew at an annualized rate of 1.05%, rice by 1.45%, and meat by 2.12% while the world population grew by 1.11%), in 2013 about 12% of the world population was undernourished (FAO, IFAD, and WFP (2013)). Despite the fact that food is available, it seems that either food is not available in a consistent manner or some people lack access to food.[1]

The FAO 2013 report (FAO, IFAD, and WFP (2013)) highlights problems in all three aspects of food security – food affordability, access to food and its nutritional content. In the period 2000-12, world real food prices rose by 4.37% annually (FAOSTAT database), which means that food was not affordable by the marginalized sections of the society. 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 the one hand the developing world is facing widely prevalent undernourishment and on the other hand the developed nations are fighting obesity problems.

Policy makers across the world have taken concrete measures to combat food insecurity. The United Nations World Food Programme has several projects aimed at improving access to nutritious food for people living in developing countries, like food e-vouchers and vouchers, cash and food for work, improving food logistics, connecting farmers to market, to name a few (World Food Programme (2013)). Several countries have laid constitutional and legal protection to the human right to food (Knuth and Vidar (2011)). Recently, India joined the existing group of nine countries[2] to provide its citizens the right to food by law. Knuth and Vidar (2011) note that while legal protection of right to food is an important step towards ensuring food security, it needs to be accompanied by dedicated government efforts in implementing it. Countries which have made significant progress in improving their food security status have done so primarily through social programs like food subsidies, employment schemes, support to agricultural production, school meals, etc. (FAO,

[1] In 2011-13, 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 these hungry people – 827 million of them – live in developing regions, where the prevalence of undernourishment is now estimated at 14.3%.(See FAO, IFAD, and WFP (2013))

[2] In 2013, the nine countries that recognized the right to food as a separate and stand-alone right were Bolivia, Brazil, Ecuador, Guyana, Haiti, Kenya, South Africa, Nepal and Nicaragua. (Knuth and Vidar (2011))

IFAD, and WFP (2014)). To consider an example, India implemented the seminal Right to Food Act in 2013, where this law aims to provide 'food and nutritional security [...], by ensuring access to adequate quantity of quality food at affordable prices to people to live a life with dignity' (The Gazette of India, September, 2013). The law plans to achieve its goals by providing subsidized food grains to approximately two-thirds of India's 1.2 billion people in the hope that it would significantly improve their nutritional status. 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' (see The Gazette of India, September, 2013).

These food subsidy programs across the globe, on the one hand 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 these social programs, which may curb investment and long run growth of the economy. Who gains, who loses and in what conditions – are some questions that need to be answered. Further, the food subsidy program has a differential impact on the output of the agricultural sector as compared to (say) the manufacturing sector. It is an interesting question to ask how do the sectoral outputs change and what are the effects on relative prices. In this paper, we isolate the 'increased nutrition' channel through which the food subsidy is intended to affect the economy, and try to understand the effects of food subsidy program on sectoral outputs, their prices and welfare of agents.

We model a developing economy, where the agents are heterogeneous in their assets ownership.[3] One agent, entrepreneur, is endowed with capital while the other agent, farmer, is not. The agents are consumer-producers, whose objectives are to maximize their individual utilities subject to their respective budgets. The farmer uses his labor to produce food crop and cash crop, where the former is a final good and the latter is an intermediate good. The entrepreneur employs cash crop, his labor, and capital to produce the manufacturing output, which is another final good.

While the consumption of both final goods provides utility to the two agents, these goods have other additional purposes. Consumption of food provides energy to the agents and is the source for their labor abilities. Agents need to consume a minimum quantity of food to survive. After this subsistence need is met, food consumption increases labor capacity. The relation is increasing and concave. This is a novel feature of this paper where we use a

[3] Antoci et al (2010) assert that in developing economies asset ownership is highly concentrated. Like our economy, in their model of a developing economy, they assume heterogenous agents where one agent owns capital while the other does not.

metabolism function to capture the food to labor supply conversion. It is this route through which the food subsidy affects the well-being of the agents and hence affects the other macroeconomic variables like output and prices. The manufacturing good has the additional role of being the capital good. The entrepreneur invests a part of his income in augmenting his next period's capital stock – this means that the entrepreneur participates in a saving technology to which the farmer has no access. This is a typical feature of developing countries (as noted in Conning and Udry (2007)) and later forms the basis for the tax structures that are imposed on the agents.

To begin with, we assume that the economy is food secure, i.e. the productivity of food production is sufficiently high so that the subsistence needs of both agents are met. The government introduces a social program where it provides subsidy on the food consumption to both agents at an exogenous rate. The two agents may get different subsidies. The government may finance this program by either levying a direct tax or an indirect tax. Under the direct tax regime, the entrepreneur has to pay taxes proportional to his income,[4] while in the indirect tax regime, a consumption tax is imposed on both the farmer and the entrepreneur on their manufacturing goods consumption. The tax rates are fixed so that the government balances its budget. The model is fairly complex. We examine the effect of farmer's subsidy and the entrepreneur's subsidy on the different variables through numerical simulations.

In this economy, we find that in both tax regimes, the subsidy program increases the steady state agriculture output but lowers the steady state manufacturing output. The two taxes are levied either on manufacturing income or manufacturing consumption, which negatively affects either the supply or the demand of manufacturing good. In both cases, the net effect is that the subsidies adversely affect the manufacturing output. At the same time, by providing food subsidy the government makes the consumption of food cheaper, which in turn boosts the demand for food. Thus, the food subsidy program increases food output at the expense of manufacturing output.

The effects on relative prices are different in the two tax regimes. In the income tax regime, the long run price of the food crop relative to the price of the manufacturing good declines with subsidies, while in the consumption tax regime it increases with subsidies. In both tax regimes, the subsidy program raises the demand for food, which increases the nominal price of food. However, the tax regime has different effects in the manufacturing sector. In the income tax regime the subsidies lower the supply of manufacturing output,

[4] In India agricultural income is exempted from taxation. China also abolished agricultural taxes in 2006. 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)).

which increases the nominal price of manufacturing good – so much so that price of food relative to that of manufacturing falls. In the consumption tax regime the subsidies lower the demand for manufacturing consumption, hence lowering the nominal price of food which implies that relative price of food relative increases. The differential effect of the tax regimes on manufacturing demand and supply explains the subsidy effect on relative prices.

We also determine the program's welfare effects on the farmer and the entrepreneur. Compared to the no subsidy regime, the agents' steady state welfare improves only for a certain range of subsidies. To understand this, let us consider the farmer's welfare. The farmer's food consumption increases with his own subsidies. This translates into higher labor units and hence increased leisure. At the same time, an increase in the farmer's subsidy decreases the supply of manufacturing output and hence the farmer's consumption of manufacturing good falls with his subsidy. It is only for medium levels of farmer's subsidy, which boosts the farmer's consumption of food and leisure, and does not have a large adverse effect on his manufacturing goods consumption, that the farmer's welfare is higher in the subsidy program. The entrepreneur's subsidy has an unambiguously negative effect on farmer' welfare. The entrepreneur's subsidy does not boost farmer's food consumption or leisure, and further it adversely affects his manufacturing consumption. Thus, it is the combination of low subsidies to the entrepreneur and medium subsidies to the farmer that improves farmer's welfare. Analogous reasoning holds for the entrepreneur's welfare – medium entrepreneurial subsidies and low farmer's subsidies yield higher entrepreneur's welfare. In fact, our simulations suggest that there may be no subsidy combination in which both the agents are better off in the subsidy program as compared to the no subsidy program. One agent's welfare improvement may be accompanied with a loss in the other agent's welfare. This highlights that government needs to be prudent in choosing the level of subsidies to the agents as different subsidy combinations benefit different categories of people.

Comparing between the income tax regime and the consumption tax regime, we find that financing this program using an indirect consumption tax regime compared to a direct income tax regime gives higher welfare to both agents. On normative grounds, our paper therefore suggests that while such a subsidy program may only have limited gains in a heterogeneous agent economy, it is best to implement this program by sharing the tax burden between the two agents – through an indirect tax – to finance the food subsidy program. The subsidy program will unequivocally improve the health status of all the beneficiaries, but this by itself does not yield any significant welfare improvements. In this economy, though subsidy increases the labor capacity of both agents, but due to capital market frictions, it comes at the cost of capital deaccumulation. The subsidy program increases only the farmer's income, but he can not invest his income in any saving technology which implies that health improvements do not translate into higher growth of the economy. The paper outlines that there are limits to the benefits of a food subsidy program. Other complementary policy interventions are needed which enable better health to yield increase in output, welfare and possibly growth.

In the next section, we model the income tax regime. We build the model and present the simulation results. In Section 3 we analyze the economy with an alternative manufacturing consumption tax. Finally we conclude in Section 4 with policy recommendations.

2 Income Tax Regime

In this section we present the model economy with the government financing the food subsidy program using a distortionary income tax. This is a heterogenous agent economy, where the two infinitely lived agents are – a farmer and an entrepreneur. The entrepreneur is born with capital, while the farmer is not. This difference in ownership of asset also dictates the choice of the agents occupation. Further, there is occupational immobility – the farmer cannot participate in entrepreneurial activities and the entrepreneur does not want to do the labor-intensive farming work. The entrepreneur does not prefer to do agricultural work over manufacturing jobs because the former is more labor-intensive and hence harder. Further, working in the capital sector may be considered more modern and hence is looked up to, which tilts the entrepreneur's occupational choice towards manufacturing production. We capture this occupational immobility in the model by assuming that agents prefer to work in the sector where they can make use of their resources. Thus, the farmer uses his labor to produce two agricultural goods – a food crop and a cash crop. The cash crop is used only as an intermediate input. The entrepreneur uses cash crop along with his labor and capital to produce manufacturing goods only. Introduction of cash crops enable us to analyze the effects of the subsidy program within the agriculture sector, in particular, to compare subsidized food crop production with other agricultural products.

As in Jiny and Zengz (2007) these agents are household producers. Consumption of the manufacturing good, food, and leisure provides utility to the agents. We now present the model economy in greater detail.

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 capacity is endogenous. We assume the following simple function, which is termed metabolism function as it captures the 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 metabolism function, L_t^F, is plotted in Figure 1. L_t^F is a continuous function in X_{at}. For $X_{at} > 1$, farmer's labor capacity is strictly increasing and concave in food consumption. $X_{at} = 1$ captures subsistence consumption, below which the farmer has no energy to supply labor.

[INSERT FIGURE 1]

The parametrization of endogenous labor capacity in our model is technically similar to the functional relationship between food consumption and labor productivity as in Bliss and Stern (1978). A similar functional relationship between labor productivity and food consumption is also assumed in Dasgupta and Ray (1986) and Dasgupta (1997). In these papers, 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 however, 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 this 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 capacity 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. The farmer has two sources of income: revenues from sale of food crop and cash crop. He spends this income in purchasing food and the manufacturing good. His budget is

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

where we have assumed that the manufacturing good is the numeraire, and p_{at} and p_{ct} denote the relative price of the food crop and the cash crop respectively. Note that 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, so effectively the farmer has to spend $(1-f_1)p_{at}$ for purchasing one unit of food. 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

$$1 - \frac{2}{X_{at}} = \frac{1}{\phi_3}\left[\frac{X_{at}(1-f_1)}{A} - \frac{1}{X_{at}}\right], \tag{5}$$

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

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

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

Eq. (5), can be rewritten as

$$X_{at} = \frac{(1-\phi_1-\phi_2)A \pm \sqrt{(1-\phi_1-\phi_2)^2A^2 + 4(1-f_1)(2\phi_1+2\phi_2-1)A}}{2(1-f_1)}, \tag{9}$$

and hence for any positive A, i.e., $A > 0$, the sufficient condition for a real solution of X_{at} is

$$\phi_1 + \phi_2 > \frac{1}{2}. \tag{10}$$

Further, this condition also ensures that there is only one positive solution of X_{at} and hence ensures a unique feasible solution of X_{at}. Henceforward, we assume condition (10) always holds true. With this condition we find that the consumption of manufacturing good and leisure are strictly positive (from (6) and (7)).

Proposition 1 *The farmer's food consumption does not change over time. Further, it is positively related with his entitled food subsidy. These properties also hold for the farmer's labor capacity.*

Proof. Condition (10) along with equation (9) gives this. ■

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 capacity. Thus, by improving the farmer's health, 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, the farmer is not eating sufficiently to have any labor capacity. Now suppose the government provides the farmer a per-unit food subsidy, i.e. $f_1 > 0$, then his food consumption increases to $X_{at} > 1$. 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 at $A = 1/(\phi_1 + \phi_2)$. Through this logic we say that food subsidy provides food security as the marginalized farmer can now meet his subsistence food requirements 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 an identical labor capacity function as the farmer, which is denoted by L^E_t. He employs labor L_{mt}, capital K_t, and the cash crop q_{ct} to produce manufactures using a CRS Cobb-Douglas production function

$$Q_{mt} = M L^{\alpha}_{mt} q^{\beta}_{ct} K^{1-\alpha-\beta}_t \tag{11}$$

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

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

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 the manufacturing good on consumption of goods, purchase of cash crops, and capital investment. Thus, his budget constraint is

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

where f_2 is the food subsidy given by the government to the entrepreneur and we have substituted the entrepreneur's full employment condition, i.e. $L_{mt}=L_t^E-Y_{lt}$, for manufacturing employment in the manufacturing production function. In the income tax regime the tax burden falls on the capital owning agent and here the entrepreneur pays a proportional tax of τ_t on his income from selling manufactures. The assumed structure of taxation mimics the developing economies. As noted in Gordon and Li (2009), in developing countries, personal income tax rates are differentiated across different income groups, where usually the capital owning agents pay higher taxes. Further, corporate income tax is one of the most important sources of revenue for these countries. In this sense, by taxing the entrepreneur's income, we capture both these features of developing economies in our model.

Conditional on his budget and given initial capital stock K_0, 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 first order conditions yield

$$Y_{lt} = \frac{1-\frac{1}{Y_{at}}}{1+\frac{\phi_1\alpha}{\phi_2}\frac{(1-\tau_t)Q_{mt}}{Y_{mt}}}, \tag{12}$$

$$(Y_{at}-1)\left[Y_{at}-\frac{(1-\phi_1-\phi_2)}{\phi_1(1-f_2)}\frac{Y_{mt}}{p_{at}}\right] = \frac{1}{1-f_2}\left[\frac{\phi_2}{\phi_1}\frac{Y_{mt}}{p_{at}}+\alpha\frac{(1-\tau_t)Q_{mt}}{p_{at}}\right], \tag{13}$$

$$q_{ct} = \frac{\beta(1-\tau_t)Q_{mt}}{p_{ct}}, \tag{14}$$

and the Euler equation,

$$\frac{Y_{mt+1}}{Y_{mt}}=\rho\left[1-\delta+(1-\alpha-\beta)\frac{(1-\tau_{t+1})Q_{mt+1}}{K_{t+1}}\right], \tag{15}$$

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

$$
\begin{aligned}
Q_{mt} &= K_{t+1} - (1-\delta)\, K_t + X_{mt} + Y_{mt} && (16)\\
AL_{at} &= X_{at} + Y_{at} && (17)\\
C\left(1 - \frac{1}{X_{at}} - X_{lt} - L_{at}\right) &= q_{ct}. && (18)
\end{aligned}
$$

Finally, the government balances budget in every time period

$$
f_1 p_{at} X_{at} + f_2 p_{at} Y_{at} = \tau_t Q_{mt}. \tag{19}
$$

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

2.4 Static System

The static system is reduced to the following four equations.

$$
\beta(1-\tau_t)\frac{Q_{mt}}{p_{at}} = A\left[\left\{1 - \frac{1}{X_{at}}\left(\frac{1-2\phi_2-\phi_1}{1-\phi_1-\phi_2}\right)\right\} - \frac{X_{at}}{A}\left(\frac{1-\phi_1-\phi_2 f_1}{1-\phi_1-\phi_2}\right)\right] - Y_{at} \tag{20}
$$

$$
Q_{mt} = M\left[\left(1-\frac{1}{Y_{at}}\right)\frac{\frac{\phi_1\alpha}{\phi_2}\frac{(1-\tau_t)Q_{mt}}{Y_{mt}}}{1+\frac{\phi_1\alpha}{\phi_2}\frac{(1-\tau_t)Q_{mt}}{Y_{mt}}}\right]^{\alpha}\left[\frac{\beta C}{A}\frac{(1-\tau_t)Q_{mt}}{p_{at}}\right]^{\beta} K_t^{1-\alpha-\beta} \tag{21}
$$

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

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

We get the first equation from (7), (8),(14), (17) and (18). 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 (12)-(14) into manufacturing production function (11). The last two equations are from entrepreneur's optimization (13) and from government budget (19) 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 few of points to note here.

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

2. The $[\cdot]$ term in eq. (20) captures the farmer's residual labor units after deducting leisure and labor required to produce own food consumption from the farmer's total labor units i.e. $(1 - 1/X_{at}) - X_{lt} - X_{at}/A$. In the absence of subsidy, $f_1 = 0$, we get from (5) that the farmer's residual labor is positive. However, in the subsidy program the farmer's leisure and food consumption increase with his subsidy and we can show that his residual labor decreases with increase in f_1. This implies that there is an upper-limit to the food subsidy offered to the farmer, beyond which the farmer's residual labor is negative. Now we know from (20) that for positive after-tax income from manufacturing production, i.e. $(1 - \tau_t)Q_{mt} > 0$, it is necessary for the $[\cdot]$ term to be positive. Thus there is an upper-limit to the food subsidy that can be feasibly 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 (15) and the capital accumulation equation (16). It is determined by the growth of two variables Y_{mt} and K_t. In this economy, there is no long run growth. At steady state,

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

Using this in the dynamic equations (15) and (16), we get

$$Q_m^* = Y_m^* + \delta K^* + X_m^* \tag{22a}$$

$$\frac{(1 - \tau^*)Q_m^*}{K^*} = \frac{{}^1/_\rho - 1 + \delta}{1 - \alpha - \beta}. \tag{22b}$$

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.

2.6 Simulation

The complexity of the model makes it difficult to analytically solve the model. Hence, we resort to numerical simulations to characterize the effect of subsidy program on output and welfare. For this purpose, India is an ideal economy to model as it is a developing country which has recently implemented a food security act. The effects of the food subsidy program, which are calculated in this simulation exercise, would also be relevant for other developing countries.

The structural parameters for India are fixed in accordance with the existing literature, discount factor is 0.98 and the annual depreciation rate is 0.1 (as in Gabriel et al. (2012)). We calculate the preference parameters using data from the RBI handbook of statistics and CSO database. The preference parameter, ϕ_2, is taken to be the share of total output which is not consumed,

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

where C/Y is the average aggregate consumption to output ratio. The ratio of private final consumption expenditure (PFCE) to GDP, averaged over the years 1999-2007, yields $\phi_2 = 0.4$. Further, as the agents consume two goods – food and manufacturing – their respective weights are

$$\phi_1 = \left(\frac{V_M}{V_M + V_A}\right) \times \frac{C}{Y}, \quad \phi_3 = \left(\frac{V_A}{V_M + V_A}\right) \times \frac{C}{Y},$$

where V_M is the average manufacturing value added, and V_A is the average agricultural value added for the period 1999-2007. We get $\phi_1 = 0.24$ and $\phi_3 = 0.36$.[5].

The manufacturing production requires three inputs, namely capital, labor, and cash crop. Thus, the value of manufacturing output Q_{mt} is the sum of capital payments, wage payments, and the spending on cash crop intermediates. Similar to the methodology in Verma (2012), wage payments is estimated by compensation of employees, and the capital payments by the sum of consumption of fixed capital and operating surplus. The estimation of expenditure on cash crops inputs is a more involved process. Dholakia (2009) tabulates the input-output (I-O) tables for India in which he reports the cash crop intermediate inputs in manufacturing production. While Dholakia (2009) reports the I-O table for the years 1968, 1973, 1978, 1983, 1989, 1993, 1999, and 2003, we consider only the last two reported years. Our choice of this time period is to maintain consistency with the time period for the other aggregate and sectoral variables. We calculate the average share of cash crop intermediates of the total intermediates inputs used in producing manufacturing good for the years 1998 and 2003. This gives that cash crop input accounts for about 8.7% of total intermediate goods consumption in the manufacturing sector. Considering this cash crop input usage constant over time, we capture the expenditure on cash crops equal to 8.7% of the intermediate

[5] See Table 3A, Handbook of Statistics on Indian Economy, RBI.

consumption in manufacturing goods production. Thus, the manufacturing sector's labor income share equals compensation of employees/(compensation of employees + operating surplus + consumption of fixed capital + 8.7% of intermediates consumption), which gives $\alpha = 0.19$. Similarly, we calculate the capital shares, $\beta = 0.25$ and $1 - \alpha - \beta = 0.56$.

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 $f_2 \in [0, 1)$.

2.7 Subsidy Program Effects

The tax revenues finance the food subsidy, therefore, it follows that the steady state income tax increases with the subsidies, $\tau^* = \tau^*(\underset{+}{f_1}, \underset{+}{f_2})$. We plot the steady state tax rates for different subsidy combinations in Figure 2. The x-axis denotes the farmer's subsidy and the y-axis captures the tax rates. For different entrepreneur's subsidies we plot different curves. As one moves along the x-axis the farmer's subsidy increases and as one moves from black solid line to purple dotted line the entrepreneur's subsidy increases. The figures shows that from zero taxes in no subsidy program (shown in green line), the taxes increase with both farmer's subsidy as well as entrepreneur's subsidy.

[INSERT FIGURE 2]

2.7.1 On Food Consumption

The subsidy program is intended to primarily affect the agents food consumption. As noted in Proposition 1, the farmer's consumption of food is higher in the food subsidy program. X_{at} increases in f_1 and is independent of f_2.

The subsidy effects on entrepreneur's food consumption is more involved. The entrepreneur's subsidy has a direct effect on his food consumption. In addition, as his food consumption linked with farmer's production, it is also affected by the farmer's subsidy. Our simulations show that in steady state, 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. In particular, the entrepreneur's food consumption is affected by the subsidy program through two channels – through income and through prices. On the one hand, an increase in 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, an increase in f_2 lowers the effective price the entrepreneur has to pay for consuming food. Our simulations suggest that in the steady state, for the entrepreneur, the latter effect of f_2 dominates the former effect, i.e., $Y_a^* = Y_a^*(\underset{-}{f_1}, \underset{+}{f_2})$. This is shown in Figure 3. It is therefore possible that for a low f_1 and a high f_2, the entrepreneur's food consumption is higher in the subsidy program.[6]

[INSERT FIGURE 3]

The trends in food consumption also determine how the subsidy program influences the agents' work capacity. The subsidies unequivocally increase the work capacity of the farmer, but the effect on the entrepreneur's work capacity depends on the subsidy combination. The low f_1 and high f_2 combination – at which the direct benefits of a higher f_2 dominates the indirect detriments of higher taxation – increases the work capacity of the entrepreneur.

2.7.2 On Farmer's Production

The food subsidy program has opposite effects on the farmer's production of the food crop and the cash crop. Simulations show that the food crop output increases in both subsidies while the cash crop output decreases in both subsidies. We have shown that the farmer's subsidy boosts his food consumption, but not the entrepreneur's food consumption. In contrast, the entrepreneur's food subsidy increases the entrepreneur's food consumption and has no effect on the farmer's food consumption. The net effect is that both subsidies raise demand for food and yield $Q_a^* = Q_a^*(\underset{+}{f_1}, \underset{+}{f_2})$. As a result, the food output is always higher in the presence of the food subsidy program. This is shown in Figure 4. This implies employment in the food production increases with subsidies.

The effect of subsidies on the production of the cash crop is exactly opposite, as illustrated in Figure 5. To comprehend this, let us rewrite eq. (20) at steady state as

$$Q_c^* = C\left[\left\{1 - \frac{1}{X_a^*}\left(\frac{1 - 2\phi_2 - \phi_1}{1 - \phi_1 - \phi_2}\right)\right\} - \frac{X_a^*}{A}\left(\frac{1 - \phi_1 - \phi_2 f_1}{1 - \phi_1 - \phi_2}\right)\right] - \frac{C}{A}Y_a^*. \tag{23}$$

We have already noted that the farmer's residual labor, [.] term above, is decreasing in f_1. In addition, our simulations show that the entrepreneur's food consumption, Y_a^*, decreases in f_1 and increases in f_2. These two findings together indicate that with increase in both f_1 and f_2 the farmer shifts his labor units involved in production (total labor minus leisure)

[6] In the case of equal subsidies, i.e. $f_1 = f_2$, the the entrepreneur's food consumption is decreasing in the 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 subsidy program adversely effects Y_a^*. It is important to highlight that if equal subsidies are offered to both agents, the farmer's food consumption increases but it reduces the entrepreneur's food consumption, in which case, the program provides additional food security only to the farmer.

towards food production and away from cash crop production. As a result, $L_c^* = L_c^*(\underset{-}{f_1}, \underset{-}{f_2})$ and $Q_c^* = Q_c^*(\underset{-}{f_1}, \underset{-}{f_2})$. Thus, the food subsidy program, by increasing the demand for food production, adversely affects the cash crop output, as shown in Figure 5.

[INSERT FIGURE 4]
[INSERT FIGURE 5]

2.7.3 On Entrepreneur's Production

To understand the effects of subsides on the manufacturing output, we rewrite the steady state manufacturing production function as

$$(Q_m^*)^{\alpha+\beta} = M\left(\frac{{}^1\!/_\rho - 1 + \delta}{1-\alpha-\beta}\right)^{1-\alpha-\beta}(1-\tau^*)^{1-\alpha-\beta}(L_m^*)^{\alpha}(q_c^*)^{\beta}$$

where we have used (22b) to substitute for K^*.As already discussed, subsidies unequivocally increase taxes and reduce the supply of cash crop. So the effect of subsidies through $\tau^*$and q_c^* is to reduce manufacturing output. At the same time, the subsidies *may* increase the labor capacity of the entrepreneur which implies that subsidies may possibly increase the manufacturing employment. Our simulations suggest that the subsidies affect the manufacturing employment in the same way as entrepreneur's work capacity, i.e., $L_m^* = L_m^*(\underset{-}{f_1}, \underset{+}{f_2})$. As shown in Figure 6, compared to the economy without the food subsidy program, a higher subsidy to the entrepreneur along with a low subsidy to the farmer increase L_m^*.

[INSERT FIGURE 6]

Summing up, the farmer's subsidy increases taxes, reduces the cash crop output, and reduces manufacturing employment. It is evident that f_1 unambiguously reduces the manufacturing output. However, the net effect of f_2 on the manufacturing output is not obvious. We look at the simulation results in Figure 7 and find that the manufacturing output decreases with increases in entrepreneur's subsidy, f_2. It appears that the effect of f_2 on lowering the cash crop and raising taxes dominates the positive effect it has on the manufacturing employment. Hence, $Q_m^* = Q_m^*(\underset{-}{f_1}, \underset{-}{f_2})$.

[INSERT FIGURE 7]

Further, as the subsidy program lowers the manufacturing output, from (22b), it follows that subsidies also lower steady state capital stock. Increase in f_1 and f_2 implies a higher tax and a lower manufacturing output, which reduces the entrepreneur's after-tax income and hence adversely affects capital accumulation. This is depicted in Figure 8, $K^* = K^*(\underset{-}{f_1}, \underset{-}{f_2})$.

[INSERT FIGURE 8]

2.7.4 On Prices

The simulations yield that the relative prices of food and cash crops are negatively related to the two subsidies. As shown in Figures 9 and 10, $p_a^* = p_a^*(\underset{-}{f_1}, \underset{-}{f_2})$ and $p_c^* = p_c^*(\underset{-}{f_1}, \underset{-}{f_2})$.

[INSERT FIGURE 9]
[INSERT FIGURE 10]

To understand this, recall that the subsides increase the demand of the food crop and reduces the supply of the manufacturing good. This increases the nominal price of both the food crop and the manufacturing good. The increase in the nominal price of the manufacturing good is however higher than that of the food crop, which implies that the price of the food crop relative to the manufacturing good falls with subsidies. Thus, both subsidies lower p_a^*. Further, from equation (8), we know that p_a^* and p_c^* are one-to-one linked. As a result, the relative price of the cash crop also falls in steady state.

2.7.5 On Welfare

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

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

Our simulations suggest that the subsidy program lowers X_m^*, as depicted in Figure 11. Intuitively, both subsidies make manufacturing consumption more expensive as compared to food consumption (as p_a^* falls), which lowers the demand for the manufacturing good.

It is easy to see that f_1 has two opposing effects on the farmer's welfare. On the one hand, it reduces the consumption of the manufacturing good and on the other hand it increases the consumption of leisure and agricultural good. We therefore find that for any given f_2, there exists an interior value of f_1 where the farmer's welfare is maximum. Further, the farmer's welfare is strictly decreasing in f_2. The farmer's per-period welfare is shown in Figure 12.

[INSERT FIGURE 11]
[INSERT FIGURE 12]

Our simulations suggest that for low levels of f_2 and medium levels of f_1 the farmer's welfare may be higher in the subsidy program.

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

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

The effect of the subsidy program on Y_m^* and Y_l^* are plotted in Figures 13 and 14 respectively. As in the farmer's case, due to an increase in the relative price of the manufacturing good as compared to the food crop, the entrepreneur reduces manufacturing consumption, which explains $Y_m^*(\underset{-}{f_1}, \underset{-}{f_2})$. Further, the entrepreneur's leisure follows the same trend as his work capacity – it increases with f_2 and decreases with f_1. It is clear that f_1 has an overall negative effect on the entrepreneur's welfare. The entrepreneur's food subsidy f_2, though negatively affects the consumption of manufacturing good, it increases leisure and consumption of the food crop. The entrepreneur's welfare effects in Figure 15 suggest that for any given f_1, there exists an interior value of f_2 where the entrepreneur's welfare is at its highest.

[INSERT FIGURE 13]
[INSERT FIGURE 14]
[INSERT FIGURE 15]

Our simulations depict that for low levels of f_1 and medium levels of f_2 the entrepreneur's welfare may be higher in the subsidy program. Our simulations also show that improvement in welfare of one agent comes at the expense of the other agent. We do not find any subsidy combination at which both agents gain from the subsidy program. However, if we look at the sum of welfare of the two agents, there are some combinations of subsidies at which the aggregate welfare of the economy is higher in the subsidy program (see Figure 16).

[INSERT FIGURE 16]

3 Consumption Tax Regime

In this section, we investigate an alternate form of financing the food subsidy program, i.e., imposing a tax on manufacturing consumption on the farmer and the entrepreneur. The idea is to see if a change in the method of financing the subsidy program has any differential effects on the economy. Importantly, unlike in the income tax regime where the entrepreneur solely bears the burden of taxation, in the consumption tax regime, the government taxes the farmer's and the entrepreneurs's consumption of the manufacturing good at a uniform rate

τ_{st}. Except for the budget constraint, the two agents' optimization problem is unchanged. The farmer's new budget is

$$(1-f_1)p_{at}^s X_{at}^s + (1+\tau_{st})X_{mt}^s = p_{at}^s A L_{at}^s + p_{ct}^s C\left(1-\frac{1}{X_{at}^s} - L_{at}^s - X_{lt}^s\right). \tag{24}$$

It is intuitive that the farmer's optimization conditions with respect to manufacturing consumption changes

$$X_{mt}^s = \left(\frac{\phi_1}{1-\phi_1-\phi_2}\right)\frac{p_{at}^s A}{1+\tau_{st}}\left[\frac{X_{at}^s(1-f_1)}{A} - \frac{1}{X_{at}^s}\right]. \tag{25}$$

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

$$X_{at}^s = X_{at}, \quad X_{lt}^s = X_{lt} \tag{26}$$

i.e., the farmer's food consumption and leisure are unchanged in the consumption tax regime. As a result, the farmer's total labor endowment L_t^{Fs} also remains unchanged, i.e.,

$$L_t^{Fs} = 1 - \frac{1}{X_{at}} = 1 - \frac{1}{X_{at}^s} = L_t^F. \tag{27}$$

We summarize this as follows:

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

The new tax regime similarly alters the entrepreneur's problem. His utility function is same as in the previous regime but now his manufacturing consumption, instead of income, is taxed. The entrepreneur's new budget constraint is

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

The first order conditions are

$$Y_{lt}^s = \frac{1-\frac{1}{Y_{at}^s}}{1+\frac{\phi_1\alpha}{\phi_2}\frac{Q_{mt}^s}{(1+\tau_{st})Y_{mt}^s}}, \tag{28}$$

$$(Y_{at}^s-1)\left[Y_{at}^s - \frac{(1-\phi_1-\phi_2)}{\phi_1(1-f_2)}\frac{(1+\tau_{st})Y_{mt}^s}{p_{at}^s}\right] = \frac{1}{1-f_2}\left[\frac{\phi_2}{\phi_1}\frac{(1+\tau_{st})Y_{mt}^s}{p_{at}^s}+\alpha\frac{Q_{mt}^s}{p_{at}^s}\right], \tag{29}$$

$$q_{ct}^s = \frac{\beta Q_{mt}^s}{p_{ct}^s}, \tag{30}$$

and the Euler equation is

$$\frac{(1+\tau_{st+1})Y_{mt+1}^s}{(1+\tau_{st})Y_{mt}^s} = \rho\left[1-\delta+(1-\alpha-\beta)\frac{Q_{mt+1}^s}{K_{t+1}^s}\right]. \tag{31}$$

The goods market clearing conditions are unchanged as in (16), (17) and (18). As before, for any given f_1 and f_2,the government fixes taxes to balance its budget, which now is

$$f_1 p_{at}^s X_{at}^s + f_2 p_{at}^s Y_{at}^s = \tau_{st}(X_{mt}^s + Y_{mt}^s). \tag{32}$$

3.1 Static System

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

$$\beta\frac{Q_{mt}^s}{p_{at}^s} = \left[A\left\{1-\frac{1}{X_{at}^s}\left(\frac{1-2\phi_2-\phi_1}{1-\phi_1-\phi_2}\right)\right\} - X_{at}^s\left(\frac{1-\phi_1-\phi_2 f_1}{1-\phi_1-\phi_2}\right)\right] - Y_{at}^s \tag{33}$$

$$Q_{mt}^s = M\left[\left(1-\frac{1}{Y_{at}^s}\right)\frac{\frac{\phi_1\alpha}{\phi_2}\frac{Q_{mt}^s}{(1+\tau_{st})Y_{mt}^s}}{1+\frac{\phi_1\alpha}{\phi_2}\frac{Q_{mt}^s}{(1+\tau_{st})Y_{mt}^s}}\right]^{\alpha}\left[\frac{\beta C}{A}\frac{Q_{mt}^s}{p_{at}^s}\right]^{\beta}[K_t^s]^{1-\alpha-\beta} \tag{34}$$

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

$$\tau_{st}\left[\left(\frac{\phi_1}{1-\phi_1-\phi_2}\right)\frac{A}{1+\tau_{st}}\left\{\frac{X_{at}^s(1-f_1)}{A}-\frac{1}{X_{at}^s}\right\}+\frac{Y_{mt}^s}{p_{at}^s}\right] = f_1 X_{at}^s + f_2 Y_{at}^s. \tag{35}$$

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 (28)-(30) into manufacturing production function (11). The third equation is the entrepreneur's optimization condition (29) and the last is the government budget constraint, where we have substituted for X_{mt}/p_{at} from (25) into (32) to get (35).

Note, we already know the value of X_{at}^s from (5), hence the static system yields

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

3.2 Steady State

The capital accumulation equation (16) and the Euler equation (31) constitute the dynamic equations of the economy. In 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

$$Q_m^{s*} = \delta K^{s*} + Y_m^{s*} + X_m^{s*} \tag{36a}$$

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

The above equations along with the static system solves for the steady state. In this regime, as was in the previous case, closed form steady state solutions do not exist. However, it can be shown,

Proposition 3 *In steady state, the entrepreneur's consumption of the food crop is same in the consumption tax regime as in the income tax regime, i.e.,* $Y_a^{s*} = Y_a^*$.

Proof. See Appendix ■

The intuition lies in the fact that the two methods of financing do not alter the behavior of the economy in steady state. In the income tax regime, depending on entrepreneur's food consumption, the cash crop employment is determined which in turn determines the entrepreneur's disposable income in terms of food prices (eq. (20)). This yields $(1-\tau^*)\,(Q_m^*/p_a^*)$ as a function of Y_a^*. This relation together with the steady state relation (22b) and the steady state entrepreneur's budget, $(1 - f_2)Y_a^* + (Y_{mt}/p_a^*) = (1-\beta)\,(1-\tau^*)\,(Q_m^*/p_a^*) - \delta(K^*/p_a^*)$, determines the budget-wise link between (Y_m^*/p_a^*) and Y_a^*. Finally all these links are brought together in optimization condition (13) which solves for Y_a^*. A change in the tax regime affects the variables but not the linkages. As compared to the income tax regime, in the presence of consumption tax, the entrepreneur's disposable income is Q_m^*/p_a^* and his expenditure on manufacturing good consumption, in terms of food prices, is $(1+\tau_s^*)\,(Y_m^*/p_a^*)$. Apart from this the chain of how demand for the entrepreneur's food determines the supply of cash crop, which in turn is linked with the entrepreneur's disposable income in terms of food prices, which finally determines the entrepreneur's food consumption, is exactly the same in both tax regimes. This explains $Y_a^{s*} = Y_a^*$.

Proposition 3, together with eqs. (12) and (28) yields that the entrepreneur's steady state total labor units, manufacturing employment and leisure remain unchanged in the two tax regimes. That is,

$$L^{Es*} = L^{E*}, \quad L_m^{s*} = L_m^*, \quad Y_l^{s*} = Y_l^*.$$

Further, Proposition 3 along with (26) implies that in steady state the farmer's allocation of labor for food production and production of cash crops also remain unchanged in the two tax regimes, i.e.,

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

We summarize these findings as follows.

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, in steady state, the entrepreneur's leisure is unaffected by the tax structures.*

Proof. Discussed above. ■

The unchanged employment in food and cash crops sectors imply that food and cash crop outputs are same in the two tax regimes. However, this equality does not hold for steady state manufacturing output:

Proposition 5 *The steady state capital and the steady state manufacturing output is higher in the consumption tax regime compared to the income tax regime, i.e., $K^{s*} > K^*$ and $Q_m^{s*} > Q_m^*$. Therefore the steady state relative price of the food crop is higher in the consumption tax regime, i.e., $p_a^{s*} > p_a^*$.*

Proof. Substituting the steady state eqs (22b) and (36b) into their respective manufacturing production functions (21) and (34), we get

$$\frac{Q_m^{s*}}{Q_m^*} = (1 - \tau^*)^{-\frac{1-\alpha-\beta}{\alpha+\beta}} > 1.$$

In both regimes, the steady marginal product of capital is the same (eqs. (22b) and (36b)). However, in the income tax regime, the after-tax value of manufacturing output is lower, hence capital stock is lower in this regime,

$$\frac{K^{s*}}{K^*} = \frac{Q_m^{s*}}{(1 - \tau^*) Q_m^*} > 1.$$

Further, as the food consumptions are equal in the two tax regimes, the cash crop market clearing conditions (20) and (33) yield,

$$\frac{p_a^{s*}}{p_a^*} = \frac{Q_m^{s*}}{(1-\tau^*)\,Q_m^*} > 1.$$

■

The higher food prices, with no change in cash crop and food crop output, implies that farmer's income is higher in the consumption tax regime. As his food consumption is unaffected by the tax structure, the increase in his income is spent on increasing his manufacturing goods consumption. Similar increase in entrepreneur's income translates into higher manufacturing consumption by the entrepreneur. We summarize this as follows

Proposition 6 *The steady state consumption of the manufacturing output for the farmer and the entrepreneur is higher in the consumption tax regime compared to the income tax regime, i.e.,* $X_m^{s*} > X_m^*$ *and* $Y_m^{s*} > Y_m^*$.

Proof. From steady state eqs. (22a) and (36a) we get,

$$\frac{X_m^{s*}+Y_m^{s*}}{X_m^*+Y_m^*} = \frac{1-\delta\Psi}{1-(1-\tau^*)\delta\Psi}\frac{Q_m^{s*}}{Q_m^*} = \frac{1-\delta\Psi}{1-(1-\tau^*)\delta\Psi}\frac{1}{(1-\tau^*)^{\frac{1-\alpha-\beta}{\alpha+\beta}}} \equiv \Omega(\tau^*), \qquad (37)$$

where $\Psi = (1-\alpha-\beta)/(^1/_\rho - 1 + \delta)$. It is easy to see that $\Omega(0) = 1$ and $\Omega(1) = \infty$. Further $\Omega'(\tau^*) > 0$. Thus for $1 > \tau^* > 0$ it is evident that $\Omega(\tau^*) > 1$. In other words, the total manufacturing consumption by the two agents in the food subsidy program is higher in the presence of consumption tax as compared to income tax. Now, as $Y_a^{s*} = Y_a^*$ and $Q_m^{s*}/p_a^{s*} = (1-\tau^*)(Q_m^*/p_a^*)$, we get from (13) and (29) that

$$\frac{(1+\tau_s^*)Y_m^{s*}}{p_a^{s*}} = \frac{Y_m^*}{p_a^*}. \qquad (38)$$

The above expression together with (6) and (25) yields

$$\frac{(1+\tau_s^*)}{p_a^{s*}}\left(X_m^{s*}+Y_m^{s*}\right) = \frac{1}{p_a^*}\left(X_m^*+Y_m^*\right). \qquad (39)$$

We know $X_m^{s*}+Y_m^{s*} > X_m^*+Y_m^*$ and with the aforementioned relation, we get $(p_a^{s*}/p_a^*)\cdot(1+\tau_s^*)^{-1} > 1$. This further with (38) and (39) gives $X_m^{s*} > X_m^*$ and $Y_m^{s*} > Y_m^*$. ■

The higher manufacturing consumption in the consumption tax regime also implies that the utility of both agents is now higher. That is,

Proposition 7 *The steady state per-period utilities of the farmer and the entrepreneur is higher in the consumption tax regime as compared to the income tax regime, i.e.,* $\Gamma^{sF} > \Gamma^{F}$ *and* $\Gamma^{sE} > \Gamma^{E}$.

Proof. As $X_a^{s*} = X_a^*$, $X_l^{s*} = X_l^*$ and $X_m^{s*} > X_m^*$, it gives that utility of the farmer is higher in the consumption tax regime as compared to income tax regime, $\Gamma^{sF} > \Gamma^{F}$. Similarly, as $Y_a^{s*} = Y_a^*$, $Y_l^{s*} = Y_l^*$ and $Y_m^{s*} > Y_m^*$, the utility of the entrepreneur is higher in the consumption tax regime as compared to income tax regime, $\Gamma^{sE} > \Gamma^{E}$. ■

Thus, financing this program using an indirect consumption tax regime compared to a direct income tax regime is Pareto improving. This is because in the steady state, moving from the income tax regime to the consumption tax regime causes an increase in the consumption of the manufacturing output by both agents. As a result, sharing the tax burden, by imposing an indirect tax, is Pareto superior. An interesting normative insight we get is that sharing the tax burden – between the farmer and the entrepreneur – via manufacturing consumption tax is beneficial in terms of aggregate welfare.

3.3 Simulation

For the same parameter values used in the income tax regime, we simulate the model to determine long run effects of the subsidy program on the economy in the consumption tax regime. As shown in Figure 17, compared to the no-subsidy case, the consumption tax is positive. Further, 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 17]

3.3.1 On Outputs

We have already shown that $X_a^{s*} = X_a^*$ and $Y_a^* = Y_a^{s*}$. Hence the food consumption plot for the entrepreneur is the same as in Figure 3. Further, employment in the food crop and cash crop production are same as were in the income tax regime. Thus, the farmer's production of the food crop and cash crop are exactly the same as in the previous regime (shown in Figures 4 and 5). Simulations show that in this regime too, subsidies reduce steady the state manufacturing output as well as capital. The subsidy program reduces the cash crop production and this adversely affect manufacturing production, which in turn also lowers the steady state capital stock. These effects are shown in Figures 18 and 19.

[INSERT FIGURE 18]
[INSERT FIGURE 19]

3.3.2 On Price

The subsidy effect on the relative prices differs in the income tax regime and consumption tax regime. In the consumption tax regime, the relative price of the food crop increases with higher f_1 and f_2, i.e., $p_a^{s*} = p_a^{s*}(\underset{+}{f_1}, \underset{+}{f_2})$. An increase in f_1 and f_2, increases the demand for the food crop and therefore increases the nominal price of food. The consumption tax reduces the demand for manufacturing consumption good which reduces the nominal price of manufacturing good. The joint effect is an increase in the relative price of the food crop. Since p_c^{s*} is proportional to p_a^{s*}, $p_c^{s*} = p_c^{s*}(\underset{+}{f_1}, \underset{+}{f_2})$. The effect of subsidies on the food crop and cash crop relative prices is shown in Figures 20 and 21.

[INSERT FIGURE 20]
[INSERT FIGURE 21]

3.3.3 On Welfare

As in the income tax regime, 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 manufacturing consumption does not qualitatively change agents' welfare effects. The effects of subsidies are still the same, except that the magnitude of the effects have altered. We present in Figures 22 and 23 that the two subsidies have a negative effect on the manufacturing consumption of both agents.

[INSERT FIGURE 22]
[INSERT FIGURE 23]

The welfare of the farmer and the entrepreneur for different subsidies is shown in Figures 24 and 25 respectively. We present the aggregate welfare in Figure 26.

[INSERT FIGURE 24]
[INSERT FIGURE 25]
[INSERT FIGURE 26]

As discussed before, simulations also show that welfare gains are higher in consumption tax regime as compared to income tax regime. An increase in consumption of the manufacturing good and unaltered consumptions of the food crop and leisure, by both farmer and entrepreneur, explains higher welfare gains in the consumption tax regime. Further, the entrepreneur witnesses larger welfare gains than the farmer as a result of moving from the income tax to the consumption tax regime. The simulation results for welfare gains from the subsidy program in the two tax regimes, for the case of $f_2 = 0.81$ and different levels of f_1, are shown in Figure 27. The pattern does not change for different subsidy combinations. Intuitively, switching from the income tax regime to the consumption tax regime has resulted in an increase in incomes for the farmer and the entrepreneur, which results in an increase in the consumption of the manufacturing output. In addition, higher gains for the entrepreneur are on the account of sharing the tax burden with the farmer. On normative grounds therefore, our model suggests that despite there being marginal gains from introducing the subsidy program, it is better to finance such a scheme using a uniform distortionary consumption tax compared to a discriminatory income tax regime.

[INSERT FIGURE (27)]

4 Conclusion

Our work is motivated by the recent food security schemes announced across several developing and middle income economies to fulfill their millennium 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 farmer and an entrepreneur, both of whom are eligible for a subsidy on food consumption. The novelty of our paper is that food consumption augments the labor capacity of a representative agent who then decides how to allocate this capacity towards work and leisure. This ensures "food security" even with low levels of agricultural productivity.

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 exercise also suggests that introducing a universal food subsidy program may not necessarily have large benefits for an economy in the long run. Introducing other welfare measures to enhance labor productivity, for instance, may complement a subsidy program which has partial coverage. This will also enable us to analyze the effectiveness of introducing such welfare schemes in highly debt driven economies. Future work can therefore 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 Proposition 3

As the tax regimes does not differentially affect the farmer's optimization conditions, so $X_{at} = X_{at}^s$. Further from eqs. (20) and (33) we get,

$$(1-\tau_t)\frac{Q_{mt}}{p_{at}} = \Upsilon_1(Y_{at}),\ \frac{Q_{mt}^s}{p_{at}^s} = \Upsilon_1(Y_{at}^s). \tag{40}$$

The two functional forms are same. forms of This implies that the respective implicit functions are equal. In steady state of the income tax regime, using (19), (22a) and (22b) we get

$$\begin{aligned}\frac{Y_m^*}{p_a^*} &= f_1 X_a^* + f_2 Y_a^* + \left(\frac{1/\rho - 1 + \delta}{1-\alpha-\beta} - \delta\right)\left(\frac{1-\alpha-\beta}{1/\rho - 1 + \delta}\right)\frac{(1-\tau^*)\,Q_m^{s*}}{p_a^{s*}} \\ &\quad - \left(\frac{\phi_1}{1-\phi_1-\phi_2}\right) A \left\{\frac{X_a^{s*}(1-f_1)}{A} - \frac{1}{X_a^{s*}}\right\},\end{aligned} \tag{41}$$

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

$$\begin{aligned}(1+\tau_s^*)\frac{Y_m^{s*}}{p_a^{s*}} &= f_1 X_a^{s*} + f_2 Y_a^{s*} + \left(\frac{1/\rho - 1 + \delta}{1-\alpha-\beta} - \delta\right)\left(\frac{1-\alpha-\beta}{1/\rho - 1 + \delta}\right)\frac{Q_m^{s*}}{p_a^{s*}} \\ &\quad - \left(\frac{\phi_1}{1-\phi_1-\phi_2}\right) A \left\{\frac{X_a^{s*}(1-f_1)}{A} - \frac{1}{X_a^{s*}}\right\}.\end{aligned} \tag{42}$$

As $X_a^* = X_a^{s*}$ and together with (40), (41) and (42) we get

$$\frac{Y_m^*}{p_a^*} = \Upsilon_2(Y_a^*),\ (1+\tau_s^*)\frac{Y_m^{s*}}{p_a^{s*}} = \Upsilon_2(Y_a^{s*}). \tag{43}$$

Substituting (40), (43) in the entrepreneur's food optimization condition (13) and (29) we get that in steady state

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

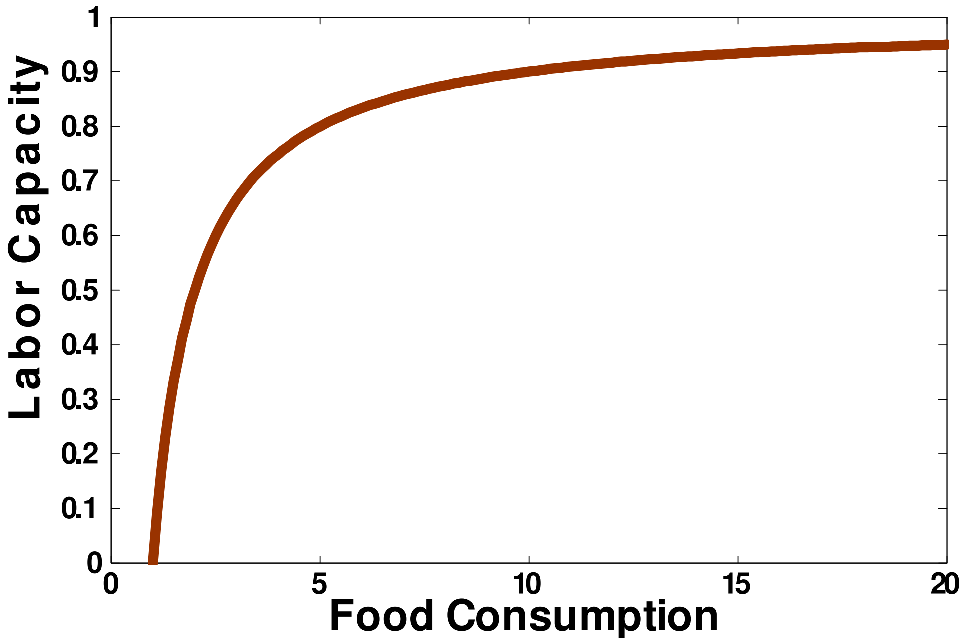

Figure 1: Metabolism Function

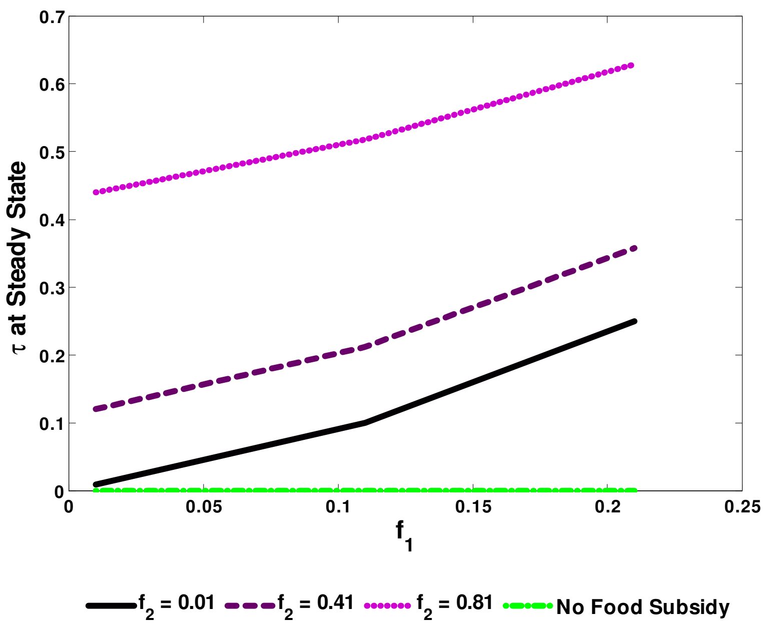

Figure 2: The effect of the food subsidy program on τ^*

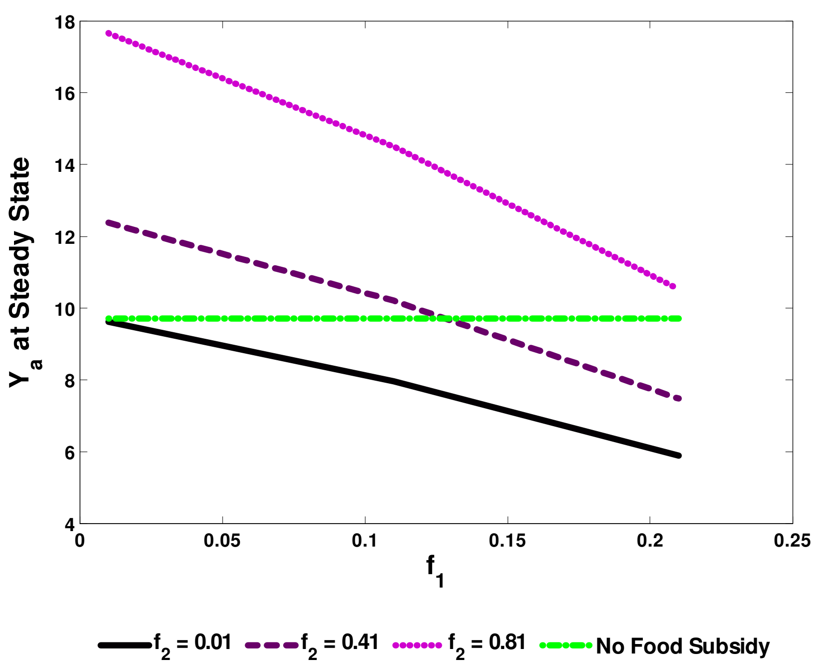

Figure 3: The effect of the food subsidy program on Y_a^*

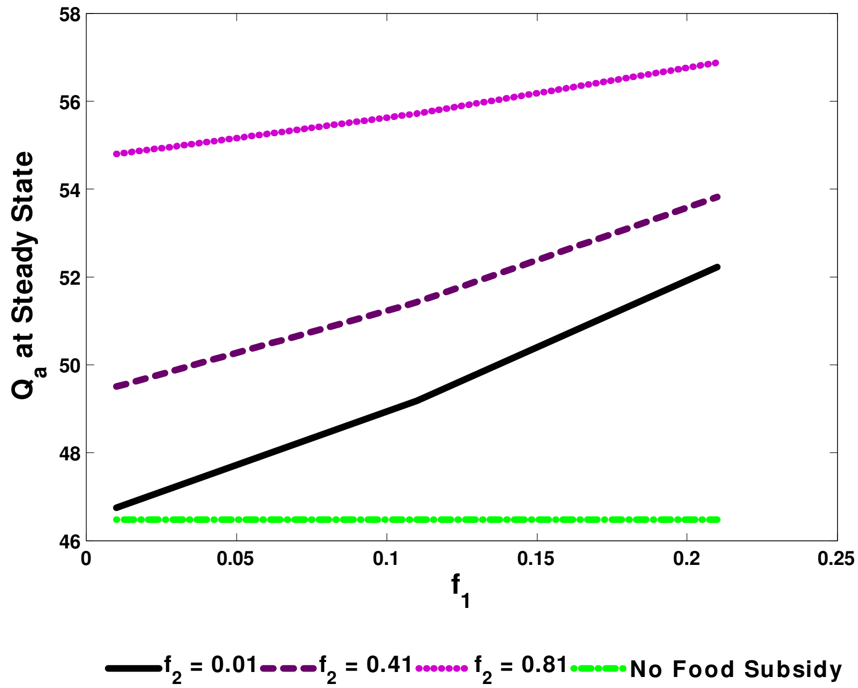

Figure 4: The effect of the food subsidy program on Q_a^*

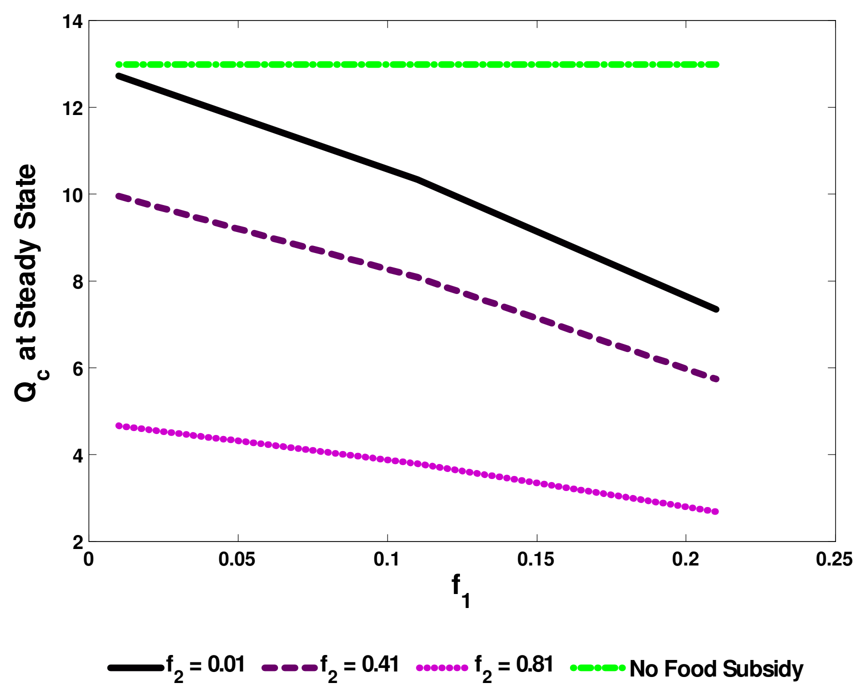

Figure 5: The effect of the food subsidy program on Q_c^*

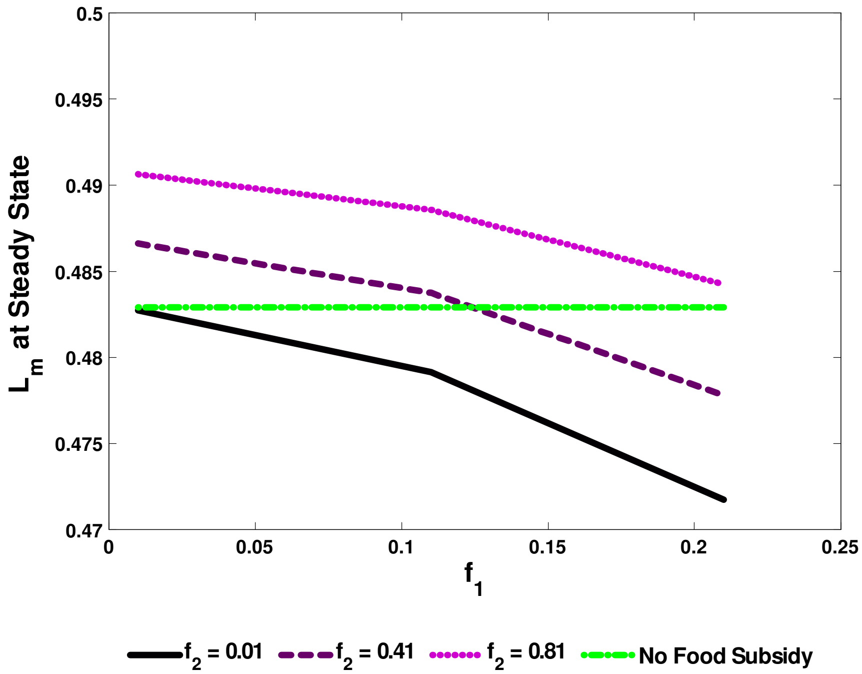

Figure 6: The effect of the food subsidy program on L_m^*

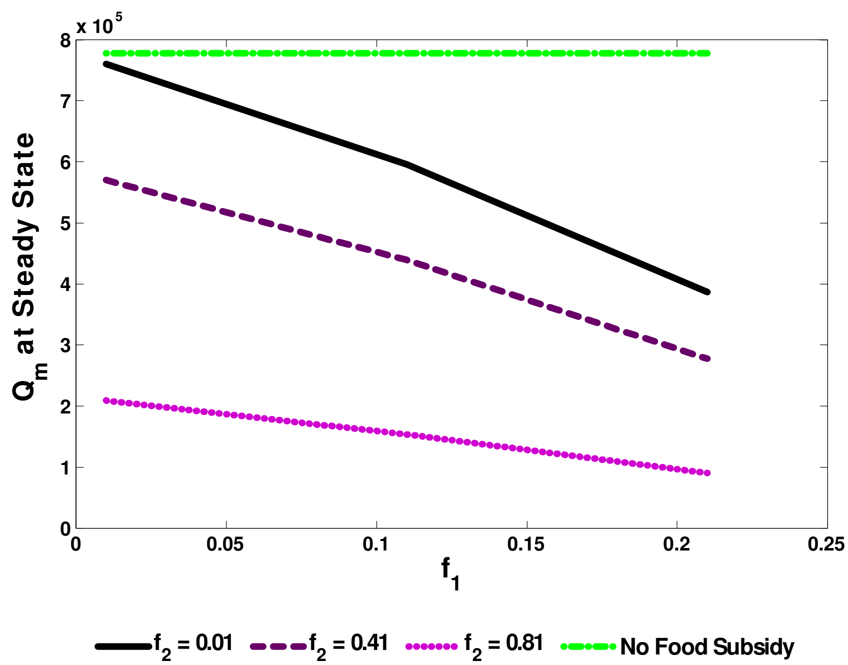

Figure 7: The effect of the food subsidy program on Q_m^*

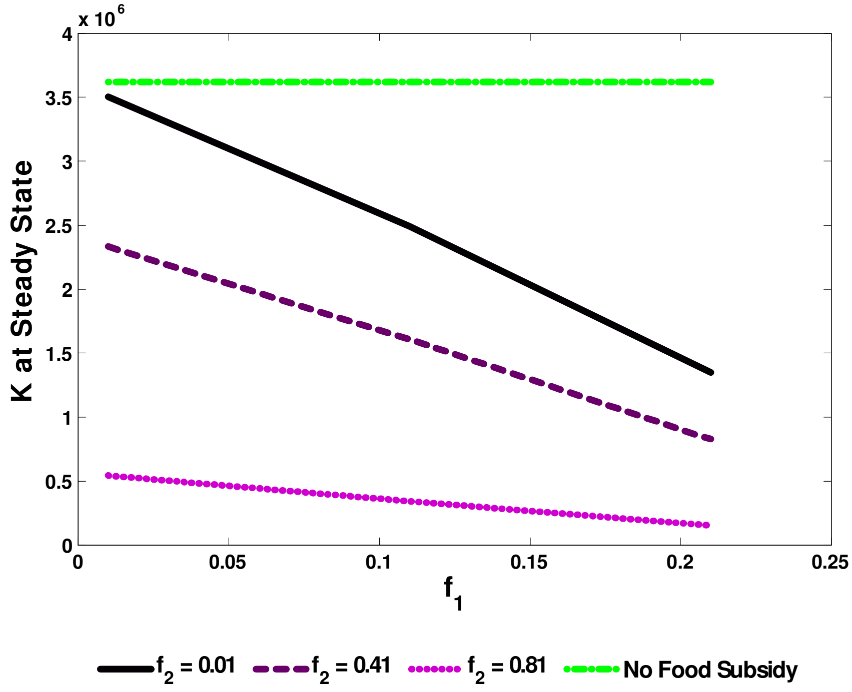

Figure 8: The effect of the food subsidy program on K^*

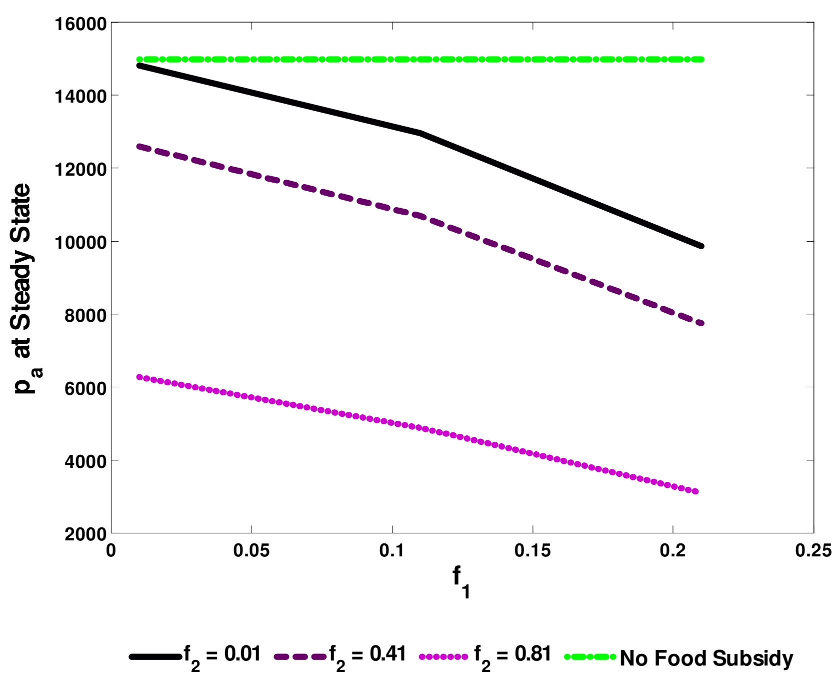

Figure 9: The effect of the food subsidy program on p_a^*

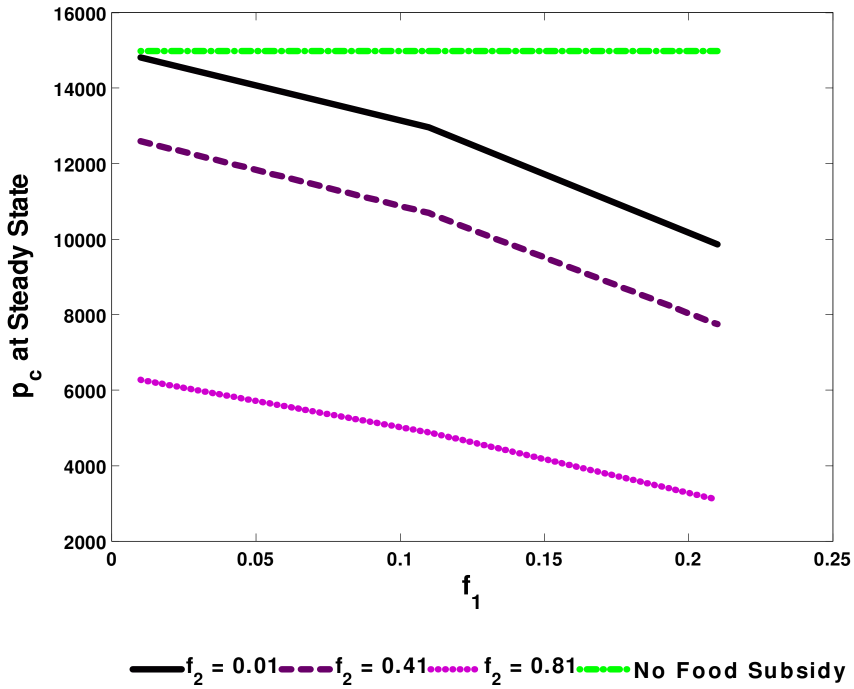

Figure 10: The effect of the food subsidy program on p_c^*

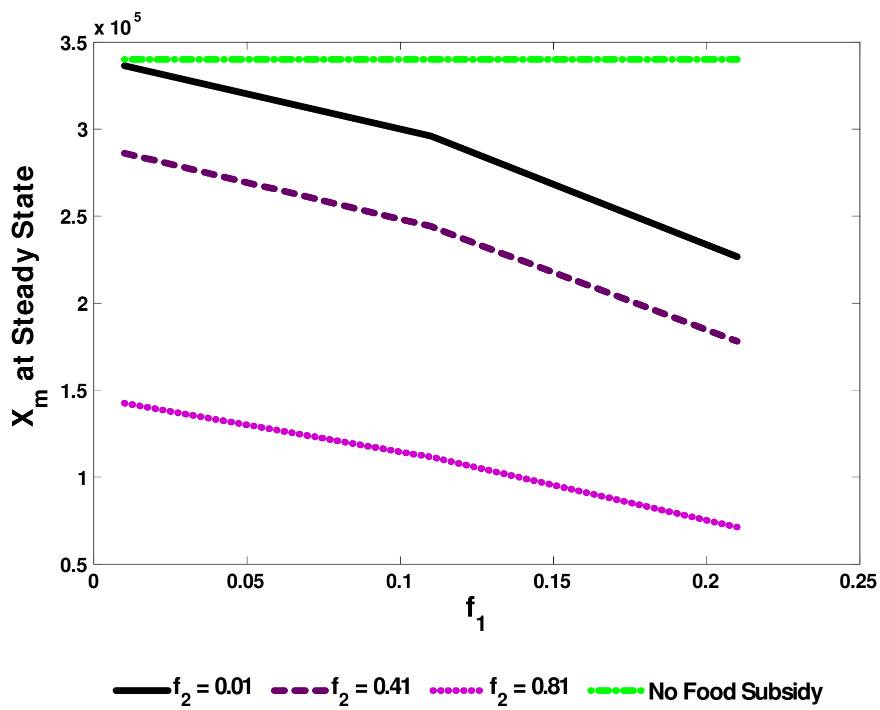

Figure 11: The effect of the food subsidy program on X_m^*

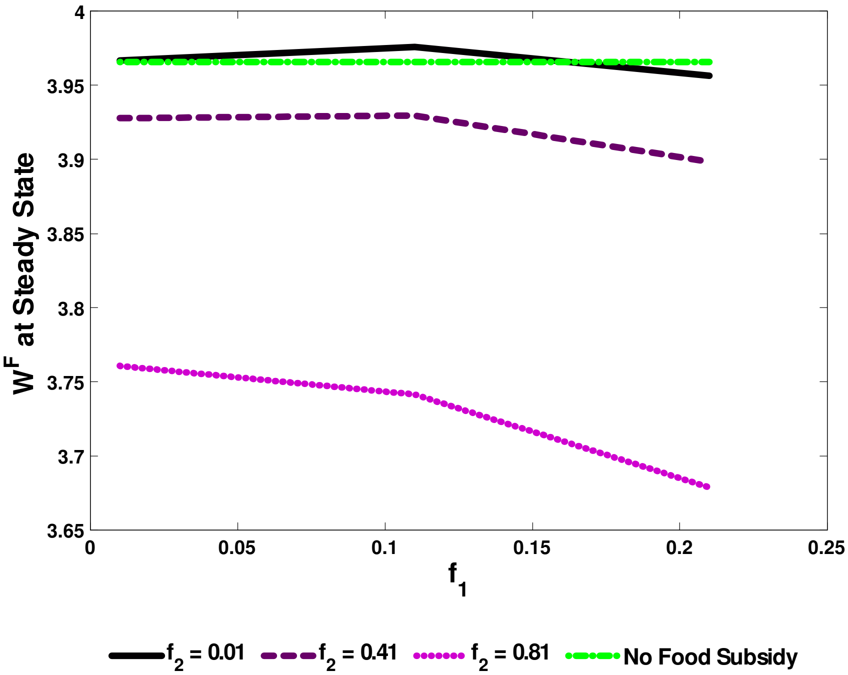

Figure 12: The effect changing f_1 for a given f_2 on W^{F*}

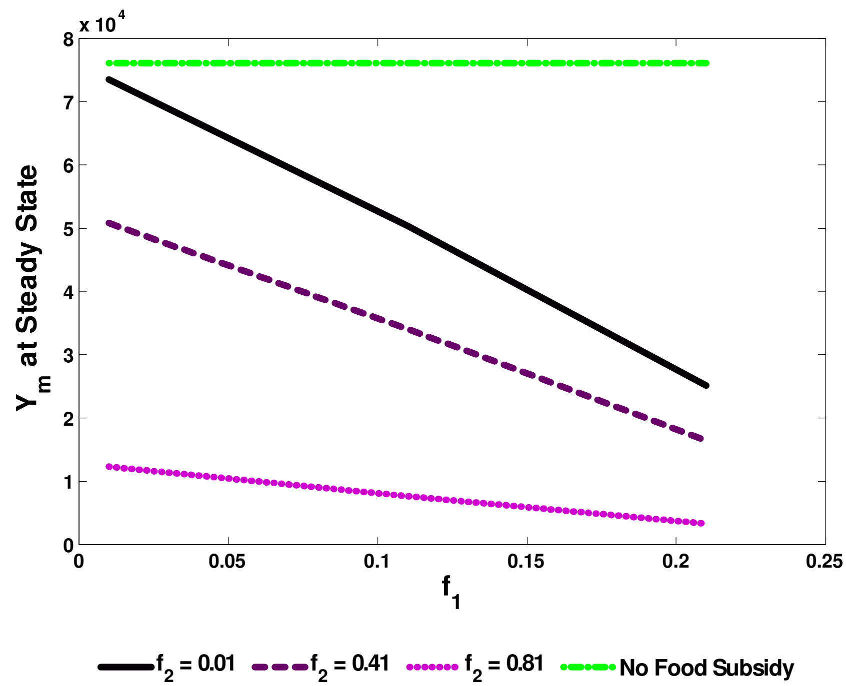

Figure 13: The effect of the food subsidy program on Y_m^*

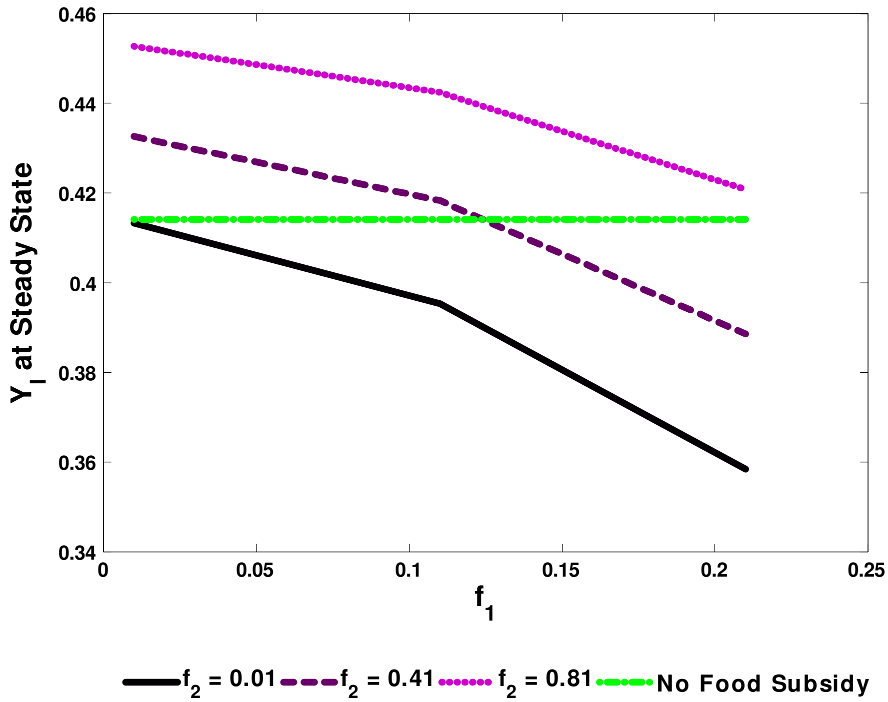

Figure 14: The effect of the food subsidy program on Y_l^*

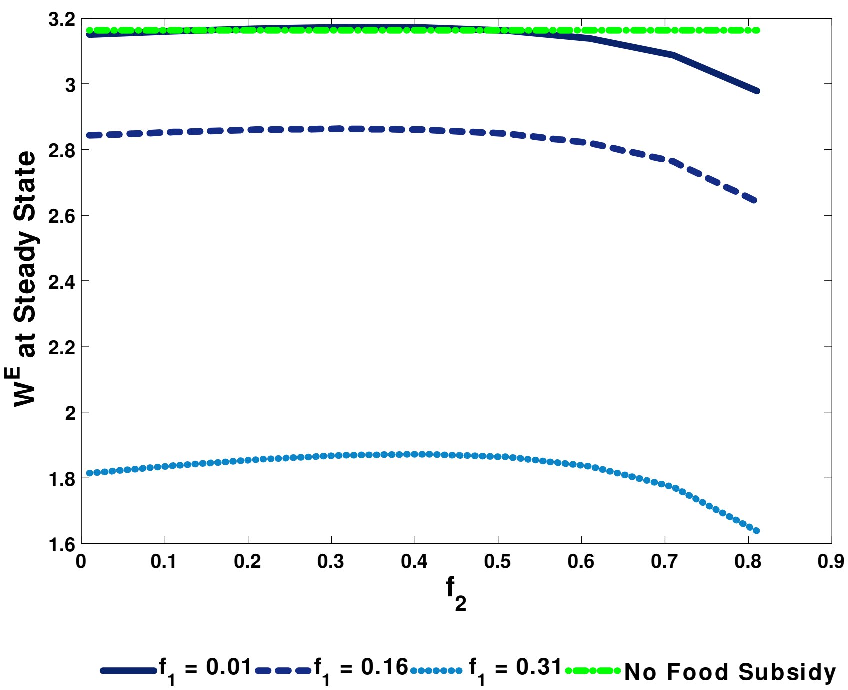

Figure 15: The effect of a change in f_2 for a given f_1 on W^{E*}

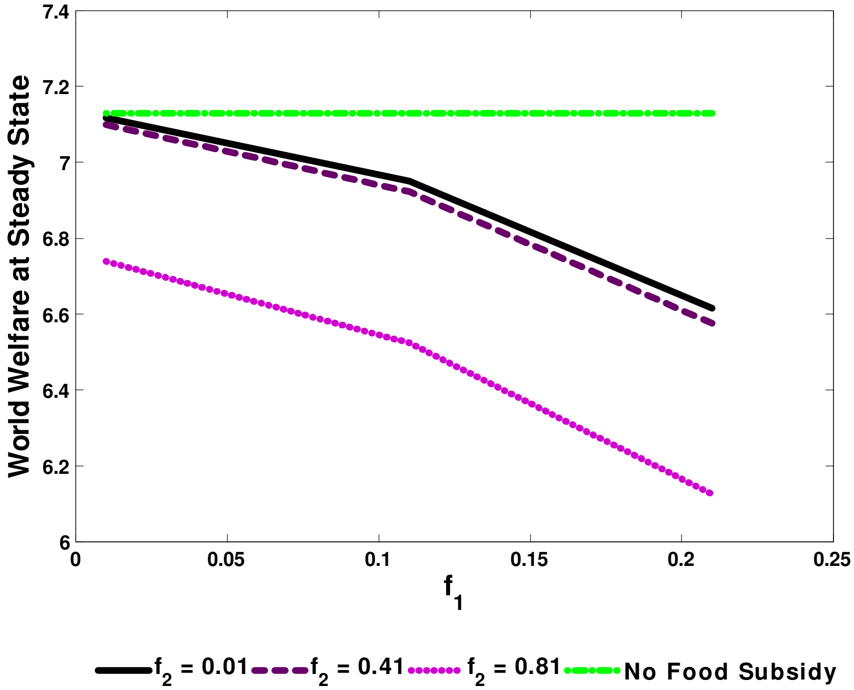

Figure 16: The effect of the subsidy program on W^{O*}

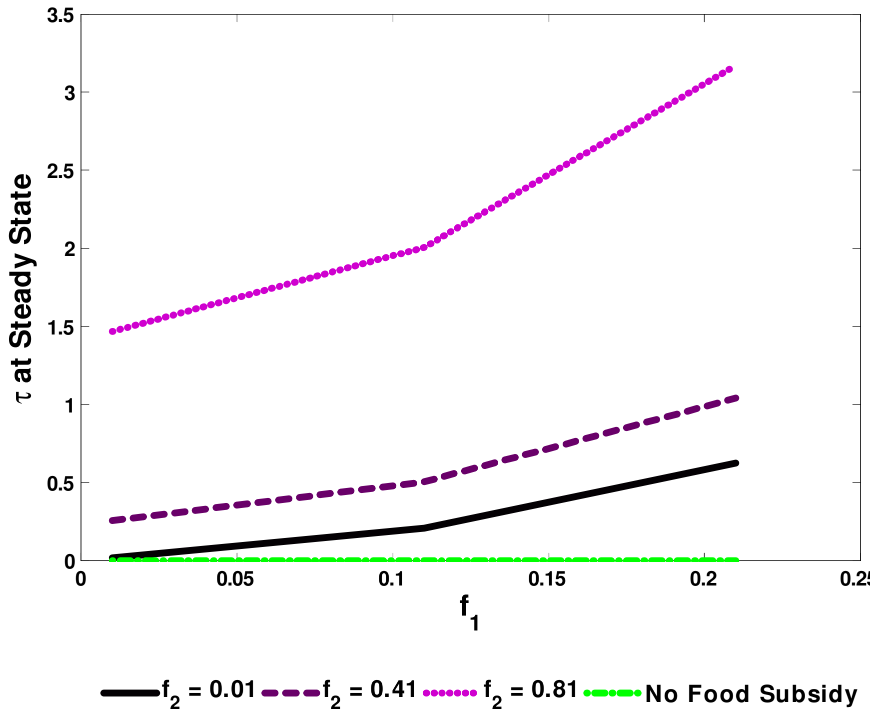

Figure 17: The effect of the subsidy program on τ_s^*

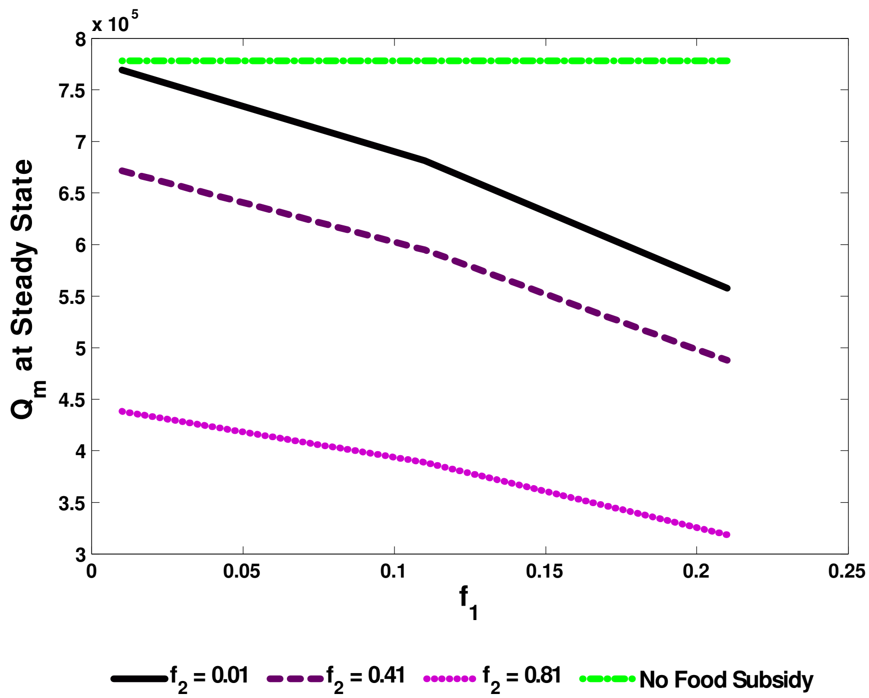

Figure 18: The effect of the subsidy program on Q_m^{s*}

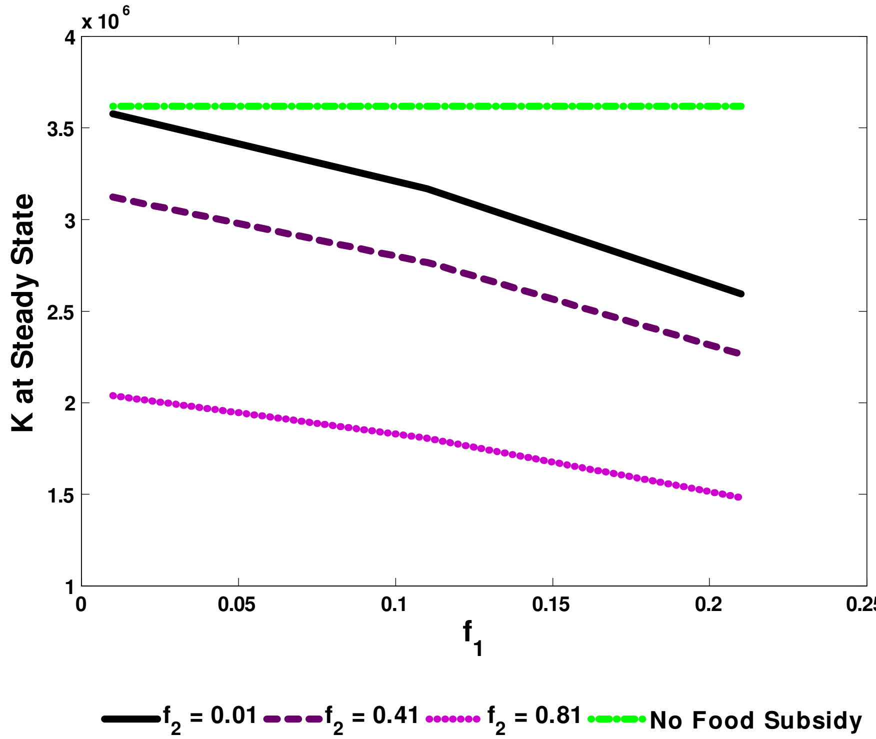

Figure 19: The effect of the subsidy program on K^{s*}

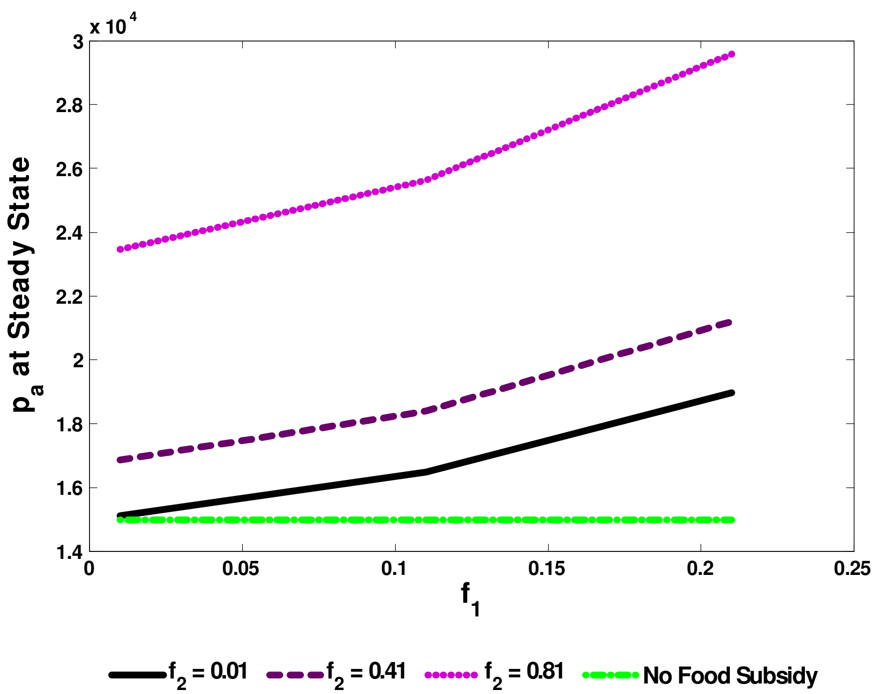

Figure 20: The effect of the subsidy program on p_a^{s*}

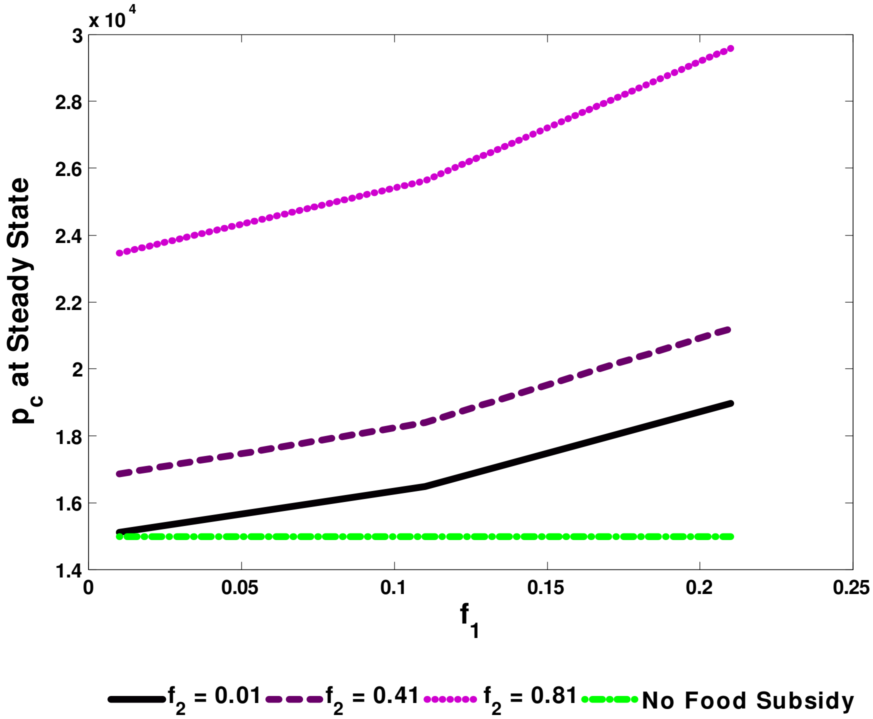

Figure 21: The effect of the subsidy program on p_c^{s*}

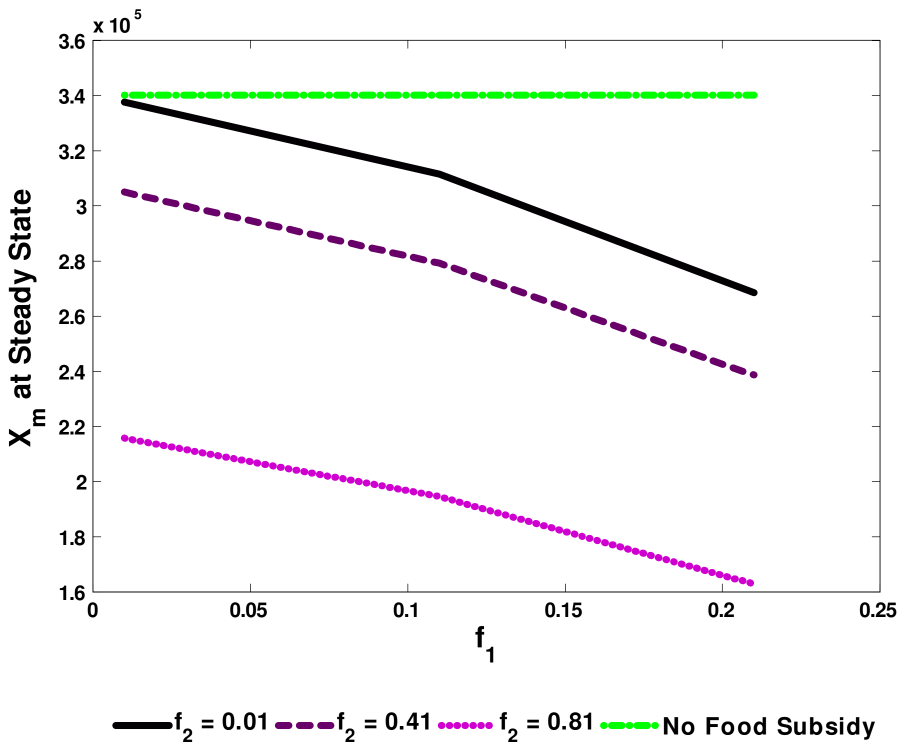

Figure 22: The effect of the subsidy program on X_m^{s*}

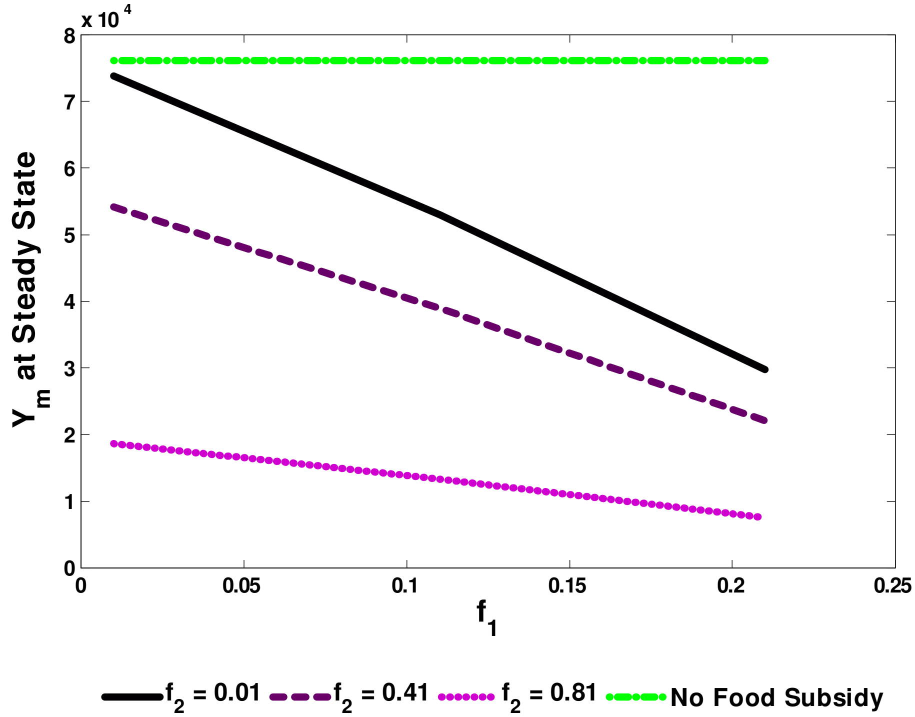

Figure 23: The effect of the subsidy program on Y_m^{s*}

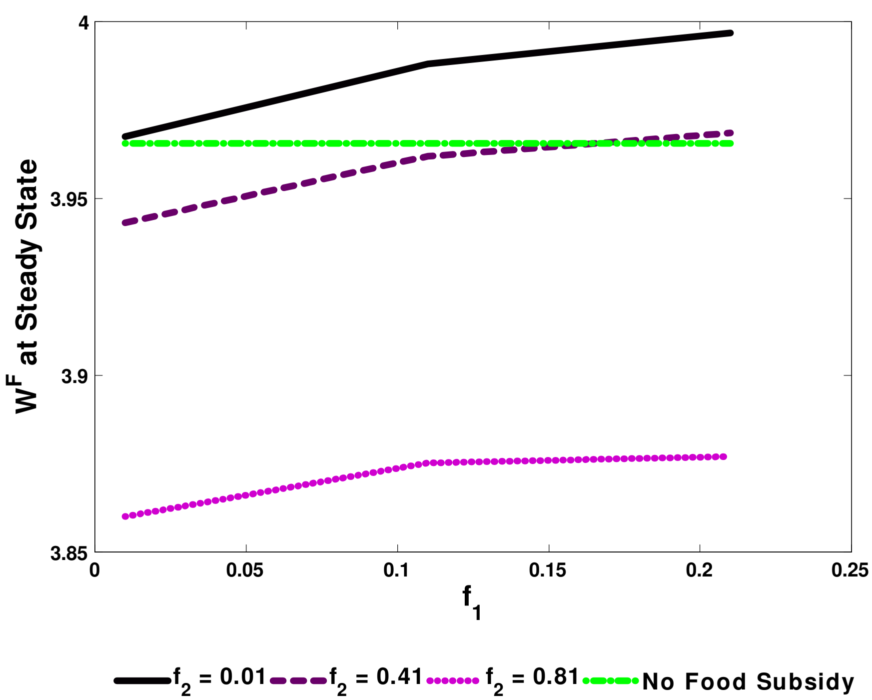

Figure 24: The effect of the subsidy program on W^{sF*}

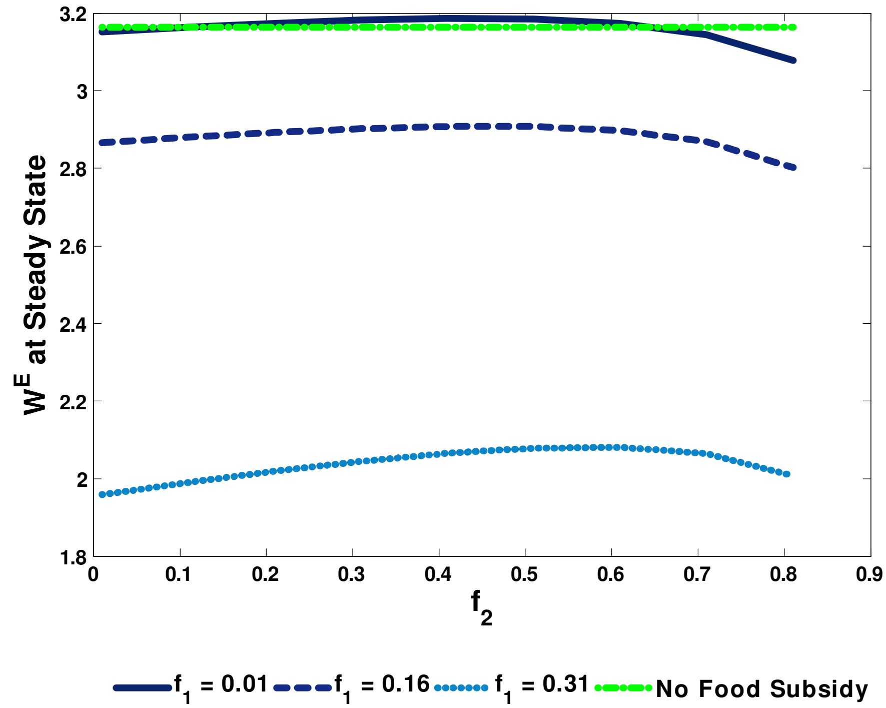

Figure 25: The effect of a change on f_2 for a given f_1 on W^{sE*}

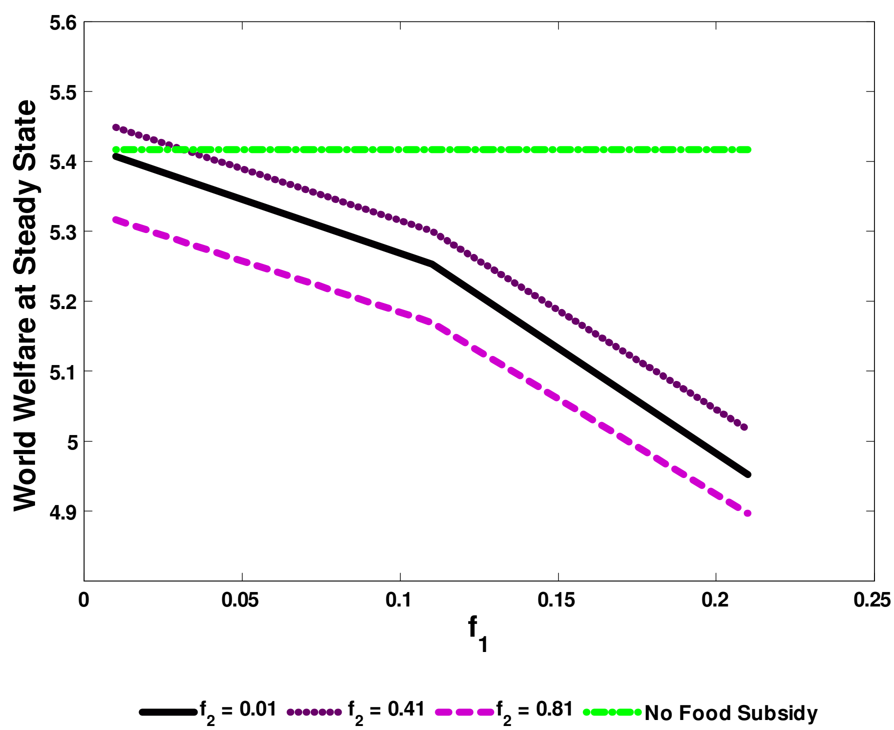

Figure 26: The effect of the subsidy program on W^{sO*}

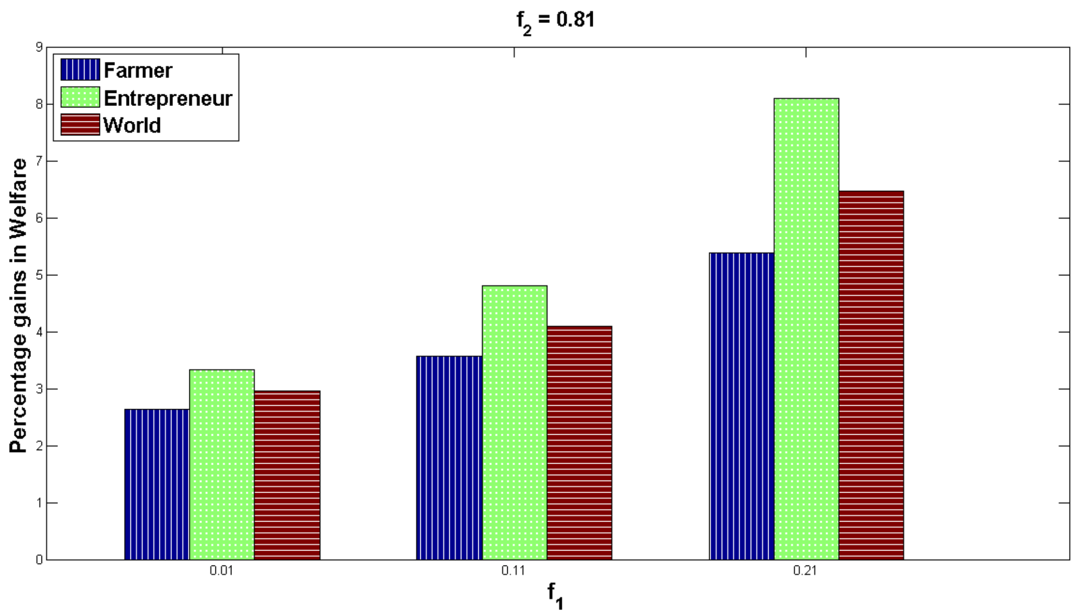

Figure 27: Percentage gains in welfare for $f_2 = 0.81$