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INVESTMENT, THE CURRENT ACCOUNT, AND THE RELATIVE PRICE OF NON-TRADED GOODS IN A SMALL OPEN ECONOMY

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This paper incorporates traded and non-traded investment expenditure into an infinite-horizon setting with optimizing economic agents, extending previous research that has incorporated traded and non-traded investment into a two-period setting. The paper analyzes the dynamic adjustment of the relative price of non-traded output, the market price of capital, and the current account following exogenous shocks to the system. The exogenous shocks considered by the paper include permanent, transitory, and anticipated changes in an income tax and an investment subsidy as well as changes in the level of government purchases of traded and non-traded output.

1. Introduction

Models of the current account based on intertemporal optimization have become standard for the analysis of disturbances in an open economy. Whether the analysis is of the Dutch disease [e.g. Bruno (1982)], oil shocks [e.g. Marion 1984)], or terms-of-trade changes [e.g. Svensson and Razin (1983), Persson and Svensson (1985)], the behavior of the current account is derived from the microeconomic structure of a model with optimizing economic agents.

Analyses of current account determination in optimizing models can be divided into four categories based on the time horizon and the structure of the goods markets in the models. One group of models uses a two-period setting while the other uses an infinite-horizon setting. The two-period setting is useful for the analysis of the current account in the medium to long run while the infinite-horizon setting is useful for studying the dynamic adjustment of the current account. Models of the current account also differ in their inclusion or exclusion of a non-traded sector of the economy. Excluding

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the non-traded sector focuses attention on the determination of the current account as the difference between aggregate income and expenditure, while including the non-traded sector emphasizes the importance of the relative price of non-traded goods (often referred to as the real exchange rate) in the behavior of the current account.

Investment expenditure has been incorporated into three of the four types of analytical settings. Of the one-good, two-period models of the current account that include investment, the model of Sachs (1981) is the most prominent. The one-good, infinite-horizon models are best represented by Frenkel and Rodriguez (1975) and Blanchard (1983), who model investment by using the microeconomic theory of the firm subject to increasing adjustment costs; by Persson and Svensson (1983), who use an overlapping generations model to determine investment; and by Obstfeld (1986), who employs a time-to-build restriction to determine investment in a setting of stochastic technology shocks. McKenzie (1982) has extended the one-good, infinite-horizon model with adjustment costs by incorporating the production of a non-traded consumption good. A number of models, including the one outlined by Obstfeld and Stockman (1985), have included non-traded investment in settings that are not based explicitly on optimizing behavior. Bruno (1982), Marion (1984), and Murphy (1986a) are examples of optimizing two-period models of the current account that include investment behavior and a non-traded sector.

No optimizing infinite-horizon models that include traded and non-traded investment expenditure have been analytically characterized in the literature. The essential difficulty in adding non-traded investment expenditure to a two-sector infinite-horizon model lies in the analysis of the dynamic adjustment of the economy when there are two capital stocks as state variables along with their associated shadow prices. Bruno and Sachs (1982) and Murphy (1986b) have employed simulations to illustrate the adjustment of economies with two capital stocks, but the complexity of possible responses of the models to various parameter values makes a complete characterization of the models quite difficult.[1]

This paper avoids the complexity of analyzing the dynamic adjustment of two capital stocks while at the same time incorporating traded and non-traded investment expenditure into an optimizing model. Non-traded investment expenditure takes the form of convex installation costs that must be incurred in order to transform a tradable investment good into an installed capital good. By including non-traded investment expenditure in an infinite-horizon model of an open economy some issues can be addressed that cannot be addressed in two-period models. One set of issues relates to the

[1]Bruno (1982, p. 204), in discussing the merits of computer simulations that allow more than one type of capital, notes that, '[these simulations] do have the drawback that it is often hard to ascertain how particular results depend on specific numerical solutions'.

impact of non-traded investment on aggregate demand and relative prices. This paper shows, for example, that an income tax cut will produce an overshooting of the relative price of non-tradables (as a result of an investment boom) coupled with a deterioration of the current account while a rise in non-traded government purchases will produce an undershooting of the relative price of non-tradables coupled with a current account surplus. The behavior of the relative price of non-tradables in the model is the outcome of optimizing behavior that spreads out capital stock adjustment over time.

The second set of issues that is addressed by the model, and which cannot be addressed by two-period models, concerns the important distinction between transitory, permanent, and anticipated shocks to the economy. For example, the paper shows that a temporary increase in the investment subsidy will cause a large upward jump in the relative price of non-tradables followed by a large downward jump at the termination of the subsidy as a result of the intertemporal shifting of investment expenditure into the period of the investment subsidy.

The organization of the paper is as follows. Section 2 presents the optimization problem facing the representative price-taking agent in the economy. Section 3 analyzes the dynamic adjustment of the capital stock and relative prices in response to changes in the government's tax and investment subsidy policies. Section 4 focuses on the behavior of the current account. Section 5 incorporates government purchases and non-traded consumption into the model. Section 6 concludes.

2. The model

The economy is composed of a single, infinitely-lived representative economic agent. The agent supplies an inelastic quantity of one unit of labor at the competitively-determined real wage rate (w) and accumulates physical capital (K) for rental at the competitively-determined rental rate (r^K). Capital depreciates at the constant rate δ. In addition to capital and labor, a third factor of production – which will be referred to as land ($\bar{R}$) but which may also be thought of as a fixed stock of economy-wide infrastructure – is employed by the agent. All factors of production are perfectly mobile between the two sectors of the economy. The agent produces a single tradable good by means of a strictly quasi-concave linearly-homogeneous production function $F(K^T, L^T, R^T)$, where K^T is the capital stock, L^T is the labor supply, and R^T is the amount of land employed in the production of the tradable. The agent produces a single non-traded good with a strictly quasi-concave production function $H(K^N, L^N, R^N)$, where K^N equals the total capital stock minus the amount allocated toward tradable production $(K-K^T)$, L^N equals one minus labor employed in the tradable sector, and R^N

equals the total amount of land minus the stock of land use by the tradable sector ($\bar{R}-R^T$).

The tradable good can be consumed (C) or invested (I) and is supplied perfectly elastically by the rest of the world. Non-traded output is used for the installation of capital.[2] Transforming the quantity I of traded investment goods into the quantity I of installed capital goods requires the use of $\phi(I/K)K$ of non-traded output, where $\phi(\cdot)>0, \phi''(\cdot)\geqq 0, \phi(\delta)=\delta, \phi'(\delta)=1$. It will be assumed throughout the paper that gross investment is non-negative.[3] The installation cost function is linearly homogeneous in investment goods and the capital stock and has been normalized around the steady state ($I/K=\delta$) to prevent the infra-marginal rents that are associated with installing capital from accruing to capital in the steady state.[4]

The agent is subject to an income tax levied by the government at the rate τ and and investment subsidy applied at the rate β toward the purchase of investment goods.[5] The representative agent's stream of income also includes interest income on its net holdings of government bonds (b^g) and foreign assets (b^f). In addition, the agent receives lump-sum transfers from the government (z). (1) is the agent's instantaneous budget constraint, where r is the exogenously-given world real interest rate, p is the relative price of non-tradables, and an overdot denotes a time derivative:

$$(1-\tau_t)[F(K_t^T, L_t^T, R_t^T)+p_t H(K_t-K_t^T, 1-L_t^T, \bar{R}-R_t^T)]$$

$$+r(b_t^g+b_t^f)-C_t-(1-\beta_t)I_t-p_t\phi\left(\frac{I_t}{K_t}\right)K_t+z_t=\dot{b}_t^g+\dot{b}_t^f. \tag{1}$$

The representative agent also faces the following standard capital accumulation constraint

$$I_t-\delta K_t=\dot{K}_t. \tag{2}$$

The agent's instantaneous utility function belongs to the class of iso-elastic

[2]This treatment of installation costs differs from McKenzie (1982) and Murphy (1986b), in which installation costs require the use of tradable output and non-traded output is used for consumption. By specifying installation costs to be non-traded, this paper provides a close analytical link between the market price of newly-installed capital and the relative price of non-tradables. With tradable adjustment costs, there is no such close link (see also footnote 13).

[3]This assumption has been made to simplify the presentation of the model, while still allowing negative net investment to take place. A more complete specification of installation costs would involve the addition of a removal cost function of the form $\psi(|I|/K)K$, $\psi'\geqq 0$, $\psi''>0$ for $I<0$.

[4]These infra-marginal rents accrue to capital that has already been installed before a change in the desired level of the capital stock takes place. See the text after eq. (8) for further discussion.

[5]To simplify the model, capital income taxation applies to gross capital income, $\tau r^K K$, and not to capital income net of depreciation.

utility functions $U(C)=C^{1-\sigma}/(1-\sigma)$, where σ is the agent's coefficient of relative risk aversion and $1/\sigma$ is the agent's intertemporal elasticity of substitution in consumption. The agent's optimization problem is given in (3), where ρ is the agent's rate of time preference and the value function $V(\cdot)$ is assumed to have continuous partial derivatives of orders less than three:

$$V(K, \bar{R}, b^g+b^f, p, t, \infty)=\max_{\substack{C,I,\\ L^T,K^T,R^T}} \int_t^\infty U(C_s)\,e^{-\rho(s-t)}ds$$

$$\text{subject to (1) and (2).} \tag{3}$$

The maximization problem given in (3) can be solved by the use of the present-value Hamiltonian associated with (3). Details of the solution are given in the appendix, where it is shown that the time path of consumption can be expressed as follows:

$$\frac{\dot{C}_t}{C_t}=\frac{1}{\sigma}(r-\rho). \tag{4}$$

Throughout the analysis of this paper it will be assumed that the real interest rate equals the rate of time preference so that consumption follows a flat time profile.

The price-taking agent will equate its marginal products of labor and capital in the two sectors to the economy-wide real wage and rental rate. Provided that production of the tradable good is relatively capital intensive, that production of the non-tradable good is relatively land intensive, and that capital and land are better substitutes for labor than for each other – in the sense of Jones and Easton (1983) – factor returns will depend on the capital stock and the relative price of non-tradables in the same manner as in the specific factors model with capital specific to tradables and land specific to non-tradables. In particular, the rental on capital will depend negatively on both the capital stock and the relative price of non-tradables while the real wage will depend positively on the capital stock and ambiguously on the relative price of non-tradables:[6]

$$F_L(K_t^T, L_t^T, R_t^T)=p_t H_L(K_t-K_t^T, 1-L_t^T, \bar{R}-R_t^T)=w(K_t, p_t), \tag{5}$$

$$F_K(K_t^T, L_t^T, R_t^T)=p_t H_K(K_t-K_t^T, 1-L_t^T, \bar{R}-R_t^T)=r^K(K_t, p_t). \tag{6}$$

[6]Tradable output is defined to be relatively capital intensive and non-tradable output to be relatively land intensive if $a_{KT}/a_{KN}>a_{LT}/a_{LN}>a_{RT}/a_{RN}$, where a_{ij} denotes the input of factor i required to produce a unit of output in the jth sector. Factor intensity reversals are assumed not to occur. Given the above factor intensities, the rental on land will depend negatively on the capital stock and positively on the relative price of non-tradables, as in specific factors model.

The market price of a newly-installed capital good will equal the world price of the investment good minus the value of the investment subsidy plus the marginal cost of installing the good. Let q be the market price of a newly-installed capital good relative to the unitary world price of an uninstalled capital good. Then eq. (7) gives the market price of capital that results from the optimization problem given in (3):

$$q_t=(1-\beta_t)+p_t\phi'\left(\frac{I_t}{K_t}\right). \tag{7}$$

The market price of capital is an asset price that will evolve over time as given by eq. (8):

$$\dot{q}_t=-(1-\tau_t)r^K(K_t,p_t)+p_t\phi\left(\frac{I_t}{K_t}\right)-p_t\phi'\left(\frac{I_t}{K_t}\right)\frac{I_t}{K_t}+(r+\delta)q_t. \tag{8}$$

In the steady state, where $\phi(\delta)=\delta$ and $\phi'(\delta)=1$, eqs. (7) and (8) together indicate that the after-tax rental on capital is equal to the world real interest rate plus the rate of physical depreciation on capital $(r+\delta)$ times the steady-state price of newly-installed capital $(1-\beta+p)$.

Consideration of the government's budget constraint completes the characterization of the economy. The government uses income tax revenue and bond issues to finance investment subsidies, lump-sum transfers, and interest payments on outstanding debt:

$$\tau[F(K_t^T,L_t^T,R_t^T)+p_tH(K_t-K_t^T,1-L_t^T,\bar{R}-R_t^T)]+\dot{b}_t^g=\beta_tI_t+z_t+rb_t^g. \tag{9}$$

Eqs. (1) and (9) determine the economy's current account ($\dot{b}^f$) in eq. (10) and the market-clearing condition for the non-traded sector in eq. (11). As in Jones and Easton (1983), given the relative factor intensities tradable output can be written as an increasing function of the capital stock and as a decreasing function of the relative price of non-tradables, $Y^T(K,p)$, while non-tradable output can be written as a decreasing function of the capital stock and an increasing function of the relative price of non-tradables, $Y^N(K,p)$:

$$Y^T(K_t,p_t)+rb_t^f-C_t-I_t=\dot{b}_t^f, \tag{10}$$

$$Y^N(K_t,p_t)=\phi\left(\frac{I_t}{K_t}\right)K_t. \tag{11}$$

To rule out a Ponzi-type scheme in which the agent forever borrows an increasing amount from the rest of the world to finance current debt service payments, the usual intertemporal budget constraint is imposed so that at any time t the stock of the economy's net foreign assets plus the present value of future trade balances must equal zero. The intertemporal budget constraint in conjunction with (4) allows aggregate consumption to be expressed as the following annuity of the agent's wealth, where wealth equals the agent's net foreign assets plus the present value of output minus investment expenditure:

$$C_t=rb_t^f+r\int_t^\infty[Y^T(K_s,p_s)-I_s]e^{-r(s-t)}ds. \tag{12}$$

The determination of aggregate investment

The representative agent's demand for new capital goods can be derived from (7) as a function of the relative price of non-traded goods, the market price of newly-installed capital goods, the investment subsidy, and the size of the capital stock:

$$I^D=I^D(p,q,\beta,K), \tag{13}$$

where

$$I_p^D=-\frac{\phi'(\cdot)K}{p\phi''(\cdot)}<0, \qquad I_q^D=I_\beta^D=\frac{K}{p\phi''(\cdot)}>0, \qquad I_K^D=\frac{I}{K}.$$

Although tradable investment goods are supplied perfectly elastically by the world market, the supply of newly-installed capital goods depends on the quantity of non-traded output used up in the installation of the investment goods. Consequently, eq. (11) can be used to derive the following investment supply equation as a function of the relative price of non-tradables and the capital stock:

$$I^S=I^S(p,K), \tag{14}$$

The dynamic analysis of sections 3 through 5 is also consistent with the assumption that tradable output is relatively capital intensive and that non-tradable output is relatively labor intensive (i.e. $a_{KT}/a_{KN}>a_{RT}/a_{RN}>a_{LT}/a_{LN}$), provided that capital and labor are better substitutes for land than for each other, as discussed by Jones and Easton (1983). Under either set of assumptions on relative factor intensities, the rental rate on capital will depend negatively on the capital stock and the relative price of non-tradables. These results are in contrast to the standard two-factor, two-good model in which the rental rate on capital depends only on the relative price of non-tradables [see Obstfeld and Stockman (1985)].

Because of the focus of this study is on the accumulation of capital and the behavior of the relative price of non-tradables, discussion of the dynamic behavior of the market price of land is left to the appendix.

where

$$I_p^S=\frac{Y_p^N}{\phi'(\cdot)}>0, \qquad I_K^S=\frac{Y_K^N-\phi(\cdot)+\phi'(\cdot)(I/K)}{\phi'(\cdot)}.$$

Fig. 1 depicts the determination of the aggregate rate of investment and the relative price of non-tradables as a function of the purchase price of newly-installed capital goods, the investment subsidy, and the stock of capital. The investment demand schedule I_0^D is shifted outward to I_1^D along the investment supply schedule by anything that raises the market price of installed capital, such as a reduction in the income tax, or that lowers the purchase price of installed capital, such as an increase in the investment subsidy. As capital accumulates following an outward shift in the investment demand schedule, the investment supply schedule shifts inward (since Y_K^N is less than zero) toward I_2^S as the investment demand schedule shifts downward to I_2^D, so that in the new steady state the capital stock and the relative price of non-tradables are both higher than in the initial equilibrium.

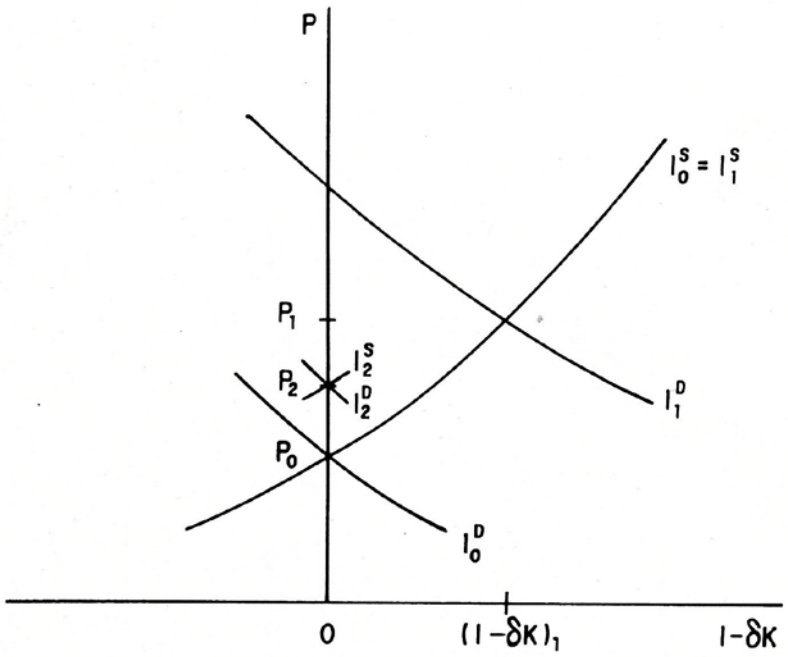

Fig. 1. The determination of aggregate investment.

3. Fiscal policy and capital stock adjustment

As mentioned in the Introduction, an infinite-horizon model of investment in an open economy can supplement two-period models of investment by focusing on the adjustment path of an economy to exogenous shocks and by analyzing the differences between permanent, temporary, and pre-announced changes in economic policy on capital accumulation, the relative price of non-tradables, and the current account. This section analyzes the dynamic adjustment of the model by considering the effects of changes in the income tax rate and the investment subsidy on the time path of the relative price of non-tradables and the capital stock.

To simplify the graphical exposition of the adjustment dynamics, it will be assumed that the installation function $\phi(I/K)K$ is linear so that the non-traded market-clearing condition (11) becomes $Y^N(K_t, p_t)=I_t$ and the market price of capital in (7) becomes $q_t=(1-\beta_t)+p_t$. In terms of Fig. 1, the simplifying assumption means that the investment demand function is horizontal.[7]

Both a permanent income tax cut and a permanent increase in the investment subsidy will raise the steady-state level of the capital stock and the steady-state relative price of non-tradables. Fig. 2 illustrates the dynamic adjustment of the economy that follows an unanticipated permanent tax cut or increase in the investment subsidy. Starting from an initial equilibrium such as point A, the tax cut or subsidy increase will shift out the $\dot{p}=0$ schedule so that the new long-run equilibrium occurs at a point such as point C. Immediately following the announcement of the tax cut or subsidy increase, the agent will begin to accumulate capital, thereby increasing expenditure in the non-traded sector of the economy and raising the relative price of non-tradables. The appendix demonstrates that the model is saddlepath stable, so the relative price in non-tradables must initially increase to a level such as p_B in Fig. 2 before declining to the new steady-state level of p_C.

With either a permanent tax cut or an increased investment subsidy the agent will initially switch factors of production out of the tradables sector in order to produce the non-traded output necessary for the installation of the tradable investment goods. The initial contraction in the size of the tradables sector is reversed as capital accumulation takes place, with labor, capital, and land shifted back toward the tradables sector. In the long run the tax cut or

[7]Eqs. (13) and (14) imply, in general, that the elasticity of changes in the relative price of non-tradables with respect to changes in the market price of capital can be written as follows:

$$\eta_{pQ}=\frac{Q}{p}\frac{dp}{dQ}=\frac{1}{1-\left(\frac{dI^S}{dp}\right)\Big/\left(\frac{dI^D}{dp}\right)}, \quad \text{where } Q=1-(1-\beta).$$

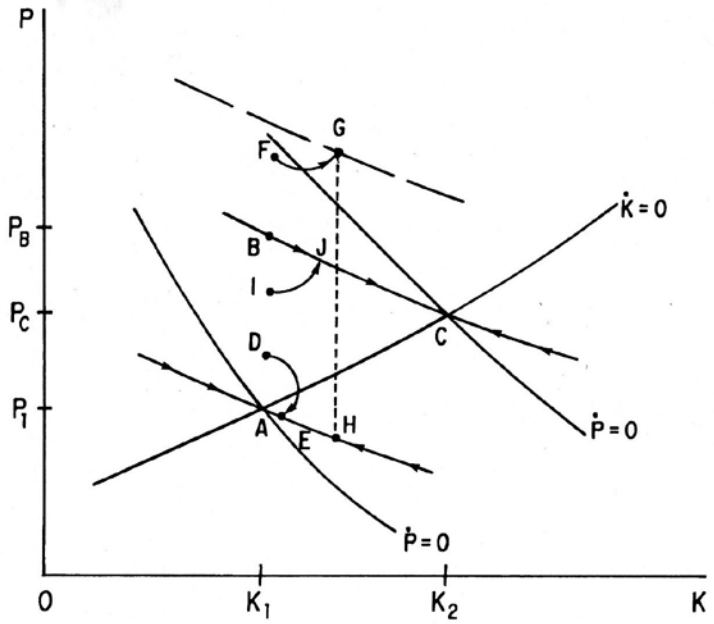

Fig. 2. Permanent and temporary tax changes and the relative price of non-tradables.

subsidy increase raises the size of both the traded and the non-traded sectors of the economy.

A temporary tax cut will also raise investment expenditure and thereby raise the relative price of non-tradables. But because a temporary tax cut will not alter the long-run equilibrium of the economy in this model, the incentives to the agent to accumulate capital are smaller than with a permanent tax cut. In Fig. 2 an illustrative unanticipated temporary tax cut is shown as a jump in the relative price of non-tradables from point A to point D that accompanies the initial increase in the rate of investment. As the termination of the temporary tax cut approaches, the relative price of non-tradables declines along the path DE as the rate of capital accumulation turns negative. The perfect foresight assumption guarantees that at the termination of the temporary tax cut the economy will be on the saddlepath trajectory leading back to the original long-run equilibrium.

Unlike a tax cut, which encourages investment by increasing the after-tax marginal product of capital, an investment subsidy encourages investment by lowering the purchase price of the capital good to the representative agent. Consequently, following a temporary increase in the investment subsidy the agent will invest more rapidly than following a permanent increase of the

same magnitude in order to take advantage of the transitorily low purchase price of investment goods.

In this model the perfect foresight assumption implies that the market value of newly-installed capital can jump in response to unexpected announcements or shocks, but then must follow a continuous path leading to a new long-run equilibrium. The relative price of non-tradables, however, is a function of the rate of investment and is not constrained to follow a continuous path. In particular, since the relative price of non-tradables is given by $p_t = q_t + \beta_t - 1$, the continuity requirement for the price of installed capital goods implies that at the termination of the temporary increase in the investment subsidy, the relative price of non-traded goods must fall by the entire change in the investment subsidy ($\Delta\beta$).[8]

In fig. 2 the dashed line containing point G is drawn parallel to the initial saddlepath leading through point A at a height $\Delta\beta$ above the initial saddlepath. A temporary increase in the investment subsidy of $\Delta\beta$ will raise investment expenditure relative to a permanent increase in the investment subsidy and will consequently cause the relative price of non-tradables to jump to a point such as point F, *above* the saddlepath leading from point B to point C.[9] During the period of the temporary subsidy increase, the agent will switch factors of production out of the tradables sector and into the non-tradables sector in order to install new capital while the subsidy is in effect. At the end of the period of the subsidy, the economy will have moved from point F to point G. The termination of the subsidy reverses the incentives to invest and the price of non-tradables falls by $\Delta\beta$ from point G to point H reflecting the sharp reduction in non-traded expenditure related to investment activity.

A pre-announced tax cut has immediate consequences for the market price of capital and for the relative price of non-tradables. Given the perfect foresight assumption, the market price of capital can only jump at the time of the announcement of the tax cut. In fig. 2 such a jump is shown from point A to point I. Along the path from point I to point J the market price of newly-installed capital (and the relative price of non-tradables) rises to reflect the increasingly greater present value of after-tax rentals on capital as the tax cut approaches. At the time of the tax cut the relative price of non-tradables peaks and begins to decline as capital accumulation continues to

[8]See Abel (1982) for a similar analysis of temporary investment subsidies in the context of a one-good model of investment.

[9]Depending on the length of the temporary subsidy increase, point F may either lie below the $\dot{p}=0$ schedule, as shown in fig. 2, or above the schedule (for briefer increases in the subsidy). By differentiating eq. (8), it is straightforward to show that the $\dot{p}=0$ schedule shifts upward by less than $\Delta\beta$: $dp/d\beta = (r+\delta)/[(r+\delta)-(1-\tau)r_p^K] < 1$. For brief increases in the investment subsidy, the upward jump in the relative price of non-tradables will be less than $\Delta\beta$ but greater than the upward shift in the $\dot{p}=0$ schedule.

take place along the saddlepath leading to the new steady-state equilibrium at point C.[10]

4. The determination of the current account

The current account in this model is determined by the optimizing behavior of the agent and reflects the agent's decisions to borrow from or lend to the rest of the world. The model's analytical structure is recursive so that the agent's investment decisions entirely determine the path of the current account over time, given the economy's intertemporal budget constraint. By combining the current account equation given in (10) with the agent's optimal consumption plan given in eq. (12), the current account can be expressed as a function of present and future values of the capital stock, the relative price of non-tradables, and the rate of investment, as shown in (15):

$$Y^{T}(K_t, p_t) - I_t - r\int_t^{\infty} [Y^{T}(K_s, p_s) - I_s]\, e^{-r(s-t)} ds = b_t^{f}. \tag{15}$$

Following any change in tax policy or government spending policy, the change in the value of the term containing the integral in (15) is the change in the level of the agent's consumption, since the agent maintains a flat consumption profile in order to maximize its utility over time. In order to analyze the effects of various policy changes on the current account, it will be assumed that the current account is initially zero and that the economy is in an initial steady state when the policy change occurs.

A permanent unanticipated income tax cut that accompanies a permanent reduction in lump-sum transfers to the agent will unambiguously deteriorate the current account. The higher after-tax rental rate and the upward jump in the relative price of non-tradables described in section 3 will transitorily raise investment expenditure and lower output of the tradables sector of the economy. Consumption will jump to a higher level following the tax reduction due to the higher future level of tradable output that will accompany the accumulation of capital over time. The combination of increased expenditure on tradables with a transitory decline in tradable output (necessary to free factors of production to produce non-traded output for the installation of new capital) produces a current account deficit that will monotonically improve, approaching zero as the economy moves toward its new long-run equilibrium.

[10]A pre-announced investment subsidy, which is not illustrated in fig. 2, would produce an initial drop in the relative price of non-tradables and a decline in the level of the capital stock prior to the implementation of the investment subsidy. At the moment the subsidy goes into effect, the relative price of non-tradables would jump by the amount of the increase in the subsidy ($\Delta\beta$) in order to put the economy on the saddlepath leading to the new long-run equilibrium at point C.

A temporary income tax cut will also initially deteriorate the current account, although to a smaller extent than will a permanent tax cut of the same magnitude. Unlike the case of a permanent tax cut, the current account following a temporary tax cut will improve and eventually go into surplus either before or at the time the tax cut terminates. The current account will go into surplus because the only way that the agent can permanently raise its consumption as the result of a temporarily lower income tax rate is by saving the increased output produced with the temporarily larger capital stock. The saving will take the form of increased claims on foreigners so that as the economy approaches the original steady-state capital stock following the termination of the tax cut, the net foreign bond holdings of the agent will be higher than before the tax cut.

A pre-announced tax cut will produce a current account deficit as a result of lower tradable output, increased investment expenditure, and increased consumption expenditure. As the time of the pre-announced tax cut approaches, the current account will continue to deteriorate: purchases of investment goods in anticipation of the tax cut will raise tradable expenditure while the production of non-tradable output for the installation of the investment goods will raise the relative price of non-tradables and lower tradable output by shifting factors of production out of the tradables sector. After the tax cut arrives, the current account will monotonically improve at the same time that the relative price of non-tradables falls.

Increases in the investment subsidy will have almost the same effect on the current account as cuts in the income tax rate. The difference lies in the possibility that consumption may fall with increases in the investment subsidy since, starting from an equilibrium with no tax distortions, increased subsidies will lower wealth by raising the capital stock above an optimal level.

5. Extensions to the model

5.1. Government purchases

The model can be easily modified to include government expenditure. Assume that the government purchases traded and non-traded output, and that the purchases have, for simplicity, no effect on the agent's level of utility or amount of production so that the pure expenditure effect of government purchases can be examined. Letting G^{N} denote non-traded government purchases and G^{T} denote traded government purchases, the left-hand side of eq. (10) (the economy's current account) now includes G_t^{T} as an expenditure term and the right-hand side of eq. (11) (the non-traded market-clearing condition) includes G_t^{N} as an expenditure term.

Changes in the level of non-traded government purchases affect investment and the relative price of non-tradables by altering the demand for non-traded output. In terms of fig. 1, an increase in government purchases of non-tradables shifts the investment supply function inward. In terms of fig. 2, an increase in government purchases of non-traded output shifts the $\dot{K}=0$ schedule inward. As in the case of tax cuts and investment subsidies, permanent, temporary, and pre-announced changes in non-traded government purchases imply different adjustment paths of the relative price of non-tradables, the capital stock, and the current account. This subsection will sketch out the economy's response to a permanent increase in government purchases.

Following an unanticipated permanent increase in government purchases of non-tradable output, the market value of installed capital rises as a result of the increased installation costs for future additions to the capital stock. However, unlike the case of a tax cut or subsidy increase, the higher market price of capital does not signal the beginning of a period of capital accumulation but rather the beginning of a period of capital *de*cumulation. Capital will decumulate following a permanent increase in the level of non-traded government purchases because the shift of factors of production into the non-traded sector lowers the present and future stream of rentals on capital. In contrast to the case of a permanent tax cut, following an inward shift of the $\dot{K}=0$ schedule the relative price of non-tradables will undershoot its new long-run equilibrium rather than overshoot the new long-run equilibrium as in fig. 2.

A permanent increase in traded government purchases will completely crowd out consumption so that the current account remains unchanged. On the other hand, a permanent increase in non-traded government purchases will produce a current account surplus. The initial rise in the relative price of non-traded output will lower the production of tradables immediately, but the undershooting of the relative price of non-tradables means that tradable output will fall even further as capital is decumulated. That is to say, output of tradables will be high relative to its long-run level following a permanent increase in non-traded government purchases. The level of investment expenditure will also be low relative to long-run levels in order to produce net disinvestment in the capital stock.[11] The combination of a lower, but still transitorily high, level of tradable output with a transitorily low level of investment implies [via the expression for the current account given in (15)] that the agent will be a net saver with the rest of the world during the transition to a lower capital stock and higher relative price of non-tradables.

[11]Because output of non-tradables is a decreasing function of the capital stock and an increasing function of the relative price of non-tradables, the market-clearing condition for the non-traded sector shows that investment must fall to its lowest level upon impact of the higher level of non-traded government purchases.

5.2. The role of non-traded consumption

The addition of non-traded consumption into the model modifies the adjustment of the economy to unexpected policy changes. If the agent's optimization problem in eq. (3) is redefined so that the agent's utility function includes traded and non-traded consumption, $U(C_t^T, C_t^N)=(C_t^T)^{\alpha}(C_t^N)^{1-\alpha}$, then the maximization of (3) subject to the agent's budget constraint (including non-traded consumption) and capital accumulation constraint alters eq. (4) in the following manner:

$$\frac{\dot{C}^T}{C^T}=\frac{r-\rho}{1-\alpha(1-\sigma)}+\frac{(1-\sigma)(1-\alpha)}{1-\alpha(1-\sigma)}\frac{\dot{C}^N}{C^N}, \tag{16}$$

where $1/\sigma$ is the agent's intertemporal elasticity of substitution in consumption. Assuming (as earlier) that the agent's rate of time preference equals the world real interest rate, movements in traded and non-traded consumption when out of long-run equilibrium will be positively correlated if the agent's intertemporal elasticity of substitution in consumption is greater than one and will be negatively correlated if the agent's intertemporal elasticity of substitution in consumption is less than one.

When consumption consists entirely of the tradable good, the agent maximizes its discounted flow of utility by choosing a flat trajectory of consumption based on the annuity formula given in eq. (12). When the agent consumes non-tradable as well as tradable output, the concavity of the utility function dictates the extent to which the agent will smooth consumption during periods in which the capital stock is adjusting to a shock. An intertemporal elasticity of substitution that is less than one indicates that the agent would rather rearrange its consumption bundle (since the *intra*temporal elasticity of substitution is unitary given the Cobb–Douglas formulation of the utility function) than shift consumption over time. For that reason, traded and non-traded consumption will be negatively correlated during any period of transition of the capital stock. If the agent's utility function is less concave, so that the intertemporal elasticity of substitution in consumption is greater than one, then the agent will choose to shift consumption intertemporally so that traded and non-traded consumption are positively correlated.

When non-traded consumption is added to the model, the investment supply schedule in fig. 1 is no longer independent of the agent's level of consumption, since non-traded consumption is a competing use for non-traded expenditure. In particular, by making use of the agent's first-order conditions for consumption – $U_N(C^T, C^N)/U_T(C^T, C^N)=p$ – it is straightforward to show that the slope of the investment supply function is

$$I_p^S=\frac{Y_p^N-U_{TT}/(U_{TT}U_{NN}-U_{TN}^2)}{\phi'(I/K)}>0.$$

The steepness of the investment supply function depends on the concavity of the agent's utility function. The greater the concavity of the utility function, the greater will be the overshooting of the relative price of non-tradables in response to a cut in the income tax rate, for example. The investment process is slowed down and the upward jump in the relative price of non-tradables increased by a more concave utility function because the agent must be rewarded more for shifting consumption over time than would be the case with a more linear utility function. In particular, the Cobb–Douglas utility function implies that the consumption real interest rate (r^C) can be expressed as the following function of the relative price of non-tradables and the world real interest rate: $r_t^C = r - (1-\alpha)(\dot{p}_t/p_t)$.[12] A more concave utility function requires a greater initial overshooting of the relative price of non-tradables in order to raise the consumption real interest rate enough to free up non-tradable output for the installation of capital.

A final important difference between the model with and without non-traded consumption has to do with the separability of consumption and production decisions by the agent. When consumption is only of the tradable good, the steady-state level of the capital stock and relative price of non-tradables are entirely determined by the production side of the economy. Consequently, a temporary tax reduction will leave the long-run level of the economy's capital stock unchanged. Once non-traded consumption is added to the model, consumption and production decisions are intertwined. The model with non-traded consumption is characterized by the property of hysteresis: the steady-state values of the variables of the model (including the capital stock and the relative price of non-tradables) depend on the history of the economy.[13] In particular, a temporary tax cut will no longer result in a return to the initial steady-state level of the capital stock. History matters once non-traded consumption is added because the savings behavior of the agent during a temporary tax reduction raises the long-run level of non-traded consumption and the relative price of non-tradables, thereby reducing the equilibrium level of the capital stock via increased installation costs.

6. Conclusion

In flexible-price models of floating exchange rates, the relative price of non-tradables is usually closely linked to movements in both the nominal exchange rate and a price-level-deflated (real) exchange rate. This paper has provided a framework for understanding movements in the relative price of non-tradables and the current account as the result of optimizing behavior related to the accumulation of capital in an economy. The series of examples discussed in sections 3, 4, and 5 should make it clear that there is no simple relation between the relative price of non-tradables and the current account of an economy. For instance, following a tax cut the relative price of non-tradables will rise and the current account will deteriorate as factors of production are moved into the non-tradable sector to install new investment goods. On the other hand, following an increase in non-traded government purchases, the relative price of non-tradables will rise and the current account will improve as the agent takes advantage of a transitorily high level of the capital stock to increase the economy's net holdings of foreign assets.

The analytical framework developed in the paper has two empirical implications that need to be explored in future research. First, the model suggests that the tax cuts of the 1960s and 1980s may have been partially responsible for the 'strong' dollar of the late 1960s and early 1980s. The rise in marginal tax rates in the 1970s, on the other hand, may have been partially responsible for the 'weak' dollar of the late 1970s. The second empirical implication of the paper is that models of investment demand based on the market value of the capital stock (i.e. q models of investment) may perform better if the level of non-traded government purchases is included. Including non-traded government purchases may correct a potential identification problem that these one-good models face due to their assumption that the investment supply function is stable over time. In particular, the tendency of q models to under-predict investment in the 1970s may be partially related to an outward shift in the investment supply schedule (as in fig. 1) associated with the decline in U.S. military spending as a proportion of GNP during the 1970s.[14]

Appendix

The agent's maximization problem given in (3) can be set up as the maximization of the following present-value Hamiltonian, where λ is the shadow value of income and q^* is the shadow value of newly-installed capital:

$$\mathcal{H} = e^{-\rho s}\Big[U(C) + \lambda\Big\{(1-\tau)[F(K^T, L^T, R^T) + pH(K-K^T, 1-L^T, \bar{R}-R^T)]$$

[12] See Dornbusch (1983) for the derivation of a similar condition in a model without capital.

[13] Another model in which the incorporation of non-traded consumption causes the initial conditions of the economy to matter for the long-run equilibrium can be found in McKenzie (1982). As is the case in this model, McKenzie shows that the existence of a single negative eigenvalue of the transition matrix of the linearized model (around the steady state) guarantees that the system's dynamics will be characterized by saddlepath stability. In McKenzie's model, installation costs of new capital are traded so that the dynamic adjustment of the relative price of non-tradables depends on non-traded consumption expenditure.

[14] See Abel and Blanchard (1986) for a review of the evidence of the performance of q models in explaining post-World War II investment in the United States.

$$+r(b^g+b^f)-(1-\beta)I-p\phi\left(\frac{I}{K}\right)K\Big\}+q^*(I-\delta K)\Big]. \qquad \text{(A.1)}$$

Eqs. (5) and (6) of the text result from setting $\partial\mathcal{H}/\partial L^T=\partial\mathcal{H}/\partial K^T=0$. By defining $q=q^*/\lambda$ to be the market value of newly-installed capital, eq. (7) results from setting $\partial\mathcal{H}/\partial I=0$. Eq. (4) of the text is derived by combining the optimality condition $\partial\mathcal{H}/\partial C=0$ with the co-state equation for the shadow value of income defined by $\mathrm{d}(\lambda e^{-\rho t})/\mathrm{d}t=-\partial\mathcal{H}/\partial(b^g+b^f)$. The asset-price equation for the market price of newly-installed capital is likewise derived from the co-state equation of the system defined by $\mathrm{d}(q^* e^{-\rho t})/\mathrm{d}t=-\partial\mathcal{H}/\partial K$. By defining the market price of land to be $q^R=q^{R*}/\lambda$, the asset-price equation for the price of land is derived from the co-state equation defined by $\mathrm{d}(q^{R*} e^{-\rho t})/\mathrm{d}t=-\partial\mathcal{H}/d\bar{R}$. Letting r^R denote the rental rate on land, the asset-price equation for land can be written as follows: $\dot{p}^R=-(1-\tau)r^R(K,p)+rq^R$.

The model has a recursive structure in which the dynamic adjustment of the capital stock determines the economy's current account. Since the movement of the shadow price of income, $\dot{\lambda}=\lambda(\rho-r)$, is set equal to zero by the assumed equality of the agent's rate of time preference and the world real interest rate, imposing an economy-wide intertemporal budget constraint that constrains the sum of the economy's stock of net foreign assets plus the present value of future trade balances to equal zero is equivalent to imposing a transversality condition on the shadow value of income to guarantee a positive shadow value. Given the intertemporal budget constraint and the condition that the shadow value is constant except for a discrete jump at the time of unanticipated changes in fiscal policy, the demonstration of saddle-path stability of the capital stock around a long-run steady state can be shown by differentiating the asset price equation for land and eqs. (2) and (8) of the text. The linearized system used for the analysis of sections 3 through 5 is given below:

$$\begin{bmatrix}\dot{q}^R\\ \dot{K}\\ \dot{q}\end{bmatrix}=\begin{bmatrix}r & -(1-\tau)r_K^R & -(1-\tau)r_p^R\\ 0 & Y_K^N-\delta & Y_p^N\\ 0 & -(1-\tau)r_K^K & -(1-\tau)r_p^K+r+\delta\end{bmatrix}\begin{bmatrix}q^R-\bar{q}^R\\ K-\bar{K}\\ q-\bar{q}\end{bmatrix}. \qquad \text{(A.2)}$$

The eigenvalues (η) for the linearized system of equations in (A.2) are the following:

$$\eta_1=r;$$

$$\eta_2,\eta_3=\tfrac{1}{2}[Y_K^N+r-(1-\tau)r_p^K]$$

$$\pm\tfrac{1}{2}\sqrt{[Y_K^N+r-(1-\tau)r_p^K]^2+4\{(Y_K^N-\delta)[(1-\tau)r_p^K-(r+\delta)]-(1-\tau)r_K^K Y_p^N\}}. \qquad \text{(A.3)}$$

Inspection of (A.3) shows that the second term in brackets under the radical sign is positive so that the linearized system of equations has two positive and one negative eigenvalues, thus assuring saddlepath stability in the neighborhood of the long-run steady state.

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