GOVERNMENT SPENDING AND REAL EXCHANGE RATE DYNAMICS

by

AZAR MURSAGULOV

(Under the direction of Santanu Chatterjee)

ABSTRACT

A dynamic dependent-economy model is developed to investigate the role of government infrastructure spending and productivity in determining the path of the real exchange rate. The analysis, which employs extensive numerical simulations, shows that government expenditure directed towards infrastructure and productivity enhancement in the traded sector leads to real exchange rate appreciation, whereas if directed to the non-traded sector results in depreciation of the real exchange rate. Different sources of financing the government expenditure have also been considered, including lump-sum and distortionary taxation. Welfare analysis does not yield any linear relationship between real exchange rate and welfare gains; however growth-welfare tradeoff is justified for an increase in the traded sector expenditure.

INDEX WORDS: Government Spending, Productivity, Taxes, Two-Sector Model, Infrastructure, Real Exchange Rate

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DEDICATIONS

This work is dedicated to the memory of my father, Dr. Ismail Mursagulov.

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CHAPTER 1 – INTRODUCTION

1. Definitions and Basic Concepts

The real exchange rate among two countries is one of the key relative prices in international finance. It is not surprising that researchers have spent so much time and effort finding determinants of the real exchange rate in the short run as well the long run.

The real exchange rate between two countries is the relative cost of the common reference basket of goods, where the comparison of the costs of baskets in two countries are made after converting them to a common numeraire; see Obstfeld and Rogoff (1996). For countries A and B with corresponding price levels P_A and P_B, both measured in some numeraire currency, we say that country A experiences a real appreciation and country B experiences a real depreciation when P_A/P_B rises, and vice versa when P_A/P_B falls.

Another very well-known concept in international economics is the purchasing power parity (PPP) doctrine, which states that the real exchange rate between two countries must equal unity in the long run, and there should be a mechanism that will adjust and move it back towards this unity level, if there is any kind of disturbance. Stated otherwise, two identical baskets of goods across two countries should cost the same when converted to a common currency. This is called absolute PPP conversion. Relative PPP is a weaker statement which states that changes in the national price levels are always equal, at least over sufficiently long periods of time. This means that the real exchange rate between two countries reverts to some constant number, not necessarily one as in the case of absolute PPP, over longer horizons. Unfortunately, these concepts do not always hold in reality and it is very hard to find empirical evidence justifying them. One obvious reason is the failure of the Law of One Price, which states that two identical goods must sell for the same price in different countries, on which both of above concepts rely. Another reason is that no country has the same basket of goods, nor do they attach the same weights to individual products in the consumption basket.

2. Literature Review

The literature on determinants of the real exchange rate starts with the famous work of Balassa (1964) and Samuelson (1964). The prediction of these studies is that productivity-based differences across countries account for the real exchange rate dynamics. Stated otherwise, home country will experience a real exchange rate appreciation if it has higher productivity in tradables compared to non-tradables. Higher productivity gains in tradable goods explain why industrialized countries have become rich. It also explains why non-tradable goods, such as services, are more expensive in wealthy countries than in poorer ones.

Previous analysis of the real exchange rate models can be separated into three, somewhat different groups. The first group adopts the Balassa (1964) and Samuelson (1964) approach that supply-side factors, such as productivity, are the sole determinants of the real exchange rate (Hsieh, 1982; Marston, 1990; Micossi and Milessi-Ferretti, 1994). The second group introduces some type of rigidity, such as installation costs to factor allocation, so that demand side factors also influence the real exchange rate determination. However, neither of these groups of studies takes into account intertemporal considerations and thus both are static in nature. The final group explicitly approaches the concept from an intertemporal framework and may or may not include a specific factor assumption.[1] For instance, Obstfeld and Rogoff (1995) introduces price rigidities to an intertemporal framework in order to generate persistence in the real exchange

[1] For an extensive survey of three groups of studies, see Chinn and Johnston (1996).

rate. Morshed and Turnovsky (2004), on the other hand, develop two-sector model in which intersectoral capital movements involve adjustment costs. This research can be considered as an extension of Morshed and Turnovsky (2004) framework with productive government expenditure, which has short run resource absorption as well as long run productivity effects. Results by Morshed and Turnovsky (2004) indicate a transitional effect of government expenditure on the real exchange rate. The long-run level, however, is independent of fiscal policy. On the contrary, this study demonstrates that productive government expenditure impact the dynamics as well as the equilibrium level of the exchange rate.

Among the early literature in the area, Hsieh (1982) uses difference in growth rates in labor productivity in the traded and the non-traded sectors to explain movements in the real exchange rate. The paper covers 1954-76 period for Germany and Japan. The work employs a time series technique, which is assumed to correct for any country specific factors that might bias cross-sectional estimation. In establishing the real exchange rate, the geometric average of major trading partners is treated as foreign country. He finds the coefficient for relative traded productivity at home, in the case of Germany, to be 0.362, and corresponding coefficient for foreign country to be -0.516. When Japan is considered as home, the coefficient estimates for relative traded productivity at home and in the foreign are 0.538 and -0.538, respectively.

Marston (1990) adopts a similar approach for G-5 countries at the time for 1973-86 period. The important difference is that the paper performs analysis on a sectoral basis. The manufacturing sector is subdivided into 11 individual sectors. The real exchange rates for the products, as well as labor productivities of these sectors are calculated for countries under the analysis. Using the above framework he finds coefficients ranging from 0.714 for the Franc/Deutschemark rate, to 1.244 for the Dollar/Deutschemark rate.[2]

Micossi and Milesi-Ferretti (1994) estimate a similar relationship using OLS for a sample of European Union countries in the period of 1970-90. Their findings for the estimates of domestic productivity differentials range from 0.10 to 0.76 and corresponding estimates for foreign country in the range between -1.10 and -0.05. All of the coefficients are of the correct sign except for Denmark case, where the foreign productivity differential enters with a positive sign of 0.29, which is thus not reported in the range.

These studies present empirical evidence in favor of a significant statistical relationship between labor productivity and the real exchange rate. However, the results are not robust to many alternative specifications, data types and samples. More importantly, it is not obvious to what extent labor productivity is a good proxy for overall factor productivity. Yet, another issue with these studies is that they only use industrialized country data, which can be characterized by relatively stable terms of trade.

To better understand the fluctuations and the determinants of the real exchange rate in developing countries, which are characterized by large fluctuations in the terms of trade, significant attention has been given to the relative price of exports to imports as another major determinant of the real exchange rate movements (Edwards, 1989; Roldos, 1990). In their paper De Gregorio and Wolf (1994) try to analyze the joint effect of productivity differentials and terms of trade movements on the real exchange rate. Government expenditure, which by assumption is completely non-tradable, and per capita GDP are used in the specification as well. The data for empirical study comes from 14 OECD countries in the period from 1970 to 1985. Regressions using SUR methodology in first differences (including a country specific constant)

[2] The coefficient estimates for home and foreign are constrained to be equal with opposite signs.

mostly overlap with existing literature. In the first specification that excludes terms of trade component, all variables, including total factor productivity, government expenditure and GDP per capita appear statistically significant with correct signs. Adding the terms of trade variable does not alter the sign or significance of productivity and government expenditure. Indeed, the estimated coefficients on relative productivity are substantially higher, suggesting that there might be an omitted-variable bias in the regression results using only productivity variables. On the other hand, GDP per capita looses its statistical significance with the inclusion of terms of trade variable. It can be the case that income variable played a proxy role for terms of trade shocks.

The Balassa-Samuelson result explains real exchange rate movements in terms of sectoral productivities. This rests on two facts: that relative price of non-traded goods reflect the relative factor productivities in the traded and non-traded sectors and that purchasing power parity holds for traded goods. Canzoneri, Cumby and Diba (1999) use cointegration techniques for a panel of 13 OECD countries to investigate the two building blocks of the Balassa-Samuelson hypothesis above. The results suggest that the relative productivities in the traded and the non-traded sectors are cointegrated with the relative prices of non-traded goods, with the slope of cointegrating relationship being close to one in most of the cases. This evidence supports the Balassa-Samuelson hypothesis that the relative price of non-tradable goods reflects the relative factor productivities in the traded and the non-traded sectors. However, the evidence presented for the second proposition of the Balassa-Samuelson model that purchasing power parity holds in traded goods is substantially weak at least when US dollar exchange rate is under consideration. The results demonstrate large and long run deviations from purchasing power parity.[3] The interesting

[3] Similar results can be found in Engel (1995).

result is that when Deutschemark exchange rate is considered the results are more favorable to purchasing power parity in traded goods, yielding an overall vague outcome.

Froot and Rogoff (1991) study intra-European Monetary System real exchange rates using a simple intertemporal model in which prices are fully flexible. The model is used to demonstrate that different government spending trajectories are a plausible explanation for the apparent divergence of the real exchange rate in the European Community. The paper considers the Balassa-Samuelson productivity framework as well as the credibility of monetary policy. The evidence supports the hypothesis that high productivity growth in the tradable sector can explain some portion of deviations in the real exchange rate, though productivity alone cannot fully account for the real exchange rate movements.

Chinn and Johnston (1996) investigate the determinants of the real exchange rate using evidence from a panel of fourteen OECD countries. The paper employs both SUR framework to measure relationship between changes in exchange rates and changes in the determinants, as well as panel cointegration technique to identify long run relationship between the levels of the real exchange and its determinants. The most successful empirical model summarizing the real exchange rate determinants includes productivity measures, government spending variables and either of terms of trade or the real price of oil. Results for cointegration studies conclude that the cointegrating vector definitely includes the real exchange rate, the relative sectoral productivity levels and government spending. Inclusion of the real price of oil, the terms of trade, income per capita is less certain and evidence on these variables is more ambiguous.

On the demand-side, studies by Penati (1987) and Balvers and Bergstrand (2002) focus exclusively on the impact of government expenditure on the real exchange rate. Using an infinitively lived representative agent framework with perfect foresight Penati (1987) is able to justify the traditional hypothesis that non-inflationary fiscal expansion will cause current account deficit and real exchange rate appreciation even in an intertemporal framework only with the assumption that government directs it's spending to the non-traded sector. It is also shown that traded government expenditure can lead to real exchange rate depreciation if production is very sensitive to changes in relative prices. Balvers and Bergstand (2002) obtain results in line with those by Penati (1987). In addition, they show that government expenditure influences the real exchange rate through resource-withdrawal effect and consumption-tilting effects, which are almost equally important channels.

Even though not much related to real exchange rate determinants, the study by Cheung and Lai (2000) focuses on the cross country differences in the persistence of the real exchange rate. Whereas most of the real exchange rate studies use industrialized country data, this work brings developing countries into the picture as well. Using four different stationarity testing techniques the paper uncovers 66 parity reversion series (out of 94) in total. When classifying countries it is found that developing countries demonstrate higher mean reversion than industrialized ones. This result would bias previous studies using only industrialized country data, as they underestimate the general relevance of parity reversion. Moreover, some of the cross country variation in the persistence of PPP deviations may partly reflect country differences in structural characteristics such as inflation and government spending (which appear to be statistically significant in explaining real exchange rate parity reversion). However, a substantial portion of those cross country variations appears still unaccounted for.

Wu (1994) is the study closely resembling this one, in the sense that it treats government spending as productive in an intertemporal framework, and affecting the efficiency of private capital in the future. Thus, a current period fiscal expansion raises marginal productivity and efficiency of the factors utilized in production and increases next period's production. Although both the demand and the supply of domestic goods increases, excess demand shows up in the first few periods, implying an appreciation of the real exchange rate in the short run.

Finally, the study that this paper owes most to is by Morshed and Turnovsky (2004) that develops a two-sector dynamic economy with intersectoral adjustment costs. Production in their model depends on private factors (capital and labor) only. New output can be costlessly converted into private capital, whereas movement of capital across sectors incurs additional costs. These adjustment costs allow one to obtain persistence in the deviation of the real exchange rate from its equilibrium level without the need to assume price rigidities, as considered for instance by Obstfeld and Rogoff (1995).

However, Morshed and Turnovsky (2004) treat government spending as a pure waste of resources, whereas I believe that government infrastructure is an important factor of private production that raises productivity and efficiency of private factors (Aschauer, 1989a; 1989b). Thus, I explicitly model public infrastructure in the private production. In my specification government consumption of private output is not a waste of resources; rather it leads to accumulation of sector-specific public infrastructure, which becomes a productive input in the private production of the same sector. This is in sharp contrast to the literature, which treats government as purely resource-absorbing entity. Thus, these studies would only propose a short-run relationship between fiscal expenditure and the real exchange rate in the presence of nominal rigidities, whereas in the long-run the real exchange rate would be independent of fiscal policy. This applies to the results obtained by Morshed and Turnovsky (2004) as well. However, the structure proposed by my study yields a long-run relationship between fiscal policy shocks and the real exchange rate. The results that I obtain justify short run responses for both non-traded and traded fiscal expansion. In addition, since government expenditure is meant to be productive and alter private production, the long-run output levels as well as the relative prices are affected.

To sum up the literature, productivity differentials in non-traded versus traded sectors, government expenditure and less frequently terms of trade and income variables seem to be among the major determinants of the dynamics of the real exchange rate. This work focuses on the impact of the first two. I find that under plausible parameter restrictions productivity shocks, as well as fiscal expenditure shocks can have long run effects on the real exchange rate and thus argue against the long run parity hypothesis.

CHAPTER 2 - GOVERNMENT SPENDING, PRODUCTIVITY AND REAL EXCHANGE RATE

1. Motivation

Both empirical and theoretical research has long been striving to identify the determinants of the real exchange rate in the long as well as the short run. The literature considers both supply-side as well as demand-side factors, with productivity differentials (supply-side) between non-traded and traded production sectors (Balassa, 1964) and (Samuelson, 1964) and government spending (demand-side) generally regarded as the principal determinants of the real exchange rate (Salter, 1959; Swan, 1960). DeGregorio, Giovannini and Wolf (1994) point out that demand side factors will affect the real exchange only in the presence of some sort of rigidity, like relaxing perfect competition or perfect capital mobility assumptions. The downside of these studies is that they are purely static and do not take intertemporal considerations into account. Subsequent studies enabled the study of the real exchange rate within a dynamics framework by introducing capital and foreign asset accumulation (Froot and Rogoff, 1991; Rogoff, 1992).

This study reconsiders the relationship between productivity, government expenditure and the real exchange rate in an intertemporal framework. This work, however, differs from the existing literature on the real exchange rate and its determinants in some very important aspects. Whereas most of the existing literature models government as a resource absorbing entity (see Frenkel and Razin, 1985; Sargent, 1987; and Hodrick, 1988), I emphasize dual role of the government in this study. In particular, I assume that government buys final goods and services in the market, which are accumulated as public capital stock. This stock of public infrastructure capital exerts a positive externality on private production factors and increases their efficiency. There are many reasons to rationalize incorporating public stock of capital into the model as opposed to public services due to Barro (1990). For instance, new highways, bridges, airports and public utility facilities are stock variables by nature. It is commonly assumed in theoretical literature that the stock of public infrastructure, rather than the flow of public services, is a productive input to the private production; see for instance Arrow and Kurz (1970) and Uzawa (1974). Theoretical and empirical justification on productivity of public capital in private production comes from the work of Ashauer (1989a, 1989b). According to these studies, the stock of public infrastructure is an important component of the production process. Besides, treating traded and non-traded public infrastructure as stock variable enriches the dynamics of the model.[4] Thus, in this framework productive government expenditure besides having short run demand side effects of a resource-absorber will also have longer run productivity effects on the production process as well as on the real exchange rate dynamics.

Modeling production is a significant aspect of the dynamic dependent economy framework. The literature generally adopts either of the two assumptions. The first approach is to assume that capital accumulates gradually, but can be allocated instantaneously, together with labor (Obstfeld, 1989; van Wincoop, 1993; Brock and Turnovsky, 1994). That is, converting new output into capital is costly, but once it is converted into capital it can be costlessly transferred between existing sectors. At the other extreme some studies assume capital being sector specific and completely immobile across sectors (Ryder, 1969; Neary, 1978; Eaton, 1987). Both of these assumptions are clearly unreasonable. An intermediate case introduced by Morshed and Turnovsky (2004) where it is possible to transfer capital from one sector to another at some extra

[4] Futagami et. al. (1993) develops an endogenous growth model incorporating productive stock of public capital.

cost is obviously more realistic. Indeed, after the Second World War many United States defense industries were converted into non-defense production industries. Similar was the case with most of the Eastern European and Post-Soviet countries at the end of the cold war. With this in mind, I assume that capital transfers from one sector to another involve convex adjustment cost of the type introduced by Hayashi (1982).[5] This setting is also convenient for analyzing the dynamics of the real exchange rate, since it generates persistence in the deviations from the long run equilibrium level. This is in contrast to generating persistence by nominal rigidities, like sticky prices; see Obstfeld and Rogoff (1995).

Since the model yields highly non-linear structure it is further analyzed numerically. Three types of experiments are conducted: (i) permanent increase in the government spending allocated to the traded sector, (ii) permanent increase in the government spending allocated to the non-traded sector, and (iii) productivity shocks in both sectors. Simulation results indicate government expenditure affects dynamics as well as the long-run level of the real exchange rate. Increase in the government spending directed towards the traded sector leads to an appreciation of the real exchange rate. Fiscal expansion in the non-traded sector on the contrary, induces depreciation of the real exchange rate. Productivity shocks in either sector result in increased output in both sectors. Whereas productivity shock in the traded sector appreciates the real exchange rate, productivity shock in the non-traded sector leads to depreciation.

The rest of the chapter is organized as follows. Section 2 describes the theoretical structure of the economy. Numerical simulation parameters and experiments are presented in section 3, which is followed by conclusions in section 5.

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[5] Turnovsky (1997) employs similar type of adjustment costs in an aggregate model of capital accumulation within small open economy framework.

2. Economic Structure

2.1 The Model

I consider a small open economy inhabited by a representative agent who is endowed with fixed supply (normalized to be one unit) of labor, which he sells at the competitive wage. The agent produces traded good T (taken to be numeraire) using private factors: a quantity of capital K_T and labor L_T. Public infrastructure capital, entirely provided by government, exerts positive externality on the production function through K_{GT}. The production takes place by means of a neoclassical production function $Y_T(K_T, L_T, K_{GT})$. Both private capital and labor are subject to diminishing marginal physical products, and production is subject to constant returns to scale in private factors. By the same token, the agent produces a non-traded good utilizing a quantity of private capital K_N and labor L_N. The externality of public capital is provided by K_{GN}. The production function in the non-traded sector is represented by $Y_N(K_N, L_N, K_{GN})$, which has the same neoclassical properties.

I assume that the traded good can be used for consumption purposes only; both private and public, while the non-traded good can either be consumed or accumulated as a capital good, to which it can be converted at no cost. With capital being non-traded, the absence of adjustment costs is consistent with a finite rate of aggregate capital accumulation, although this would not be so if capital were traded; see Turnovsky (1997), Chapter 4.

The agent also accumulates net foreign bonds, that pay an exogenously given world interest rate r. Equation (1a) describes the agent's instantaneous budget constraint:

$$\dot{B} = Y_T(K_T, L_T, K_{GT}) - C_T + p \cdot \left[Y_N(K_N, L_N, K_{GN}) - C_N - I \right] - T_L + r \cdot B \qquad (1a)$$

where C_T and C_N are the agent's consumption of traded and non-traded goods, respectively; p is the relative price of the non-traded to the traded good; I denotes new investment, and T_L denotes the lump-sum taxes. In this framework, p is sometimes referred as the real exchange rate; an increase in which represents a real appreciation.

It is further assumed that the capital stock in either sector does not depreciate and that it cannot move freely across sectors. Only non-traded new output can be converted into private capital, and once it becomes capital in the non-traded sector it takes extra resources to transform it into capital suitable for use in the traded sector. These are generally referred to as intersectoral adjustment costs, which are investigated extensively for instance by Morshed and Turnovsky (2004). Thus, capital accumulation in this economy can be described as follows;

$$\dot{K}_T = X \tag{1b}$$

$$\dot{K}_N = I - X\left(1 + \frac{hX}{2K_N}\right) \tag{1c}$$

where X is the capital transfers from the non-traded to the traded sector, and

$$I = Y_N(K_N, L_N, K_{GN}) - C_N - G_N \tag{1d}$$

describes the amount of non-traded capital available for new investment, which is the total of non-traded production less the amount of non-traded good consumed by the agent and the government. The amount $\frac{hX^2}{2K_N} > 0$ represents the intersectoral adjustment cost, which must be incurred in order to transfer X amount of capital into the traded sector. The coefficient $h > 0$ parameterizes the degree of the sectoral adjustment costs. Couple of things should be noted at this point. First, $X > (<) 0$, the direction of sectoral flows depends on the relative return to capital in the two sectors. For instance, if capital is more productive in the traded sector, there would be a positive flow amount of $X > 0$ flowing from the non-traded to the traded sector, and vice versa.

Total rate of capital accumulation in the economy can then be represented as;

$$\dot{K} = \dot{K}_T + \dot{K}_N = I - \frac{hX^2}{2K_N} \qquad \text{(1e)}$$

where the last term points to the loss of resources due to sectoral movements. In the case of $h=0$, or the absence of sectoral adjustment costs, the equation reduces to standard aggregate capital accumulation equation in the form of $\dot{K} = I$. It should also be noted at this point, that equation (1e) allows for aggregate disinvestment, or stated otherwise the agent is permitted to consume his capital stock or sell it in the market.

Labor market clears at every point in time as labor is perfectly mobile across sectors. The full employment condition requires;

$$L_N + L_T = 1 \qquad \text{(1f)}$$

Given the above setup the agent chooses his consumption levels C_T, C_N, labor allocations L_T, L_N, the rate of investment I, the capital allocation decisions K_T and K_N, and his rate of accumulation of net foreign bonds to maximize the following intertemporal utility function;

$$\int_0^\infty U(C_T, C_N) \cdot e^{-\beta t} \mathrm{dt} \qquad \text{(2)}$$

subject to constraints (1a) - (1f) and given initial stocks of capital $K_{T,0}$, $K_{N,0}$ and initial stock of foreign assets B_0. The instantaneous utility function is assumed to be strictly concave and both consumption goods are assumed to be normal. The agent's rate of time preference β is taken to be constant.

The current value Hamiltonian for the problem is;

$$H = U(C_T, C_N)\cdot e^{-\beta t} + \lambda e^{-\beta t}\left\{Y_T - C_T + p\cdot\left[Y_N - C_N - I\right] - T_L + r\cdot B - \dot{B}\right\} + q_1^* e^{-\beta t}[X - \dot{K}_T]$$

$$+\ q_2^* e^{-\beta t}\left[I - X\left(1 + \frac{hX}{2K_N}\right) - \dot{K}_N\right] \qquad (3)$$

denoting the shadow price of the foreign bonds by λ and those of traded and non-traded capital by q_1^*, and q_2^*, we can define the shadow values $q_1 = \frac{q_1^*}{\lambda}$, and $q_2 = \frac{q_2^*}{\lambda}$ which maybe interpreted as the market prices of traded and non-traded capital relative to that of the foreign bonds. The optimality conditions are;

$$\frac{\partial H}{\partial C_T} = 0 \rightarrow U_T(C_T, C_N) = \lambda \qquad (3a)$$

$$\frac{\partial H}{\partial C_N} = 0 \rightarrow U_N(C_T, C_N) = p\cdot\lambda \qquad (3b)$$

$$\frac{\partial Y_T}{\partial L_T} = p\frac{\partial Y_N}{\partial L_N} \qquad (3c)$$

$$\frac{\partial H}{\partial X} = 0 \rightarrow \frac{X}{K_N} = \frac{q_1 - q_2}{h\cdot q_2} \qquad (3d)$$

$$\frac{\partial H}{\partial I} = 0 \rightarrow -\lambda\cdot p + q_2^* = 0 \rightarrow p = {q_2^*}/{\lambda} = q_2 \qquad (3e)$$

$$\frac{\partial H}{\partial B} = \frac{\partial H / \partial \dot{B}}{\partial t} \rightarrow \beta = \frac{\dot{\lambda}}{\lambda} + r \qquad (3f)$$

$$\frac{\partial H}{\partial K_T} = \frac{\partial H / \partial \dot{K}_T}{\partial t} \rightarrow \frac{\partial Y_T / \partial K_T}{q_1} + \frac{\dot{q}_1}{q_1} = r \qquad (3g)$$

$$\frac{\partial H}{\partial K_N} = \frac{\partial H / \partial \dot{K}_N}{\partial t} \rightarrow \frac{\partial Y_N}{\partial K_N} + \frac{hX^2}{2K_N^2} + \frac{\dot{q}_2}{q_2} = r \qquad (3h)$$

together with transversality conditions;

$$\lim_{t\to\infty} \lambda B e^{-\beta t} = \lim_{t\to\infty} q_1 \lambda K_T e^{-\beta t} = \lim_{t\to\infty} q_2 \lambda K_N e^{-\beta t} = 0 \qquad (3i)$$

Equations (3a) and (3b) equate the marginal utilities of consumption of the two goods to the shadow price of wealth, appropriately measured in terms of the numeraire. The perfect labor mobility assumption implies equation (3c), which states that the marginal physical product of labor in two sectors must be equal. Equation (3d) determines the transfer rate of capital between the two sectors. Capital movement occurs as long as the shadow values of two types of capital are unequal. Non-traded new output can either be consumed or converted into capital. Hence, the marginal utility of consumption of non-traded good must be equal to the shadow value of the capital in the non-traded sector, which yields the equation (3e). Applying the standard optimality condition with respect to B implies the usual arbitrage relationships, equating the rate of return on consumption to the cost of borrowing depicted in equation (3f). In order to obtain a well defined steady state in which marginal utility and consumption remain finite, it is required that $\beta = r$ which implies $\dot{\lambda} = 0$ for all t, so that the marginal utility does not change over time, i.e. $\lambda = \bar{\lambda}$.[6] The last two efficiency conditions equate the return on capital in each sector appropriately evaluated at marginal physical product to the rate of return on foreign bonds. The transversality conditions (3i) ensure that no asset or either type of capital is wasted at the end of time horizon.

The government in this economy plays an active role. It raises lump-sum taxes to provide the stock of physical infrastructure capital in both sectors, a vital component of the production process that raises the efficiency and productivity of the private sector. Public capital in two sectors evolves according to;

[6] This assumption is standard in deriving intertemporal models of small open economies, although it is not particularly appealing. Its consequences for the equilibrium dynamics are discussed by Turnovsky (1997) in some detail.

$$\dot{K}_{GT} = G_T - \delta_{GT} K_{GT} \quad (4a)$$

$$\dot{K}_{GN} = G_N - \delta_{GN} K_{GN} \quad (4b)$$

where it is assumed that public capital depreciates at a rate of δ_{GT} and δ_{GN} in the traded and the non-traded sector, respectively. Moreover, domestic government expenditure is tied to the scale of the economy.

$$G_N = g_N (Y_T + p \cdot Y_N) \quad (4c)$$

$$G_T = g_T (Y_T + p \cdot Y_N) \quad (4d)$$

where $0 < g_N, g_T < 1$.

Substituting the above definitions into the accumulation equation of public infrastructure capital in each sector yields the following dynamic equations;

$$\dot{K}_{GT} = \left(g_T\right)(Y_T + p \cdot Y_N) - \delta_{GT} K_{GT} \quad (4a')$$

$$\dot{K}_{GN} = \left(g_N\right)(Y_T + p \cdot Y_N) - \delta_{GN} K_{GN} \quad (4b')$$

Thus economy-wide infrastructure capital evolves according to

$$\dot{K}_G = \dot{K}_{GT} + \dot{K}_{GN} = \left[g_T + g_N\right](Y_T + Y_N) - \delta_{GT} K_{GT} - \delta_{GN} K_{GN}$$

The government balances its budget at every instant of time according to

$$T_L = p \cdot G_N + G_T \rightarrow T_L = \left[p \cdot g_N + g_T\right] \cdot (Y_T + p \cdot Y_N) \quad (4f)$$

Combining (1a) and (4f) yields the economy's current account dynamics:

$$\dot{B} = Y_T + r \cdot B - C_T - g_T (Y_T + p \cdot Y_N) \quad (1a')$$

2.2 Macroeconomic Equilibrium

To obtain the macroeconomic equilibrium, first solve equations (3a) and (3b) for non-traded and traded consumption in the following form:

$$C_T = C_T\left(\overline{\lambda}, p\right) \quad (5a)$$

$$C_N = C_N\left(\overline{\lambda}, p\right) \quad (5b)$$

Also, from the condition on efficient labor allocation (3c) and labor endowment equation (1f) labor allocation in each sector can be derived as;

$$L_T = L_T\left(K_T, K_N, p, K_{GT}, K_{GN}\right) \qquad \frac{\partial L_T}{\partial K_T} > 0,\ \frac{\partial L_T}{\partial K_N} < 0,\ \frac{\partial L_T}{\partial p} < 0,\ \frac{\partial L_T}{\partial K_{GT}} > 0,\ \frac{\partial L_T}{\partial K_{GN}} < 0 \quad (5c)$$

$$L_N = L_N\left(K_T, K_N, p, K_{GT}, K_{GN}\right) \qquad \frac{\partial L_N}{\partial K_T} < 0,\ \frac{\partial L_N}{\partial K_N} > 0,\ \frac{\partial L_N}{\partial p} > 0,\ \frac{\partial L_N}{\partial K_{GT}} < 0,\ \frac{\partial L_N}{\partial K_{GN}} > 0 \quad (5d)$$

The logic behind the above partial derivatives is very intuitive. An increase in either type of capital in the non-traded sector, increases marginal physical product of labor in that sector, attracting labor from the traded sector, while an increases of capital in traded sector has the reverse effect on labor.

Taking into account (5a)-(5d), the macroeconomic equilibrium can be summarized by the following autonomous system in the six variables;

$$\dot{K}_T = X \quad (6a)$$

$$\dot{K}_N = Y_N - C_N - G_N - X\left(1 + \frac{hX}{2K_N}\right) \quad (6b)$$

$$\dot{K}_{GT} = \left(g_T\right)(Y_T + p \cdot Y_N) - \delta_{GT} K_{GT} \quad (6c)$$

$$\dot{K}_{GN} = \left(g_N\right)(Y_T + p \cdot Y_N) - \delta_{GN} K_{GN} \quad (6d)$$

$$\dot{p} = p\left[r - \frac{\partial Y_N}{\partial K_N} - \frac{hX^2}{2K_N^2}\right] \quad (6e)$$

$$\dot{X} = \left[\frac{Y_N - C_N - G_N}{K_N} + \frac{\partial Y_N}{\partial K_N}\right]X - \frac{X^2}{2K_N} - \frac{K_N}{hp}\left[\frac{\partial Y_T}{\partial K_T} - p\frac{\partial Y_N}{\partial K_N}\right] \quad (6f)$$

together with the current account condition;

$$\dot{B} = Y_T + r \cdot B - C_T - g_T(Y_T + p \cdot Y_N) \quad (6g)$$

Equations (6a) and (6b) repeat (1b) and (1c) describing the rate of accumulation of two types of private capital. Equations (6c) and (6d) are the analogs for the two types of public capital. Equation (6e) describes the rate of change of the real exchange rate. This equation is obtained by combining equations (3e) and (3h). The last equation in the system (6f) represents the flow of capital transferred from the non-traded sector to the traded one. Finally, (6g) determines the current account of the economy. Total domestic production of traded goods less private and public consumption of that good together with interest earned on the outstanding stock of foreign bonds determines the current account of the economy and the rate of accumulation of the traded bonds.

Linearizing (6a)-(6f) around the steady denoted by tildes, the dynamics can be approximated by;

$$\begin{pmatrix} \dot{K}_T \\ \dot{K}_N \\ \dot{K}_{GT} \\ \dot{K}_{GN} \\ \dot{p} \\ \dot{X} \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} & a_{16} \\ a_{21} & a_{22} & a_{23} & a_{24} & a_{25} & a_{26} \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} & a_{36} \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} & a_{46} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} & a_{56} \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & a_{66} \end{pmatrix} \cdot \begin{pmatrix} K_T - \tilde{K}_T \\ K_N - \tilde{K}_N \\ K_{GT} - \tilde{K}_{GT} \\ K_{GN} - \tilde{K}_{GN} \\ p - \tilde{p} \\ X - \tilde{X} \end{pmatrix} \tag{7}$$

The above system (7) is a sixth order linear dynamic system. Analyzing its characteristics it can be established that there are four negative (stable) eigenvalues and two positive (unstable) ones, implying that equilibrium is a saddlepoint. The capital stocks, K_T, K_N, K_{GT} and K_{GN} evolve sluggishly, whereas the real exchange rate , *p*, and amount of non-traded investment transferred to the traded sector, *X*, are jump variables and can adjust instantaneously to the new information. It can be verified numerically that equilibrium yields a unique stable saddlepath.

2.3 Steady State

The steady-state equilibrium is attained when $\dot{K}_N = \dot{K}_T = \dot{X} = \dot{p} = \dot{K}_{GT} = \dot{K}_{GN} = 0$, which implies that at steady state, $X = 0$, capital transfer from the non-traded to the traded sector is zero. Imposing these conditions yields the following set of steady state equations:

$$Y_N(\tilde{K}_N, \tilde{L}_N, \tilde{K}_{GN}) = C_N(\bar{\lambda}, \tilde{p}) + g_N\left[Y_T(\tilde{K}_T, \tilde{L}_T, \tilde{K}_{GT}) + \tilde{p} \cdot Y_N(\tilde{K}_N, \tilde{L}_N, \tilde{K}_{GN})\right] \tag{8a}$$

$$(g_T)\left[Y_T(\tilde{K}_T, \tilde{L}_T, \tilde{K}_{GT}) + \tilde{p} \cdot Y_N(\tilde{K}_N, \tilde{L}_N, \tilde{K}_{GN})\right] = \delta_{GT}\tilde{K}_{GT} \tag{8b}$$

$$(g_N)\left[Y_T(\tilde{K}_T, \tilde{L}_T, \tilde{K}_{GT}) + \tilde{p} \cdot Y_N(\tilde{K}_N, \tilde{L}_N, \tilde{K}_{GN})\right] = \delta_{GN}\tilde{K}_{GN} \tag{8c}$$

$$\frac{\partial \tilde{Y}_N}{\partial \tilde{K}_N} = r \tag{8d}$$

$$\frac{\partial \tilde{Y}_T}{\partial \tilde{K}_T} = \tilde{p} \cdot \frac{\partial Y_N}{\partial K_N} \tag{8e}$$

$$\frac{\partial \tilde{Y}_T}{\partial \tilde{L}_T} = \tilde{p}\frac{\partial \tilde{Y}_N}{\partial \tilde{L}_N} \tag{8f}$$

$$Y_T(\tilde{K}_T, \tilde{L}_T, \tilde{K}_{GT}) = C_T(\bar{\lambda}, \tilde{p}) + g_T \cdot \left[Y_T(\tilde{K}_T, \tilde{L}_T, \tilde{K}_{GT}) + \tilde{p} \cdot Y_N(\tilde{K}_N, \tilde{L}_N, \tilde{K}_{GN})\right] - r \cdot \tilde{B} \tag{8g}$$

$$\tilde{L}_T + \tilde{L}_N = 1 \tag{8h}$$

Equation (8a) is a market clearing condition for non-traded good, which states that at the steady-state all non-traded output must be consumed either by private agents or government. Equations (8b) and (8c) show that accumulation of public traded and non-traded capital respectively is zero at the steady-state. Equations (8d) and (8e) jointly demonstrate that the marginal product of capital in both sectors are equal and that in turn is equal to the exogenously given world interest rate and accordingly all intersectoral transfers of capital cease. Since labor is perfectly mobile across sectors, equation (8f) states that marginal product of labor across two sectors will always be equal. Equation (8g) is another way of saying that in the steady-state a change in the current account must be equal to zero. Finally, equation (8h) is the market clearing condition for labor.

Equations (8a)-(8h) give us eight equations that can be solved for the eight unknowns of the system $\tilde{K}_N, \tilde{K}_T, \tilde{K}_{GT}, \tilde{K}_{GN}, \tilde{L}_T, \tilde{L}_N, \bar{\lambda}, \tilde{p}$.[7] Finally the current account of the economy can be derived using equation (6g),

$$\dot{\tilde{B}}=\tilde{Y}_T - \tilde{C}_T - g_T \cdot \left[\tilde{Y}_T + \tilde{p} \cdot \tilde{Y}_N\right] + r \cdot \tilde{B} \qquad \text{(6g')}$$

3. Numerical Analysis of Transitional Paths

3.1 Calibration

Better insights into the effects of changes in the government expenditure composition on the real exchange rate are obtained by analyzing the model numerically. A small open economy is characterized by the following production and utility functions;

Production Functions:

$$Y_T = A_T K_T^{\alpha} \left(L_T K_{GT}^{\eta}\right)^{1-\alpha} = A_T k_T^{\alpha} K_{GT}^{\eta(1-\alpha)} L_T$$

$$Y_N = A_N K_N^{\varphi} \left(L_N K_{GN}^{\phi}\right)^{1-\varphi} = A_N k_N^{\varphi} K_{GN}^{\phi(1-\varphi)} L_T \qquad 0 < \alpha, \varphi < 1$$

Utility Function:

$$U(C_T, C_N) = \frac{1}{\gamma}\left[C_T \cdot C_N^{\theta}\right]^{\gamma} \qquad 0 < \theta < 1; \qquad -\infty < \gamma < 1$$

where γ is related to the intertemporal elasticity of substitution s, by $s = 1/(1-\gamma)$.[8] The exponents α, φ parameterize the respective degrees of private capital intensity and η, ϕ represent the positive externality of public capital in the two sectors.

Parameter values are all reported in Table 1A. For instance, I assume $\gamma = -1.5$, which results in an intertemporal elasticity of substitution of 0.4. The intertemporal rate of time preference is $\beta = 0.06$. The world interest rate is fixed at 6%, and $\theta = 0.5$ represents the share of

[7] In arriving at the result, it is assumed that the initial stock of foreign bonds is equal to zero $B_0 = 0$.

[8] In the extreme case, when $\gamma = 0$ we obtain a logarithmic utility function.

non-traded good in the consumption portfolio. A_T =1.5 and A_N=1 are the productivity parameters in each sector. Sectoral production elasticities are represented by $\alpha = 0.35, \varphi = 0.25$.

The only difference is in the composition of the government expenditure as a percentage of GDP. In the first case g_N=0.08 and g_T=0.02 where government allocates larger proportion of its spending on the non-traded sector. In the second case, I reverse the composition of expenditure to g_N=0.02 and g_T=0.08, where government allocates most of its productive expenditure on the traded sector. It should be noted at this point that total government expenditure in both cases is constant and equal to %10 of GDP.[9]

Morshed and Turnovsky (2004) uses government expenditure data for 30 countries in 1990, disaggregated into twelve sectors to find the average share of expenditure in the traded and the non-traded sector. Their statistics indicate that on the average governments spend %2 of their GDP on the traded sector and around %24 of GDP on the non-traded sector. Given these statistics the case where government spends more on the non-traded sector seems (case 1) to be the most plausible one.

Sections B and C of Table 1 report steady-state equilibrium ratios corresponding to the different government expenditure compositions. In the first case, reported in section B, the capital-labor ratios in the traded and the non-traded sectors are around 15.5 and 9.6, respectively. The ratio of capital to output is 3.8 in the traded sector and 4.1 in the non-traded sector, with overall capital to output ratio in the economy being close to 4. Almost 56 percent of labor is employed in the traded sector producing around 60 percent of the total output. Government purchases around 3.5 percent of traded output and 20 percent of non-traded output, with overall

[9] Note that $g_N + g_T$=0.1 in both cases.

share of public purchases of 10 percent out of the total production. The long-run real exchange rate is 1.51.

Steady-state ratios for the case where government spends relatively more on the traded sector are reported in part C of Table 1. The capital-labor ratios of the traded and the non-traded sector are 11.78 and 7.29, respectively. The capital-to-output ratio in the traded sector is 2.95, and the corresponding ratio for the non-traded sector is 4.16, with economy wide capital-to-output ratio being 3.35. The traded sector produces almost 67 percent of total output and employs 63 percent of labor. Twelve percent of total traded production and almost three percent of total non-traded output is purchased by government. The long run real exchange rate is 1.98.

3.2 Government expenditure in the non-traded sector is larger (g_N=0.08, g_T=0.02)

Given the statistics presented by Morshed and Turnovsky (2004) this case is the most plausible one. Government spends 8 percent of GDP on non-traded productive purchases and 2 percent on traded ones. The benchmark steady-state equilibrium ratios are presented in Table 2. Following two subsections will describe the impact of government expenditure increase in the non-traded and the traded sectors separately.

(i) Fiscal expansion in the non-traded sector

Effects of an increase of government purchases in the non-traded sector by 5 percent of GDP on the long run steady-state ratios are reported in panel A of Table 2. In the short-run the expansionary fiscal policy in the non-traded sector attracts resources from the traded sector into the non-traded sector, which results in higher level of employment and output in the non-traded sector. The real exchange rate appreciates as a result of higher demand for non-traded goods [*p(0)* is 0.046]. The transitional paths of the real exchange rate, employment, output and capital in the traded and the non-traded sectors are illustrated in panel A of Figure 1.

Higher government spending increases public infrastructure capital in the non-traded sector, which results in a higher marginal product of private factors. Agent starts to accumulate both types of private capital, though non-traded private capital is accumulated faster. Marginal product of labor in the traded sector starts to increase as a result of private capital accumulation in that sector. This results in a flow of labor from the non-traded sector back to the traded sector. However, the level of traded employment attained in the long run is still lower than the initial equilibrium.[10] In the long run, output of the non-traded sector rises to 1.205 from 1.02, with employment increasing by 2.6 percent. Output in the traded sector however, mildly decreases. The capital-labor ratio in both sectors raises (K_T/L_T increases from 15.529 to 17.232 and K_N/L_N increases from 9.613 to 10.667). The increase in capital-to-labor ratio is higher in traded sector, which can be explained by loss in employment. Even though production of the traded sector shrinks, the total output of the economy increases (from 3.787 to 3.92) as a result of larger non-traded production. Private consumption of traded good as a share of the production falls from 0.966 to 0.889. Similar is the case for non-traded private consumption-over-output ratio, which falls from 0.703 to 0.577. The real exchange rate gradually depreciates as the productivity and output in the non-traded sector rises. The long run level of the real exchange rate is 1.416, which is lower than its initial equilibrium level of 1.512.

(ii) Fiscal expansion in the traded sector

The effects of traded government expenditure increase are summarized in panel B of Table 2. This case closely mirrors the previous one with similar mechanism working in favor of

[10] Short-run jump in employment overshoots the long-run equilibrium level.

the traded sector. Immediate effect of an increase in productive expenditure is movement of labor from the non-traded to the traded sector. This results in a substantial fall of non-traded production, which causes the real exchange rate to appreciate slightly (lower than the first case).

Transitional paths of the real exchange rate, employment, output and capital in the traded and the non-traded sectors are illustrated in panel B of Figure 1. Higher efficiency from increased level of public infrastructure capital in the traded sector leads agent to accumulate more private capital in both sectors. Capital-to-labor ratio in the traded sector increases from 15.529 to 15.842 and analogous ratio in the non-traded sector increases from 9.613 to 9.807. Gradually marginal product of labor in the non-traded sector increases, which brings back some of the labor lost in the short-run. Output in the non-traded sector starts to increase as well. However, in the long-run both employment and output in the non-traded sector are still lower than their initial equilibrium levels. Consumption over output in each sector decreases; in the traded sector from 0.966 to 0.778 and in the non-traded sector from 0.703 to 0.651. This is due to higher public consumption of both types of output (G_T/Y_T rises from 0.034 to 0.112 and G_N/Y_N rises from 0.297 to 0.349). The long run level of the real exchange rate is 1.629, which is higher than initial steady state. Higher government expenditure on the traded sector, which raises the productivity of the traded sector, results in a long-run appreciation of the real exchange rate.

3.3 Government expenditure in the traded sector is larger (g_N=0.02, g_T=0.08)

Given the composition of government expenditure statistics by Morshed and Turnovsky (2004) this case where government devotes larger proportion of its expenditure on the traded sector is less realistic. Still both types of fiscal expansion shocks will be investigated. First, I will analyze the effects of an increase in the non-traded expenditure by 5 percent of GDP compared to benchmark of 2 percent. Following, I will present consequences of an increase in traded government expenditure from 8 percent of GDP to 13 percent, keeping non-traded expenditure at its benchmark level of 2 percent.

(i) Fiscal expansion in the non-traded sector

Outcome of an increase in non-trade government expenditure in this benchmark specification closely mimics the previous benchmark case. Resources are attracted away from the traded sector and into the non-traded sector. Employment in the non-traded sector overshoots its long run equilibrium level. Output in the non-traded sector rises. Output in the traded sector initially declines, but gradually recovers and in the long run is higher than its prior equilibrium level. In the long run, capital-labor ratio in both sectors increases. Public share of consumption in both sectors rises, at the expense of private consumption. Key steady-state ratios are reported in panel A of Table 3. Transitional paths of private capital, output, traded employment and the real exchange rate are illustrated in section A of Figure 2. As can be seen from the graph, the real exchange rate initially depreciates. As productive government expenditure increases efficiency in the non-traded sector, the real exchange rate further depreciates reaching its long run equilibrium level of 1.672, compared to the initial level of 1.98.

(ii) Fiscal expansion in the traded sector

Key steady-state ratios are reported in panel B of Table 3. Picture does not change much when increased government spending is directed to the traded sector, compared to prior benchmark composition of government expenditure. There is no major change in capital to labor, capital to output ratios. Employment and output rise in the traded sector at the expense of the non-traded sector. Public consumption increases in both sectors at the expense of the private consumption. As predicted by the real exchange rate literature the higher productivity in the traded sector caused by larger government expenditure results in a long run appreciation of the real exchange rate; see e.g. Balassa (1964), Samuelson (1965) and Hsieh (1982). Transitional paths of the real exchange rate, traded labor, outputs and private capitals are illustrated in section B of Figure 2.

3.4 Productivity shocks

Long-run responses of productivity shocks in the non-traded and the traded sectors are presented in panel A and B of Table 5, respectively. Transitional paths of key variables are illustrated in Figure 3.

The direct effect of a non-traded productivity shock is to raise output in the non-traded sector. In this case the long-run real exchange rate substantially depreciates. This depreciation of the real exchange rate leads to a movement of capital and labor into the traded sector, where the flow of output increases as well. Consequently, we observe higher employment in the traded sector. Capital to labor ratio in both sectors increases substantially, due to higher productivity. Larger share of the each sectors production output is devoted to private consumption, as opposed to public consumption.

In the case of a traded productivity shock, the immediate effect is a rise in the traded output. This puts an upward pressure on the real exchange rate. Consequently, resources such as labor and capital move to the non-traded sector where output raises as well. Capital to labor ratio in each sector increases, though substantially less compared to a same shock in the non-traded sector. Private consumption of non-traded output increases, with the same indicator in the traded sector almost unaffected.

These results are in line with Morshed and Turnovsky (2004), which also demonstrates a positive impact of traded and a negative impact of non-traded productivity shocks on the real exchange rate. These results justify the hypothesis that long-run real exchange level crucially depends on the productivity differential between traded and non-traded production. In addition, numerical analysis presented above demonstrates that composition of government expenditure plays a crucial role in determining the level of the real exchange rate in the short as well as the long-run.

4. Conclusions

A two-sector dynamic dependent economy model is developed to investigate the link between government expenditure, productivity and the real exchange rate. Production in each sector depends on private factors, such as capital and labor, as well as public capital stock provided entirely by the government. This is in sharp contrast to the literature which has portrayed the government as purely resource absorbing unit. While converting output to private capital is assumed to be costless, sectoral capital transfers incur extra costs. This specification proposed by Morshed and Turnovsky (2004) allows one to obtain persistence in the deviation of the real exchange rate from its equilibrium level without the need to assume price rigidities, as for instance by Obstfeld and Rogoff (1995).

The model yields highly non-linear structure. It is possible to provide general characterization, but further insight requires the extensive use of numerical analysis. For plausible parameterizations of the economy three major results can be pointed out. First, it is shown that permanent fiscal expansion in the traded sector, irrespective of the benchmark expenditure composition, leads to appreciation of the real exchange rate in the long-run. Second, a similar fiscal policy in the non-traded sector depreciates the real exchange rate from its equilibrium level. Finally, productivity shock in either sector results in increased output in both sectors. Whereas productivity shock in the traded sector appreciates the real exchange rate, productivity shock in the non-traded sector has an opposite effect.

Table 2.1 – Benchmark parameters and steady state statistics

(A) Base parameter Values

Preference parameters: γ=-1.5; θ=0.5;

Rate of time preference: β=0.06;

World interest rate: r=0.06;

Productivity: A_T=1.5; A_N=1; $\eta=\phi$=0.15;

Production parameters (traded sector is capital intensive): α=0.35; φ=0.25;

(B) Key steady-state ratios (government spending composition: g_T=0.02; g_N=0.08;)

K_T/L_T	K_N/L_N	K_T/Y_T	K_N/Y_N	K/Y	L_T	Y_T/Y	G_T/Y_T	G_N/Y_N	G/Y	$\tilde{p}$
15.529	9.613	3.859	4.167	3.984	0.558	0.593	0.034	0.297	0.1	1.511

(C) Key steady-state ratios (government spending composition: g_T=0.08; g_N=0.02;)

K_T/L_T	K_N/L_N	K_T/Y_T	K_N/Y_N	K/Y	L_T	Y_T/Y	G_T/Y_T	G_N/Y_N	G/Y	$\tilde{p}$
11.78	7.292	2.945	4.167	3.352	0.634	0.667	0.12	0.119	0.1	1.98

Table 2.2 - Steady-state responses to permanent changes in government spending (Benchmark: g_N =0.08; g_T=0.02)

(i) Fiscal expansion in the non-traded sector: g_N=0.13; g_T=0.02;

	K_T/L_T	K_N/L_N	K_T/Y_T	K_N/Y_N	K/Y	L_T	Y_T	GDP	C_T/Y_T	C_N/Y_N	G_T/Y_T	G_N/Y_N	$p(0)$	$\tilde{p}$
Benchmark	15.529	9.613	3.859	4.167	3.984	0.558	2.245	3.787	0.966	0.703	0.034	0.297	0.0	1.512
	17.232	10.667	4.119	4.167	4.14	0.529	2.215	3.92	0.889	0.577	0.035	0.423	0.046	1.416

(ii) Fiscal expansion in the traded sector: g_N=0.08; g_T=0.07;

	K_T/L_T	K_N/L_N	K_T/Y_T	K_N/Y_N	K/Y	L_T	Y_T	GDP	C_T/Y_T	C_N/Y_N	G_T/Y_T	G_N/Y_N	$p(0)$	$\tilde{p}$
Benchmark	15.529	9.613	3.859	4.167	3.984	0.558	2.245	3.787	0.966	0.703	0.034	0.297	0.0	1.512
	15.842	9.807	3.58	4.167	3.8	0.592	2.62	4.184	0.778	0.651	0.112	0.349	0.035	1.629

Table 2.3 - Steady-state responses to permanent changes in government spending (Benchmark: g_N =0.02; g_T=0.08)

(i) Fiscal expansion in the non-traded sector: g_N=0.07; g_T=0.08;

	K_T/L_T	K_N/L_N	K_T/Y_T	K_N/Y_N	K/Y	L_T	Y_T	GDP	C_T/Y_T	C_N/Y_N	G_T/Y_T	G_N/Y_N	$p(0)$	$\tilde{p}$
Benchmark	11.78	7.292	2.945	4.167	3.352	0.634	2.537	3.804	0.88	0.881	0.12	0.119	0.0	1.98
	15.442	9.559	3.489	4.167	3.717	0.632	2.796	4.208	0.658	0.651	0.12	0.349	-0.086	1.672

(ii) Fiscal expansion in the traded sector: g_N=0.02; g_T=0.13;

	K_T/L_T	K_N/L_N	K_T/Y_T	K_N/Y_N	K/Y	L_T	Y_T	GDP	C_T/Y_T	C_N/Y_N	G_T/Y_T	G_N/Y_N	$p(0)$	$\tilde{p}$
Benchmark	11.78	7.292	2.945	4.167	3.352	0.634	2.537	3.804	0.88	0.881	0.12	0.119	0.0	1.98
	11.876	7.352	2.862	4.167	3.263	0.661	2.742	3.962	0.772	0.868	0.188	0.132	-0.015	2.039

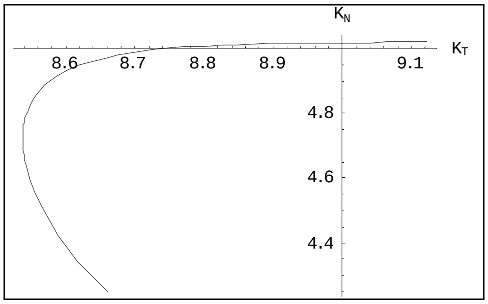
Table 2.4 - Steady-state responses to permanent changes in productivity (Benchmark: g_N =0.08; g_T=0.02)

(i) Productivity shock in the non-traded sector: A_N=1.5

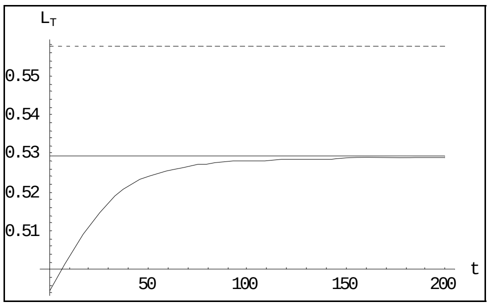
	K_T/L_T	K_N/L_N	K_T/Y_T	K_N/Y_N	K/Y	L_T	Y_T	GDP	C_T/Y_T	C_N/Y_N	G_T/Y_T	G_N/Y_N	$\tilde{p}$
Benchmark	15.529	9.613	3.859	4.167	3.984	0.558	2.245	3.787	0.966	0.703	0.034	0.297	1.512
	27.88	17.259	5.563	4.167	5.029	0.583	2.922	4.733	0.968	0.78	0.032	0.219	1.048

(ii) Productivity shock in the traded sector: A_T=2

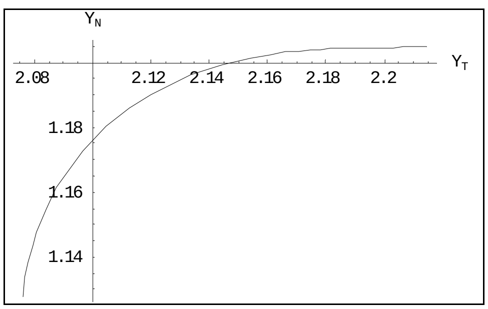
	K_T/L_T	K_N/L_N	K_T/Y_T	K_N/Y_N	K/Y	L_T	Y_T	GDP	C_T/Y_T	C_N/Y_N	G_T/Y_T	G_N/Y_N	$\tilde{p}$
Benchmark	15.529	9.613	3.859	4.167	3.984	0.558	2.245	3.787	0.966	0.703	0.034	0.297	1.512
	16.584	10.266	2.956	4.167	3.479	0.533	2.988	5.26	0.965	0.635	0.035	0.365	1.973



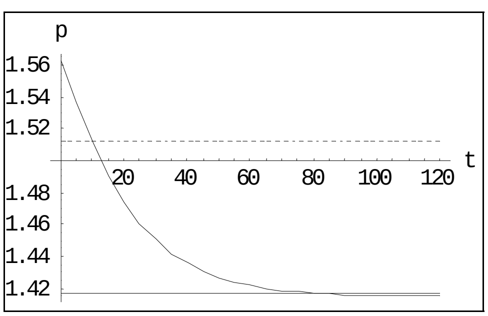
(i) Adjustment of Capital Stocks



(ii) Labor in Traded Sector

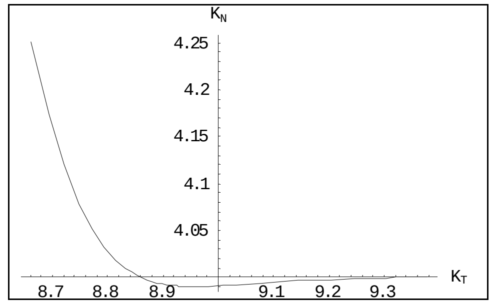


(iii) Adjustment of Outputs

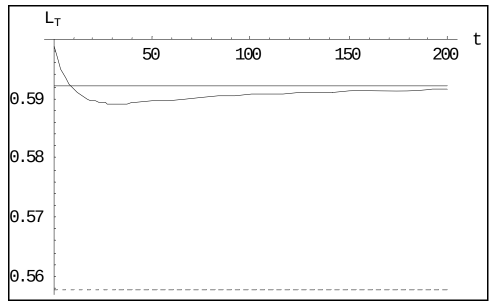


(iv) The Real Exchange Rate

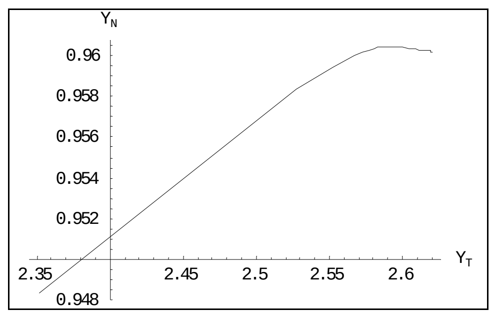
(A) Increase in g_N



(i) Adjustment of Capital Stocks



(ii) Labor in Traded Sector



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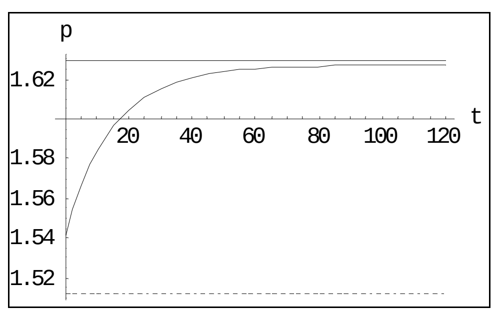
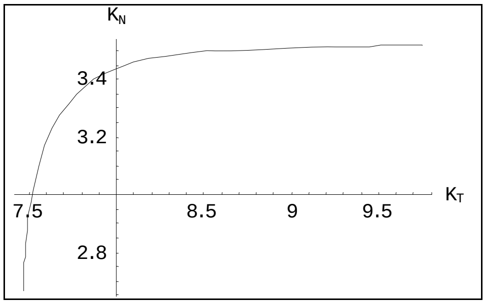


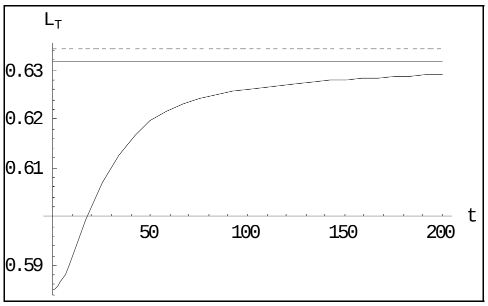
(iv) The Real Exchange Rate

(B) Increase in g_T

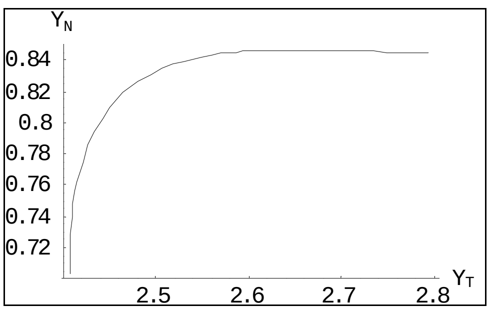
Figure 2.1 – Government spending increase (Benchmark: g_N=0.08, g_T=0.02)



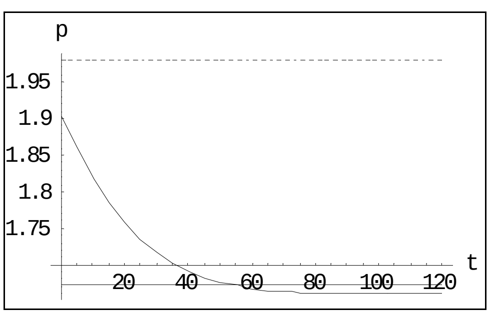
(i) Adjustment of Capital Stocks



(ii) Labor in Traded Sector

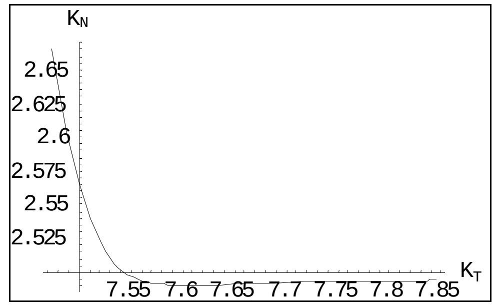


(iii) Adjustment of Outputs

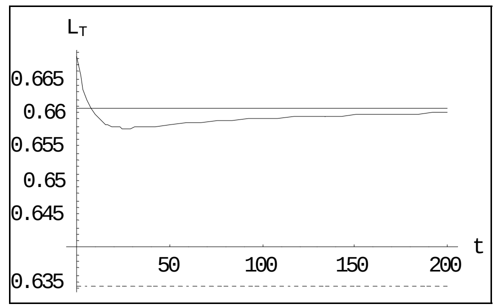


(iv) The Real Exchange Rate

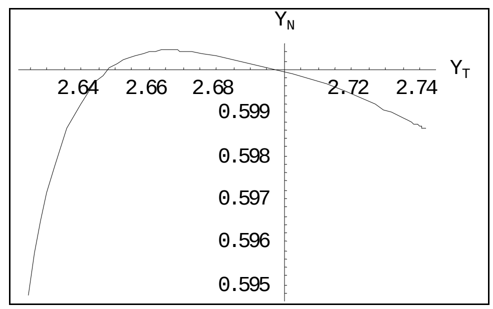
(A) Increase in g_N



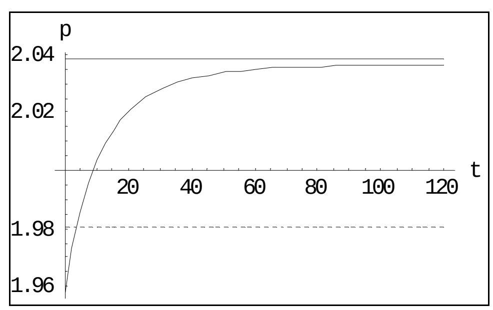
(i) Adjustment of Capital Stocks



(ii) Labor in Traded Sector



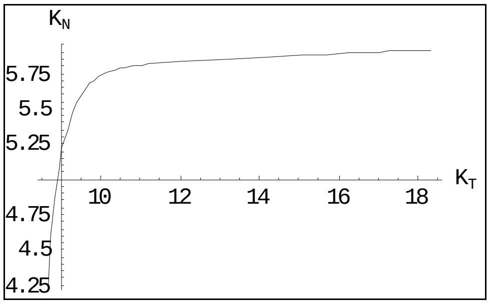
(iii) Adjustment of Outputs



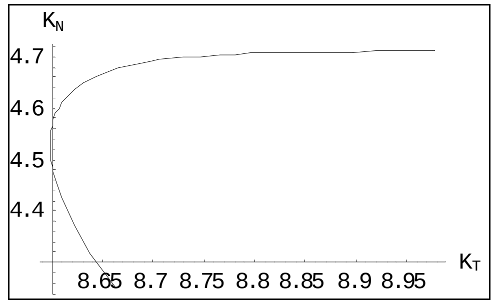
(iv) The Real Exchange Rate

(B) Increase in g_T

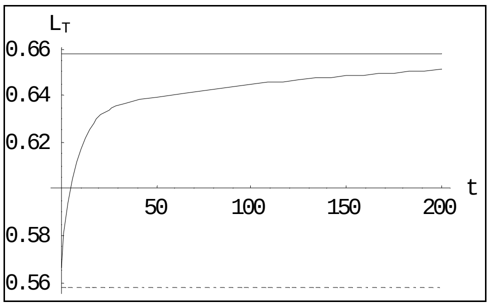
Figure 2.2 - Government spending increase (Benchmark: g_N=0.02, g_T=0.08)



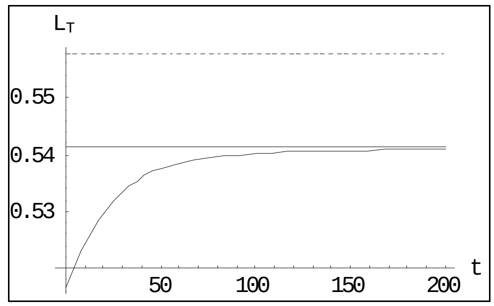
(i) Adjustment of Capital Stocks



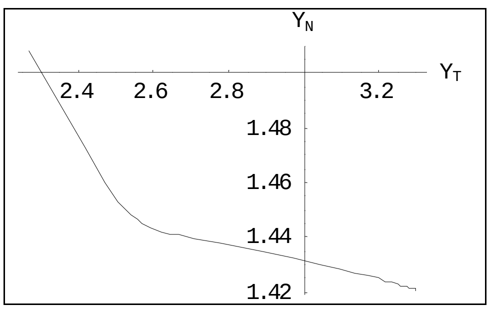
(i) Adjustment of Capital Stocks



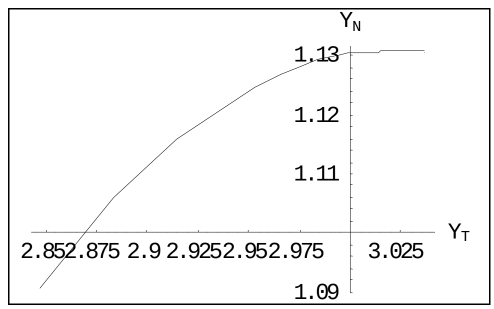
(ii) Labor in Traded Sector



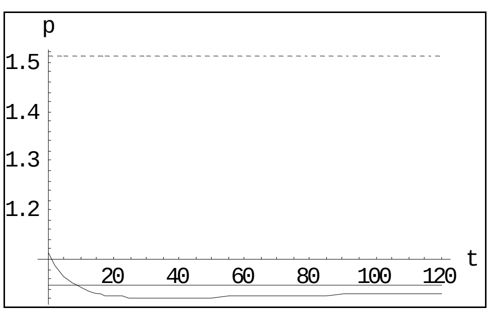
(ii) Labor in Traded Sector



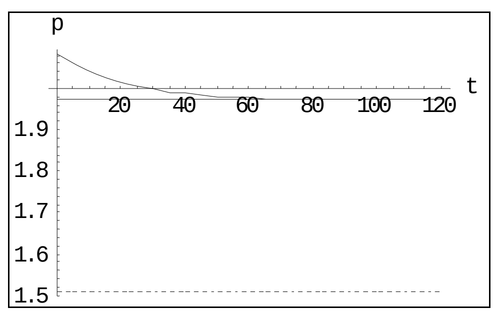
(iii) Adjustment of Outputs



(iii) Adjustment of Outputs



(iv) The Real Exchange Rate



(iv) The Real Exchange Rate

(A) Increase in A_N

(B) Increase in A_T

Figure 2.3 – Increase in productivity (Benchmark: g_N=0.08, g_T=0.02)

CHAPTER 3 – GOVERNMENT SPENDING, TAXATION AND REAL EXCHANGE RATE

1. Motivation

The analysis in the first chapter of this dissertation focused primarily on the relationship between government expenditure, productivity and the dynamics of the real exchange rate. An important aspect that has not received required attention in the previous setting is the source of financing for public expenditure. In practice, the structure of funding government expenditure is an essential component of fiscal policy. Baier and Glomm (2001), and Corsetti and Roubini (1996) provide a theoretical justification of the importance of distortionary taxation in context of analyzing the effects of fiscal policy. Bleaney et al. (1999) on the other hand use extensive data set for 22 OECD countries to demonstrate importance and effectiveness of distorionary taxes as a fiscal policy tool. Thus it would be interesting to see how different modes of financing productive public expenditure on the traded and non-traded sectors affect the dynamics of the real exchange rate. Another interesting dimension to this problem is the effect of such fiscal policy on welfare in a two sector open economy.

This chapter of the dissertation is extended to include distortionary income taxes in each sector as potential sources of financing sector-specific public expenditure, in addition to pure lump-sum taxes. In practice, distortionary income taxes can be considered as a main source of revenue for the government. For instance, in the United States, 60 percent of total federal revenue can be attributed to income taxes in 2007 (45 percent from individual income tax and 15 percent from corporate). Moreover, in contrast to pure lump-sum taxation this setup enriches the dynamics as tax policy affects marginal returns of private factors and their allocation among sectors, thereby influencing the relative price of two goods.

Taxes in this setting are levied on the output produced in each sector. So, a five percent tax on the non-traded sector implies that there would be five percent less output that can be either consumed or invested by the agent (bear in mind that non-traded output can either be consumed or converted to private capital in that sector at no extra cost). This obviously diminishes the marginal return on the existing private capital stock and puts downward pressure on additional capital accumulation. As capital in the economy shrinks, so does the output in each sector (except for one case where a tax on traded sector eventually leads to an increase in output in the non-traded sector). Since the marginal return on consumption exceeds the after tax marginal return on capital, the agent in all of the cases consumes more of each type of output. Given that the production of output is affected, the relative price changes accordingly to equate marginal utilities.

Government expenditure policy plays a crucial role in this economy. As in the previous chapter, government consumption of goods and services in the market is accumulated as a stock of public capital. This stock of infrastructure exerts a positive externality on the private production of the same sector. In this regard, increase in the level of taxation accompanied by an increase in the level of government expenditure can be considered a balanced strategy which in some cases may lead to economic growth.

The model yields sixth order dynamic system, which is impossible to track analytically. Thus policy experiments are analyzed numerically. Since dynamics of a two-sector dependent economy model are very sensitive to the relative capital intensities, two different scenarios are considered: (i) the traded sector is more capital intensive ($\alpha = 0.35, \varphi = 0.25$), and (ii) the non-traded sector is more capital intensive ($\alpha = 0.25, \varphi = 0.35$ **).** Under both of these cases six policy experiments are conducted: (a) increase in government expenditure accompanied by lump-sum taxes, (b) government expenditure financed by distortionary taxes and (c) solely imposition of distortionary taxes for the traded and non-traded sector separately.

The results show that imposition of taxes under any circumstances lowers capital accumulation, capital per labor and capital per output in each sector. Contrary to the case with lump-sum taxes, expansionary fiscal policy financed by distortionary taxation leads to economic growth only in the non-traded sector. In addition, it is shown that distortionary taxes levied on the traded sector output result in depreciation, whereas taxes in the non-traded sector lead to appreciation of the real exchange rate. This experiment justifies the direct link between tax policy and real exchange rate dynamics.

The rest of the chapter is organized as follows. Next section is devoted to describing the theoretical structure of the economy. Since model yields complex non-linear structure use of numerical calibration is inevitable. I present the numerical calibration setup and benchmark parameters as well as responses to fiscal policy shocks (both tax policy changes and government expenditure shocks) in section 3. Welfare analysis is presented in section 4, which is followed by conclusion in section 5.

2. Economic Structure

2.1 The Model

The economic structure can be considered to be an extension of the first chapter with the incorporation of distortionary income taxes into the model. As in chapter one, we start with a representative agent who is endowed with a unit of labor, which he allocates across the two sectors at the competitive wage rate. The agent produces the traded good by means of a neoclassical production function $Y_T(K_T, L_T, K_{GT})$, where K_T is the quantity of private capital, L_T is the quantity of labor and K_{GT} is the stock of public infrastructure capital, which is entirely funded by the government. The two private factors of production produce diminishing marginal physical product and production is subject to constant returns to scale. Production in the non-traded sector $Y_N(K_N, L_N, K_{GN})$ has similar characteristics and utilizes the same input variables.

It is also assumed that the traded good can be used for consumption purposes only; both private and public, whereas the non-traded good can either be consumed or accumulated as a capital good, to which it can be converted at zero cost.

Excess output after consumption and tax payments is accumulated in the form of foreign bonds, that pay an exogenously given world interest rate, *r*. Equation (1a) below describes the agent's instantaneous budget constraint:

$$\dot{B} = (1-\tau_T)\cdot Y_T(K_T, L_T, K_{GT}) - C_T + p\cdot\left[(1-\tau_N)\cdot Y_N(K_N, L_N, K_{GN}) - C_N - I\right] - T_L + r\cdot B \qquad \text{(1a)}$$

where all of the variables are denoted as in chapter one, except for τ_T and τ_N, which represent income tax on production of the traded and the non-traded good respectively. In this framework, *p* refers to the real exchange rate; an increase in which represents a real appreciation.

As before, the capital stock in either sector does not depreciate and only non-traded new output can be converted into private capital. Capital in the non-traded sector takes extra resources to be transformed into capital suitable for use in the traded sector. These are generally referred to as intersectoral adjustment costs, which are investigated extensively for instance by Morshed and Turnovsky (2004). Capital accumulation in the economy, therefore, can be described as follows;

$$\dot{K}_T = X \quad (1b)$$

$$\dot{K}_N = I - X\left(1+\frac{hX}{2K_N}\right) = Y_N - C_N - G_N - X\left(1+\frac{hX}{2K_N}\right) \quad (1c)$$

where again all variables are as described in chapter one. The amount $\frac{hX^2}{2K_N} > 0$ represents the intersectoral adjustment cost necessary to transfer X amount of the non-traded private capital into the traded sector.

Labor markets clear at every instant of time as labor is fully mobile across sectors. The full employment condition is;

$$L_T + L_N = 1 \quad (1d)$$

The agent chooses the consumption of the traded and the non-traded goods, allocation across the sectors, the rate of investment, capital allocation between two sectors, and accumulation of net foreign bonds to maximize the intertemporal utility function;

$$\int_0^\infty U(C_T, C_N)\cdot e^{-\beta t}\text{dt} \quad (2)$$

subject to the constraints (1a) – (1d) and given initial stocks of private capital and foreign bonds. The agent's rate of time preference β is taken to be constant and the instantaneous utility function is assumed to be strictly concave. Both consumption goods are taken to be normal.

The current value Hamiltonian for the problem then becomes;

$$H = U(C_T, C_N)\cdot e^{-\beta t} + \lambda e^{-\beta t}\left\{(1-\tau_T)Y_T - C_T + p\cdot\left[(1-\tau_N)Y_N - C_N - I\right] - T_L + r\cdot B - \dot{B}\right\}$$

$$+q_1^* e^{-\beta t}[X - \dot{K}_T] + q_2^* e^{-\beta t}\left[I - X\left(1+\frac{hX}{2K_N}\right) - \dot{K}_N\right] \quad (3)$$

Denoting the shadow price of the foreign bonds by λ and those of traded and non-traded capital by q_1^*, and q_2^*, we can define the shadow values $q_1 = \frac{q_1^*}{\lambda}$, and $q_2 = \frac{q_2^*}{\lambda}$ which maybe interpreted as the market prices of traded and non-traded capital relative to that of the foreign bonds. The optimality conditions are;

$$\frac{\partial H}{\partial C_T} = 0 \rightarrow U_T(C_T, C_N) = \lambda \tag{3a}$$

$$\frac{\partial H}{\partial C_N} = 0 \rightarrow U_N(C_T, C_N) = p \cdot \lambda \tag{3b}$$

$$(1-\tau_T)\frac{\partial Y_T}{\partial L_T} = (1-\tau_N)p\frac{\partial Y_N}{\partial L_N} \tag{3c}$$

$$\frac{\partial H}{\partial X} = 0 \rightarrow \frac{X}{K_N} = \frac{q_1 - q_2}{h \cdot q_2} \tag{3d}$$

$$\frac{\partial H}{\partial I} = 0 \rightarrow -\lambda \cdot p + q_2^* = 0 \rightarrow p = {q_2^*}/{\lambda} = q_2 \tag{3e}$$

$$\frac{\partial H}{\partial B} = -\frac{\partial H / \partial \dot{B}}{\partial t} \rightarrow \beta = \frac{\dot{\lambda}}{\lambda} + r \tag{3f}$$

$$\frac{\partial H}{\partial K_T} = -\frac{\partial H / \partial \dot{K}_T}{\partial t} \rightarrow \frac{(1-\tau_T)\cdot \partial Y_T / \partial K_T}{q_1} + \frac{\dot{q}_1}{q_1} = r \tag{3g}$$

$$\frac{\partial H}{\partial K_N} = -\frac{\partial H / \partial \dot{K}_N}{\partial t} \rightarrow (1-\tau_N)\frac{\partial Y_N}{\partial K_N} + \frac{hX^2}{2K_N^2} + \frac{\dot{q}_2}{q_2} = r \tag{3h}$$

together with transversality conditions;

$$\lim_{t\to\infty} \lambda B e^{-\beta t} = \lim_{t\to\infty} q_1 \lambda K_T e^{-\beta t} = \lim_{t\to\infty} q_2 \lambda K_N e^{-\beta t} = 0 \tag{3i}$$

Equations (3a) and (3b) equate the marginal utilities of consumption of the two goods to the shadow price of wealth, appropriately measured in terms of the numeraire. The perfect labor mobility assumption implies equation (3c), which states that the after tax marginal physical product of labor in each sector must be equal. Equation (3d) determines the movement of capital between the two sectors. Capital movement occurs as long as the shadow values of two types of capital are unequal. Non-traded new output can either be consumed or converted into capital. Hence, the marginal utility of consumption of non-traded good must be equal to the shadow value of the capital in the non-traded sector, which yields the equation (3e). Applying the standard optimality condition with respect to *B* implies the usual arbitrage relationships, equating the rate of return on consumption to the cost of borrowing depicted in equation (3f). In order to obtain a well defined steady state in which marginal utility and consumption remain finite, it is required that $\beta = r$ which implies $\dot{\lambda} = 0$ for all t, so that the marginal utility does not change over time, i.e. $\lambda = \overline{\lambda}$.[11] The last three efficiency conditions equate the return on capital in each sector appropriately evaluated at marginal physical product to the rate of return on foreign bonds. The last three transversality conditions (3i) must hold to ensure that the agent's intertemporal budget constraint is satisfied.

The government in this setting plays a very active role. It provides a vital component of the production process, the stock of physical infrastructure capital in both sectors that raises the efficiency and productivity of private capital. Whereas in the first chapter the source of funding for these expenditures was lump-sum taxation, I introduce distortionary income taxes in this chapter. Thus, besides lump-sum taxes the government takes a share of production in both sectors and uses it to fund public investments. As before public capital in the two sectors evolves according to;

[11] This assumption is standard in deriving intertemporal models of small open economies, although it is not particularly appealing. Its consequences for the equilibrium dynamics are discussed by Turnovsky (1997) in some detail.

$$\dot{K}_{GT} = G_T - \delta_{GT} K_{GT} \tag{4a}$$

$$\dot{K}_{GN} = G_N - \delta_{GN} K_{GN} \tag{4b}$$

where δ_{GT} and δ_{GN} are respective depreciation rates in each sectors' public capital. Government expenditure is tied to the scale of the economy in the following form;

$$G_N = g_N (Y_T + p \cdot Y_N) \tag{4c}$$

$$G_T = g_T (Y_T + p \cdot Y_N) \tag{4d}$$

where $0 < g_N, g_T < 1$.

Substituting the above definitions into the accumulation equation of public infrastructure capital in each sector yields the following dynamic equations;

$$\dot{K}_{GT} = (g_T)(Y_T + p \cdot Y_N) - \delta_{GT} K_{GT} \tag{4a'}$$

$$\dot{K}_{GN} = (g_N)(Y_T + p \cdot Y_N) - \delta_{GN} K_{GN} \tag{4b'}$$

Thus economy-wide infrastructure capital evolves according to

$$\dot{K}_G = \dot{K}_{GT} + \dot{K}_{GN} = [g_T + g_N](Y_T + p \cdot Y_N) - \delta_{GT} K_{GT} - \delta_{GN} K_{GN}$$

The government maintains a balanced budget at every instant of time according to,

$$T_L + \tau_N \cdot p \cdot Y_N + \tau_T \cdot Y_T = p \cdot G_N + G_T \tag{4f}$$

Combining (1a) and (4f) yields the economy's current account dynamics:

$$\dot{B} = Y_T + r \cdot B - C_T - g_T (Y_T + p \cdot Y_N) \tag{1a'}$$

2.2 Macroeconomic Equilibrium

To obtain the macroeconomic equilibrium, first solve equations (3a) and (3b) for non-traded and traded consumption in the following form:

$$C_T = C_T\left(\bar{\lambda}, p\right) \tag{5a}$$
$$C_N = C_N\left(\bar{\lambda}, p\right) \tag{5b}$$

Also, from the condition on efficient labor allocation (3c) and labor endowment equation (1d) labor allocation in each sector can be derived as;

$$L_T = L_T\left(K_T, K_N, p, K_{GT}, K_{GN}\right) \qquad \frac{\partial L_T}{\partial K_T} > 0,\ \frac{\partial L_T}{\partial K_N} < 0,\ \frac{\partial L_T}{\partial p} < 0,\ \frac{\partial L_T}{\partial K_{GT}} > 0,\ \frac{\partial L_T}{\partial K_{GN}} < 0 \tag{5c}$$
$$L_N = L_N\left(K_T, K_N, p, K_{GT}, K_{GN}\right) \qquad \frac{\partial L_N}{\partial K_T} < 0,\ \frac{\partial L_N}{\partial K_N} > 0,\ \frac{\partial L_N}{\partial p} > 0,\ \frac{\partial L_N}{\partial K_{GT}} < 0,\ \frac{\partial L_N}{\partial K_{GN}} > 0 \tag{5d}$$

The logic behind the above partial derivatives is very intuitive. An increase in the either type of capital in the non-traded sector, increases marginal physical product of labor in that sector, attracting labor from the traded sector, while an increase of capital in traded sector has the reverse effect on labor.

Taking into account (5a)-(5d), the macroeconomic equilibrium can be summarized by the following autonomous system in six variables;

$$\dot{K}_T = X \tag{6a}$$
$$\dot{K}_N = Y_N - C_N - G_N - X\left(1 + \frac{hX}{2K_N}\right) \tag{6b}$$
$$\dot{K}_{GT} = \left(g_T\right)(Y_T + p \cdot Y_N) - \delta_{GT} K_{GT} \tag{6c}$$
$$\dot{K}_{GN} = \left(g_N\right)(Y_T + p \cdot Y_N) - \delta_{GN} K_{GN} \tag{6d}$$
$$\dot{p} = p\left[r - (1-\tau_N)\cdot\frac{\partial Y_N}{\partial K_N} - \frac{hX^2}{2K_N^2}\right] \tag{6e}$$
$$\dot{X} = \left[\frac{Y_N - C_N - G_N}{K_N} + (1-\tau_N)\cdot\frac{\partial Y_N}{\partial K_N}\right]X - \frac{X^2}{2K_N} - \frac{K_N}{hp}\left[(1-\tau_T)\cdot\frac{\partial Y_T}{\partial K_T} - (1-\tau_N)\cdot p\frac{\partial Y_N}{\partial K_N}\right] \tag{6f}$$

together with the current account condition;

$$\dot{B} = Y_T - C_T - G_T + r \cdot B \tag{6g}$$

The first two equations describe the evolution of private capital in each sector. Analogously, third and fourth equations described the evolution of public capital in the two sectors. Equation (6e) describes the dynamics of the real exchange rate, which can be obtained by combining equations (3e) and (3h). The last equation in the system, (6f) represents the flow of capital transferred among the sectors. Equation (6g) is the current account of the economy described by (1a) before.

Linearizing (6a)-(6f) around the steady denoted by tildes, the dynamics can be approximated by;

$$\begin{pmatrix} \dot{K}_T \\ \dot{K}_N \\ \dot{K}_{GT} \\ \dot{K}_{GN} \\ \dot{p} \\ \dot{X} \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} & a_{16} \\ a_{21} & a_{22} & a_{23} & a_{24} & a_{25} & a_{26} \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} & a_{36} \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} & a_{46} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} & a_{56} \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & a_{66} \end{pmatrix} . \begin{pmatrix} K_T - \tilde{K}_T \\ K_N - \tilde{K}_N \\ K_{GT} - \tilde{K}_{GT} \\ K_{GN} - \tilde{K}_{GN} \\ p - \tilde{p} \\ X - \tilde{X} \end{pmatrix} \quad (7)$$

The above system (7) is a sixth order linear dynamic system. Analyzing its characteristics it can be established that there are four negative (stable) eigenvalues and two positive (unstable) ones, implying that equilibrium is a saddlepoint. The capital stocks K_T, K_N, K_{GT} and K_{GN} evolve sluggishly, whereas the real exchange rate , *p*, and amount of non-traded investment transferred to the traded sector, *X*, are jump variables and can adjust instantaneously to the new information. It can be verified numerically that equilibrium yields a unique stable saddlepath.

2.3 Steady State

The steady-state equilibrium is attained when $\dot{K}_N = \dot{K}_T = \dot{X} = \dot{p} = \dot{K}_{GT} = \dot{K}_{GN} = 0$, which implies that at steady state, $X = 0$, capital transfer from the non-traded to the traded sector is zero. Imposing these conditions yields the following set of steady state equations:

$$\tilde{Y}_N = \tilde{C}_N + g_N \left[\tilde{Y}_T + \tilde{p} \cdot \tilde{Y}_N \right] \tag{8a}$$

$$\left(g_T \right) \left[\tilde{Y}_T + \tilde{p} \cdot \tilde{Y}_N \right] = \delta_{GT} \tilde{K}_{GT} \tag{8b}$$

$$\left(g_N \right) \left[\tilde{Y}_T + \tilde{p} \cdot \tilde{Y}_N \right] = \delta_{GN} \tilde{K}_{GN} \tag{8c}$$

$$(1 - \tau_N) \cdot \frac{\partial \tilde{Y}_N}{\partial \tilde{K}_N} = r \tag{8d}$$

$$(1 - \tau_T) \cdot \frac{\partial \tilde{Y}_T}{\partial \tilde{K}_T} = \tilde{p} \cdot (1 - \tau_N) \cdot \frac{\partial \tilde{Y}_N}{\partial \tilde{K}_N} \tag{8e}$$

$$(1 - \tau_T) \cdot \frac{\partial \tilde{Y}_T}{\partial \tilde{L}_T} = \tilde{p} \cdot (1 - \tau_N) \cdot \frac{\partial \tilde{Y}_N}{\partial \tilde{L}_N} \tag{8f}$$

$$\tilde{Y}_T = \tilde{C}_T + g_T \cdot \left[\tilde{Y}_T + \tilde{p} \cdot \tilde{Y}_N \right] - r \cdot \tilde{B} \tag{8g}$$

$$\tilde{L}_T + \tilde{L}_N = 1 \tag{8h}$$

The first equation is a market clearing condition for the non-traded good, which states that at the steady state all non-traded output must be consumed either by government or by the agent since private capital transfers cease. The next two equations show that public capital accumulation is zero at the steady state. Equations (8d) and (8e) jointly demonstrate that the after-tax marginal product of capital in both sectors are equal and that in turn is equal to the exogenously given world interest rate. Similarly, equation (8f) equates the marginal product of labor across sectors. Equation (8g) is another way of saying that in the steady-state a change in the current account must be equal to zero and there is no change in the outstanding stock of international bonds that the agent holds. The last equation is a market clearing condition for labor market.

Equations (8a)-(8h) give us eight equations that can be solved for the eight unknowns of the system $\tilde{K}_N, \tilde{K}_T, \tilde{K}_{GT}, \tilde{K}_{GN}, \tilde{L}_T, \tilde{L}_N, \bar{\lambda}, \tilde{p}$.[12] Finally the current account of the economy can be derived using equation (6g),

$$\dot{\tilde{B}} = \tilde{Y}_T - \tilde{C}_T - g_T \cdot \left[\tilde{Y}_T + \tilde{p} \cdot \tilde{Y}_N \right] + r \cdot \tilde{B} \qquad \text{(6g')}$$

3. Numerical Analysis of Transitional Paths

Because an analytical closed-form solution of the model is not possible, it will be evaluated numerically. The small open economy that I consider is characterized by the following production and utility functions;

Production Functions:

$$Y_T = A_T K_T^{\alpha} \left(L_T K_{GT}^{\eta} \right)^{1-\alpha} = A_T k_T^{\alpha} K_{GT}^{\eta(1-\alpha)} L_T$$

$$Y_N = A_N K_N^{\varphi} \left(L_N K_{GN}^{\phi} \right)^{1-\varphi} = A_N k_N^{\varphi} K_{GN}^{\phi(1-\varphi)} L_T \qquad 0 < \alpha, \varphi < 1$$

Utility Function:

$$U(C_T, C_N) = \frac{1}{\gamma} \left[C_T \cdot C_N^{\theta} \right]^{\gamma} \qquad 0 < \theta < 1; \qquad -\infty < \gamma < 1$$

where γ is related to the intertemporal elasticity of substitution s, by $s = 1/(1-\gamma)$.[13] I calibrate the benchmark economy using the parameter values summarized in the Table 1. For instance, I assume $\gamma = -1.5$, which results in an intertemporal elasticity of substitution of 0.4. The intertemporal rate of time preference is $\beta = 0.06$. The world interest rate is fixed at 6%, and $\theta = 0.5$ represents the share of non-traded good in the consumption portfolio. A_T = A_N=1.5 are the productivity parameters in each sector. These parameters choices, though arbitrary, are

[12] In arriving at the result, it is assumed that the initial stock of foreign bonds is equal to zero, $B_0 = 0$.

[13] In the extreme case, when $\gamma = 0$ we obtain a logarithmic utility function.

standard for most of the calibration models used in the literature.[14] The base values for the government expenditures in the traded and non-traded sectors are initially set to be equal, $g_N = g_T = 0.05$. While these values are arbitrary, though not implausible, results of the numerical analysis are insensitive to these assumptions. The dynamics of a two-sector dependent economy model are very sensitive to the relative capital intensities, so I consider two different scenarios: (i) the traded sector is more capital intensive ($\alpha = 0.35, \varphi = 0.25$), and (ii) the non-traded sector is more capital intensive ($\alpha = 0.25, \varphi = 0.35$**).**

3.1 Initial Benchmark Equilibrium

Substituting the benchmark parameters into functional forms characterizing the steady-state yields the benchmark equilibrium ratios reported in Table 2. Panel A of the table reports the key steady-state ratios where traded sector is assumed to be more capital intensive. The sectoral capital-output ratios are 5.08 and 4.17 in the traded and non-traded sector accordingly, yielding an economy wide capital to output ratio of 4.76. The traded sector employs 61% of labor to produce just above 64% of the total output. The long-run level of the real exchange rate is reported in the final column ($\tilde{p} = 1.147$). Panel B reports the key steady state equilibrium ratios for the second scenario where the non-traded sector is assumed to be more capital intensive. The sectoral capital to output ratios in the traded and non-traded sectors are 6.45 and 5.83, respectively, yielding an overall capital to output ratio of 6.24. Moreover, capital-labor ratios have switched magnitudes in favor of non-traded sector, which is not surprising given the change in capital intensiveness. The traded sector in this benchmark employs 69% of labor and produces

[14] Chatterjee et al. (2003), Morshed and Turnovsky (2004), Cerra et el. (2008) have used similar parameters in calibrating a two-sector dynamic dependent economy.

almost 66% of the overall output. The long run relative price of the non-traded good is ($\tilde{p} = 0.646$).

3.2 Traded sector is more capital intensive ($\alpha = 0.35, \varphi = 0.25$)

The following two subsections will elaborate on consequences as well as transitional dynamics of fiscal policy changes in the traded and non-traded sectors separately. Benchmark steady state equilibrium ratios are presented in Table 3.

3.2.1 Traded Sector Shocks

(i) Lump-sum tax financed fiscal expenditure increase

This exercise presents an increase in the level of public expenditure to the traded sector by 5% of GDP without altering the level of distortionary taxation. Section A of Table 3 presents the long-run steady state ratios of selected variables. In the short-run an increase in public expenditure acts like pure demand shock. As government consumption of the traded good increases, so does the demand for it, which pushes up the price of the traded good. This results in an immediate depreciation of the real exchange rate (*dp(0)*= -0.0157) which can be observed from panel (viii) of Figure 1. Furthermore, in order to meet the higher demand for traded production labor adjusts instantaneously, moving from non-traded sector to the traded. It should be pointed that this short-run movement overshoots the long-run level of employment in the traded sector.

In the medium and long-run higher government expenditure in the traded sector is accumulated as a stock of productive infrastructure which raises marginal product of additional private factors. Agent starts to accumulate more capital, which is represented by higher aftershock capital-labor ratios, 25.59 and 15.84 for the traded and non-traded sectors respectively. It is worth mentioning at this point, that capital-labor ratios in this setting are slightly higher that would normally be obtained in the literature, the reason for which is the additional productivity gains from public capital that makes the individual labor more efficient and thus requires additional private capital. Since capital can only be accumulated in the non-traded sector and then transferred to the traded one, marginal product of labor in this sector exceeds that of the traded and gradually labor moves back to non-traded sector to reach a long-run employment level 36%. Output in the long-run rises in the traded sector (by 9.5%) at the expense of a contraction in the non-traded sector (by 7.5%). However, total output of the economy (i.e. GDP) increases by 4.2%.

Further, since marginal product of investing additional unit of output into private capital is higher now, agent cuts back on his consumption as well. Overall consumption to output ratio falls from initial 89% to 79%. Finally, the joint effect of rise in productivity and output in the traded sector and a decline in the non-traded output is the appreciation of the real exchange rate. An initial demand driven depreciation is outweighed by the long-run supply driven appreciation of the real exchange rate that reaches its long-run steady state at $\tilde{p} = 1.18$. These results are in line with Balassa-Samuelson findings.

(ii) Distortionary tax financed fiscal expenditure increase

Contrary to the previous exercise, here, an increase in the fiscal expenditure to the traded sector is financed by an increase in the level of distortionary taxation in the same sector. Long-run steady state equilibrium ratios for selected variables are presented in the second row of Panel A of Table 3. In the short-run this policy change acts as a pure demand shock. However, when compared to the previous case, this policy has a stronger effect as both increase in expenditure and the taxes crowd out private consumption of the traded good even more and increase its price. Consequently, immediate response in exchange rate is (*dp(0)*= -0.103), which is substantially higher jump compared to a lump-sum tax financed expenditure increase. Tax on traded production prevents big movement of labor from non-traded sector to meet the higher demand in the traded one. In the short-run there is only minor change in sectoral employment, which can be observed from panel (vi) of Figure 2. Dynamic time paths of other selected variables are also presented in Figure 2.

In the medium and long-run government expenditure is transformed into productive public infrastructure. Higher marginal return in the traded sector makes the agent transform his non-traded capital to the traded. As a result, output in the traded sector increases by 4.6% at the expense of non-traded sector contraction by 1.4%. Gross Domestic Product of the economy declines by 0.3% as a result of the policy shock. Increased public consumption crowds out the private one, consequently, total consumption to GDP ratio declines from 0.89 to 0.81.

Initial jump in the real exchange rate overshoots the long-run level. Even though, higher public expenditure results in increased productivity in the traded sector, higher tax rates lower the incentive for traded production and decrease its price. Overtime real exchange rate starts to appreciate to reach its long run steady state level at 1.066 back from 1.148.

These two experiments clearly show that tax financed expenditure increase in the traded sector does not have any implications for economic growth and lead to depreciation of the real exchange rate. On the other hand, lump-sum financed fiscal expansion in the traded sector has solid contribution to growth and leads to appreciation of the real exchange rate in the long-run.

(iii) Increase in the level of distortionary taxes only

In this exercise I analyze solely the change in the level of distortionary taxation without altering the expenditure policy; a 10% tax is imposed on traded output. The results are straightforward given the analysis in the previous two sections. Long-run key equilibrium ratios are reported in final row of Panel A of Table 3. Dynamic paths of selected variables are presented in Figure 3.

The policy change results in less output in the traded sector per private factors utilized. Consequently, there is an instantaneous movement of labor to the non-traded sector for higher returns. Output of the traded sector diminishes. Non-traded output, on the contrary, increases in the short-run as a result of labor transfer. To equate marginal products of private factors however, overtime some of the labor moves back to the traded sector. In the long-run traded sector employs 58% of labor force to produce 64% of the total output, where as non-traded sector uses 42% of labor to produce 36% of overall output. With less output per existing private capital in each sector, marginal utility of consuming additional output outweighs that of investing it. Consequently, consumption to output rises from benchmark ratio of 0.89 to 0.92.

Dynamic path of the real exchange rate is straightforward. Lower production in the traded sector pushes the prices of that good up. Similarly, increased production in the non-traded sector puts downward pressure on the price sectors output. Combined effect of the above mechanisms results in substantial depreciation of the real exchange rate, which ends up at a new long-run level of $\tilde{p} = 1.037$. This experiment justifies the existence of direct link between the tax policy and the dynamics of the real exchange rate.

3.2.2 Non-traded Sector Shocks

(i) Lump-sum tax financed fiscal expenditure increase

As before, the initial response of the policy change is increased demand for non-traded good. Obviously, this high demand raises the relative price of non-traded good in the very short-run which can be observed from the dynamic paths presented in the Figure 4. Long-run key steady state ratios are reported in panel B of Table 3.

Higher expenditure in non-traded sector increases the efficiency of private factors in that sector and leads to transfer of around 10% of labor, although this is partially reversed over time. Gradually, as marginal returns between sectors start to equate, some of the labor moves back to the traded sector. Since return to capital is now higher in each sector, agents heavily invests new output in capital accumulation, which is reflected in higher capital-labor ratios in each sector.

In the long-run, non-traded sector utilizes 33% of total private capital stock, 43% of total labor supply to produce 40% of total output. Although output of traded sector slightly shrinks, the increase in non-traded output leads to 5% increase in gross domestic product. Total private consumption as a ratio of total output is slightly crowded out by public consumption, which increases by 1% and 10% of GDP in traded and non-traded sectors respectively.

The real exchange rate in the medium and long-run starts to depreciate as large infrastructure investments increase productivity of the non-traded sector. Initial demand driven appreciation is reversed by supply side productivity increase and long-run level of the relative price is stabilized at a point below the benchmark.

(ii) Distortionary tax financed fiscal expenditure increase

Similar to the same exercise in the traded sector, immediate effect of the change is to raise the demand for non-traded good, both from increased government consumption of it, as well as lost output from production as a result of taxation. This leads to a big jump in the real exchange rate as non-traded goods are relatively expensive now (*dp(0)*=0.104). In addition, higher demand drags private factors from traded to the non-traded sector, which results in lower output in the traded sector. Long-run key steady state ratios are reported in panel B of Table 3.

Overtime agent accumulates more of non-traded capital which boosts output of the sector. On the contrary, traded capital being less productive now is diminished and so does the output of the traded sector. In the long-run, non-traded sector employs 33% of labor force, almost 35% of total private capital to produce around 42% of overall output. Economy wide output increases by 4.3% mostly due to non-traded sector expansion. In contrast to the same shock in the traded sector, private consumption as a share of total output raises. This can primarily be attributed to higher traded consumption and the fact that only non-traded output can be converted into private capital. In line with previous analysis, public consumption of both types of goods increases.

The real exchange rate in the long-run does not change much from the benchmark level. Preliminary demand shock is fully offset by supply side productivity gains in the non-traded sector.

(iii) Increase in the level of distortionary taxes only

Long-run key steady state ratios are reported in panel B of Table 3 for a 10% tax levied on non-traded production. Imposition of tax leaves less non-traded output for the private factors utilized in the sector. Immediate response is the jump in the price of non-traded goods due to shortage of supply. Since labor adjusts simultaneously, there is an immediate movement of labor into the traded sector seeking higher returns.

In the medium and long-run, lower marginal return of private capital demonstrates that economy has excess capital, which is gradually reduced over time. This, in turn, leads to a decrease in the production of both sectors: traded sector contracts by 3.6% and non-traded sector by 5.5%. Overall economy shrinks by 1%. It should be pointed that this is a reduction in nominal GDP, which incorporates the spike in the price level.

Initial jump in the real exchange rate is further mitigated by reduction of capital and relatively larger decrease in output of the non-traded sector. In long run, the relative price of the non-traded output rises by almost 10%.

3.3 Non-traded sector is more capital intensive ($\alpha = 0.25, \varphi = 0.35$)

In what follows I will be elaborating on the effects of a change in expenditure and tax policy by the government on the benchmark economy characterized by a capital intensive non-traded sector. Table 4 summarizes benchmark steady state relationships as well as after shock long-run ratios of selected variables.

3.3.1 Traded Sector Shocks

(i) Lump-sum tax financed fiscal expenditure increase

Consequences in this part are very similar to those obtained under the assumption of traded sector being more capital intensive. Increase in expenditure initially acts as a demand shock to raise the relative price of traded good (*dp(0)*= -0.0146). Transitional dynamics of selected variables are presented in Figure 7 and long-run key steady state ratios a reported in panel A of Table 4. Labor instantaneously moves to traded sector to meet the excess demand, while with gradual efficiency gains some of it returns back.

As marginal returns of private production factors equate over medium to long-run, the traded sector ends up with 3% higher employment, higher capital-labor ratio and 9% higher production. The non-traded sector shrinks by almost 10%. GDP of the economy grows by 3.6%, taking into account the adjustment in prices. Private consumption is partially crowded out by public expenditure, which increases by 6% and 1% in traded and non-traded sector, respectively.

Initial depreciation in the real exchange rate is offset by productivity gains in traded sector. In the long-run the relative price of non-traded goods appreciates by 3.4%.

(ii) Distortionary tax financed fiscal expenditure increase

Combined impact of distortionary taxation and increased expenditure is a stronger short-run demand driven price surge in traded goods. Private production factors are attracted from non-traded sector to meet high demand in the traded one. Long-run equilibrium ratios of certain variable are reported in panel A of Table 4 with transitional dynamics plotted in Figure 8.

Overtime efficiencies from increased public expenditure and loss of output due to taxation are incorporated into agent's private factor allocation and marginal returns of the factors are equated between sectors. The traded sector, in the long-run, employs 70% of existing labor force to produce 69% of total output. Though non-traded sector contracts by 2.1%, total output of the economy slightly grows primarily due to expansion in the traded sector. As before, private consumption is lower in favor of public consumption, which does not change much in non-traded sector, but increases by 6% of total traded production.

In the long-run, impact of lost output due to taxation dominates the increased productivity as a result of higher public expenditure and consequently real exchange rate depreciates.

(iii) Increase in the level of distortionary taxes only

Output lost due to taxation diminishes the marginal product of private factors in the traded sector. Consequently, labor instantaneously moves to non-traded sector seeking higher returns. Less traded output available for private consumption results in higher price for the good, leading to depreciation in the real exchange rate. Refer to Figure 9 for dynamic paths of selected variables.

Gradually private capital is also transferred to non-traded sector because of higher marginal product. At the steady state, marginal returns of both private factors are equal among sectors. Non-traded sector being more capital intensive utilizes 60% more capital per labor employed compared to the traded sector to produce close 35% of total output. Total consumption over total output increases by 2%, because marginal utility of consumption now exceeds the marginal return for investing additional unit of output. Less output and higher price of traded good leads to a lower rate of the real exchange at the new steady.

3.3.2 Non-traded Sector Shocks

(i) Lump-sum tax financed fiscal expenditure increase

Analyses here resemble the ones under the capital intensive traded sector setting. However, there are also slight differences. Benchmark and after shock steady state ratios for the exercises are reported in panel B of Table 4. Dynamic paths of selected variables are presented in Figure 10-12.

With increase in expenditure, demand for the non-traded good obviously rises. However, contrary to the analysis with traded sector being more capital intensive, the effect of higher demand on the relative price level is negligibly small (*dp(0)*=0.001). The primary adjustment takes place in quantity of non-traded output produced that instantaneously increases by close to 15%. There are two underlying mechanisms allowing for this. First one is a huge transfer of labor in the short-run. Second relies on the assumption that private capital can only be created in the non-traded sector. Converting it into private capital useful in traded sector requires extra resources and time. With this in mind and given that non-traded sector is more capital intensive in this setting, I can postulate that output adjustment can be done much faster in this setting, compared to the one with traded sector being more capital intensive.

Medium and long-run dynamics primarily follow along the lines of previous analysis with just one major difference. In this setting output of traded sector, though very slightly, rises in the long-run. This was not the case with traded sector being more capital intensive. In general, capital-labor ratios of each sector rise. Output of the non-traded sector substantially increases. Finally, the relative price depreciates in the long-run due to productivity gains from increased infrastructure spending.

(ii) Distortionary tax financed fiscal expenditure increase

In the above section, I have already mentioned that under the current setting (non-traded sector is more capital intensive) price elasticity of demand is negligibly small, thus there is no immediate effect of increased public expenditure. However, price elasticity of supply still remains high and as such, imposition of distortionary taxes on non-traded production leads to a real exchange rate appreciation.

In the long-run employment in the non-traded sector marginally increases, output of the sector expands. Capital-labor ratios slightly decrease and traded output shrinks. Total public and private consumption per output increase. Real exchange rate over time depreciates to rich its long-run steady state, just above the pre-shock level.

(iii) Increase in the level of distortionary taxes only

This policy has contractionary impact on overall economy, which substantially mimics the case with tax shock in more capital intensive traded sector environment. Economy wise capital accumulation slows down, output in both sectors contract. Consumption-output ratios increase, because of higher marginal utility. Real exchange rate appreciates in the long-run.

4. Welfare Analysis

With all these contrasting responses, it is of great importance to determine the net impact of changes on economic welfare of the agent. Overall effects of intertemporal welfare, as measured by the equivalent increase in the consumption of both goods, are summarized in Table 5. Both cases of sectoral capital intensities are considered. Each table also reports associated percentage change in the real exchange rate (positive meaning appreciation) and percentage change in the gross domestic product of the economy enabling us to see the possible tradeoffs.

In both cases, increase in government expenditure has positive influence on gross domestic product, though impact under more capital intensive traded sector dominates. In either scenario with capital intensity, non-traded government expenditure has a larger effect on the economic growth compared to the traded one. Distortionary taxes in all cases have negative impact on economic growth. This negative impact is larger under capital intensive traded sector case. Irrespective of capital intensity taxes in traded sector have bigger impact on overall economic activity.

In both capital intensity cases, increase in fiscal expenditure on traded sector leads to welfare gains, whereas increase in fiscal expenditure on non-traded sector leads to welfare losses. Impact of either type of expenditure is bigger in magnitude under capital intensive non-traded sector setting. At the same time, per-output tax imposed on traded sector leads to welfare gains and the same tax in non-traded sector results in welfare loses in both cases of capital intensity. Magnitudes of tax impact on welfare are mixed. These results demonstrate the growth-welfare tradeoff with expansionary fiscal policy in the traded sector, whereas the same judgment is ambiguous for the non-traded sector.

Finally, expansionary fiscal policy in traded sector inevitably leads to appreciation of the real exchange rate in the long-run, whereas the same policy in non-traded sector results in a substantially larger depreciation (in magnitude) of the relative price irrespective of capital intensity settings. Distortionary taxes, on the contrary, have opposite effects. They lead to appreciation of exchange rate when imposed on traded sector and depreciation when imposed on non-traded sector. Magnitudes for both sectors are very close. For either policy the impact is magnified under the setting with non-traded sector being more capital intensive.

5. Conclusions

This paper is a fruitful extension of the previous chapter of this dissertation. As before, I considered a two-sector dynamic dependent economy. Production in each sector depends on labor, private and public capital, latter of which is entirely provided by the government. This public capital which is accumulated over time can be in the form of infrastructure; like roads, airports, railways and etc that enable healthy private sector development.

The results demonstrate that government expenditure directed towards infrastructure and productivity enhancement in the traded sector lead to real exchange rate appreciation, whereas if directed to non-traded sector will result in depreciation of real exchange rate. This is the famous Balassa-Samuelson effect which is also justified by recent study of Cerra et al. (2008)[15]. The experiments also show that imposition of taxes under any circumstances lowers capital accumulation, capital per labor and capital per output in each sector. Contrary to the case with lump-sum taxes, expansionary fiscal policy financed by distortionary taxation leads to economic growth only in the non-traded sector. Moreover, it is demonstrated that distortionary taxes levied on the traded sector output result in depreciation, whereas taxes in the non-traded sector lead to appreciation of the real exchange rate. The latter findings establish a direct link between tax policy and real exchange rate dynamics.

Finally welfare analysis does not yield any linear relationship between real exchange rate and welfare gains; however growth-welfare tradeoff is justified for an increase in the traded sector expenditure.

[15] The paper utilizes foreign aid framework to demonstrate that aid directed to productivity enhancement affect real exchange rate dynamics via Balassa-Samuelson.

Table 3.1 - The benchmark economy

Preference parameters:	$\gamma = -1.5$, β=0.06, θ=0.5
Production parameters:	I. α = 0.35, φ = 0.25 II. α = 0.25, φ = 0.35
Productivity parameters:	$A_T = 1.5$, $A_N = 1.5$
Depreciation rates:	$\delta_{g1} = 0.05$, $\delta_{g2} = 0.05$
World interest rate:	$r = 0.06$
Government expenditure:	$g_T = 0.05$, $g_N = 0.05$
Elasticities of government expenditure:	$\eta = 0.07$, $\phi = 0.20$

Table 3.2 – Steady state statistics

A. Traded sector more capital intensive α = 0.35, φ = 0.25

	K_T/L_T	K_N/L_N	K_T/Y_T	K_N/Y_N	K/Y	L_T	Y_T	Y_N	C_N/Y_N	C/Y	G_T/Y_T	G_N/Y_N	GDP	$\tilde{p}$
Benchmark	25.38	15.71	5.08	4.17	4.76	0.61	3.05	1.46	0.84	0.89	0.07	0.16	4.73	1.147

B. Traded sector more capital intensive α = 0.25, φ = 0.35

	K_T/L_T	K_N/L_N	K_T/Y_T	K_N/Y_N	K/Y	L_T	Y_T	Y_N	C_N/Y_N	C/Y	G_T/Y_T	G_N/Y_N	GDP	$\tilde{p}$
Benchmark	22.58	36.48	6.45	5.83	6.24	0.69	2.42	1.92	0.90	0.92	0.08	0.1	3.666	0.646

Table 3.3 – Steady state responses to permanent changes (traded sector is more capital intensive)

A. Traded sector changes

	K_T/L_T	K_N/L_N	K_T/Y_T	K_N/Y_N	K/Y	L_T	Y_T	Y_N	C_N/Y_N	C/Y	G_T/Y_T	G_N/Y_N	GDP	$\tilde{p}$
Benchmark gT=gN=0.05 $T_N=T_T=0$	25.38	15.71	5.08	4.17	4.76	0.61	3.05	1.46	0.84	0.89	0.07	0.16	4.73	1.148
gT=0.1, gN=0.05 $T_T=T_N=0$	25.59	15.84	4.94	4.17	4.69	0.64	3.34	1.35	0.82	0.79	0.15	0.18	4.93	1.18
gT=0.1, gN=0.05 $T_T=0.1$, $T_N=0$	25.36	15.7	4.92	4.17	4.68	0.62	3.19	1.44	0.84	0.81	0.15	0.16	4.72	1.066
gT=gN=0.05 $T_T=0.1$, $T_N=0$	25.14	15.56	5.06	4.17	4.74	0.58	2.9	1.55	0.85	0.92	0.08	0.15	4.51	1.037

B. Non-traded sector changes

	K_T/L_T	K_N/L_N	K_T/Y_T	K_N/Y_N	K/Y	L_T	Y_T	Y_N	C_N/Y_N	C/Y	G_T/Y_T	G_N/Y_N	GDP	$\tilde{p}$
Benchmark gT=gN=0.05 $T_N=T_T=0$	25.38	15.71	5.08	4.17	4.76	0.61	3.05	1.46	0.84	0.89	0.07	0.16	4.73	1.147
gT=0.05, gN=0.1 $T_T=T_N=0$	29.43	18.22	5.58	4.17	5.02	0.57	2.98	1.90	0.74	0.88	0.08	0.26	4.97	1.044
gT=0.05, gN=0.1 $T_T=0$, $T_N=0.1$	25.54	15.81	5.09	3.75	4.53	0.57	2.87	1.80	0.73	0.91	0.09	0.27	4.934	1.145
gT=gN=0.05 $T_T=0$, $T_N=0.1$	22.0	13.62	4.63	3.75	4.31	0.62	2.94	1.38	0.83	0.92	0.08	0.17	4.68	1.259

Table 3.4 - Steady state responses to permanent changes (non-traded sector is more capital intensive)

A. Traded sector changes

	K_T/L_T	K_N/L_N	K_T/Y_T	K_N/Y_N	K/Y	L_T	Y_T	Y_N	C_N/Y_N	C/Y	G_T/Y_T	G_N/Y_N	GDP	$\tilde{p}$
Benchmark gT=gN=0.05 T_N=T_T=0	22.58	36.48	6.45	5.83	6.24	0.69	2.42	1.92	0.90	0.92	0.08	0.10	3.666	0.646
gT=0.1, gN=0.05 T_T=T_N=0	22.74	36.74	6.24	5.83	6.12	0.72	2.64	1.73	0.89	0.81	0.14	0.11	3.8	0.668
gT=0.1, gN=0.05 T_T=0.1, T_N=0	22.59	36.49	6.22	5.83	6.10	0.70	2.54	1.88	0.90	0.83	0.14	0.10	3.67	0.603
gT=gN=0.05 T_T=0.1, T_N=0	22.42	36.21	6.43	5.83	6.22	0.67	2.32	2.08	0.91	0.94	0.08	0.09	3.53	0.583

B. Non-traded sector changes

	K_T/L_T	K_N/L_N	K_T/Y_T	K_N/Y_N	K/Y	L_T	Y_T	Y_N	C_N/Y_N	C/Y	G_T/Y_T	G_N/Y_N	GDP	$\tilde{p}$
Benchmark gT=gN=0.05 T_N=T_T=0	22.58	36.48	6.45	5.83	6.24	0.69	2.42	1.92	0.90	0.92	0.08	0.10	3.666	0.646
gT=0.05, gN=0.1 T_T=T_N=0	26.16	42.27	7.19	5.83	6.69	0.67	2.43	2.40	0.84	0.92	0.08	0.16	3.83	0.58
gT=0.05, gN=0.1 T_T=0, T_N=0.1	22.24	35.93	6.36	5.25	5.94	0.67	2.35	2.24	0.83	0.95	0.08	0.17	3.82	0.655
gT=gN=0.05 T_T=0, T_N=0.1	19.18	30.99	5.71	5.25	5.55	0.70	2.35	1.77	0.90	0.96	0.08	0.10	3.64	0.73

Table 3.5 - Welfare analysis

A. Traded sector is more capital intensive $\alpha = 0.35, \varphi = 0.25$

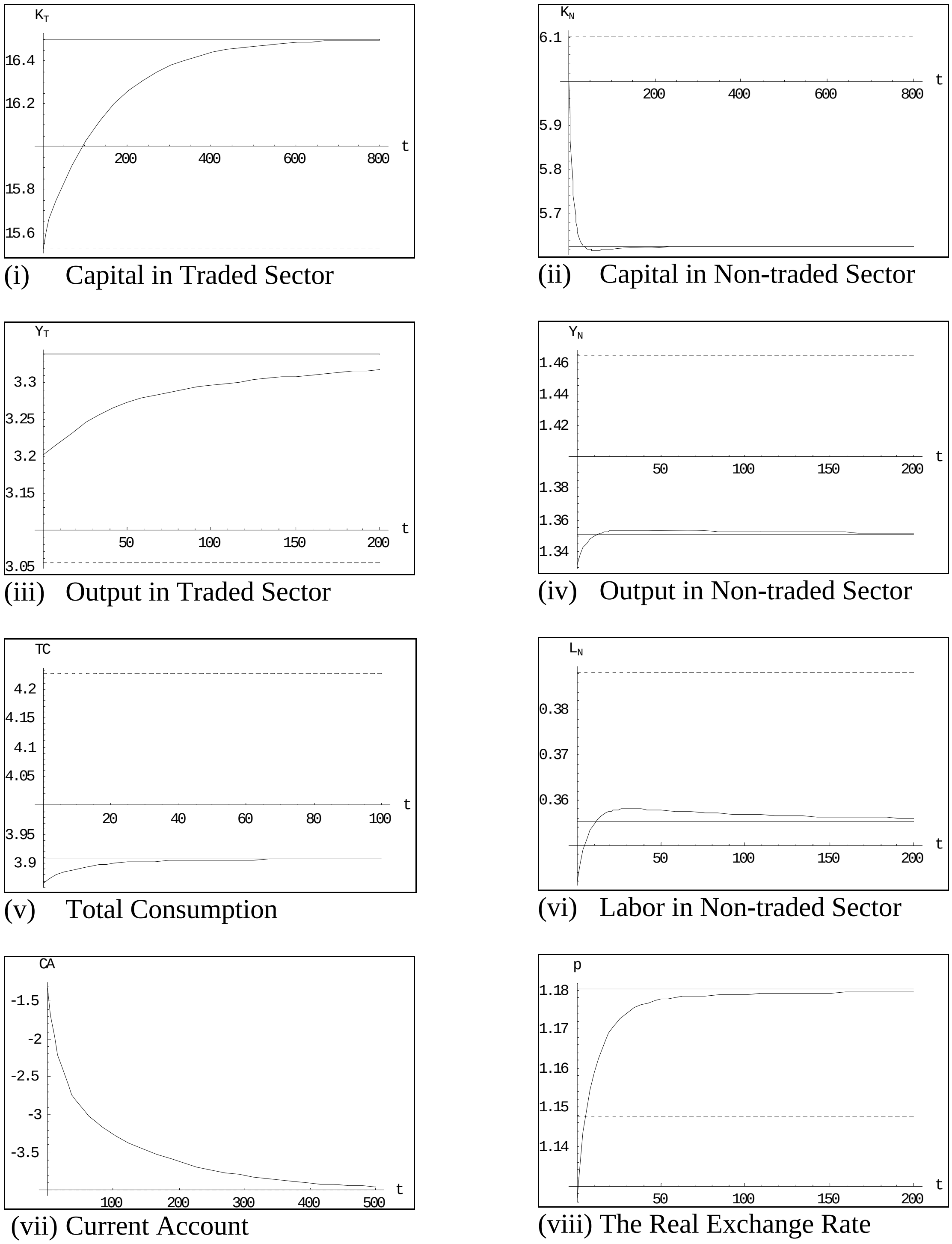
	$\%\Delta\,\tilde{p}$	$\%\Delta GDP$	% Long-run Welfare Gain
gT=0.1, gN=0.05 $T_T=T_N=0$	2.85	4.18	-12.06
gT=0.1, gN=0.05 $T_T=0.1$, $T_N=0$	-7.09	-0.32	-10.02
gT=gN=0.05 $T_T=0.1$, $T_N=0$	-9.63	-4.73	1.62

	$\%\Delta\,\tilde{p}$	$\%\Delta GDP$	% Long-run Welfare Gain
gT=0.05, gN=0.1 $T_T=T_N=0$	-8.98	4.87	9.79
gT=0.05, gN=0.1 $T_T=0$, $T_N=0.1$	-.022	4.22	8.88
gT=gN=0.05 $T_T=0$, $T_N=0.1$	9.67	-1.14	-1.04

B. Non-traded sector is more capital intensive $\alpha = 0.25, \varphi = 0.35$

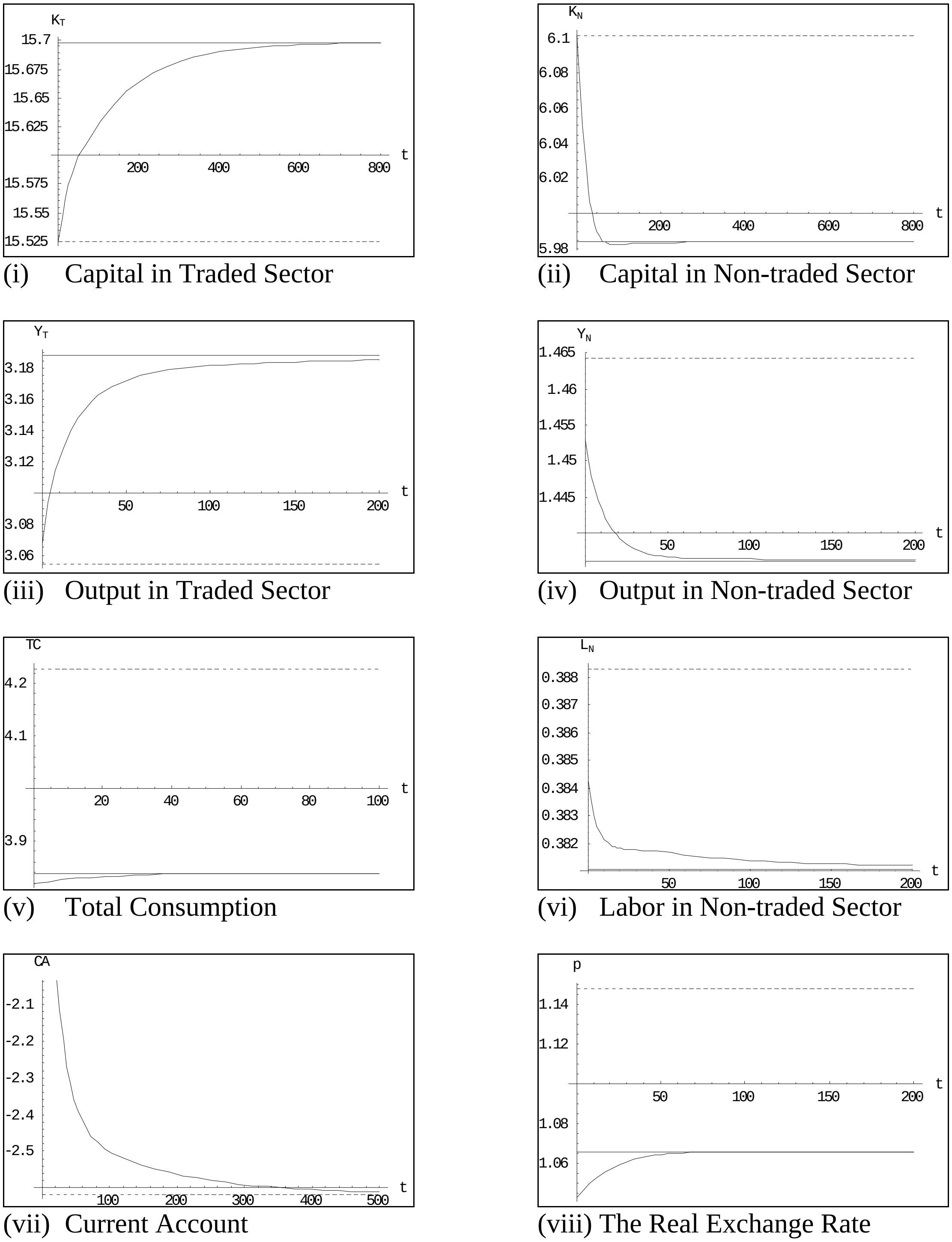
	$\%\Delta\,\tilde{p}$	$\%\Delta GDP$	% Long-run Welfare Gain
gT=0.1, gN=0.05 $T_T=T_N=0$	3.35	3.59	-13.22
gT=0.1, gN=0.05 $T_T=0.1$, $T_N=0$	-6.68	0.19	-10.04
gT=gN=0.05 $T_T=0.1$, $T_N=0$	-9.67	-3.65	3.13

	$\%\Delta\,\tilde{p}$	$\%\Delta GDP$	% Long-run Welfare Gain
gT=0.05, gN=0.1 $T_T=T_N=0$	-10.25	4.35	11.27
gT=0.05, gN=0.1 $T_T=0$, $T_N=0.1$	1.38	4.12	11.25
gT=gN=0.05 $T_T=0$, $T_N=0.1$	12.99	-0.59	-0.44



(i) Capital in Traded Sector
(ii) Capital in Non-traded Sector
(iii) Output in Traded Sector
(iv) Output in Non-traded Sector
(v) Total Consumption
(vi) Labor in Non-traded Sector
(vii) Current Account
(viii) The Real Exchange Rate

Figure 3.1 - Lump sum tax financed government spending increase in the traded sector
$(\alpha = 0.35, \varphi = 0.25)$



(i) Capital in Traded Sector

(ii) Capital in Non-traded Sector

(iii) Output in Traded Sector

(iv) Output in Non-traded Sector

(v) Total Consumption

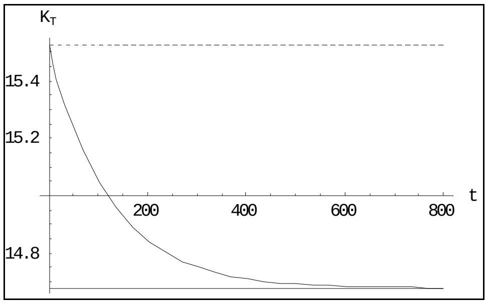
(vi) Labor in Non-traded Sector

(vii) Current Account

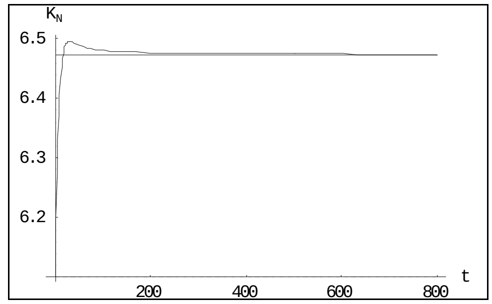
(viii) The Real Exchange Rate

Figure 3.2 - Distortionary tax financed government spending increase in the traded sector

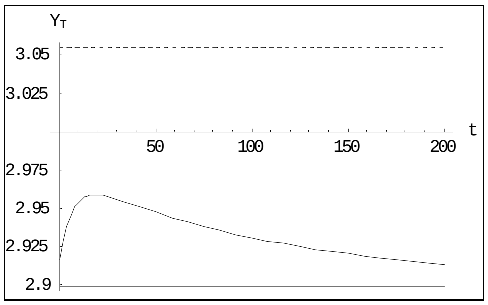
$(\alpha = 0.35, \varphi = 0.25)$



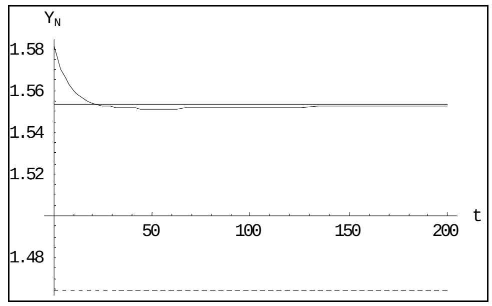
(i) Capital in Traded Sector



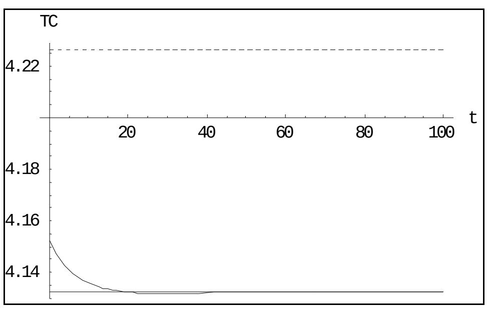
(ii) Capital in Non-traded Sector



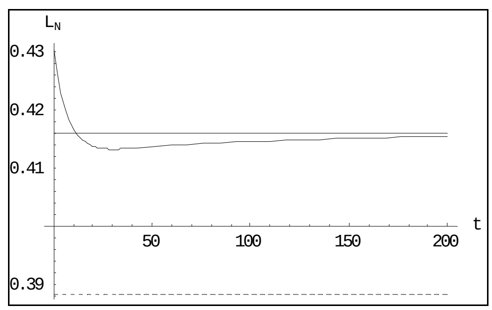
(iii) Output in Traded Sector



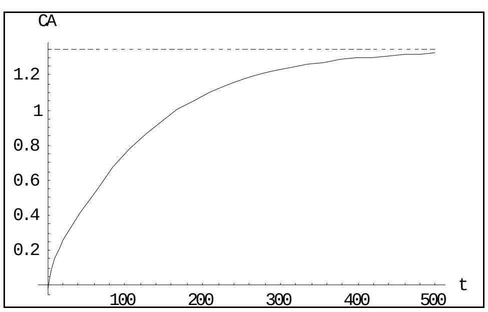
(iv) Output in Non-traded Sector



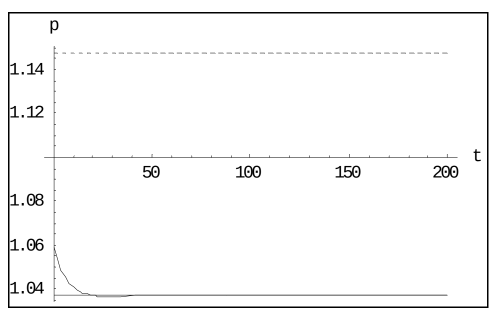
(v) Total Consumption



(vi) Labor in Non-traded Sector

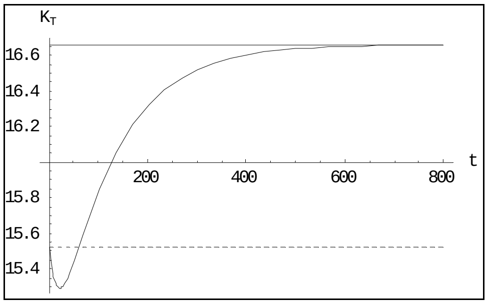


(vii) Current Account

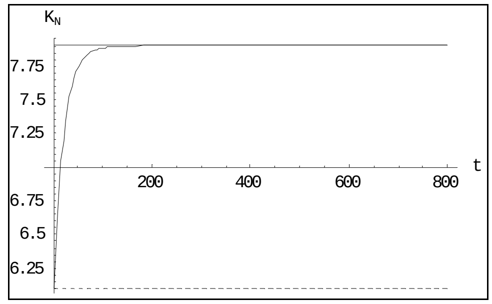


(viii) The Real Exchange Rate

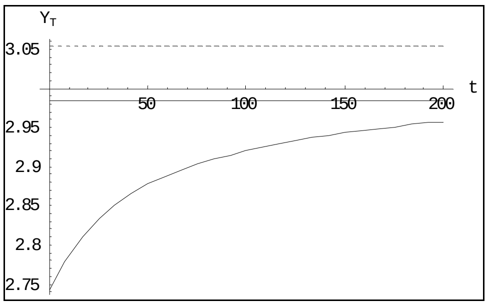
Figure 3.3 - Increase in the level of taxation in the traded sector ($\alpha = 0.35, \varphi = 0.25$)



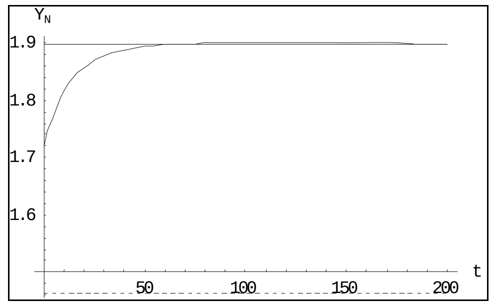
(i) Capital in Traded Sector



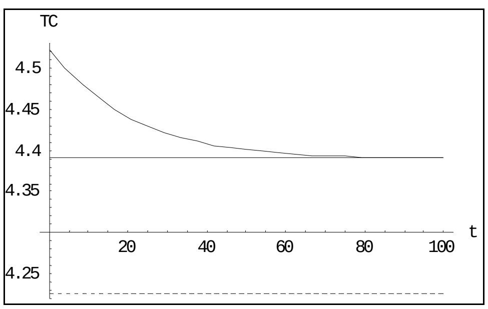
(ii) Capital in Non-traded Sector



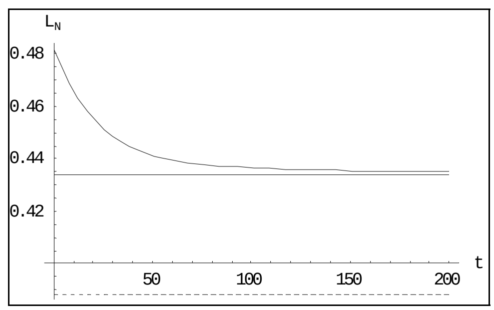
(iii) Output in Traded Sector



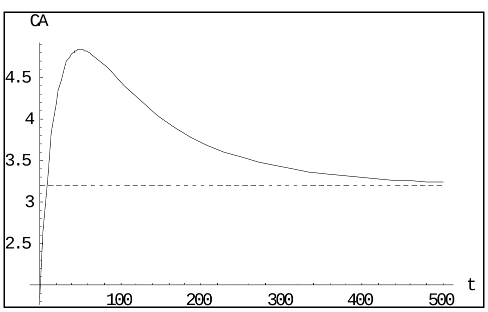
(iv) Output in Non-traded Sector



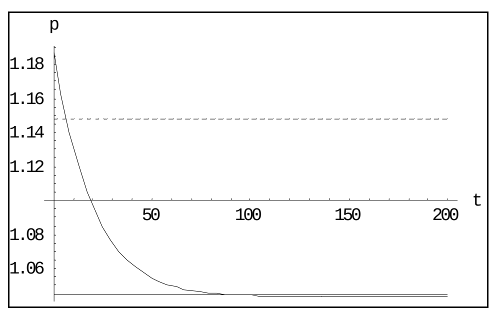
(v) Total Consumption



(vi) Labor in Non-traded Sector

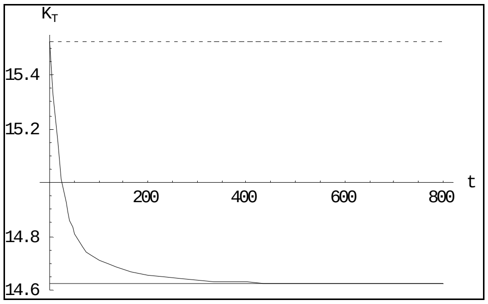


(vii) Current Account

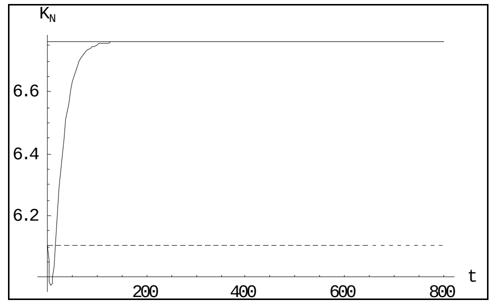


(viii) The Real Exchange Rate

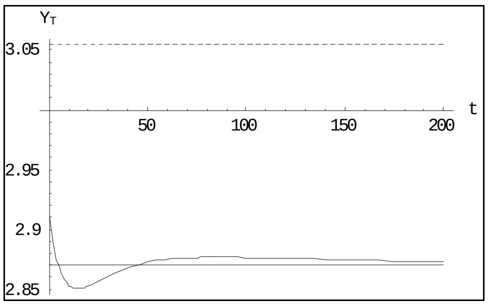
Figure 3.4 - Lump sum tax financed government spending increase in the non-traded sector ($\alpha = 0.35, \varphi = 0.25$)



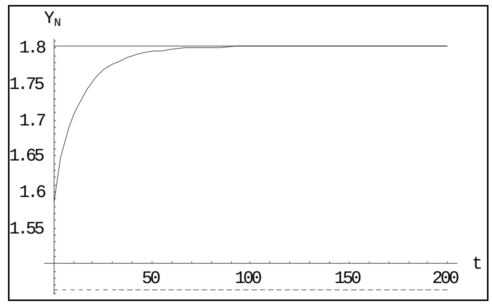
(i) Capital in Traded Sector



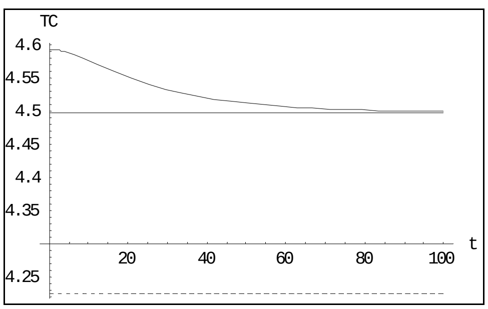
(ii) Capital in Non-traded Sector



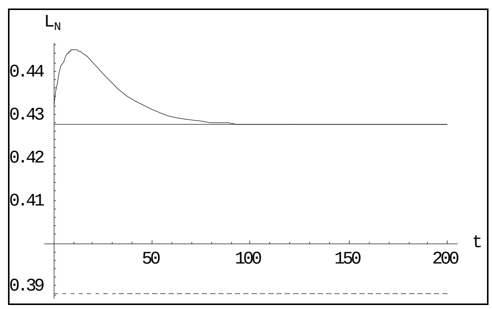
(iii) Output in Traded Sector



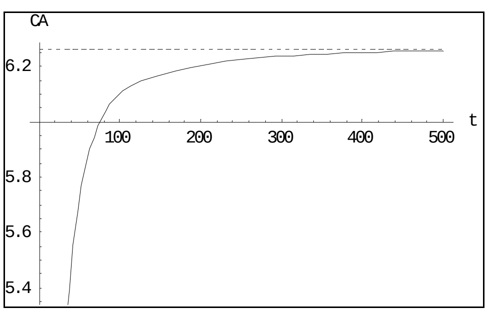
(iv) Output in Non-traded Sector



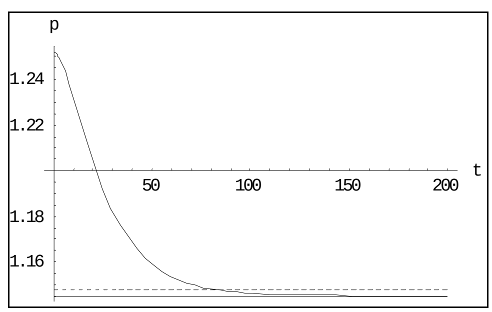
(v) Total Consumption



(vi) Labor in Non-traded Sector



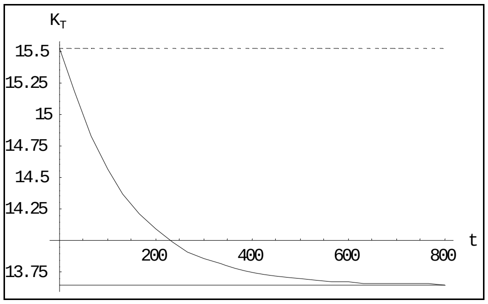
(vii) Current Account



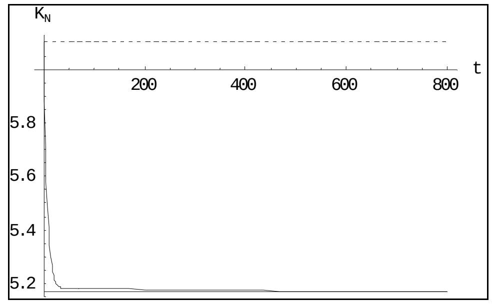
(viii) The Real Exchange Rate

Figure 3.5 - Distortionary tax financed government spending increase in the traded sector

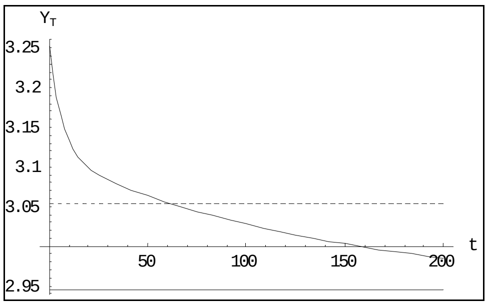
($\alpha = 0.35, \varphi = 0.25$)



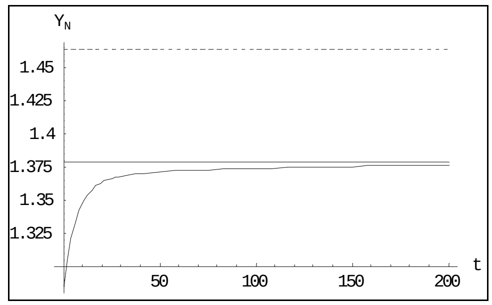
(i) Capital in Traded Sector



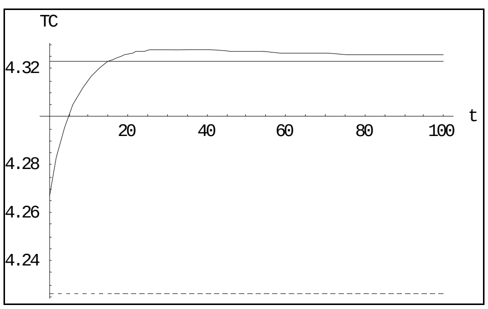
(ii) Capital in Non-traded Sector



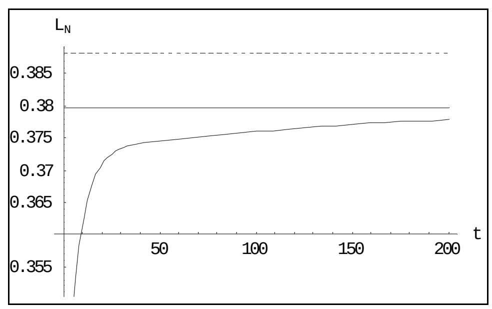
(iii) Output in Traded Sector



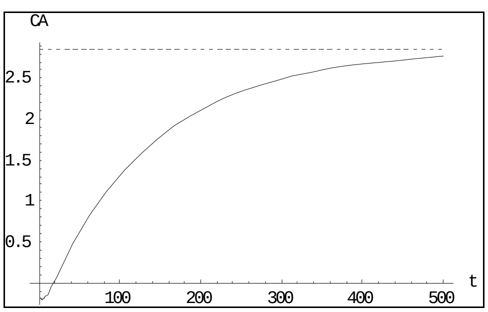
(iv) Output in Non-traded Sector



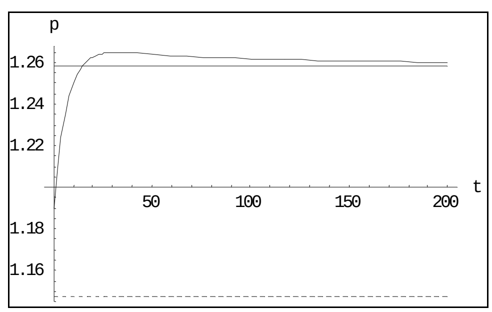
(v) Total Consumption



(vi) Labor in Non-traded Sector

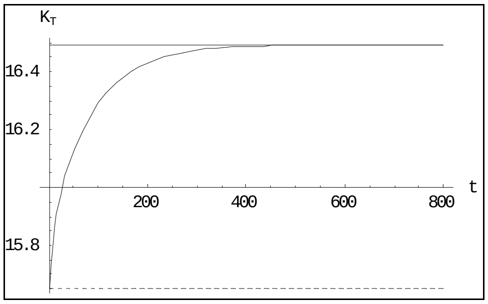


(vii) Current Account

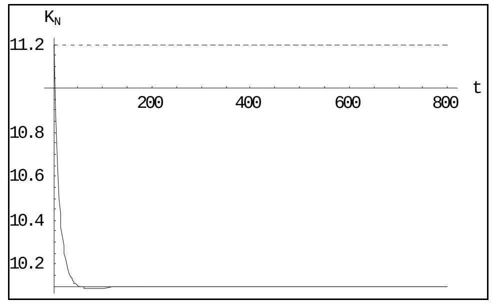


(viii) The Real Exchange Rate

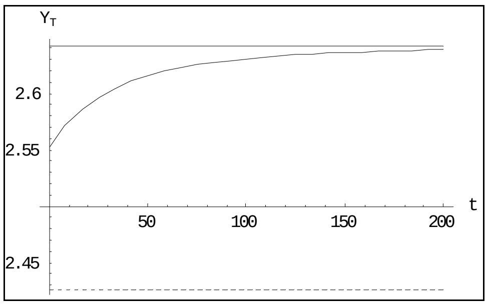
Figure 3.6 - Increase in the level of taxation in the non-traded sector ($\alpha = 0.35, \varphi = 0.25$)



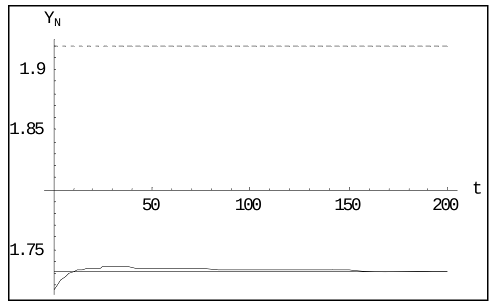
(i) Capital in Traded Sector



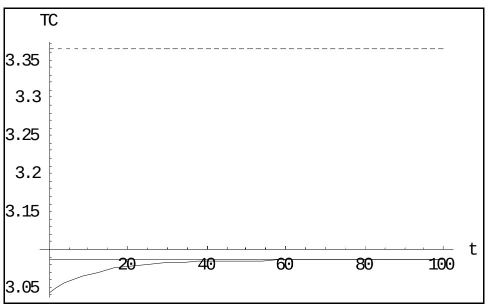
(ii) Capital in Non-traded Sector



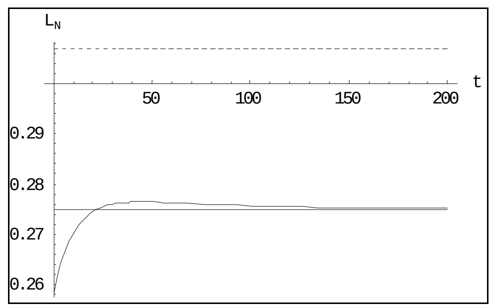
(iii) Output in Traded Sector



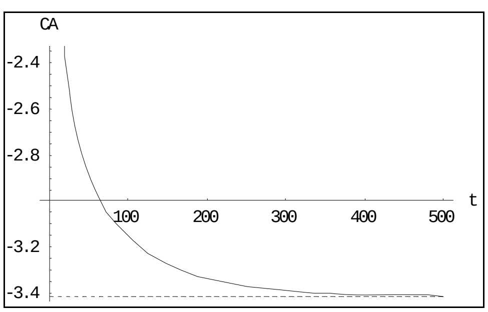
(iv) Output in Non-traded Sector



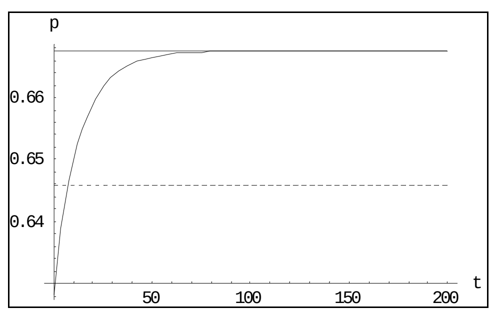
(v) Total Consumption



(vi) Labor in Non-traded Sector



(vii) Current Account



(viii) The Real Exchange Rate

Figure 3.7 – Lump sum tax financed government spending increase in the traded sector

$(\alpha = 0.25, \varphi = 0.35)$

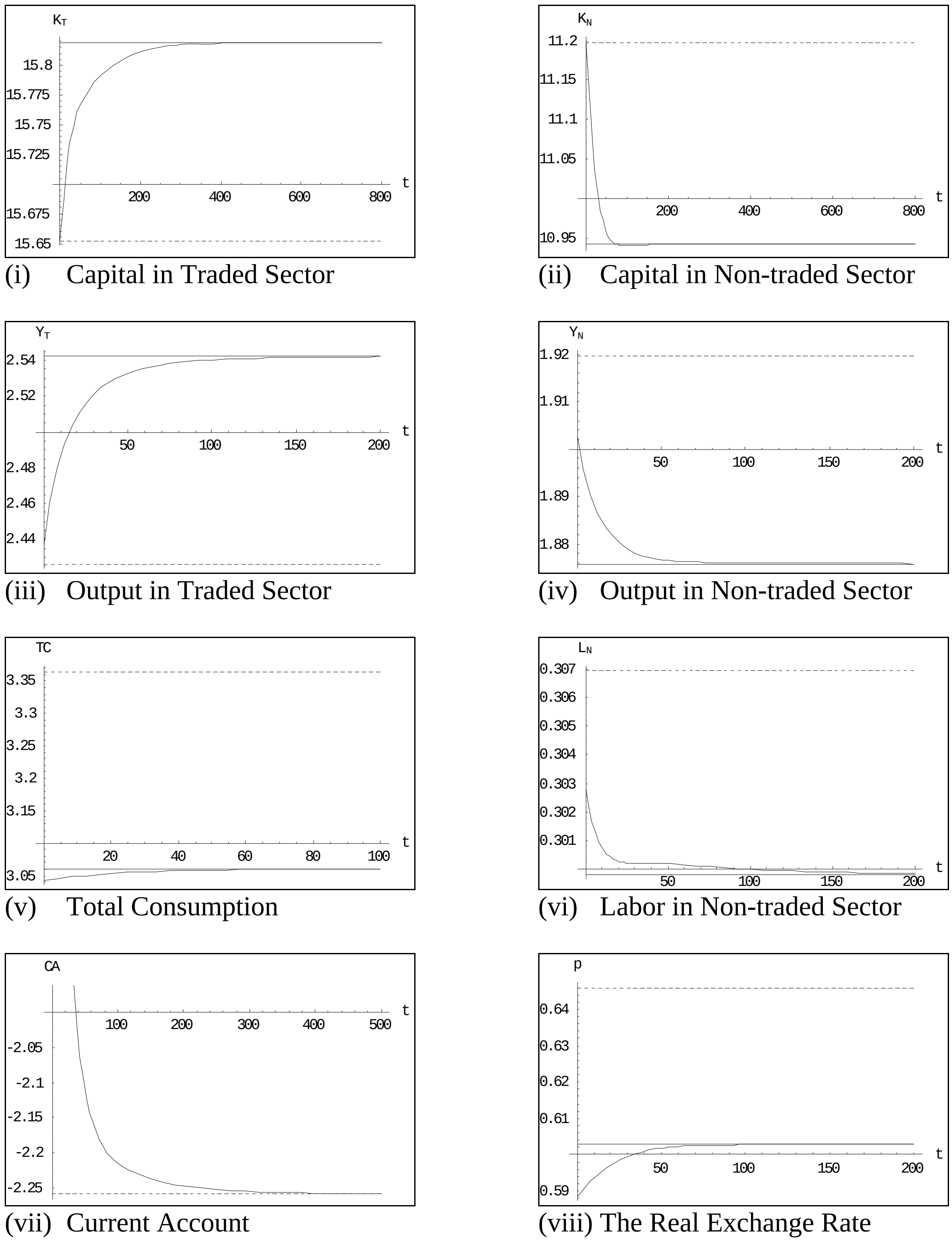
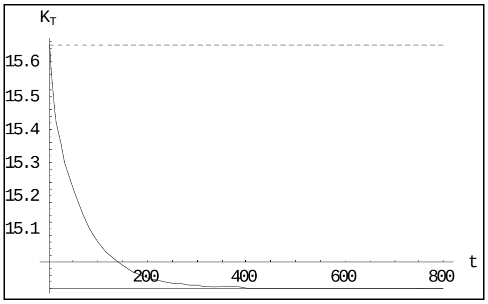
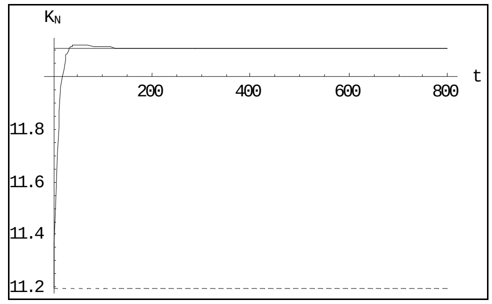


Figure 3.8 – Distortionary tax financed government spending increase in the traded sector

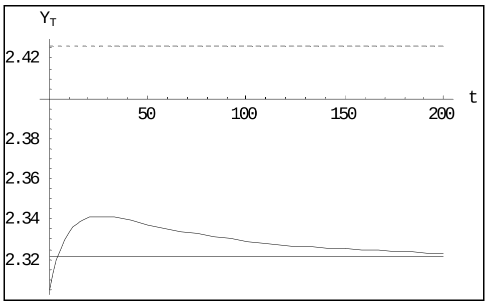
$(\alpha = 0.25, \varphi = 0.35)$



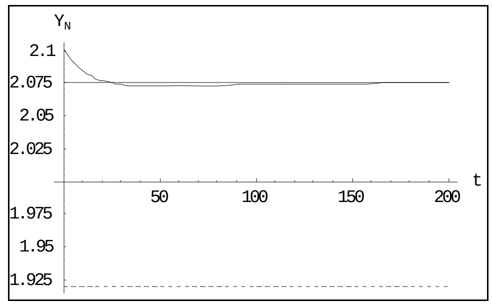
(i) Capital in Traded Sector



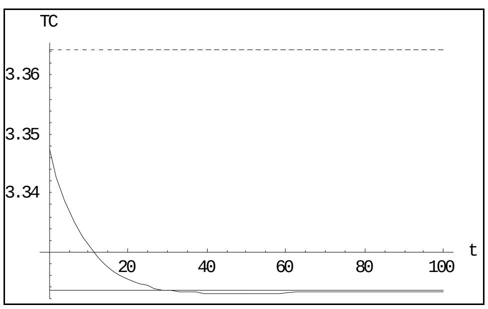
(ii) Capital in Non-traded Sector



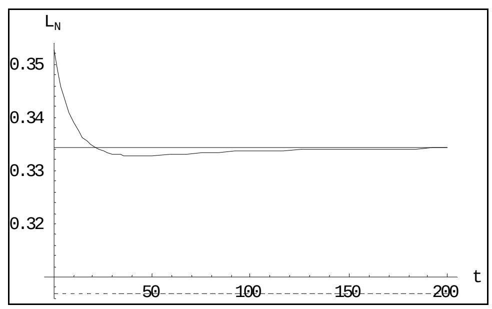
(iii) Output in Traded Sector



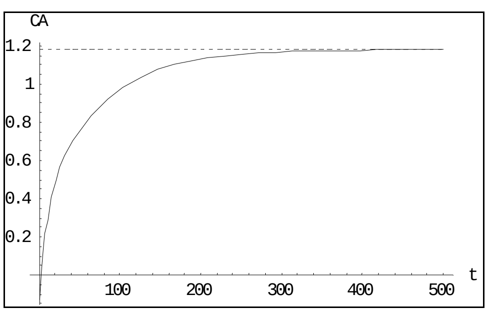
(iv) Output in Non-traded Sector



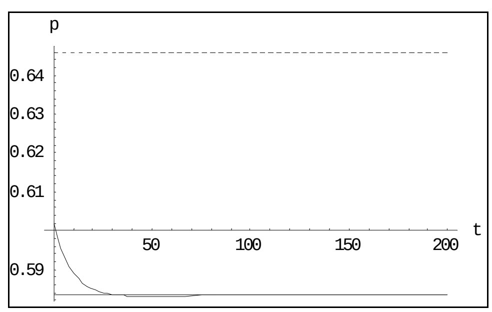
(v) Total Consumption



(vi) Labor in Non-traded Sector



(vii) Current Account



(viii) The Real Exchange Rate

Figure 3.9 – Increase in the level of taxation in the traded sector ($\alpha = 0.25, \varphi = 0.35$)

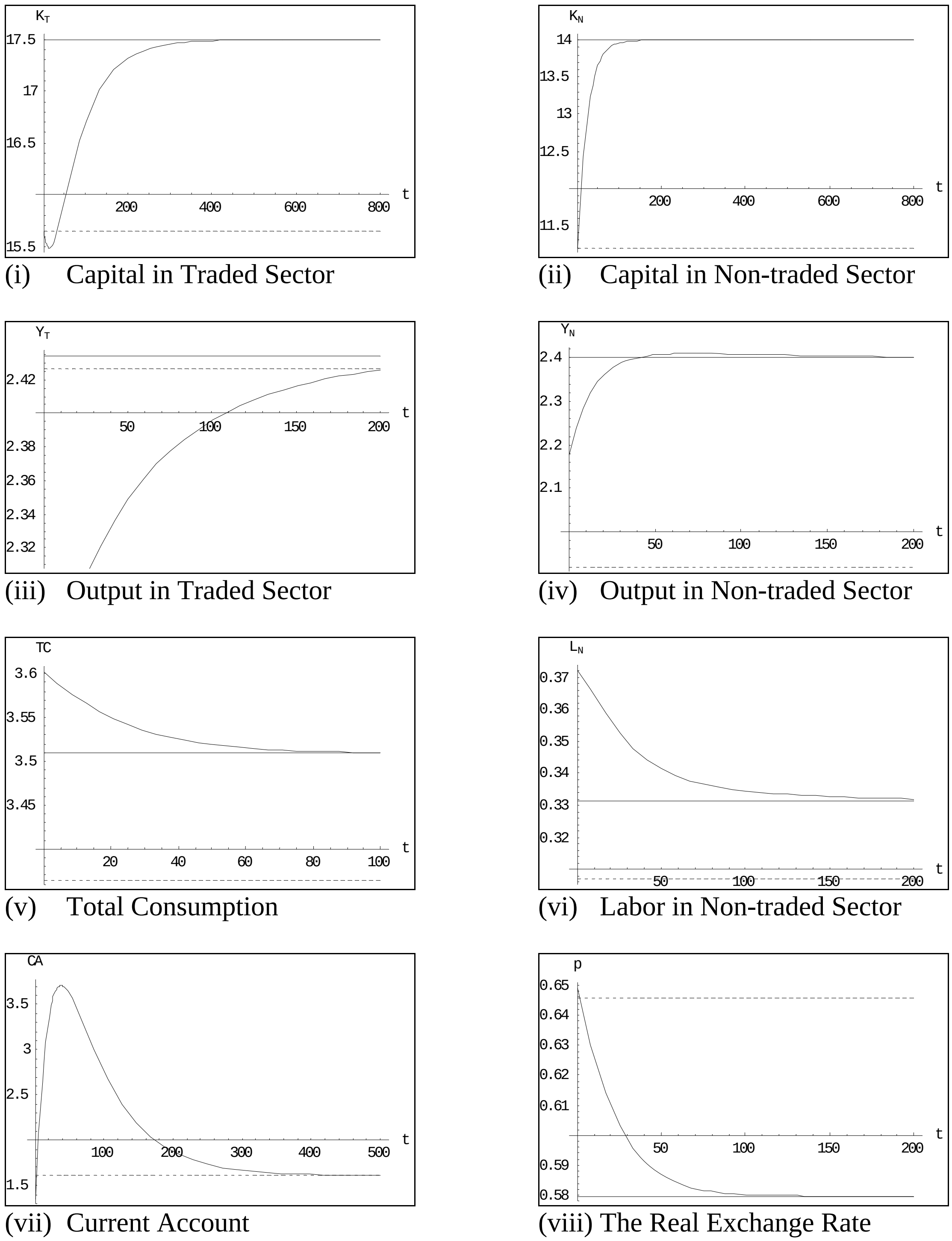
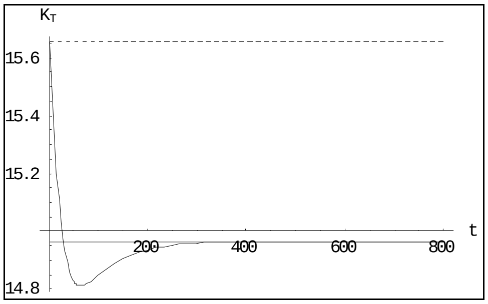
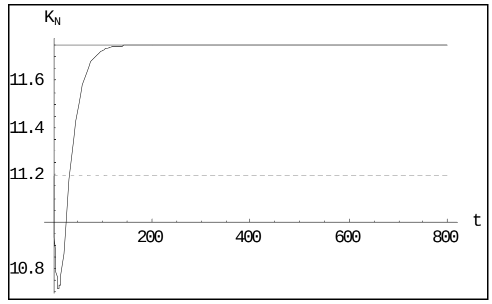


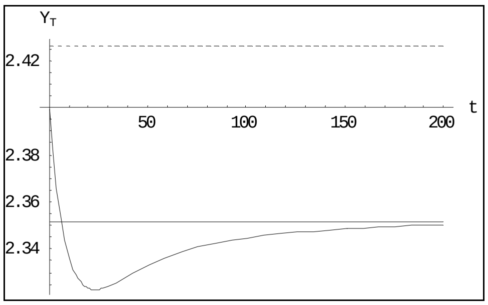
Figure 3.10 – Lump sum tax financed government spending increase in the non-traded sector ($\alpha = 0.25, \varphi = 0.35$)



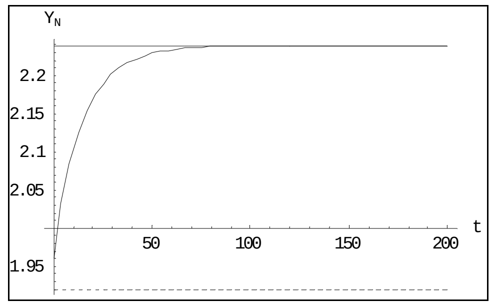
(i) Capital in Traded Sector



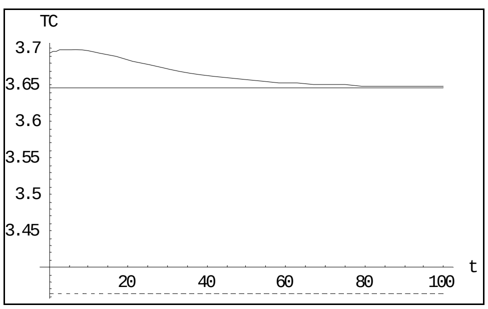
(ii) Capital in Non-traded Sector



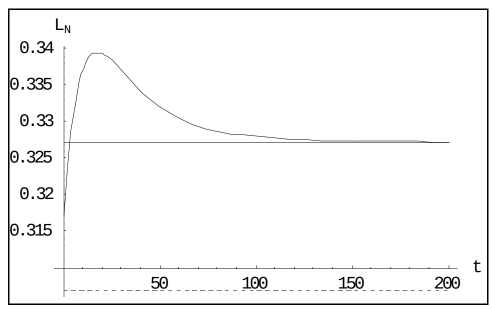
(iii) Output in Traded Sector



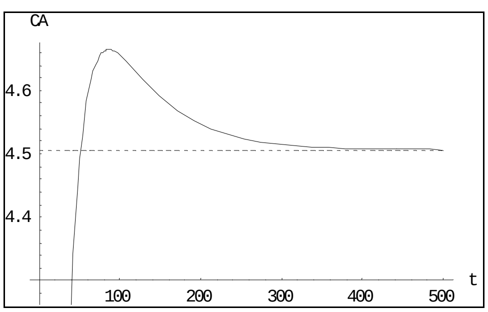
(iv) Output in Non-traded Sector



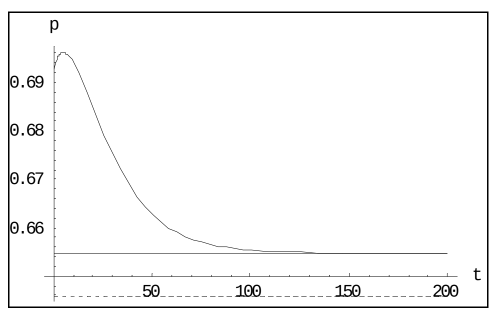
(v) Total Consumption



(vi) Labor in Non-traded Sector

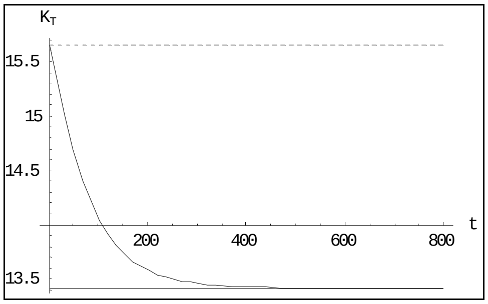


(vii) Current Account

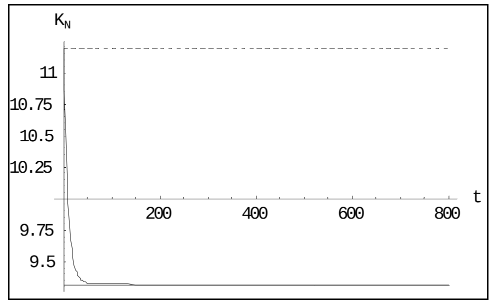


(viii) The Real Exchange Rate

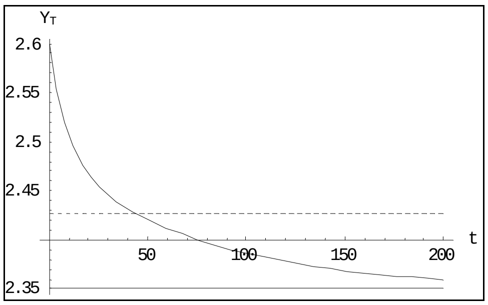
Figure 3.11 – Distortionary tax financed government spending increase in the traded sector ($\alpha = 0.25, \varphi = 0.35$)



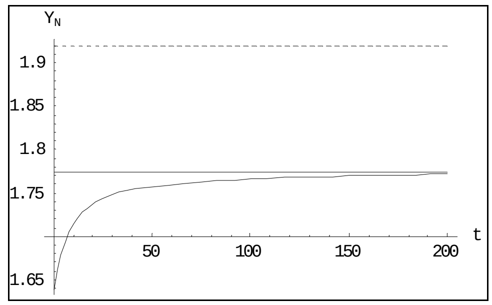
(i) Capital in Traded Sector



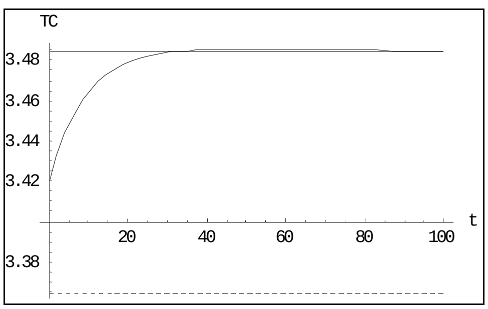
(ii) Capital in Non-traded Sector



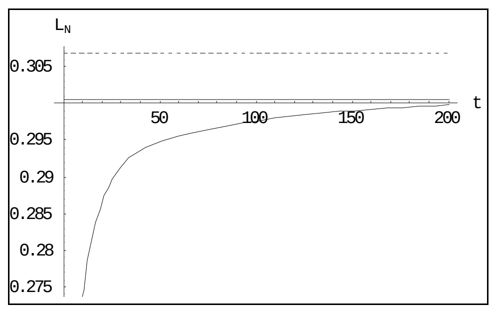
(iii) Output in Traded Sector



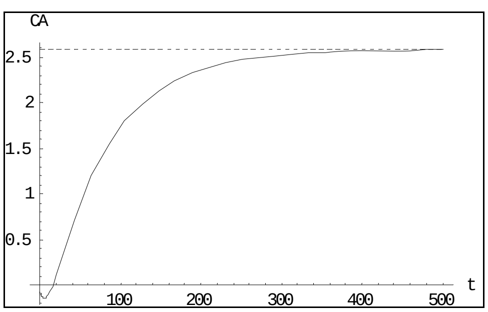
(iv) Output in Non-traded Sector



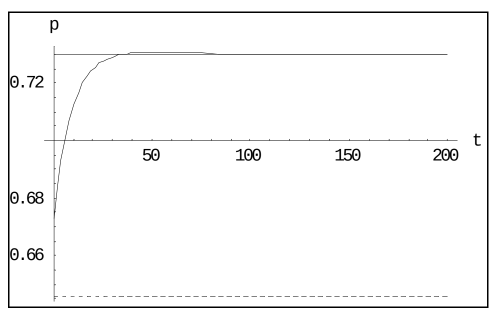
(v) Total Consumption



(vi) Labor in Non-traded Sector



(vii) Current Account



(viii) The Real Exchange Rate

Figure 3.12 – Increase in the level of taxation in the non-traded sector

($\alpha = 0.25, \varphi = 0.35$)

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