Sectoral Infrastructure Investment In An Unbalanced Growing Economy: The Case Of India*

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Abstract

We study the sectoral allocation of public infrastructure investments in the agriculture and manufacturing sectors in India. In addition to the changing employment and output shares of these two sectors, the capital output ratio in agriculture in India has fallen, while it has risen in manufacturing. To match these observations we construct a two sector OLG model with Cobb-Douglas technologies in both sectors. The preferences are semi-linear. We later extend the analysis to allow for a CES production function in the manufacturing sector. We conduct several policy experiments on the sectoral allocation of infrastructure across agriculture and manufacturing. We find: 1. The growth maximizing share of public capital going to agricultural is small with about 10%. This fraction stays constant even in the face of the relative decline of the agricultural sector. 2. The optimal funding level for public infrastructure is far bigger than the one suggested by one sector growth models. 3. Growth rates are decreasing in manufacturing tax rates and increasing in agricultural tax rates.

Keywords: Indian Economic Growth, Structural Transformation, Unbalanced Growth, Public Capital, Two-Sector OLG Growth Models
JEL code: H2, O1, O2, O4

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1 Introduction

This paper studies the effects of public infrastructure investment in an unbalanced growing economy that is undergoing fundamental changes in the structure of production and employment.

Our paper is related to two literatures in the field of growth and development: First, there is a large literature that studies how structural change and growth are related in the development process (see for example Caselli and Colman (2001), Glomm (1992), Gollin, Parente and Rogerson (2002), Laitner (2000), Lucas (2004)). However, there has been relatively little work within this literature focusing on developing countries in general and India in particular.

Second, there is a large literature studying the effects of infrastructure investment on economic growth. Usually these types of analyses are carried out in a one sector growth model with an aggregate production function, often of the Cobb-Douglas kind. Examples here include Barro (1990), Turnovsky and Fischer (1995) Turnovsky (1996), Glomm and Ravikumar (1994, 1997), Eicher (2000), Agenor and Morena-Dodson (2006), Agenor (2008), Ott and Turnnovsky (2006), Angelopoulus, Economides and Kammas (2007) and many others. There are also many empirical studies to go along with the above theoretical investigations. Examples of such empirical papers include papers by Barro (1990), Ai and Cassou (1995), Holtz-Eakin (1994), and Lynde and Richmond (1992).[1]

Most economies have undergone substantial structural changes with large shifts of resources across the three sectors, agriculture, manufacturing and services and with very large changes in the capital-output ratios in the three sectors. In the context of the developing process, India stands out for three reasons.[2] First, India's service sector has grown rapidly in the last three decades, constituting 51% of GDP in 2006 (Banga, 2005). This large size of the service sector growth in India is comparable to the size

[1]Combining these two areas of growth and development research, there is a smaller literature that analyses the effects of infrastructure investment in economies undergoing structural changes such as large shifts or productive activity across from agriculture to manufacturing and then to services. Examples include Arcalean, Glomm, and Schiopu (2007), Carrera, Freire-Seren, and Manzano (2008), de la Fuente, Vives, Dolado and Faini (1995), Carminal (2004), and Ott and Soretz (2010).

[2]These structural shifts are documented in Verma (2012).

of the service sector in developed economies where services often provide more than 60% of total output and an even larger share of employment. Since many components of services (such as financial services, business services, hotels and restaurants) are income related and increase only after a certain stage of development, it is the fact that India's service sector is very large relative to its level development that is puzzling.

Second, the entire decline in the share of agriculture in GDP in India in the last two decades has been picked up by the service sector with manufacturing sector's share almost remaining the same. In general, such a trend is experienced by high-income countries and not by developing countries. In developing countries the typical pattern is for the manufacturing sector to replace the agricultural sector at first. Only at higher levels of aggregate income does the service sector play an increasingly large role. In addition, in spite of the rising share of services in GDP and trade, there has not been a corresponding rise in the share of services in total employment.

Third, unlike the case of aggregate data where capital-output ratios are often constant over time, the sectoral capital-output ratios in India exhibit large changes over time (see Verma (2012)). This is illustrated in Table 1. While agriculture's capital-output ratio has fallen from 3.3 to 0.85 between 1970 and 2000, the manufacturing sector's capital-output ratio has risen from 0.6 to 4.33, and the service sector capital-output ratio has fallen from 11 to 1.82. India's overall capital-output ratio has fallen from 2.43 in 1980 to 2.04 in 2005 thus exhibiting a relatively small decline over time.

In this paper we address the following question: what is the effect of the allocation of infrastructure investment on economic growth in a dynamic general equilibrium model where one sector, say agriculture, shrinks over time, and another sector, manufacturing or services, rises over time. We then calibrate the model to India. We use the calibrated version of the model to conduct a variety of counter-factual policy experiments on the sectoral allocation of public infrastructure investment.

The model we employ for these purposes is a two-sector overlapping generations (OLG) model where all individuals live for two periods. We refer to these two sectors as "agriculture" and "manufacturing", although this identification is not strictly necessary. We just need two sectors whose output and employment shares in the total economy rise and fall, respectively, and whose capital-output ratios are not constant over relatively long time horizons. We assume that the utility function of all individuals is of the semi-linear variety so that the income elasticity for the agricultural good, food, is small. In each production technology the stock of public infrastructure is a productive input. The technology in both sectors is assumed to be Cobb-Douglas. Later, in the sensitivity analysis, we deviate from the typical assumption of Cobb-Douglas production functions in both sectors, by allowing one production technology, the technology in the "manufacturing" sector to be of the CES variety. We assume perfect mobility of both private factors of production, labor and capital, between the two sectors.

We find: First, the share of infrastructure going to agriculture that is GDP maximizing is rather small at around 10%. Consequently, larger public investment shares in agriculture would not increase GDP, but only serve to depress the agricultural price. Second, the effects of increasing the agricultural consumption subsidy holding the other expenditure levels constant are qualitatively very similar to the effect of increasing agriculture's share of infrastructure investment. A high subsidy of agricultural consumption shifts resources away from manufacture into agriculture, which depresses employment, capital accumulation and output in the former sector. Third, manufacturing output is hump shaped in the fraction of public investment going to agriculture. Evidently, the manufacturing sector benefits in terms of output from a modest agricultural investment that supports a relatively sizeable agricultural sector. Fourth, GDP is hump-shaped in public infrastructure funding. The growth maximizing funding level for infrastructure investment is much larger than the one suggested by one-sector growth models. Exogenous fiscal policies thus can thus potentially play an important role in accounting for structural transformation in sectoral output shares, sectoral capital-output ratios, and sectoral employment shares in the Indian context.

2 The Model

The economy is populated by an infinite number of generations. Each generation is alive for two periods. The two periods are young age and old age, each accounts for 25 years. All individuals work when young and are retired when old. Within a generation all individuals are identical. For simplicity we assume that all individuals consume only in the second period of life. Thus all income from the first period is saved for consumption when old. There are two sectors, one we call "agriculture" and a second sector we call "manufacturing", although the names are not crucial. What is crucial is that there are two sectors, with one sector declining and one sector increasing along the development path. We chose a utility function which helps generate one declining and one rising sector in equilibrium, namely the semi-linear utility function. The utility function for all households is given by:

$$u(c_{m,t+1}, c_{a,t+1}) = c_{m,t+1} + \phi ln c_{a,t+1}, \quad \phi > 0, \tag{2.1}$$

where $c_{m,t+1}$ denotes the household consumption of the manufacturing good and $c_{a,t+1}$ the consumption of the agricultural good. The semi-linear utility also captures the observation that the income elasticities for the demand for food are (close to) zero.

Households working in the *agricultural* sector solve the following problem:

$$\begin{aligned} \max_{c_m, c_a} \quad & c_{m,t+1} + \phi ln c_{a,t+1}, \\ s.t. \quad & c_{m,t+1} + (1-\xi) p_{t+1} c_{a,t+1} = (1-\tau_a) p_t w_{a,t} (1+r_t) \end{aligned} \tag{2.2}$$

Here $w_{a,t}$ is the real wage rate, r_t is the real interest rate, p_t and p_{t+1} are the prices of agricultural good relative to the manufacturing good in period t and $t+1$ respectively, and ξ is the excise subsidy applied to agricultural goods.

Households working in the *manufacturing* sector solve the following problem:

$$\begin{aligned} \max_{c_m, c_a} \quad & c_{m,t+1} + \phi ln c_{a,t+1}, \\ s.t. \quad & c_{m,t+1} + (1-\xi)p_{t+1}c_{a,t+1} = (1-\tau_m)w_{m,t}(1+r_t) \end{aligned} \tag{2.3}$$

The only difference in the two household problems are the sources of income. Solving the problem of the households in the agricultural sector yields the demand for the two consumption goods as:

$$\begin{aligned} c^a_{a,t+1} &= \frac{\phi}{(1-\xi)p_{t+1}} \\ c^a_{m,t+1} &= (1-\tau_a)p_t w_{a,t}(1+r_t) - \phi \end{aligned} \tag{2.4}$$

Similarly, the manufacturing sector households solve their maximization problem which yields their demand function as:

$$\begin{aligned} c^m_{a,t+1} &= \frac{\phi}{(1-\xi)p_{t+1}} \\ c^m_{m,t+1} &= (1-\tau_m)w_{m,t}(1+r_t) - \phi \end{aligned} \tag{2.5}$$

The production functions in both sectors are:

$$A_{a,t}G^{\psi_a}_{a,t}K^{\alpha}_{a,t}L^{1-\alpha}_{a,t} \tag{2.6}$$

$$A_{m,t}G^{\psi_m}_{m,t}K^{\beta}_{m,t}L^{1-\beta}_{m,t} \tag{2.7}$$

Here $A_{a,t}$ and $A_{m,t}$ are total-factor-productivity (TFP) in the agricultural and manufacturing sectors, respectively. $K_{a,t}$ and $K_{m,t}$ are the total amount of physical capital used and $L_{a,t}$ and $L_{m,t}$ stand for the total amount of labor employed in the two sectors. Lastly, the production of the agricultural and manufacturing goods is augmented by an investment in a public good (infrastructure), denoted by $G_{a,t}$ and

$G_{m,t}$. The use of these types of technologies with public capital as an input was pioneered by Barro (1990) and Turnovsky (1996) and others. We assume that such investments in public infrastructure can be financed by a tax on (1) labor income in the manufacturing sector, or (2) labor income in the agriculture sector, or (3) both. In addition to financing the public good investment, the government also subsidies consumption of agricultural products.

The government budget constraint can be written as

$$G_{a,t} + G_{m,t} + \xi p_t c_{a,t} = \tau_a w_{a,t} L_{a,t} + \tau_m w_{m,t} L_{m,t} \tag{2.8}$$

where ξ is the subsidy for agricultural goods consumption. Note that $\tau_a \geq 0$ and $\tau_m \geq 0$. We do not allow public debt in our model.

Letting $\delta_a \in [0, 1]$ denote the fraction of government revenue which is allocated to agricultural infrastructure, we can write

$$G_{a,t} = \delta_a[\tau_a w_{a,t} L_{a,t} + \tau_m w_{m,t} L_{m,t} - \xi p_t c_{a,t}] \tag{2.9}$$

$$G_{m,t} = (1 - \delta_a)[\tau_a w_{a,t} L_{a,t} + \tau_m w_{m,t} L_{m,t} - \xi p_t c_{a,t}] \tag{2.10}$$

The returns to factors in the two sectors are:

$$w_{a,t} = (1 - \alpha) A_{a,t} G_{a,t}^{\psi_a} (K_{a,t}/L_{a,t})^{\alpha} \tag{2.11}$$

$$w_{m,t} = (1 - \beta) A_{m,t} G_{m,t}^{\psi_m} (K_{m,t}/L_{m,t})^{\beta} \tag{2.12}$$

$$q_{a,t} = \alpha A_{a,t} G_{a,t}^{\psi_a} (K_{a,t}/L_{a,t})^{\alpha-1} \tag{2.13}$$

$$q_{m,t} = \beta A_{m,t} G_{m,t}^{\psi_m} (K_{m,t}/L_{m,t})^{\beta-1} \tag{2.14}$$

Assuming costless mobility of labor, we can equate the wage rates across the two sectors:

$$(1-\tau_a)p_t(1-\alpha)A_{a,t}G_{a,t}^{\psi_a}(K_{a,t}/L_{a,t})^{\alpha} = (1-\tau_m)(1-\beta)A_{m,t}G_{m,t}^{\psi_m}(K_{m,t}/L_{m,t})^{\beta} \quad (2.15)$$

Similarly, we equate interest rates across the two sectors:

$$p_t\alpha A_{a,t}G_{a,t}^{\psi_a}(K_{a,t}/L_{a,t})^{\alpha-1} = \beta A_{m,t}G_{m,t}^{\psi_m}(K_{m,t}/L_{m,t})^{\beta-1} \quad (2.16)$$

The market clearing condition for the two goods are:

$$\begin{aligned} c_{a,t}^{a}L_{a,t-1} + c_{a,t}^{m}L_{m,t-1} &= A_a G_{a,t}^{\psi_a}K_{a,t}^{\alpha}L_{a,t}^{1-\alpha} \\ c_{m,t}^{a}L_{a,t-1} + c_{m,t}^{m}L_{m,t-1} &= A_m G_{m,t}^{\psi_m}K_{m,t}^{\beta}L_{m,t}^{1-\beta} \end{aligned} \quad (2.17)$$

The law of motion for capital:

$$K_{a,t+1} + K_{m,t+1} = (1-\tau_a)p_t w_{a,t}L_{a,t} + (1-\tau_m)w_{m,t}L_{m,t} \quad (2.18)$$

Note that households only consume in the second period of life, therefore all income is saved and funds the future capital stock. We assume that there is no population growth so that the labor force is constant over time. Assuming competitive labor markets, the labor allocations in the two sectors must add up to the total labor supply.

$$\begin{aligned} L_{a,t} + L_{m,t} &= L_t \\ L_t &= L_{t+1} \end{aligned} \quad (2.19)$$

3 Results

3.1 Overall effects in the long run

In this section we describe how changes in fiscal policy measures influence the equilibrium trajectories. Here we focus on the qualitative effects of the following policy reforms:

1. Increasing the share of infrastructure investment going to agriculture (δ_a) with a corresponding decrease in manufacturing's share (δ_m).

2. Increasing the agricultural subsidy (ξ), holding both tax rates constant.

3. Raising the agricultural tax (τ_a), while increasing all government expenditure proportionately, holding the manufacturing tax rate fixed.

4. Raising the manufacturing tax (τ_m), while increasing all government expenditures proportionately, holding the agricultural tax rate fixed.

5. Increasing both tax rates simultaneously, holding all expenditure shares constant.

The parameter values used for our simulations are presented in Table 2. These values, such as the income shares of capital and other production function parameters, are standard in the literature. For India-specific values, such as the level and growth rate of Total Factor Productivity (TFP), we have followed Verma (2012). The long term trajectories are illustrated in Figures (1)-(4). Under the economic and policy parameters chosen for the simulations, the dynamic equilibrium results generated by our model are very similar with the data from Verma (2012). In particular aggregate capital, aggregate labor, GDP and both sectoral outputs are increasing over time. The fraction of labor employed in agriculture is declining over time, agriculture's share of GDP is declining over time. Interestingly and consistent with the data, the capital-output ratio falls in agriculture and rises in manufacturing over time. The model matches the data for all fiscal policies chosen for our simulations.

As is evident from Figure (1), increasing the share of agricultural infrastructure investment from 0.1 to 0.4 shifts both capital and labor from manufacturing into agriculture. As a consequence agricultural output rises, while manufacturing output falls. The price of the agricultural good falls. The negative effect on manufacturing outweighs the positive effect on agriculture and therefore overall GDP falls. The effects of shifting infrastructure towards agriculture on the overall GDP are very small. The four-fold increase in agriculture's share of infrastructure decreases GDP after six periods only by 5.3%.

The effects of increasing the agricultural subsidy, see Figure (2), are qualitatively very similar to the effect of increasing agriculture's share of infrastructure investment. A high agricultural subsidy shifts resources away from manufacture into agriculture, which depresses employment, capital accumulation and output in the former sector. Quantitatively increasing the size of the agricultural subsidy on GDP seems very small.

Figure (3) shows that, raising the tax rate in the agricultural sector massively shifts resources out of the agricultural sector, agricultural output falls, manufacturing output rises and overall GDP increases. The relative price of food rises. This effect is large. Raising the tax on income from the manufacturing sector (see Figure (4)) is just the flip side of the policy considered in Figure (3). Since the income elasticity for the agricultural good is zero and the income elasticity for the manufacturing good is positive, we can think of manufacturing as the "dynamic" sector and agriculture as the "stagnant" sector. From these last two experiments we learn that increasing taxes on the stagnant (dynamic) sector increases (decreases) GDP.

3.2 Optimal split of government funding between two sectors - δ_a

One of the important policy issues we consider is how public infrastructure investment should be split between the modern dynamic manufacturing sector and the more traditional agricultural sector. Holding all other dimensions of fiscal policy constant we change the share of the infrastructure capital going to agriculture rather than manufacturing and compute how the GDP growth rate depends upon δ_a. We calculate the level of δ_a which maximizes the level of GDP. We do this in periods two, four and six, and the corresponding results are illustrated in Figures (5), (6), and (7). What stands out in these figures is that the share of infrastructure going to agriculture that is GDP maximizing is rather small at around 10%. This small fraction reflects the fact that given the specified utility function the income elasticity for the demand for the agricultural good is zero. Notice that in this experiment both coefficients on infrastructure in the two sectoral production functions are the same. With symmetric treatment of both goods in the utility function the output maximizing share of agricultural infrastructure will be around 50%. The small size of the optimal agricultural share in infrastructure is entirely due to the semi-linear nature of the utility function. Consequently larger public investment shares in agriculture would not increase GDP, but only serve to depress the agricultural price. It is also noteworthy that this output maximizing fraction stays rather constant at 10% over time even as the agricultural sector shrinks relative to the modern manufacturing sector. Surprisingly, manufacturing output is hump shaped in the fraction of public investment going to agriculture. One might have expected that shifting resources away from manufacturing uniformly decreases manufacturing output, but evidently the manufacturing sector benefits in terms of output from a modest agricultural investment that supports a relatively sizeable agricultural sector.

3.3 Optimal tax rates

To find the optimal tax rates, we conduct the following experiments:

1. Raising the agricultural tax rate (τ_a), while holding the manufacturing tax rate (τ_m) constant.
2. Raising the manufacturing tax rate (τ_m), while holding the agricultural tax rate (τ_a) constant.
3. Raising the two tax rates (τ_a, τ_m) at the same time.

When we vary the agricultural tax rate holding the manufacturing tax rate and the split of infrastructure between the two sectors constant, the results are illustrated in Figure (8). Increasing the agricultural tax rate decreases agricultural output and increases manufacturing output by shifting resources out of agriculture sector. Since the manufacturing sector is the dynamic sector, this policy increases the growth rate of overall GDP. The results of increasing the tax in the manufacturing sector, which are illustrated in Figure (9), are diametrically opposite: there is a decrease in manufacturing output, an increase in agricultural production and a decrease in overall GDP. Varying the sectoral tax rates has very large effects. Increasing the agricultural tax rate from about 20% to 50% increases the level of GDP by over 40%. Similarly large effects are found for changes in the manufacturing tax rate. Getting the sectoral allocation of these tax burdens right thus has potentially large effects on GDP and therefore on welfare.

Varying the two tax rates τ_a and τ_m simultaneously has the expected effects as seen in Figure (10). Increasing the manufacturing tax rates decreases the level of output, while increasing the agricultural tax rate increases the output level. Varying both tax rates has the expected composite effect.

In Barro (1990) and similar papers the relationship between the funding level for public infrastructure and the growth rate (or the level) of GDP is hump-shaped with the peak occurring when the tax rate is equal to the coefficient on public capital in the production function. We now investigate to what extent that result carries over to the two-sector setting. Since we have two tax rates we have to fix the relationship between the two tax rates. First we set the agricultural tax rate equal to the manufacturing tax rate and then increase both rates proportionately. As is illustrated in Figure (11), this policy leads to a monotonic relationship between the tax rate and the growth rate of GDP. Higher tax rates are associated with higher levels of income over the entire relevant range suggested by the size of the infrastructure productivity coefficients.

We next set $\tau_m = 1.5\tau_a$ and scale up the size of the government. In this case, see Figures (12)-(14), the relationship between tax rates and the level of income turns out to be hump shaped. As the tax rates are increased, the size of agricultural production rises, manufacturing output is hump shaped in the tax rates. Putting these effects together generates the hump shaped relationship between tax rates and overall GDP. It is noteworthy that the tax rate which maximizes the level of GDP is substantially larger than the infrastructure coefficient in the production function ($\psi_a = \psi_m = 0.12$ in this experiment). Moreover, it is apparent from Figures (12)-(14) that, unlike in Barro (1990), the tax rate which maximizes GDP is not constant, but rising over time. As the relative role of agriculture shrinks and the role of the modern dynamic manufacturing sector rises, the funding requirement for public infrastructure rises as well so that the GDP maximizing funding level increases over time.

In Figure (15), we show how the GDP maximizing tax rate depends upon the infrastructure productivity coefficients ψ_a and ψ_m assuming they are equal. If a Barro like result had obtained in our model, the maximizing tax rate would line up on the 45 degree line. As we can see from Figure (15), the maximizing tax rate is higher than the one in Barro (1990) and the gap between the 45 degree line and the GDP maximizing funding level increases as public capital becomes more productive.

4 Sensitivity analysis

In order to investigate the robustness of our results we relax the Cobb-Douglas assumption for the production technologies and allow the manufacturing technology to be of the CES variety. The production function is given by

$$Y_{m,t} = A_{m,t} G_{m,t}^{\psi_m} ((1-\theta) K_{m,t}^{\rho} + \theta L_{m,t}^{\rho})^{\frac{1}{\rho}}, \qquad -\infty < \rho < 1 \tag{4.1}$$

We now let the parameter ρ vary from -100 (almost perfect complements) to 0.5 (very close substitutes). In Figures (16)-(18) we illustrate how the output maximizing share of public investment going to agriculture as opposed to manufacturing depends upon the elasticity of substitution parameter ρ. The result is remarkably robust: For all the values of ρ ranging from -100 to 0.5, the output maximizing share going to agriculture is very close to 0.1. Figure (16) illustrates the case for $T = 2$. We have also run this experiment for $T = 4$ and $T = 6$. The results for these two other periods are basically the same.

In Figures (19)-(21) we show how output depends upon the change in the overall tax rate for the same values of ρ going from -100 to 0.5. The case for period $t = 2$ is illustrated in Figure (19). As ρ increases from -100 to 0.5 the output maximizing tax rate rises from about 0.22 to about 0.24. This sensitivity is slightly more pronounced in later periods. In period $T = 6$ (see Figure Figures (21)) the output maximizing tax rate goes from around 0.25 to almost 0.3.

5 Conclusion

We constructed a tractable two-sector model to study the effects of sectoral infrastructure allocations on economic growth. The model we use fits the growth observations for Indian as documented by Verma (2012). In our simulations we show that public infrastructure policies can play an important role in influencing the allocation of private capital and labor across sector, which then in turn has a powerful influence on overall economic growth. In particular we establish: First, the growth maximizing allocation of infrastructure invest to the agricultural sector is small. Second, the growth effects of agricultural subsidies are large. Third, sectoral taxation can have very large effects on economic growth. Lastly, the growth maximizing infrastructure funding level is much larger than that suggested by the one sector growth model.

In this paper we have used the competitive market assumption and abstracted from a variety of distortions in factor markets such as large public sector involvement in the manufacturing production. We leave such extensions for future work.

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Table 1: Data

	Agriculture		Manufacturing		Services	
	1970	2000	1970	2000	1970	2000
Employment Shares[a]	77%	62%	12%	19%	12%	20%
GDP Shares	48%	25%	23%	27%	29%	48%
K/Y Ratios	3.3	0.85	0.6	4.33	11	1.82
Gross Capital Formation	18%	9%	33%	30%	49%	61%

Source: Verma(2012)

(a): the employment share data are for 1970 and 1997.

Table 2: Calibration Values

	Definition	Normal	Experiments			
			1	2	3	4
A_a	initial TFP in agriculture	2				
A_m	initial TFP in manufacturing	1				
g_a	growth rate of agri TFP (20 yrs)	1.2				
g_m	growth rate of manuf TFP (20 yrs)	1.05				
α	income share of K in agri	0.3				
β	income share of K in manuf	0.4				
ϕ	parameter in consumption func	2				
ψ_a	power param of G in agri prod.	0.12$\sim$ 0.2				
ψ_m	power param of G in manuf prod.	0.12$\sim$ 0.2				
δ_a	govt funding share for agri	0.5	$\{0.1, 0.4\}$			
ξ	govt subsidy of agricultural prices	0.05		$\{0.01, 0.1\}$		
τ_a	tax rate of agricultural income	0.3			$\{0.2,0.4\}$	
τ_m	tax rate of manufacturing income	0.3				$\{0.01,0.35\}$

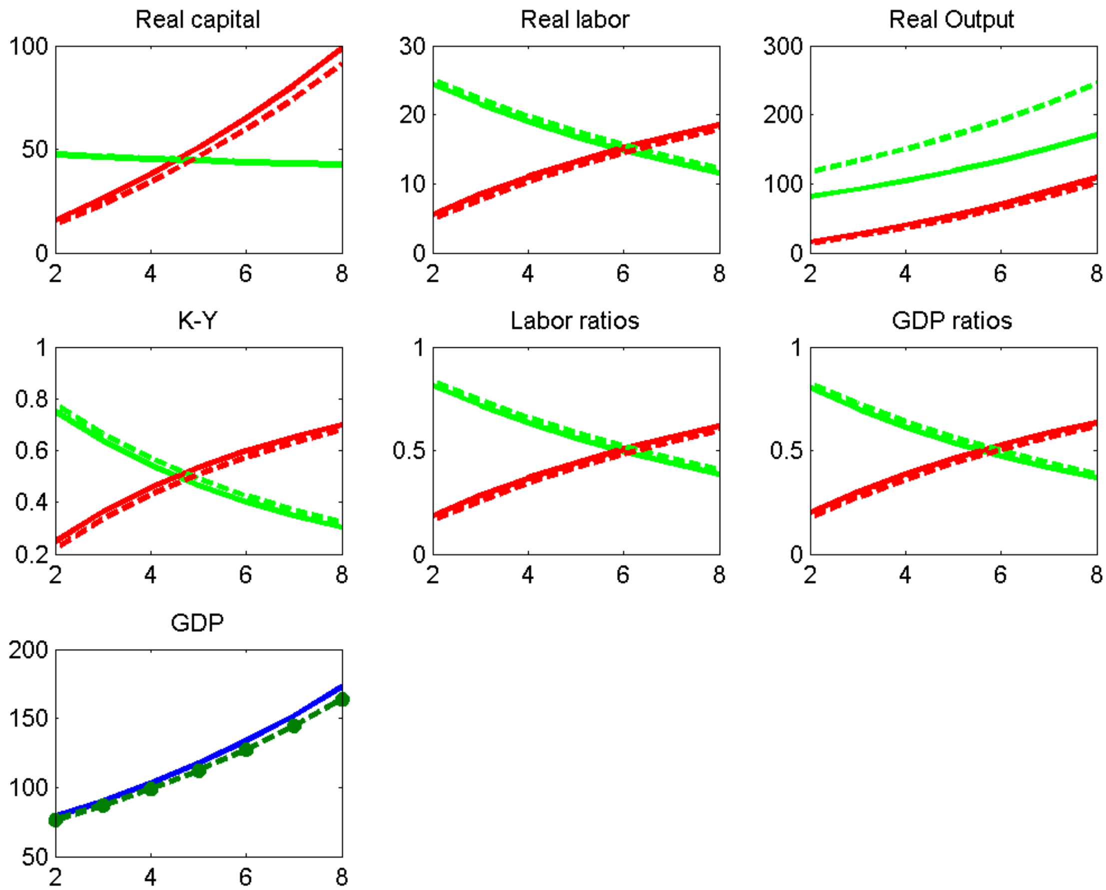

Figure 1: Policy experiment 1: raising δ_a (allocation of govt funding to agriculture) from 0.1 to 0.4. Green: agriculture; Red: Manufacturing; Solid line: before experiment; Dashed line: after experiment.

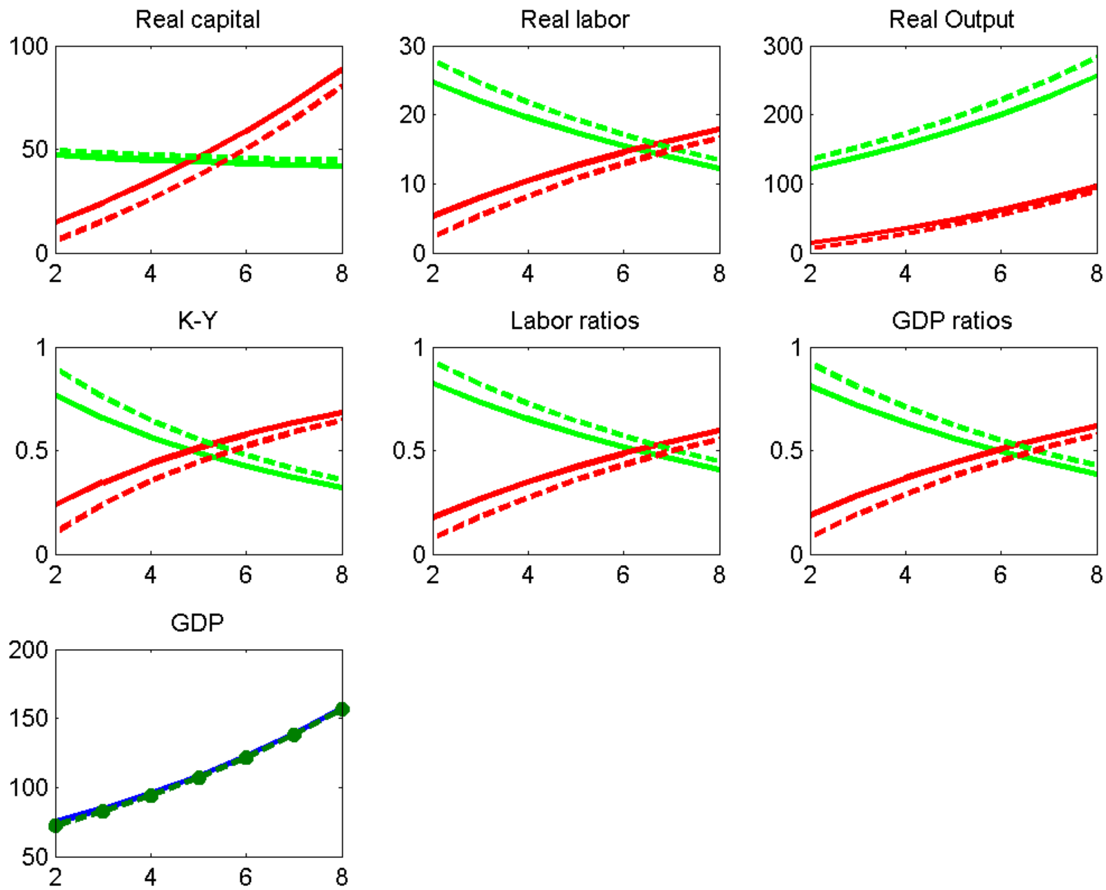

Figure 2: Policy experiment 2: raising ξ (subsidies of agriculture goods) from 0.01 to 0.1. Green: agriculture; Red: Manufacturing; Solid line: before experiment; Dashed line: after experiment.

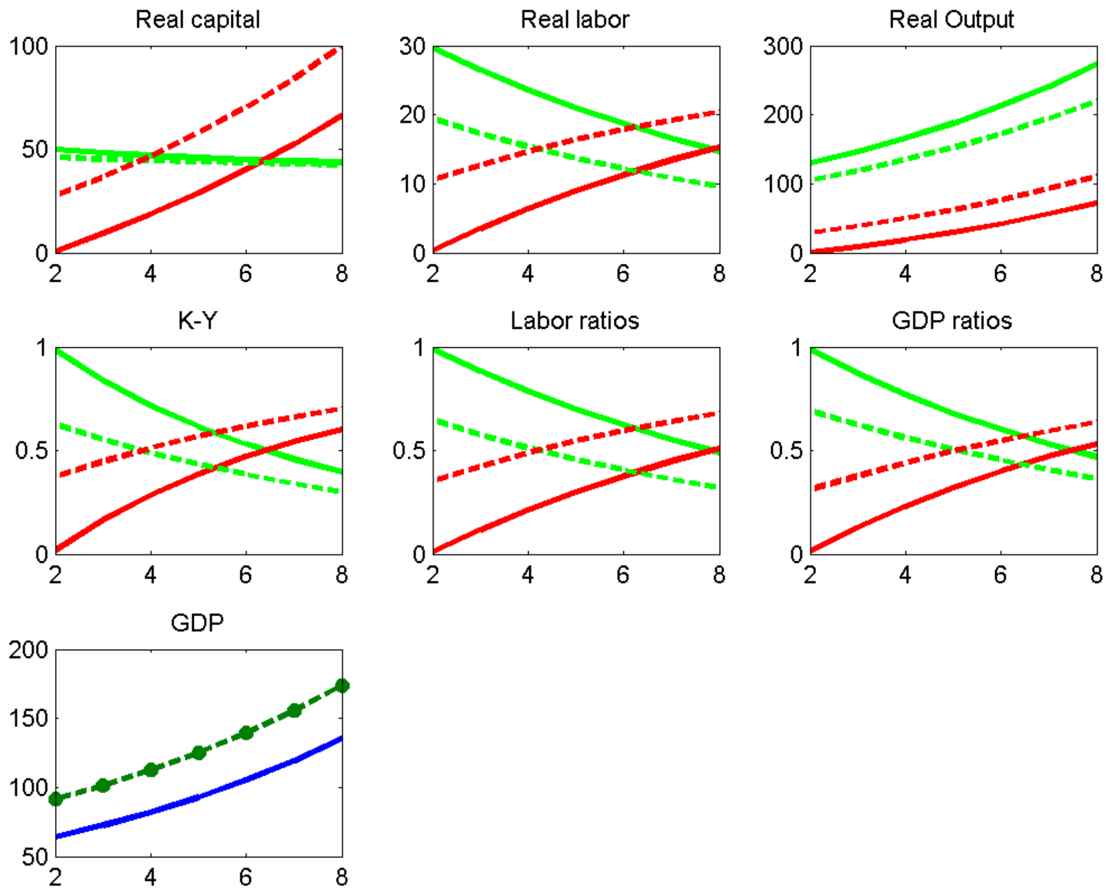

Figure 3: Policy experiment 3: raising τ_a (income tax rate on agricultural workers) from 0.2 to 0.4. Green: agriculture; Red: Manufacturing; Solid line: before experiment; Dashed line: after experiment.

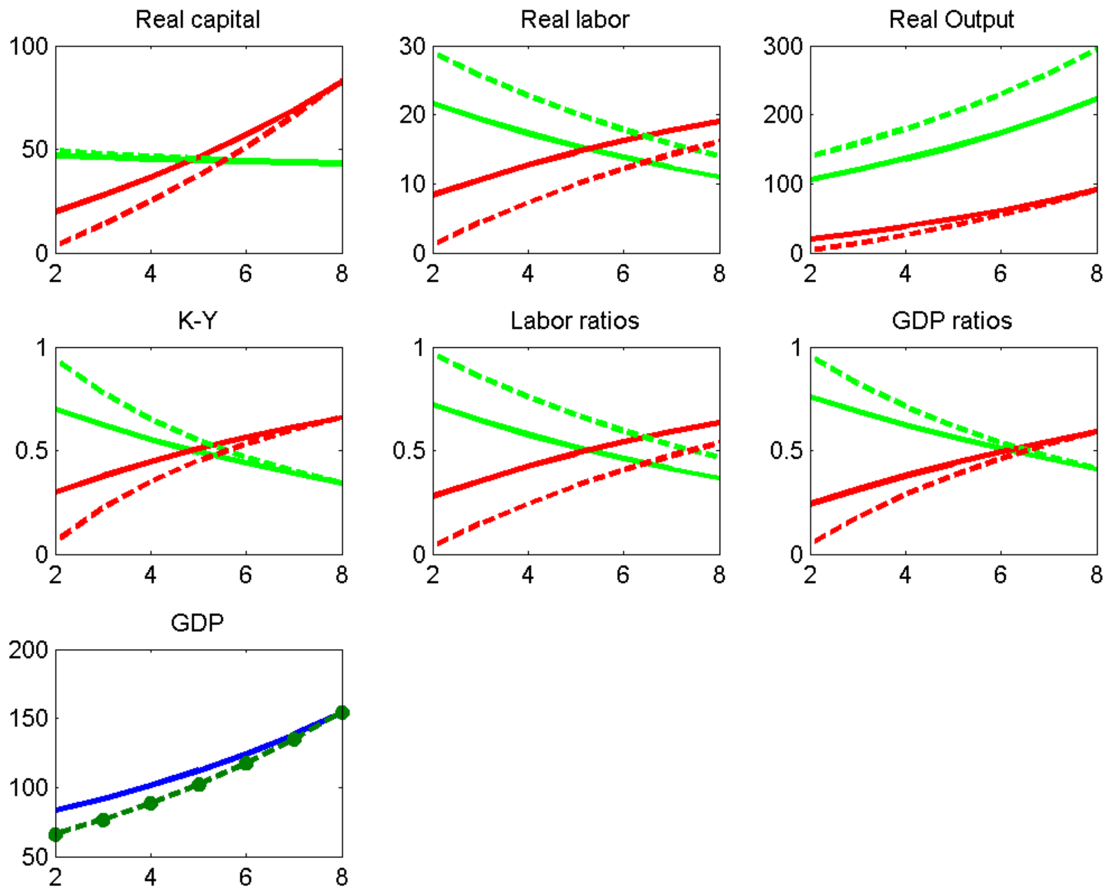

Figure 4: Policy experiment 4: raising τ_m (income tax rate on manufacturing workers) from 0.01 to 0.35. Green: agriculture; Red: Manufacturing; Solid line: before experiment; Dashed line: after experiment.

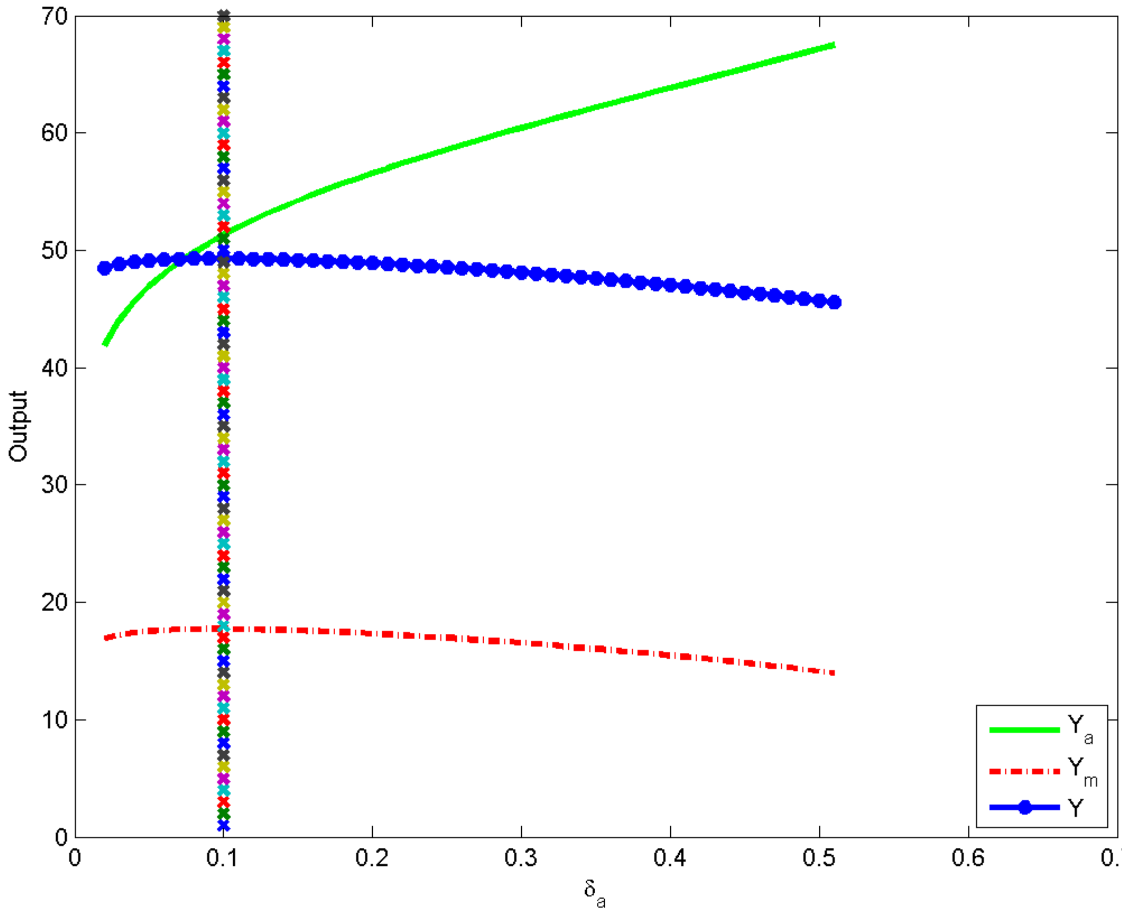

Figure 5: Optimal Sectoral Infrastructure Allocation ($T = 2$)

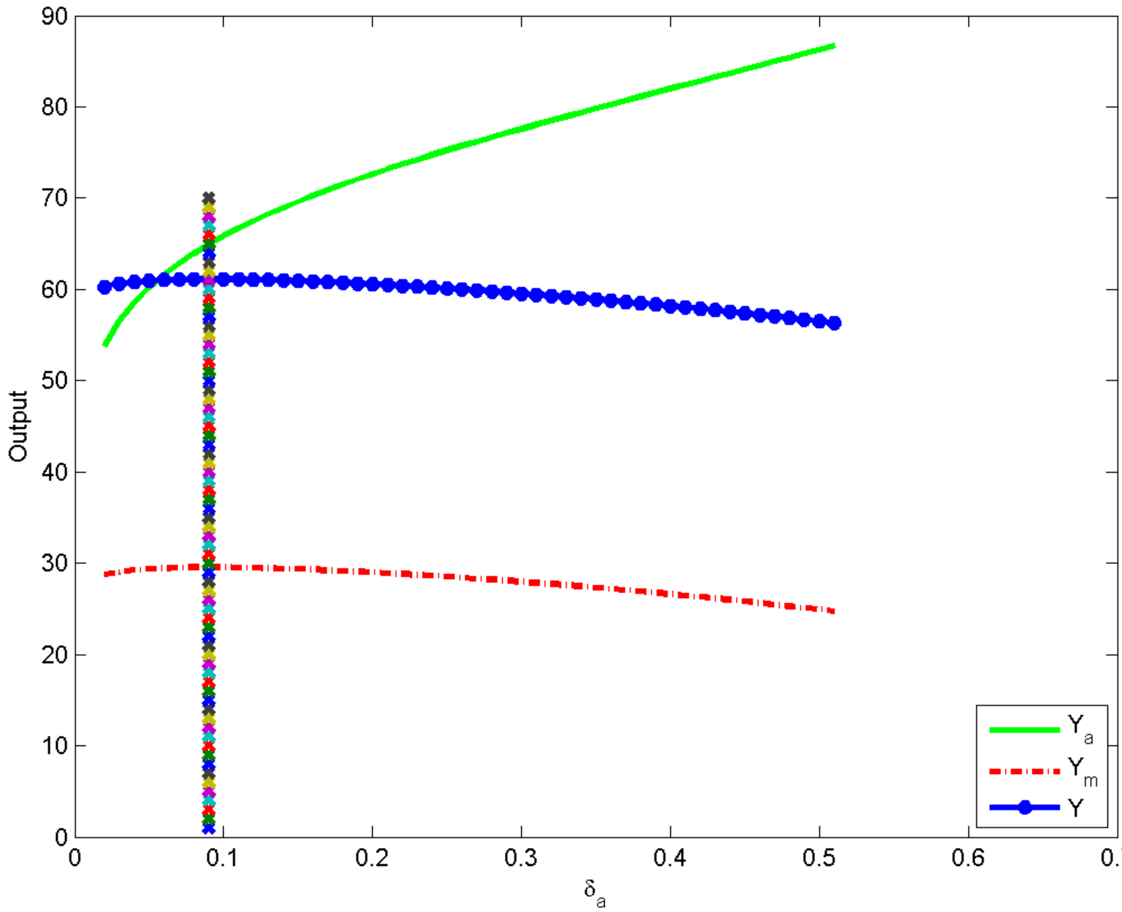

Figure 6: Optimal Sectoral Infrastructure Allocation ($T = 4$)

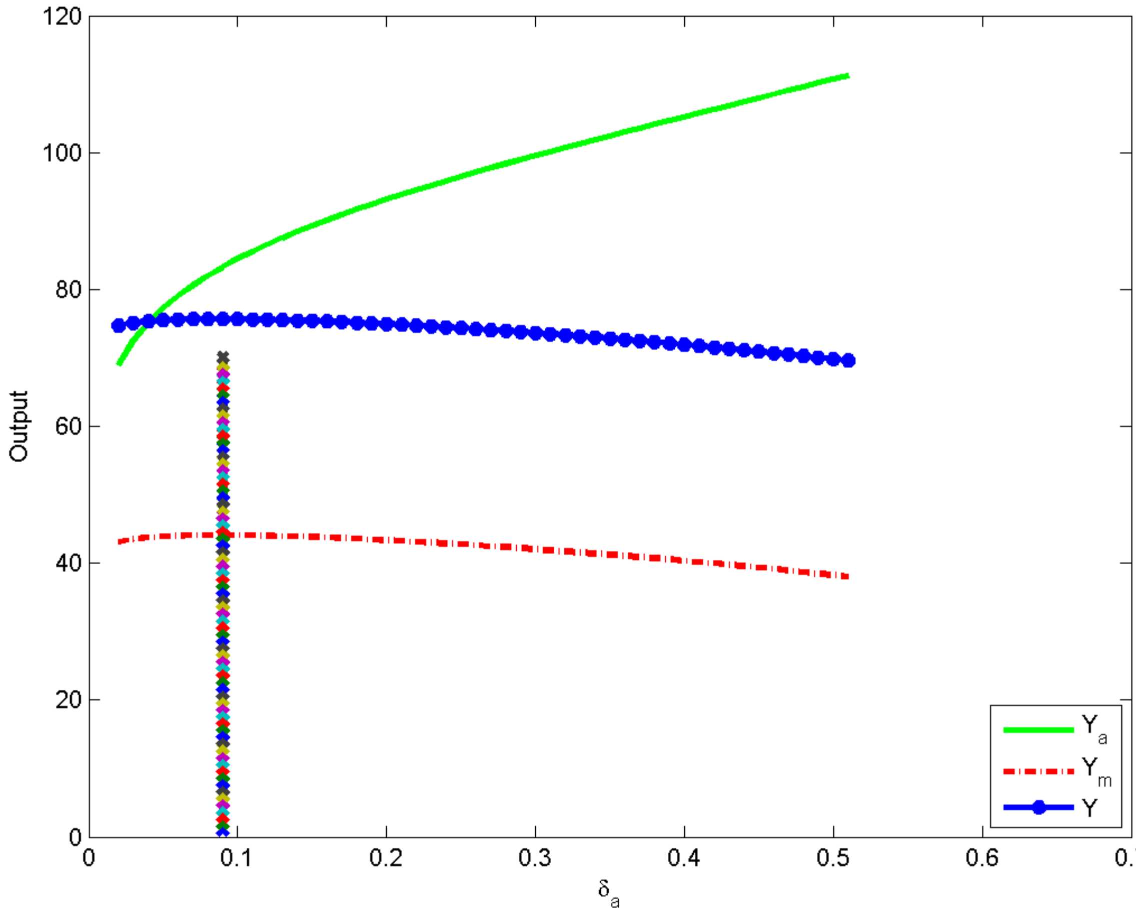

Figure 7: Optimal Sectoral Infrastructure Allocation ($T = 6$)

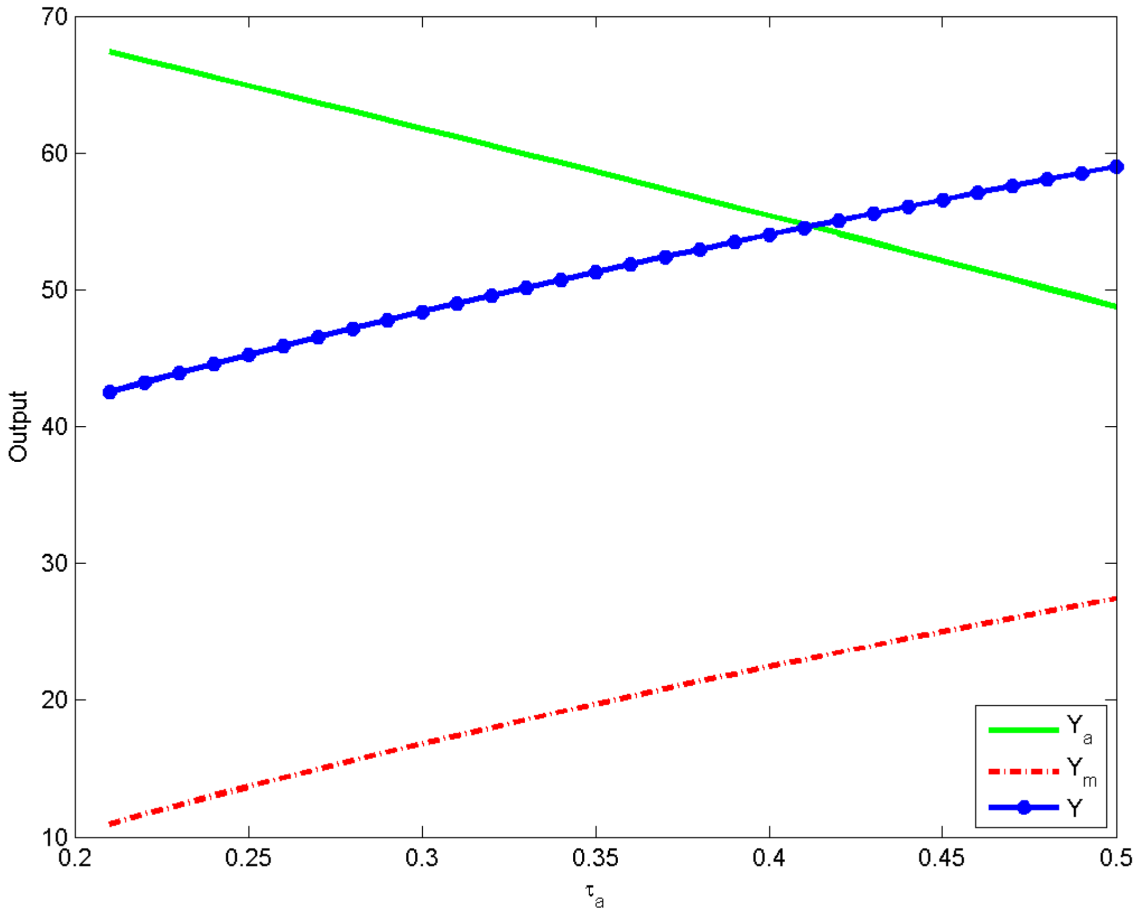

Figure 8: Varying agricultural tax rate, while holding manufacturing tax rate constant. ($T = 2$)

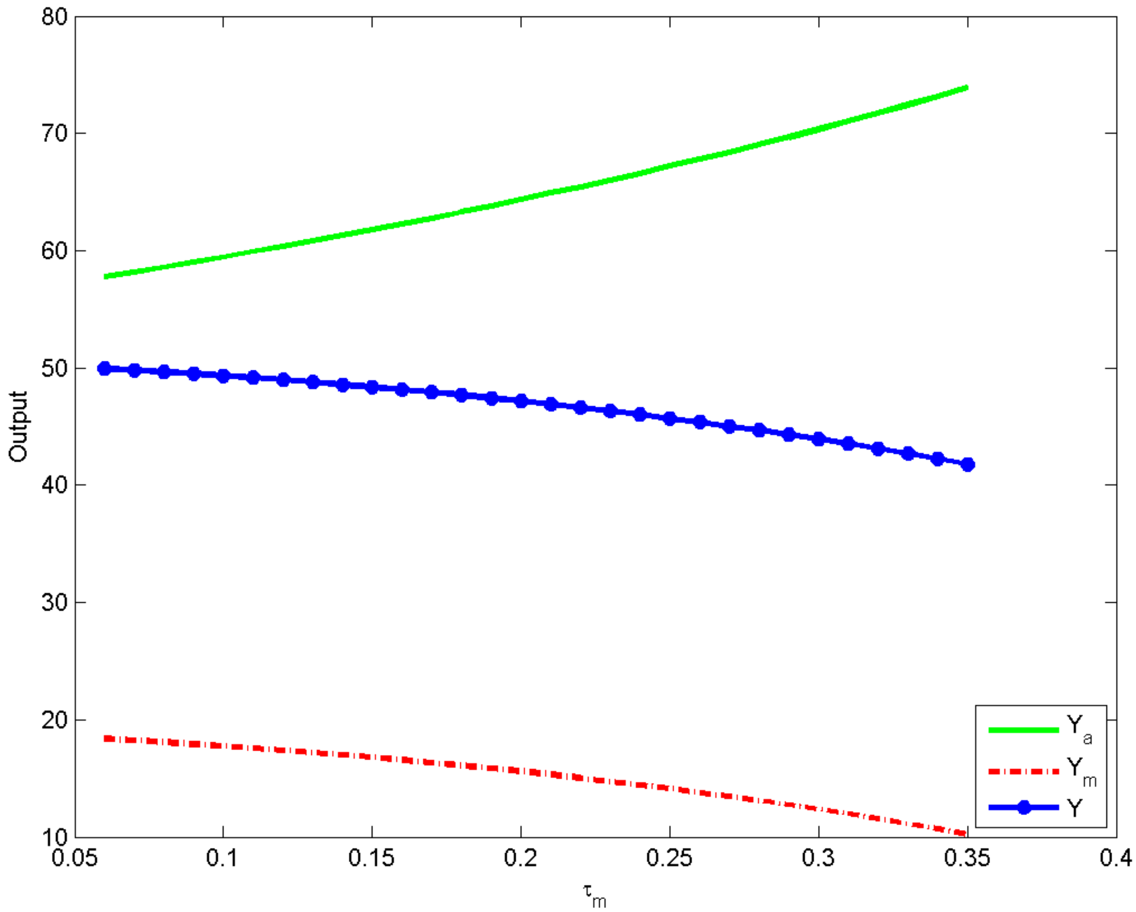

Figure 9: Varying manufacturing tax rate, while holding agricultural tax rate constant. ($T = 2$)

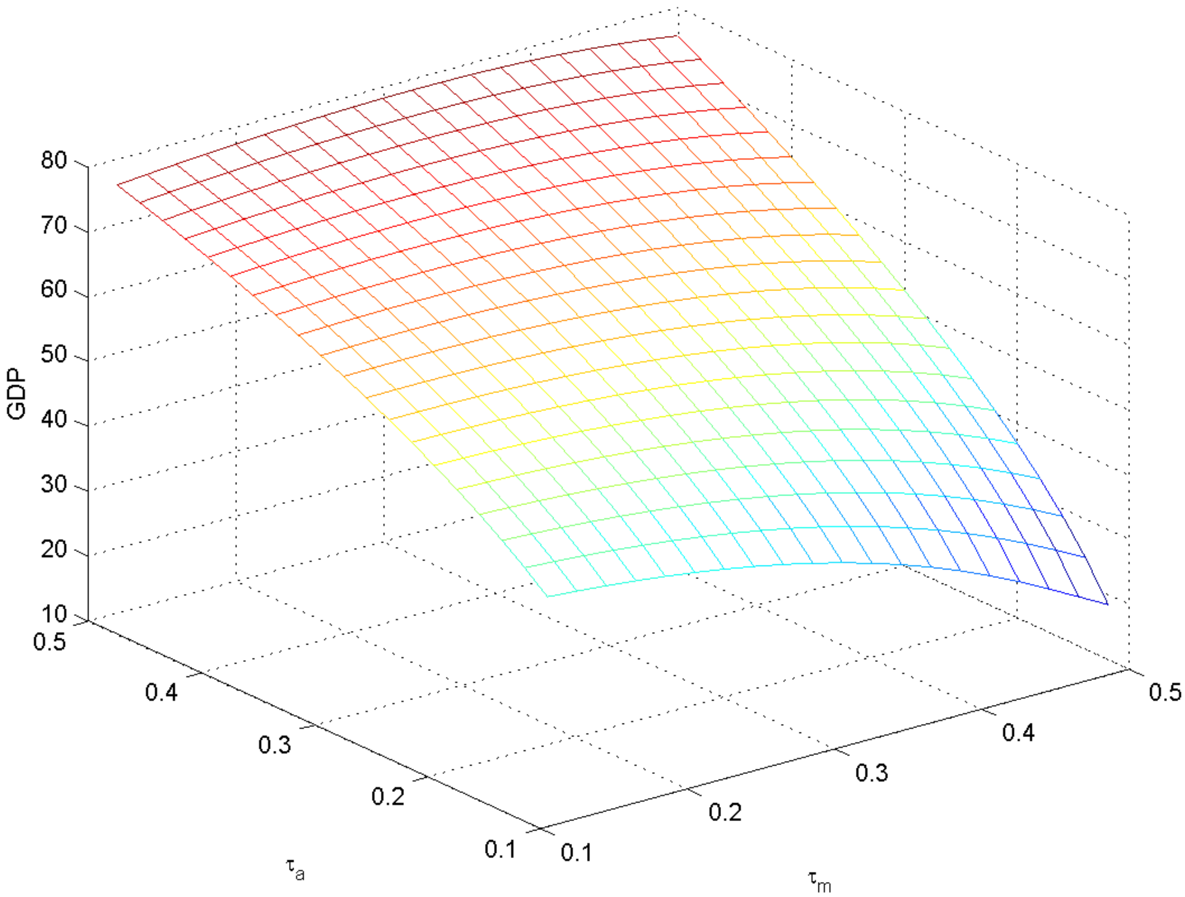

Figure 10: Output Effects of Changes in Both Tax Rates (T=2)
Note: Output is an increasing function of τ_a and a decreasing function of τ_m.

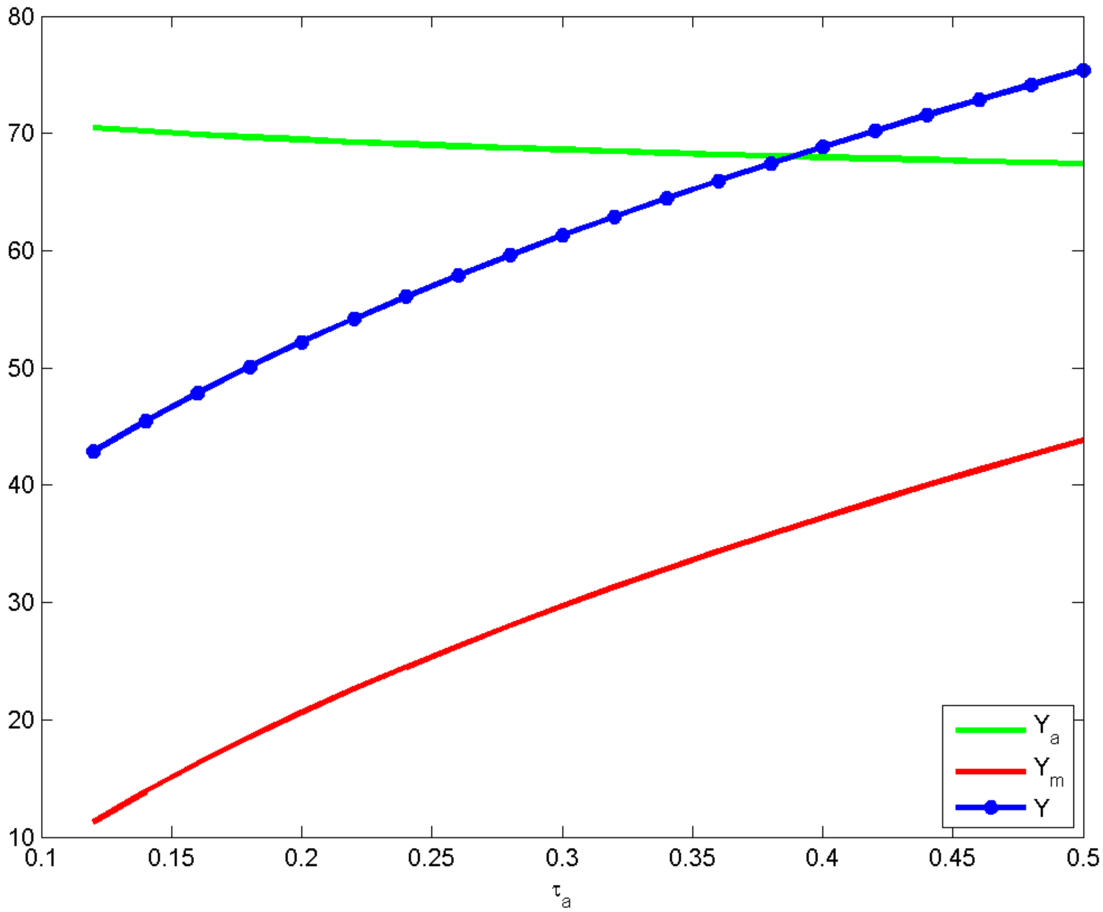

Figure 11: Optimal Effects of Simultaneous Changes in the Two Tax Rates ($T = 2$, $\tau_m = \tau_a$)

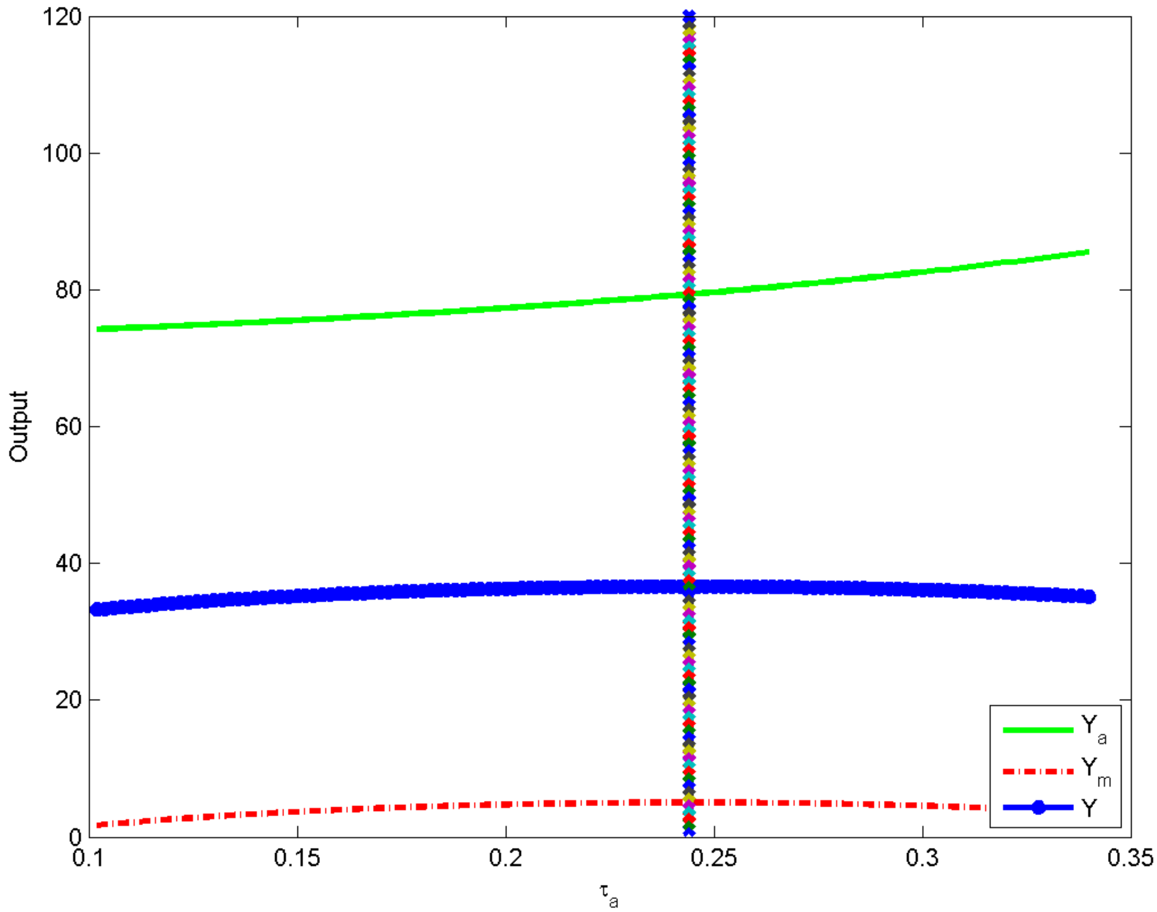

Figure 12: Optimal Effects of Simultaneous Changes in the Two Tax Rates ($T = 2$, $\tau_m = 1.5\tau_a$)

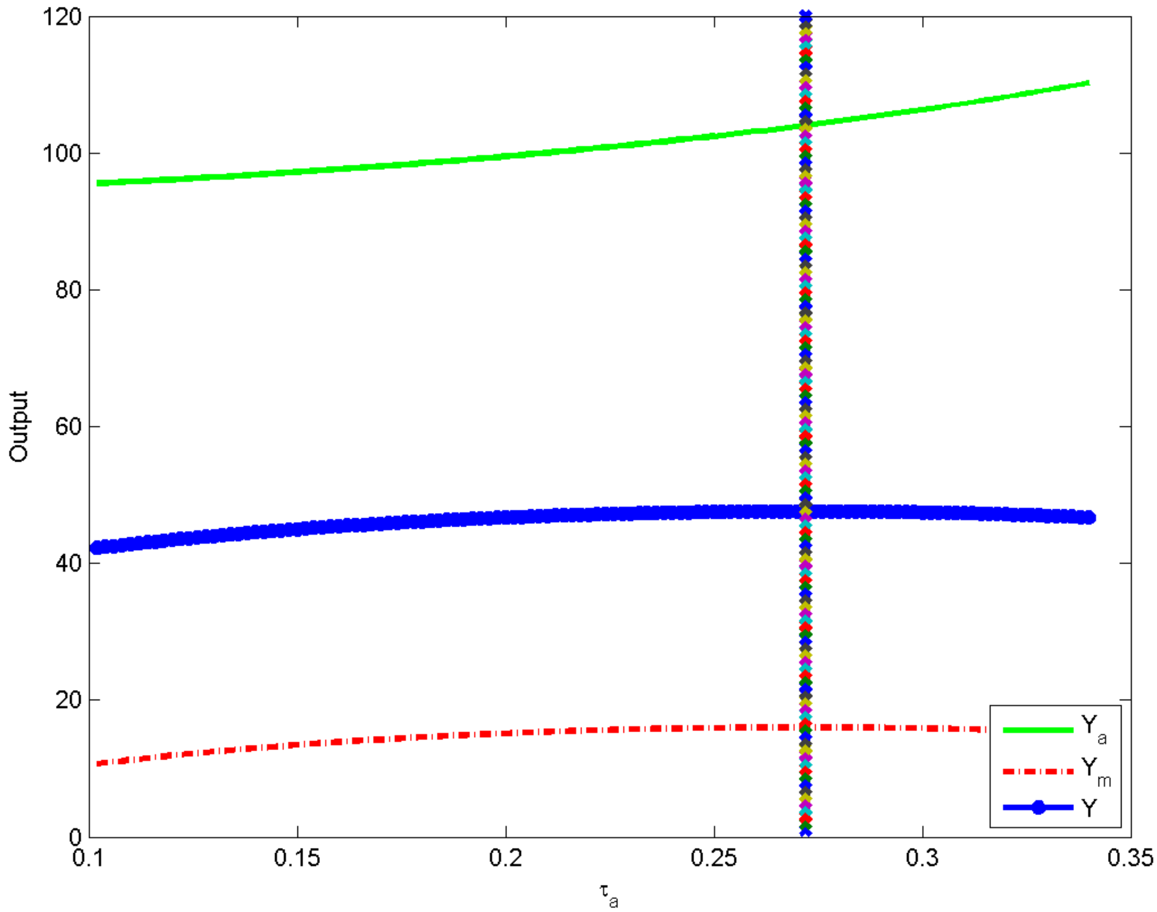

Figure 13: Optimal Effects of Simultaneous Changes in the Two Tax Rates ($T = 4$, $\tau_m = 1.5\tau_a$)

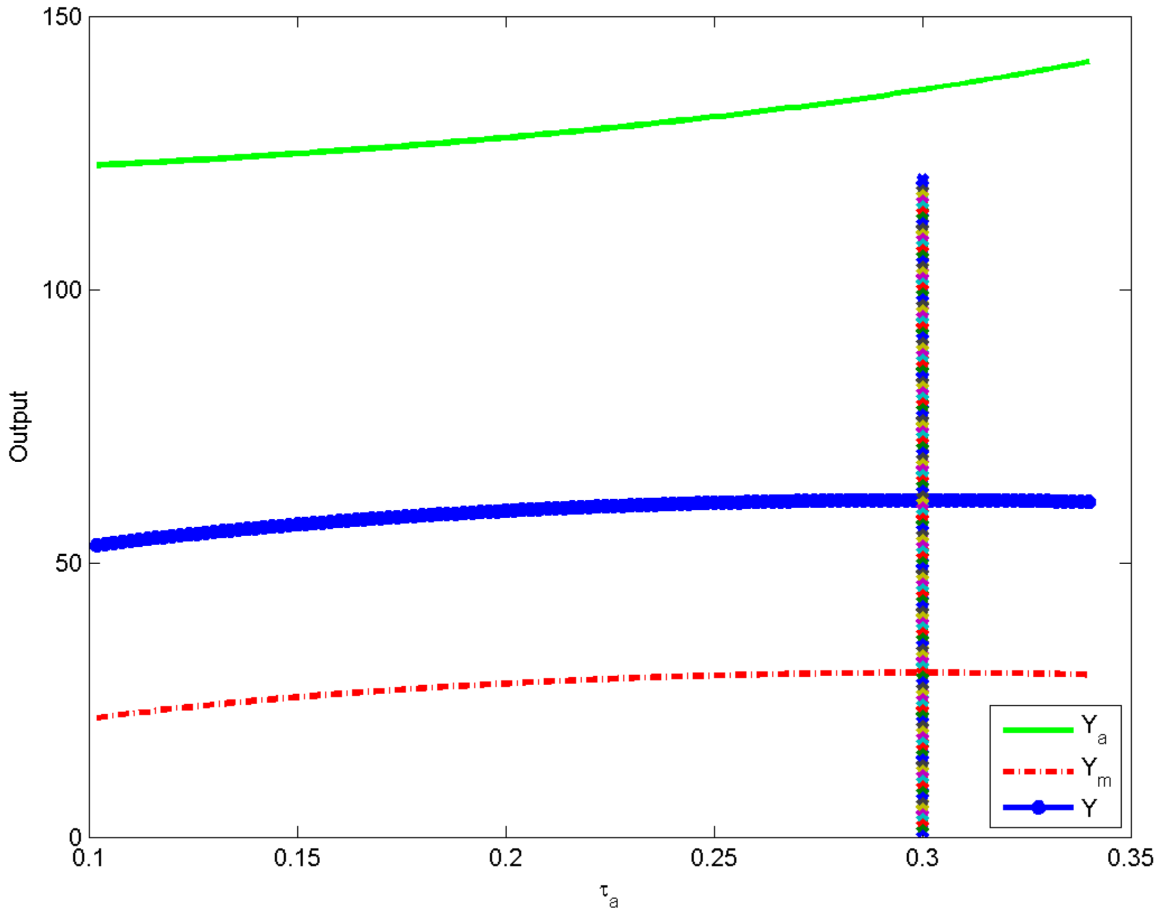

Figure 14: Optimal Effects of Simultaneous Changes in the Two Tax Rates ($T = 6$, $\tau_m = 1.5\tau_a$)

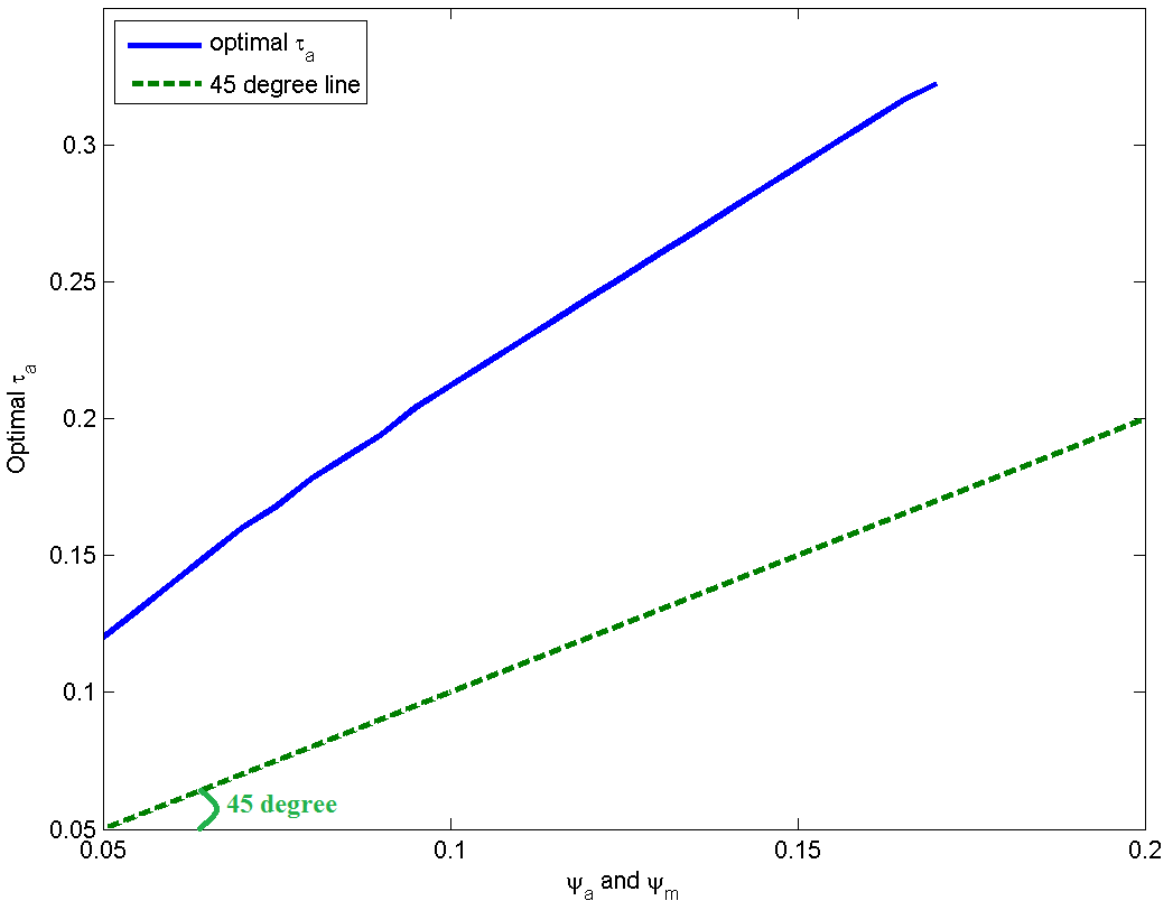

Figure 15: Output Maximizing Tax Rates for Varying Levels of ψ ($T = 2, \psi_a = \psi_m, \tau_m = 1.5\tau_a$)

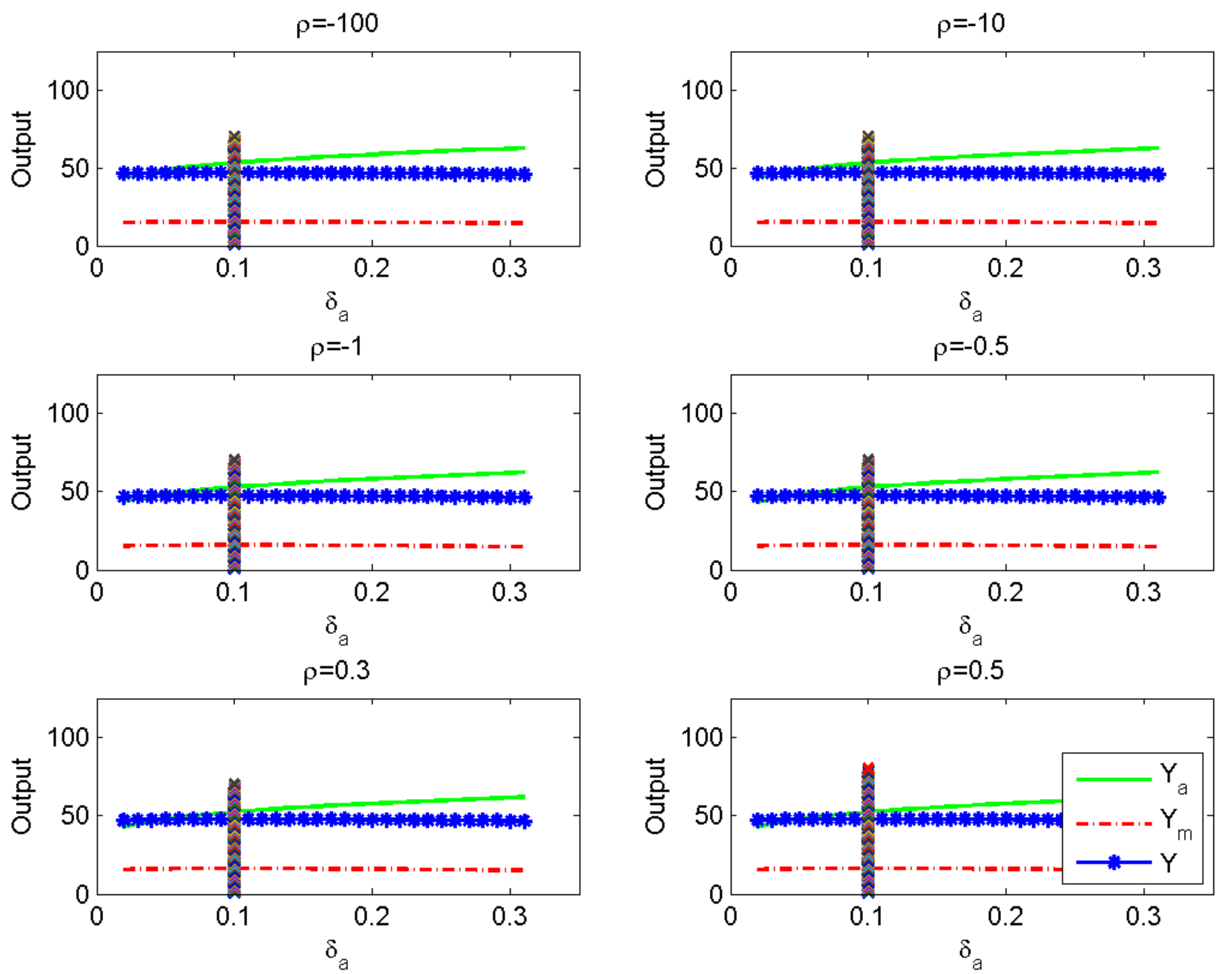

Figure 16: Output Maximizing δ_a for the CES Production Function ($T = 2$)

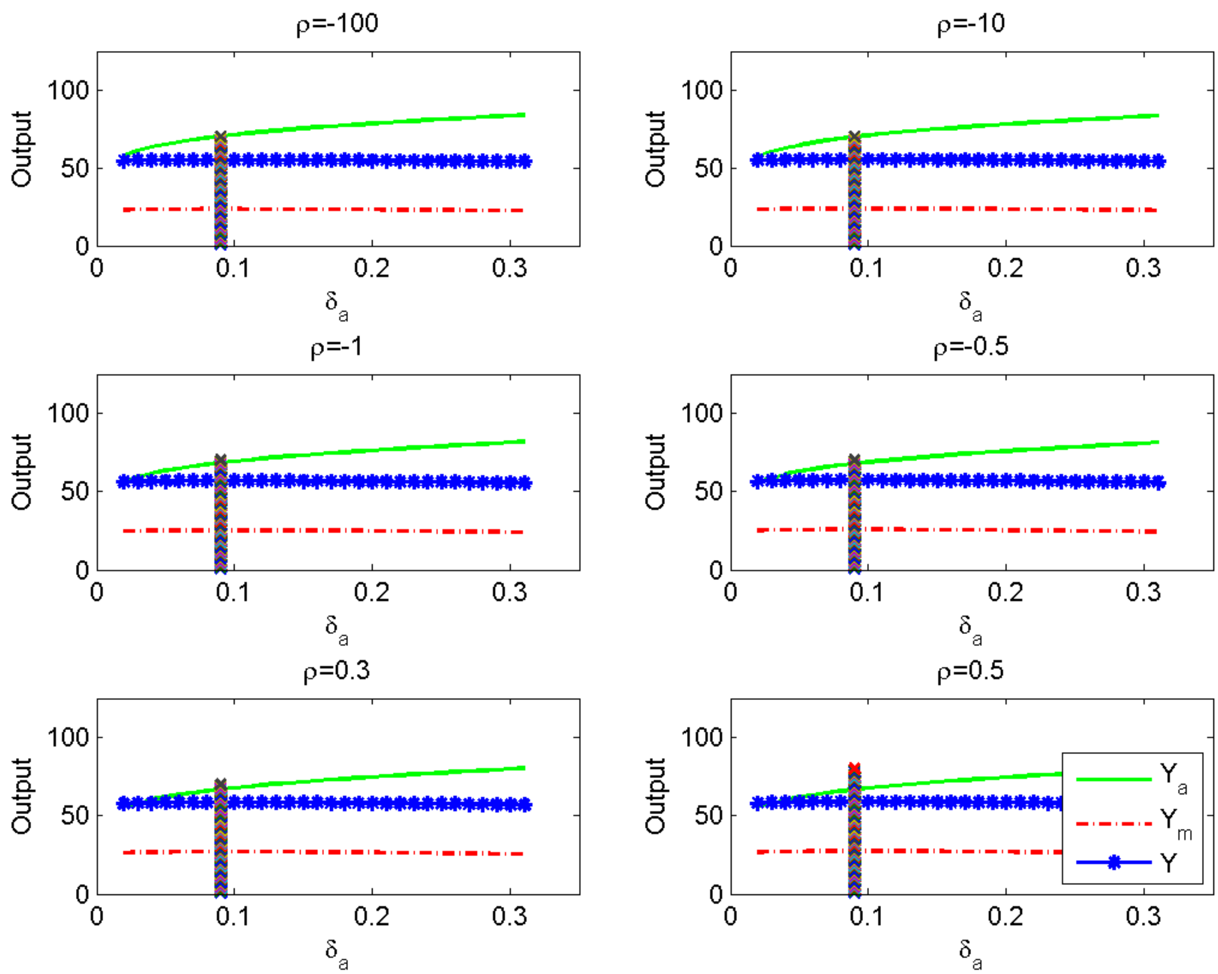

Figure 17: Output Maximizing δ_a for the CES Production Function ($T = 4$)

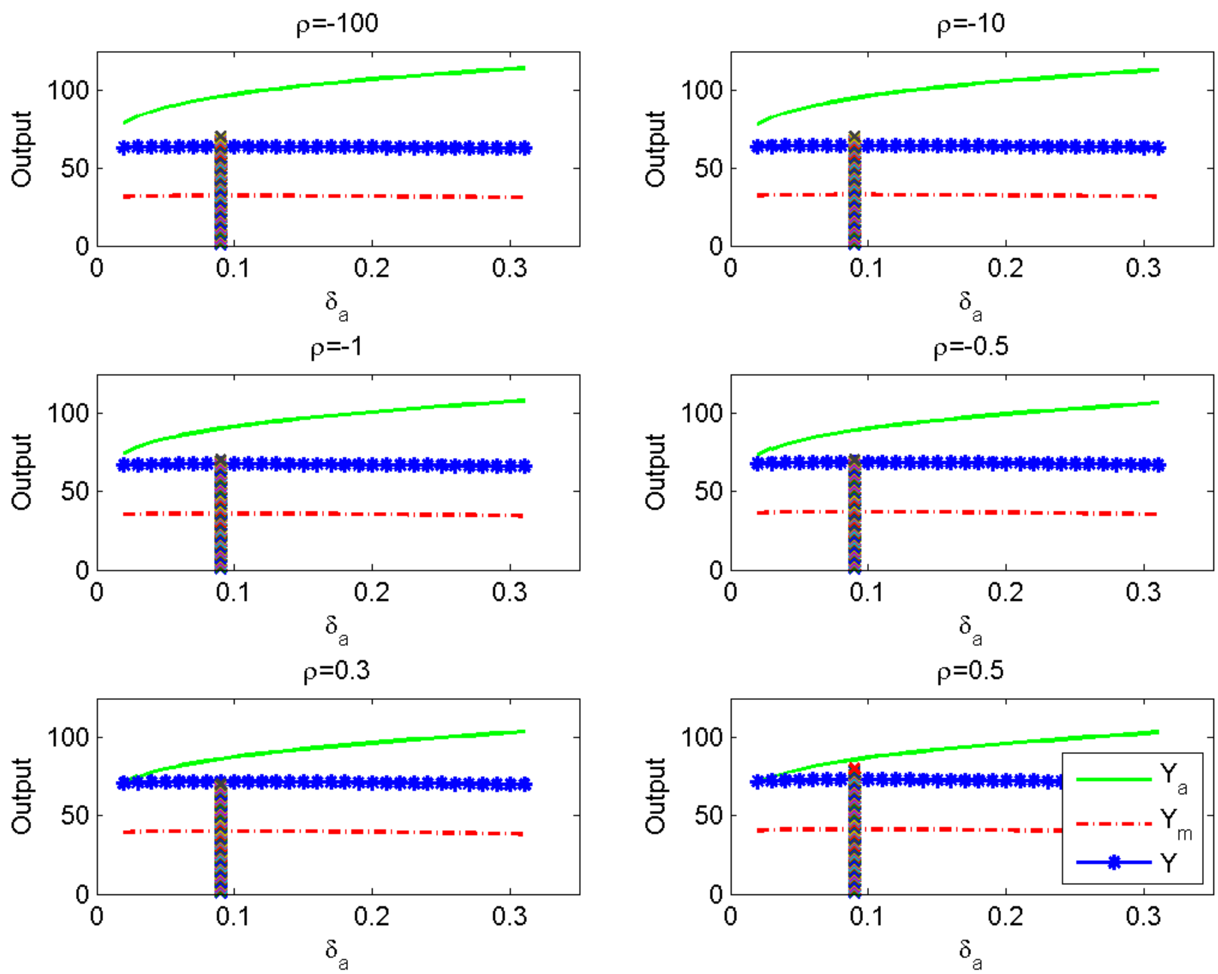

Figure 18: Output Maximizing δ_a for the CES Production Function ($T = 6$)

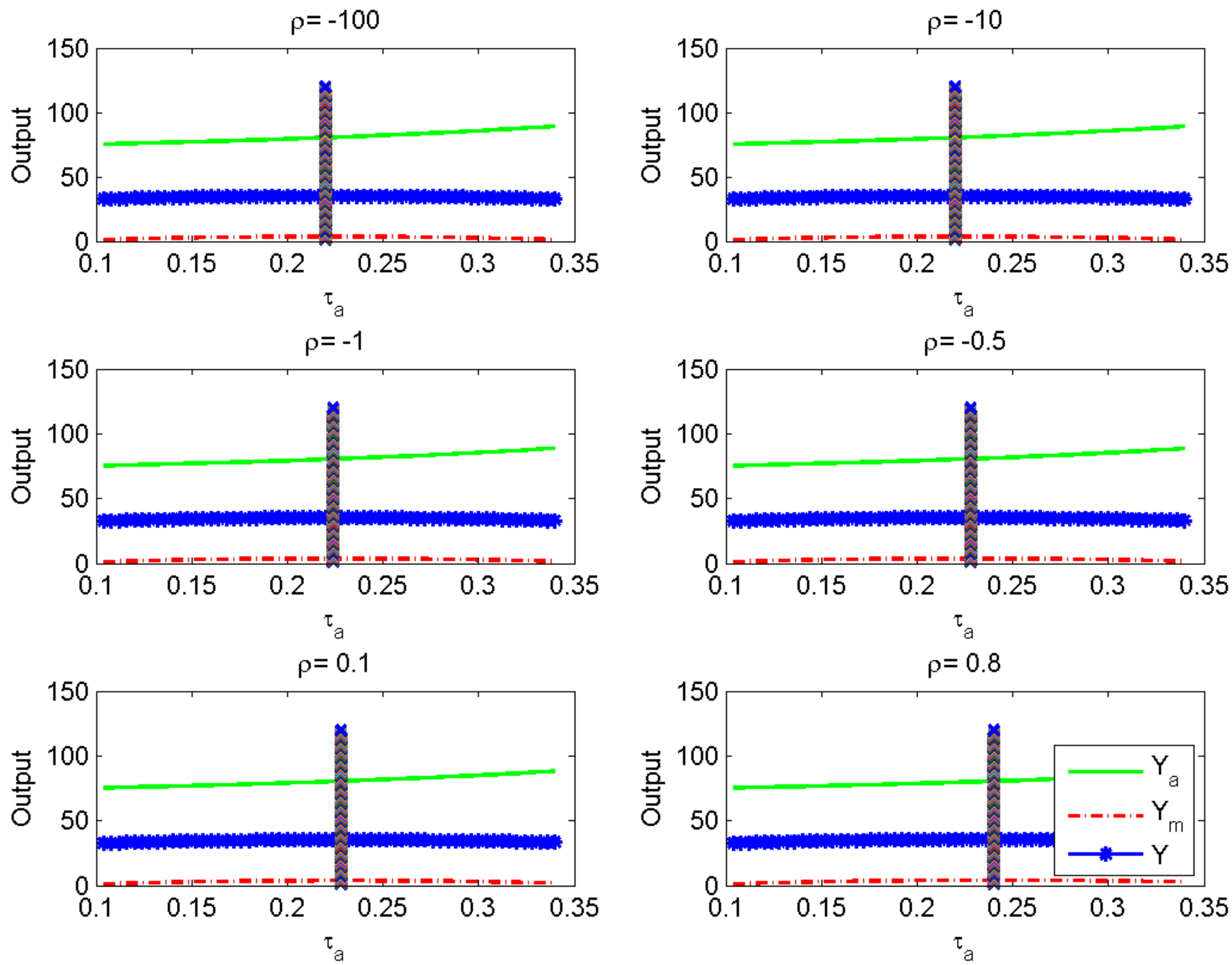

Figure 19: Output Effects of Simultaneous Changes in the Tax Rates for the CES Production Function ($T = 2$, $\tau_m = 1.5\tau_a$)

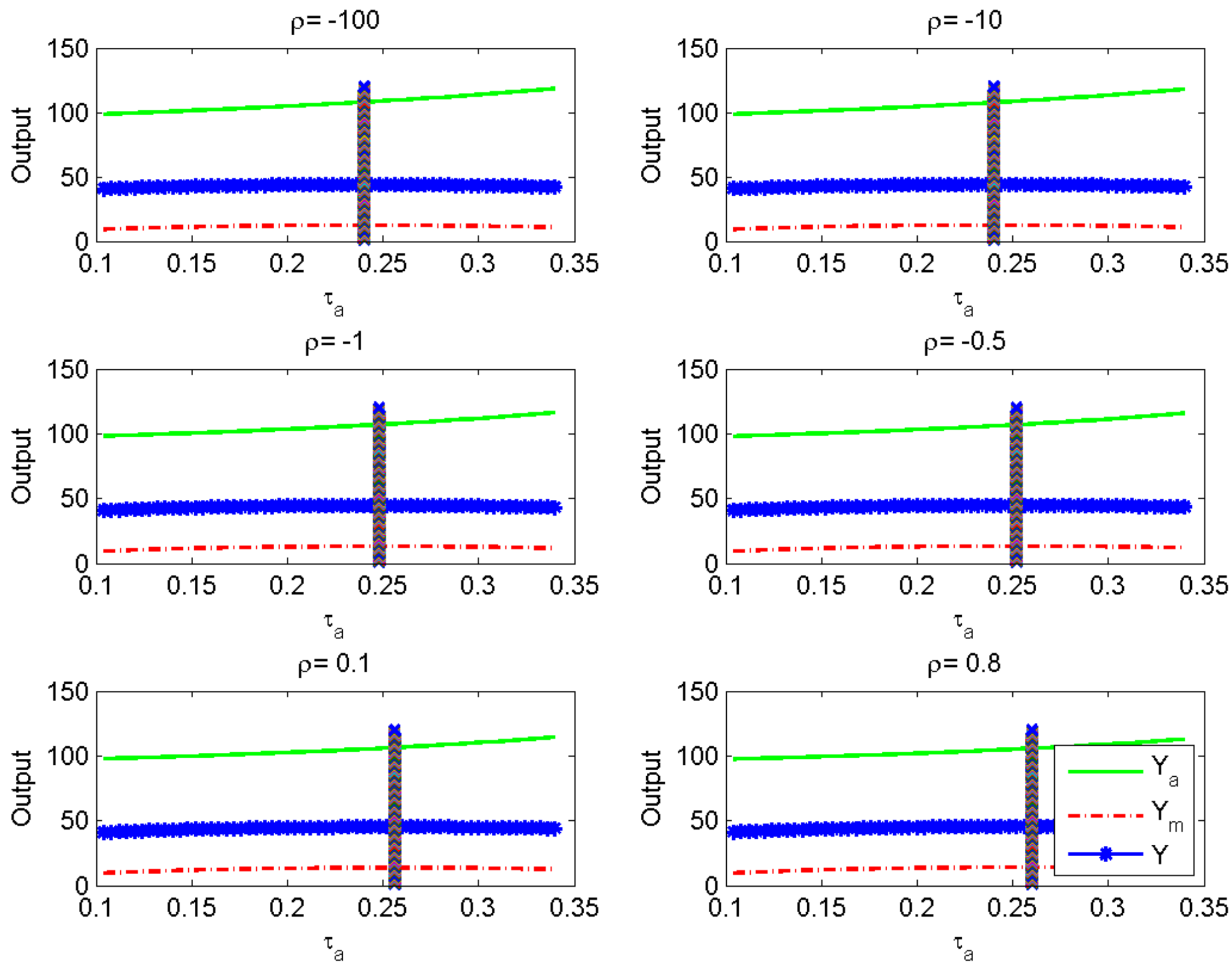

Figure 20: Output Effects of Simultaneous Changes in the Tax Rates for the CES Production Function ($T = 4$, $\tau_m = 1.5\tau_a$)

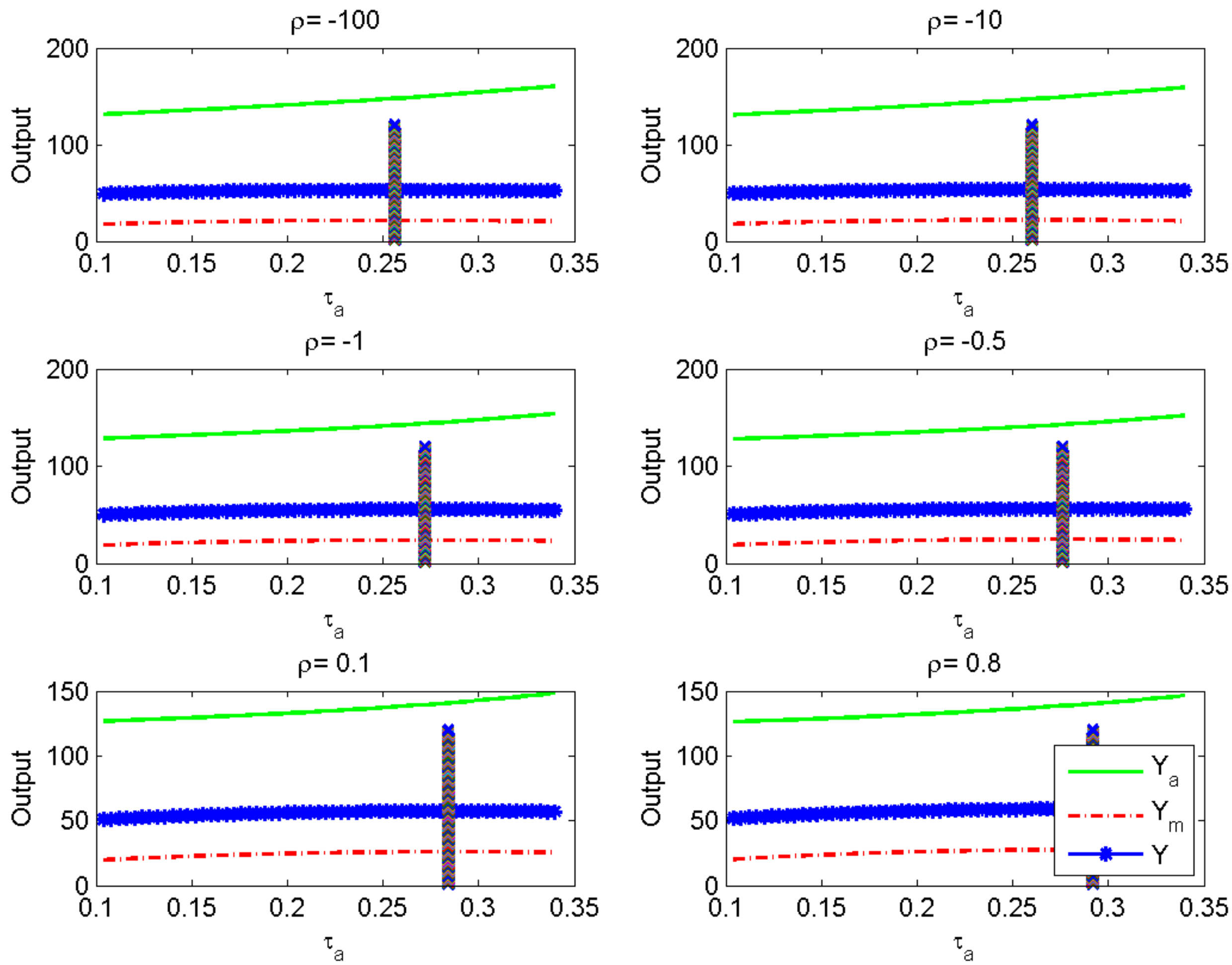

Figure 21: Output Effects of Simultaneous Changes in the Tax Rates for the CES Production Function ($T = 6$, $\tau_m = 1.5\tau_a$)