NBER WORKING PAPER SERIES

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Working Paper No. 3298

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
March 1990

Previous versions of this paper were presented at the University of Illinois, the International Economic Study Group, and the Midwest International Economic Meeting. We are grateful to Earl Grinols, Charles Kahn, David Wildasin, Jay Wilson, and two anonymous referees for helpful comments. This paper is part of NBER's research program in International Studies. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

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ABSTRACT

This paper contrasts the effects of a permanent and temporary investment tax credit in an open economy. In both cases an ITC will initially stimulate investment, while reducing employment and output, and generating a current account deficit. If the ITC is permanent, the accumulation of capital leads to a higher equilibrium capital stock, higher employment and output, and a reduction in the economy's stock of net credit. If the ITC is temporary, after its removal, the economy eventually moves to a new steady-state equilibrium having a lower permanent capital stock and employment, together with a higher stock of net credit.

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1. INTRODUCTION

Most OECD countries subsidize, or have subsidized, investment expenditures by firms through an investment tax credit (ITC) in order to stimulate investment and growth. But it is also true that the use of the ITC and the rate at which it has been set have been subject to substantial variation over time. For instance, in the case of the U.S., an ITC was introduced in 1962, which was suspended in 1967, only to be reintroduced two years later and again removed the following year. In 1972 the ITC was again reinstated and in 1975 the rate was increased to 10 percent. It was once again suspended as part of the 1986 tax reform. Likewise, Britain and Canada are also currently in the process of dismantling their respective ITCs.[1]

In contrast to other forms of taxation, the ITC has received relatively little theoretical analysis. Almost all of the existing studies deal with a closed economy. For instance, Abel (1982) uses a partial equilibrium framework to discuss the different effects of permanent versus temporary ITC's. He shows that a temporary ITC has a larger impact on capital accumulation while it is in effect, but the economy gradually returns to it original equilibrium once the policy is reversed. Abel and Blanchard (1983) consider a general equilibrium framework and draw an analogy between an ITC and technical progress.

There is a paucity of models analyzing the impact of an investment tax credit in an open economy. One exception is a recent paper by Brock (1988) which considers an investment subsidy, along with other forms of fiscal shocks. In part, this lack of analysis is a consequence of a comparative neglect of modelling the capital accumulation process itself in an international context. A number of models which do include investment are two period models where installation takes one period. The analysis of the ITC here would be trivial and the distinction between permanent and temporary of relatively little significance.[2]

In this paper, we analyze the effects of an investment tax credit (investment subsidy) in a general equilibrium model of a small open economy in which both employment and the rate of capital accumulation are endogenously determined through the intertemporal optimizing behavior of infinitely lived private agents in the economy. Investment is modelled by postulating installation costs for capital. Two types of changes are analyzed, namely an unanticipated permanent and an unanticipated temporary ITC. The effects of these changes on a number of key variables are considered. These include the rate of investment, output, and consumption, as well as the current account. In particular, an ITC, as long as it is in effect, is shown to lead to an investment boom, which is accompanied by a current account deficit.

The most striking implication of our analysis is the contrast between the effects of a permanent and temporary ITC on the long–run equilibrium of the economy. When the ITC is permanent, capital accumulation takes place along the entire adjustment path to the new steady state. Employment is also higher in the new steady state. By contrast, if the ITC is only temporary, then capital accumulation takes place while the policy is in effect, but a greater decumulation begins once the policy is reversed and the economy ends up with a *lower* steady state stock of capital and employment than it began with. A *temporary* ITC will lead to only a *temporary* expansion, but a *permanent* contraction. The reason for this is that, as we will demonstrate below, the steady state corresponding to some sustained policy depends upon the initial conditions of the economy prevailing at the time this policy is implemented. The adjustment which occurs during some temporary investment subsidy will have a critical bearing on the initial conditions in existence at the time the temporary policy is permanently revoked.

We view this result as being an extremely important one. First, it is in sharp contrast to the behavior of a closed economy, as well as the Brock (1988) analysis of the open economy, both of which find temporary shocks to have only temporary effects. Secondly, the fact that ITC's have been subject to such frequent change makes the analysis of temporary policies particularly relevant. Moreover, the assumption of the small open economy which is at the root of our key result—in particular that the economy can borrow or lend as much as it wants at the world interest rate, which it takes as given—is not unreasonable for OECD countries such as Canada and Britain.

At the same time, we should note that the hysteretic adjustment to a temporary shock being emphasized here is known to generally (but not always) characterize small open economies in which the rate of time discount equals the given world interest rate, as will be assumed here; see e.g., Obstfeld and Stockman (1985), Blanchard and Fischer (1989), Sen and Turnovsky (1989). In these examples, the permanent effects of the temporary shock are typically a dampening of the responses resulting from the corresponding permanent shock and they therefore operate in the same direction. By contrast in the present case of the ITC, the long–run effect of the temporary policy is in fact perverse!

The remainder of the paper proceeds as follows. Section 2 outlines the framework, with the equilibrium dynamics and steady state being derived in the following section. The long–run effects of a permanent increase in the ITC is discussed in Section 4. Sections 5 and 6 then analyze the transitional dynamics in response to both permanent and temporary changes, respectively. The conclusions are summarized in the final section.

2. THE FRAMEWORK

The economy comprises three sectors: (i) consumers, (ii) firms, and (iii) the government. To preserve simplicity, we assume that all consumers and firms are identical, enabling us to focus on the representative individual in each group.

A. Structure of Economy

We consider a small open economy, which produces a single traded good. The model is real, with the only financial asset held by domestic residents being a traded asset, enabling them to borrow or lend as much as they want at the exogenously given world interest rate, i^*, subject to their intertemporal budget constraint. Domestic firms are owned by domestic consumers, to whom profits therefore accrue.

The representative consumer's plans are obtained by solving the following intertemporal optimization problem:[3]

$$Max \int_0^{\infty} U(x,\ell)e^{-i^* t}dt \qquad \begin{array}{l} U_x > 0, U_\ell < 0, \\ U_{xx} < 0, U_{\ell\ell} < 0, U_{x\ell} < 0, U_{xx}U_{\ell\ell} - U_{x\ell}^2 > 0 \end{array} \tag{1a}$$

subject to

$$x + \dot{n} = w\ell + \pi + i^* n - T \tag{1b}$$

and initial condition

$$n(0) = n_0 \tag{1c}$$

where

n = stock of traded assets,

ℓ = labor,

x = consumption of traded good,

w = real wage rate,

π = real profit, and

T = lump sum tax.

Several aspects of this specification merit comment. First, the consumer's rate of time preference is taken to be the given world real rate of interest, i^*. As is well known, as long as the rate of time preference is assumed to be constant, then this is the only value which under the assumption of perfect capital mobility being assumed here, is consistent with the ultimate attainment of steady state equilibrium; see footnote 9. This will have important consequences for the dynamics of the economy.

Secondly, consumers are assumed to derive positive marginal utility from the consumption of the good and positive marginal disutility from providing labor services. Further, the instantaneous utility function is assumed to be strictly concave in its arguments x and ℓ, implying diminishing marginal utility with respect to x and increasing marginal disutility with respect to ℓ. We also make the plausible assumption $U_{x\ell} < 0$, that the marginal utility of consumption decreases with labor (increases with leisure).[4]

In determining his optimal plans for x, ℓ, and n, the representative consumer is assumed to take π, w, T, as given. These decisions are made subject to the budget constraint (1b), which is expressed in flow terms, and the initial condition (1c).

Firms produce output y, from labor and capital, k, by means of a production function, which is assumed to have the usual neoclassical properties of positive, but diminishing, marginal products, and constant returns to scale, i.e.,

$$y = f(k,\ell) \quad f_k > 0, f_\ell > 0$$
$$f_{kk} < 0, f_{\ell\ell} < 0, f_{kk}f_{\ell\ell} = f_{k,\ell}^2 \tag{2}$$

Profit net of investment expenditure at time t say, is defined to be [5]

$$\pi(t) = f(k,\ell) - w\ell - (1-z)I(1 + h(\frac{I}{k})) \tag{3}$$

where

I = rate of investment,

z = rate of investment tax credit.

In equation (3) following Hayashi (1982) and Abel and Blanchard (1983) it is assumed that there are installation costs associated with investment I. The installation cost function h is a convex function of $\frac{I}{k}$ $(h' > 0, h'' > 0)$. In addition we assume $h(0) = 0, h'(0) = 1$.

To save on cumbersome notation we shall assume that the rate of depreciation is zero. The interpretation of equation (3) then would be that the firm receives an investment tax credit if I is positive. If I is negative then there are dismantling costs given by h, but $z = 0$.

Thus the firm's optimization problem is to

$$Maximize \int_0^\infty \pi(t)e^{-i^* t}dt = \int_0^\infty [f(k,\ell) - w\ell - (1-z)I(1+h(\frac{I}{k}))]e^{-i^* t}dt \qquad (4a)$$

subject to

$$\dot{k} = I \qquad (4b)$$

and the initial condition

$$k(0) = k_0. \qquad (4c)$$

As a semantic point, we may note that since there are no corporate taxes in the model, z is not really a credit against taxes; rather it is a pure subsidy. We shall, however, use the terms ITC and investment subsidy interchangeably.

The domestic government follows a balanced budget policy, i.e.,

$$T = zI(1+h(\frac{I}{k})). \qquad (5)$$

Subtracting (5) from (1b) and noting (3), the sectoral budget constraints imply

$$\dot{n} = f(k,\ell) - x - I(1+h(\frac{I}{k})) + i^* n. \qquad (6)$$

That is, the rate of change of net credit of the domestic economy equals the balance of payments on current account, which in turn equals the balance of trade plus the net interest income earned on the traded assets.

B. Macroeconomic Equilibrium

To obtain the macroeconomic equilibrium, we first derive the optimality conditions for households and firms and then combine these with the accumulation equations. Omitting details, this leads to the following set of equations

$$U_x(x,\ell) = \lambda \tag{7a}$$

$$U_\ell(x,\ell) = -f_\ell(k,\ell)\lambda \tag{7b}$$

$$(1-z)(1+h+\frac{I}{k}h') = q \tag{7c}$$

$$\dot{q} = i^*q - [f_k(k,\ell) + h'\frac{I^2}{k^2}] \tag{7d}$$

$$\dot{k} = I \tag{7e}$$

$$\dot{n} = f(k,\ell) - x - I[1+h(\frac{I}{k})] + i^*n \tag{7f}$$

$$\dot{\lambda} = 0, \text{i.e.} \quad \lambda = \overline{\lambda} \tag{7g}$$

$$T = zI[1+h(\frac{I}{k})] \tag{7h}$$

where λ and q are the costate variables associated with the dynamic equations (1b) and (4b) respectively. In addition, there are the transversality conditions

$$\lim_{t\to\infty} \lambda n e^{-i^*t} = \overline{\lambda} \lim_{t\to\infty} n e^{-i^*t} = 0 \tag{8}$$

$$\lim_{t\to\infty} qke^{-i^*t} = 0. \tag{9}$$

Equations (7a, 7b) describe the consumer's optimality condition for the consumption-leisure tradeoff; the marginal rate of substitution between consumption and work equals the after-tax real wage. This pair of equations may be solved as follows for x and ℓ:[6]

$$x = x(\overline{\lambda}, k) \quad x_{\overline{\lambda}} < 0, x_k < 0 \tag{10a}$$

$$\ell = \ell(\overline{\lambda}, k) \quad \ell_{\overline{\lambda}} > 0, \ell_k > 0. \tag{10b}$$

Intuitively, an increase in the marginal utility of consumption, $\overline{\lambda}$ (which is constant from (7g) and is determined by the steady state) shifts the consumption-leisure tradeoff against consumption and in favor of labor. An increase in k raises the real wage, thereby also leading to a substitution of work for consumption. It is evident from (7a) that the dependence of consumption upon capital, and therefore its time dependence, arises because of (i) the fact that $U_{x\ell} \neq 0$; (ii) the assumption that employment is variable. If instead ℓ is fixed, then consumption depends solely upon $\overline{\lambda}$ and therefore also remains constant over time.

The third equation equates the net marginal cost of capital to the shadow price of capital q.[7] This relationship may be solved

$$I = I(q, k; z) \quad I_q > 0 \quad I_k > 0 \tag{10c}$$

and is essentially a "Tobin q" theory of investment.[8]

The next three equations describe the dynamics. Equation (7d) is the equation describing the evolution of q, while (7e) describes the relationship between the rate of investment and the rate of capital accumulation. Substituting the solution for ℓ and I from (10b) and (10c), these describe a pair of autonomous differential equations in k and q. These constitute the core of the dynamics of the system.[9]

Having determined the "core" dynamics, equation (7f) then yields the dynamics of the net credit of the domestic economy (n). Equation (7h) is the government budget (equation

(5)) reproduced for convenience. The transversality condition (8) imposes an intertemporal budget constraint on the economy, thereby ruling out the possibility of it running up infinite debt or credit. Equation (9) is the transversity condition for the accumulation of capital.

3. EQUILIBRIUM DYNAMICS AND STEADY STATE

As noted in Section 2, the dynamics can be determined sequentially. Equations (7a)–(7e) can be reduced to a pair of autonomous differential equations in k and q. Substituting the solutions to these equations into (7f), one can then solve for n.

Consider first equations (7d) and (7e), which we write as

$$\dot{k} = I(q, k; z)$$
$$\dot{q} = i^* q - f_k(k, \ell(\overline{\lambda}, k) - (\frac{I^2(q, k; z)}{k^2})(\frac{h'(I(q, k; z)}{k})).$$

Linearizing this pair of equations about the steady state yields

$$\begin{bmatrix} \dot{k} \\ \dot{q} \end{bmatrix} = \begin{bmatrix} 0 & I_q \\ -[f_{kk} + f_k \ell \frac{\partial \ell}{\partial k}] & i^* \end{bmatrix} \begin{bmatrix} k - \tilde{k} \\ q - \tilde{q} \end{bmatrix} \tag{11}$$

where $\tilde{k}, \tilde{q}$ denote the steady-state values of k and q and noting that in steady state $I = 0, h' = 1$. The determinant of the matrix of coefficients in (11) is

$$D \equiv I_q[f_{kk} + f_{k\ell} \frac{\partial \ell}{\partial k}]$$

which evaluating $\frac{\partial \ell}{\partial k}$ can be shown to equal

$$D = I_q f_{kk} \frac{[U_{\ell\ell} U_{xx} - U_{\ell x}^2]}{\Delta} < 0$$

where $\Delta \equiv U_{\ell\ell} U_{xx} - U_{x\ell}^2 + \overline{\lambda} F_{\ell\ell} U_{xx} > 0$. The eigenvalues are say $u_1 < 0, u_2 > 0$, so that the dynamics is a saddlepoint. We assume that while the capital stock always evolves gradually, the shadow price of capital, q, may jump instantaneously in response to new information.

Starting from an initial capital stock k_0, the stable dynamic time paths followed by k and q are therefore

$$k = \tilde{k} + (k_0 - \tilde{k})e^{u_1 t} \tag{12a}$$

$$q = \tilde{q} + \frac{u_1}{I_q}(k_0 - \tilde{k})e^{u_1 t}. \tag{12b}$$

To determine the dynamics of the current account, consider (6), which upon substitution from (10a), (10b) becomes

$$\dot{n} = f[k, \ell(\overline{\lambda}, k)] - x(\overline{\lambda}, k) - I(q, k)(1 + h(\frac{I(q,k)}{k})) + i^* n.$$

Linearizing this equation around steady state yields

$$\dot{n} = (f_k + f_\ell \ell_k - x_k)(k - \tilde{k}) - I_q(q - \tilde{q}) + i^*(n - \tilde{n}) \tag{13}$$

where we are using the fact that $h = 0, h' = 1$ at steady state, when $I = 0$. Assuming that the domestic economy starts out with an initial stock of net credit $n(0) = n_0$, the solution to (13) is (by substituting (12a) and (12b))

$$n = \tilde{n} + \frac{\Omega(k_0 - \tilde{k})}{u_1 - i^*}e^{u_1 t} + [n_0 - \tilde{n} - \frac{\Omega}{u_1 - i^*}(k_0 - \tilde{k})]e^{i^* t} \tag{14}$$

where $\Omega \equiv f_k + f_\ell \ell_k - x_k - u_1 > 0$.

Invoking the intertemporal budget constraint of the economy, (8), implies

$$n_0 = \tilde{n} + \frac{\Omega}{u_1 - i^*}(k_0 - \tilde{k}) \tag{15}$$

so that the solution for $n(t)$, consistent with long-run solvency, is

$$n(t) = \tilde{n} + \frac{\Omega}{u_1 - i^*}(k_0 - \tilde{k})e^{u_1 t}. \tag{16}$$

This equation describes the relationship between the stock of capital and the stock of traded bonds. Differentiating this relationship with respect to t we have

$$\dot{n}(t) = \frac{\Omega}{u_1 - i^*}\dot{k}(t). \tag{17}$$

Under mild conditions we can show[10]

$$\frac{\Omega}{i^* - u_1} > 1 \tag{18}$$

so that a unit increase in the rate of capital accumulation leads to a greater than unit decrease in the net credit position of the domestic economy. Net non–human wealth, $n + k$, therefore declines.

The steady state of the economy, obtained when $\dot{k} = \dot{q} = \dot{n} = 0$, is given by the following set of equations

$$U_x(\tilde{x}, \tilde{\ell}) = \overline{\lambda} \tag{19a}$$

$$U_\ell(\tilde{x}, \tilde{\ell}) = -\overline{\lambda} f_\ell(\tilde{k}, \tilde{\ell}) \tag{19b}$$

$$\tilde{q} = 1 - z \tag{19c}$$

$$f_k(\tilde{k}, \tilde{\ell}) = i^*(1 - z) \tag{19d}$$

$$f(\tilde{k}, \tilde{\ell}) - \tilde{x} + i^*\tilde{n} = 0 \tag{19e}$$

$$\tilde{n} + \frac{\Omega}{i^* - u_1}\tilde{k} = n_0 + \frac{\Omega}{i^* - u_1}k_0 \tag{19f}$$

$$\tilde{T} = 0. \tag{19g}$$

These equations jointly determine the steady–state equilibrium values of $\tilde{x}, \tilde{\ell}, \tilde{k}, \tilde{\lambda}, \tilde{q}, \tilde{n}$, and $\tilde{T}$.

The steady state is straightforward, although several aspects merit comment. Note that the steady–state value of $\frac{q}{(1-z)}$ is unity, consistent with the Tobin q theory of investment. The steady–state marginal physical product of capital is equated to the foreign interest rate, net of the investment tax credit. Equation (19e) asserts that in steady–state equilibrium, the balance of payments on current account must be zero; the trade balance must offset net interest earnings on the traded bonds. Equation (19f) describes the equilibrium relationship between the change in the stock of capital and the change in the net credit of the economy. This equation is in effect a long–run intertemporal national budget constraint. The quantity $n_0 + \frac{\Omega k_0}{(i^* - \mu_1)}$ represents the initial present value of total resources available to the economy and can be termed national wealth. This can be broken down into the initial non–human wealth $(n_0 + k_0)$ plus the present value of resources generated by the accumulation of capital starting from the initial stock k_0. Through this term, the steady state depends upon the initial stocks of assets k_0 and n_0 and it is this dependence upon initial conditions which is the source of the *temporary* investment subsidy having *permanent* effects. Finally, with no steady–state investment, and therefore a zero long–run investment subsidy, the steady–state lump sum tax required to balance the government budget is zero.

4. STEADY–STATE EFFECTS OF PERMANENT INCREASE IN ITC

Since the analysis is based on the assumption of perfect foresight, the transitional adjustment is determined in part by the expectations of the long–run steady state. It is therefore convenient to begin with a consideration of the long–run equilibrium effects of the investment subsidy.

The long–run effects of a permanent increase in the investment tax credit are summarized in column 1 of Table 1. From (19d), an increase in z will lower the equilibrium rental rate $i^*(1-z)$, thereby reducing the marginal physical product of capital and increasing the capital–labor ratio. The resulting rise in the real wage induces workers to substitute labor for consumption, while the lower cost of capital simulates capital accumulation. With both the long–run stock of capital and the employment of labor increased, output also rises, though consumption falls. In addition, the long–run increase in the capital stock leads to a long–run decrease in the domestic economy's level of net credit. The reduced interest earnings from abroad require a long–run improvement in the trade balance, which is brought about by the combination of increased output together with reduced consumption. The reduction in private consumption coupled with the increase in employment means a reduction in total steady–state utility. The marginal utility of wealth $\bar{\lambda}$, also falls if and only if (18) holds, as we assume.[11] The effect on steady–state consumption, however, is ambiguous. While on the one hand, the lower marginal utility of wealth will tend to raise equilibrium consumption, this is offset by the substitution away from consumption towards labor, resulting from the higher real wage. If the utility function is additively separable in its two arguments, this latter effect does not exist and the result is an unambiguous increase in consumption. Finally, even though the consumption effect is in general ambiguous, one can nevertheless establish that the increase in employment is sufficiently large to lead to a reduction in total steady–state utility.[12]

5. TRANSITIONAL DYNAMICS: PERMANENT INCREASE IN ITC

As noted previously, the dynamics of q and k are described by a saddlepoint in $k-q$ space. The stable arm XX in Fig. 1.A is given by

$$q = 1 - z + \frac{u_1}{I_q}(k - \tilde{k}) \tag{20a}$$

and is negatively sloped. The unstable arm (not illustrated) is described by

$$q = 1 - z + \frac{u_2}{I_q}(k - \tilde{k}) \tag{20b}$$

and is positively sloped.

As long as no future change is anticipated, the economy must lie on the stable locus XX. The initial jump in the shadow price $q(0)$ following an unanticipated permanent increase in the ITC z is therefore given by

$$\frac{dq(0)}{dz} = -1 - \frac{u_1}{I_q}\frac{d\tilde{k}}{dz}. \tag{21}$$

This depends critically upon the long–run response of the capital stock, where the latter, obtained by taking the differential of the steady–state equations (19) is given by

$$\frac{d\tilde{k}}{dz} = \frac{i^*}{\Delta}[f_\ell \ell_{\bar{\lambda}} - x_{\bar{\lambda}}] > 0$$

where[13]

$$\Delta \equiv [(1 - \Omega/(i^* - u_1))]u_1 f_{k\ell}\ell_{\bar{\lambda}} - [f_{kk} + f_{k\ell}\ell_k][f_\ell \ell_{\bar{\lambda}} - x_{\bar{\lambda}}] > 0.$$

Combining these terms yields

$$\frac{dq(0)}{dz} = \frac{-1}{\Delta}[[1 - \Omega/(i^* - u_1)]]u_1 f_{k\ell}\ell_{\bar{\lambda}} + u_1^2[f_\ell \ell_{\bar{\lambda}} - x_{\bar{\lambda}}].$$

Under the mild conditions noted in footnote 10 $[1 - \Omega/(i^* - u_1)] < 0$, so that $\frac{dq(0)}{dz} < 0$.

The dynamics of the system in response to an unanticipated permanent increase in the investment tax credit are illustrated in Figures 1.A and 1.B. Suppose that the economy starts initially in steady state equilibrium at P on the stable arm XX. A permanent increase in z will shift the new steady state to Q, having a higher capital stock, k, together with a lower q. In the short run, the shadow price jumps down from P to A on the new stable locus $X'X'$. While the increase in z raises the shadow price $\frac{q}{(1-z)}$, thereby stimulating investment, the initial reduction in $q(0)$ has the opposite effect. On balance, the expansionary effect dominates, and capital begins to accumulate.[14]

The initial effect of the increase in the investment tax credit on consumption and employment are given by

$$\frac{dx(0)}{dz} = \frac{\partial x}{\partial \bar{\lambda}}\frac{\partial \bar{\lambda}}{\partial z} > 0 \tag{22a}$$

$$\frac{d\ell(0)}{dz} = \frac{\partial \ell}{\partial \bar{\lambda}}\frac{\partial \bar{\lambda}}{\partial z} < 0. \tag{22b}$$

In this case, the steady state fall in marginal utility implies a short–run increase in consumption, accompanied by a short–run reduction in employment and therefore in output. The marginal physical product of capital is lowered, although by an amount less than the reduction in i^*q, thereby causing q to begin falling. The system therefore begins to move continuously along the locus AQ, towards the new steady state Q. Over time, the accumulation of capital causes output and employment to rise steadily and consumption to fall, so that in the long run these short–run responses are reversed; output and employment rise, while consumption falls.

The movement along AQ in part A corresponds to a movement along LM in part B. By decreasing output, while increasing consumption and investment, the investment tax credit leads to an immediate reduction in the balance of trade, leading to an immediate decumulation of foreign bonds. Over time, the increasing employment and rising output, together with decreasing consumption, leads to a reversal of this trade deficit, and as noted, in the long–run the trade balance is increased.

6. TEMPORARY INCREASE IN ITC

The two previous sections have shown how an unanticipated permanent increase in the rate of investment tax credit leads to a new long–run equilibrium having a lower q, a higher capital stock and employment of labor, and a lower level of net foreign credit. The dynamic adjustment involves an investment boom, accompanied by a current account deficit.

But as noted at the outset, ITC's have been introduced only sporadically as policy instruments. The question we therefore address in this section is the following. What are the long–run and short–run consequences of an investment tax credit which is introduced at some initial time 0 say, but is expected to be removed at time T, so that it is expected to be only temporary? The closed economy literature suggests the following. A known temporary investment tax credit will cause firms to take advantage of the policy while it is in effect, so that for its duration it is more expansionary than an equivalent permanent ITC. But once the subsidy is removed, the system gradually returns to its initial long–run equilibrium.

For the small open economy, as explained below, the first part of this explanation remains valid. That is, the policy is expansionary, and indeed more expansionary while in effect, than if it were permanent. However, the second part is *not*. The economy does not go back to its initial stocks of capital and foreign assets. Instead, the new steady state has a lower stock of capital (and lower employment) and a higher stock of foreign assets than initially, so a temporary investment tax credit turns out to be contractionary in the long run.[15]

This is shown in Fig. 1 and the transitional dynamics is now as follows.[16] As soon as the ITC is increased, the stable arm XX will shift down instantaneously (and temporarily) to $X'X'$, while the shadow price q drops to the point B, which lies above A (the corresponding point for a permanent increase in the same magnitude). Therefore $\frac{q}{(1-z)}$ is initially higher for the temporary investment subsidy and hence in the short run it is more expansionary. At the same time, the marginal utility of consumption $\overline{\lambda}$ will fall by precisely the same (constant) amount as if the shock were permanent and the same is true of employment. As is the case for a permanent expansion, the initial fall in (i^*q) is less than the fall in the marginal physical product of capital resulting from the decline in employment, so that q begins to fall; see (11f). Moreover, the accumulation of capital is accompanied by a decumulation of traded bonds. Hence immediately following the initial jump, q and k follow the path BC in Fig. 1.A, while k and n follow the corresponding path LH in Fig. 1.B. At time T, when the investment tax credit is restored to its original level, the stock of capital and traded bonds will have reached a point such as H in Fig. 1.B. The accumulated stocks of these assets, denoted by k_T and n_T respectively, will now serve as initial conditions for the dynamics beyond time T when z is permanently removed. As noted in Section 4, they will therefore in part determine the new steady state equilibrium. With no new information being received at time T (since the temporary nature of the ITC was known at the outset), and no further jumps, the stable locus relevant for subsequent adjustments in q and k beyond time T is the locus $X''X''$. parallel to XX which passes through the point $k = k_T$. Likewise, the relevant locus linking the accumulation of capital and traded bonds is now $Z'Z'$.

After time T, q and k follow the stable locus CR in Fig. 1.A to the new steady state equilibrium at R, while correspondingly k and n follow the locus HN in Fig. 1.B to the new equilibrium point N. One can establish formally that $X''X''$ lies below the original stable locus XX, while $Z'Z'$ lies above ZZ, as these curves have been drawn. In the new steady state, the shadow price q reverts to its original level, but with a lower stock of capital and a higher stock of traded bonds than originally. The striking feature of the adjustment is that the temporary increase in the ITC leads to a permanent decrease in the stock of capital, accompanied by a higher stock of traded bonds. The reason is that during the temporary phase that the ITC is in effect, the economy accumulates net wealth. As a consequence, the higher level of national wealth at the time the ITC is removed (the new initial condition for the subsequent adjustment) encourages more consumption and less investment thereafter. The result is that capital decumulates more than if the initial accumulation of wealth had not occurred.

In summary, we find that the new steady–state equilibrium resulting from the temporary investment subsidy is one where the stock of capital, the marginal utility of wealth, and labor supply are all reduced, but the level of consumption and leisure time are both higher. It therefore follows that despite the decline in activity, the new steady–state is associated with an increased level of utility.

7. CONCLUSION

In this paper we contrast the effects of a permanent and a temporary investment tax credit in a small open economy. In both cases, an ITC will initially stimulate the rate of investment, while reducing employment and output and generating a current account deficit. If the ITC is permanent, the accumulation of capital will eventually lead to a higher equilibrium stock of capital and higher employment and output, leading to a long–run trade surplus and a corresponding reduction in the long–run stock of net credit of the economy. If the ITC is only temporary, after it is removed, the economy does not go back to its original steady state equilibrium. Rather, it moves to a new steady–state equilibrium having a lower stock of capital and employment, together with a higher stock of net credit, than it began with.

There are two aspects of our model which contribute to the result that a temporary policy has a permanent effect. The first, and more important, is the assumption of perfect capital mobility. A consequence of this is that in order for a well–defined steady–state equilibrium to exist, the discount rate must be set equal to the exogenously given world interest rate. This introduces a zero root into the dynamics, the effect of which is to make the steady state depend upon initial conditions.[17] As a consequence, a temporary policy, by altering these initial conditions for some later date when the policy ceases, has permanent effects on the economy.

Secondly, but to a lesser degree, the endogeneity of employment also plays a role. If instead, labor were fixed, then it is clear that the marginal product condition (19d) determines the equilibrium stock of capital, rendering it independent of initial conditions.[18] In this case, a temporary ITC will have no permanent effect on the long-run capital stock in the economy. Instead, n_0 and k_0 will impact on the long-run stock of traded bonds through the intertemporal budget constraint (19f), and then in turn determine steady-state consumption and marginal utility through (19e) and (19a) respectively. These variables will therefore continue to respond permanently to transitory shocks.

Our model then provides an example of hysteresis in employment in a competitive model having policy shocks. The unemployment in our model is of course voluntary, in contrast to the insider-outsider models of hysteresis as in Blanchard and Summers (1986). The analysis suggests using caution in the conduct of temporary policies in a small open economy in the mistaken belief that these have no long-run consequences.

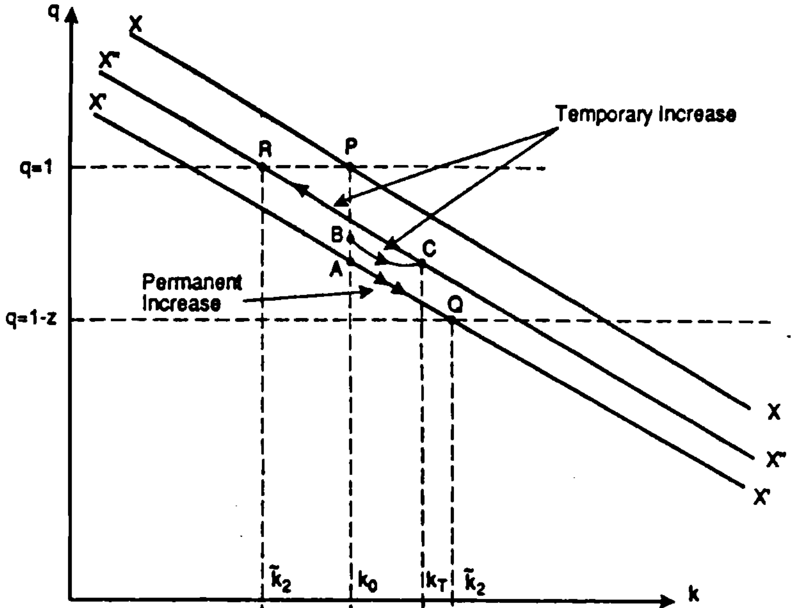

Figure 1.A

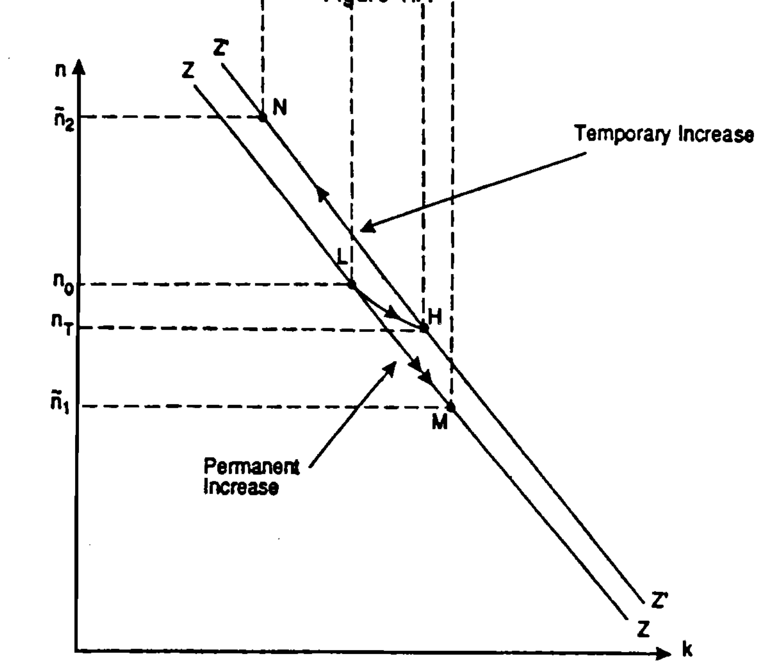

Figure 1.B

Increase in Investment Tax Credit

TABLE 1

EFFECTS OF PERMANENT INCREASE IN ITC

	Steady State Effects	Short Run Effects
Capital Stock	+	0
Employment	+	-
Consumption	?	+
Output	+	-
Balance of Trade	+	-
Real Rental Rate	-	-
Level of International Credit	-	0
Marginal Utility of Wealth	-	-
Total Utility	-	-
Investment	0	+

FOOTNOTES

[1]Canada is retaining ITC's for regional development.

[2]There is a currently growing literature analyzing the accumulation of capital in open economies in response to various types of disturbances. Some of these papers include Buiter (1987) and Obstfeld (1989) who consider fiscal shocks; Matsuyama (1987) who analyzes input shocks, and Sen and Turnovsky (1989) who examine the effects of terms of trade disturbances.

[3]We shall use the following notation. A subscript denotes a partial derivative, a prime denotes a total derivative, and a dot denotes a time derivative. Whenever no confusion may arise, the time subscript is omitted.

[4]All the significant results we obtain, and in particular the hysteresis characteristic remain unchanged if $U_{x\ell} = 0$, so that U is additively separable in x and ℓ. The only difference is that consumption remains constant through time at its steady-state level. Also note that $U_{x\ell} < 0$ is a sufficient, but not necessary condition for signing certain derivatives, below. All results would also continue to hold if instead, we were to assume that consumption and labor supply are normal, in the sense that the former is a decreasing function of, and the latter is an increasing function of, the marginal utility of wealth. This imposes a weaker restriction on the cross derivative $U_{x\ell}$ in that normality may still obtain even if $U_{x\ell} > 0$.

[5]We assume for expositional convenience that investment is financed through retained earnings. As is well known, in a model such as this all modes of financing are equivalent.

[6]The partial derivatives appearing in (10a) and (10b) can be determined by taking differentials of (9a) and (9b).

[7]The quantity q is the ratio of the shadow price of capital (investment) to the marginal utility of wealth. For convenience, we refer to q as being the shadow price of capital.

[8]In this model average and marginal q can be shown to be the same.

[9]The degenerate dynamic equation (7g) is the optimality condition for consumers with respect to their holdings of traded bonds. In general, if the consumer's rate of time discount is δ say, then this optimality condition is $\dot{\lambda} = \lambda(\delta - i^*)$. For this to have a steady state we require $\delta = i^*$, in which case it reduces to (7g).

[10]It can be easily established that in general $\Omega/(i^* - \mu_1) > (1 - z)$. The strengthening of this condition to (18) holds if and only if $z < (f_\ell \ell_k - \lambda_k)/i^*$. Obviously this is met if the rate of investment tax credit is sufficiently small. The alternative case where $1 > \Omega/(i^* - \mu_1) > (1 - z)$ leads to little change in results; see footnotes 12 and 14 below.

[11]A referee has pointed out the possibility that this result depends on the assumption of no depreciation of capital. If instead, capital depreciates at a positive rate, then the long-run response of $\overline{\lambda}$ might be reversed due to the need to maintain a higher stock of capital.

[12]In the alternative case where $1 > \Omega/(i^* - \mu_1) > 1 - z$, steady-state capital and employment still rise, while the economy's level of net credit still declines. The main change is that the marginal utility of wealth $\overline{\lambda}$ now also rises rather than falls, leading to an unambiguous reduction in consumption and in steady-state welfare.

[13]It can be shown by direct evaluation that $\Omega/(i^* - \mu_1) > 1 - z$ implies $\Delta > 0$.

[14]In the alternative case noted in footnote 10, when $1 > \Omega/(i^* - \mu_1) > 1 - z, dq(0)/dz > 0$, both the increase in z and the higher initial q stimulate investment.

[15]Note that in this example we start from a zero ITC and return to that zero rate at time T, when capital decumulation begins. This helps simplify the analysis in that no subsidies are given when investment is negative.

[16]The formal derivations of these adjustment paths are given in the Appendix.

[17]See Giavazzi and Wyplosz (1984) and Buiter (1986) for further discussion of this point.

[18]Alternatively, the role played by labor in this model can be captured by introducing a non-traded consumption good; see Brock (1988).

APPENDIX

FORMAL SOLUTIONS FOR TEMPORARY DISTURBANCES

Suppose that the economy starts out from steady state at time 0 with the investment tax credit set initially at the level z_0, and with the corresponding stocks of physical capital k_0, and foreign assets, n_0. At time 0, the ITC is changed to z_1, where it remains until time T, when it is changed back permanently to its original level z_0. Because of the shift nature of these changes, it is convenient to consider the dynamics over two periods: (i) the period $(0, T)$ when the temporary policy change is in effect; (ii) the period after T, when the policy is permanently removed.

We begin by considering the steady state which *would* prevail if z_1, the temporary level of the ITC *were* to continue indefinitely. From equations (19) of the text, this is given by the set of equations

$$U_x(\tilde{x}_1, \tilde{\ell}_1) = \bar{\lambda}_1 \tag{A.1a}$$

$$U_\ell(\tilde{x}_1, \tilde{\ell}_1) = -\bar{\lambda}_1 f_\ell(\tilde{k}_1, \tilde{\ell}_1) \tag{A.1b}$$

$$\tilde{q}_1 = 1 - z_1 \tag{A.1c}$$

$$f_k(\tilde{k}_1, \tilde{\ell}_1) = i^*(1 - z_1) \tag{A.1d}$$

$$f(\tilde{k}_1, \tilde{\ell}_1) - \tilde{x}_1 + i^* \tilde{n}_1 = 0 \tag{A.1e}$$

$$\tilde{n}_1 - n_0 = -\frac{\Omega_1}{i^* - u_1}(\tilde{k}_1 - k_0) \tag{A.1f}$$

where, as in the text $u_1 < 0$ is the stable eigenvalue and now $\Omega_1 \equiv f_k + f_\ell \ell_x - x_k - u_1 > 0$. Also, tildes denote steady states, and the subscript 1 denotes the first regime (i.e., when the temporary policy is in effect). These equations may be solved for k_1, n_1, in particular, in the form

$$\tilde{k}_1 = \beta(k_0, n_0, z_1) \tag{A.2a}$$

$$\tilde{n}_1 = \alpha(k_0, n_0, z_1). \tag{A.2b}$$

Using this notation, the fact that k_0, n_0 are initial steady states, implies

$$k_0 = \beta(k_0, n_0, z_0) \tag{A.3a}$$

$$n_0 = \alpha(k_0, n_0, z_0). \tag{A.3b}$$

The partial derivatives of the functions β, α, can be obtained by taking differentials of the system (A.1). In particular, we may establish

$$\frac{\partial\beta}{\partial k_0} \equiv \beta_k = \frac{\Omega_1}{i^* - u_1}\beta_n \tag{A.4a}$$

$$\frac{\partial\beta}{\partial n_0} \equiv \beta_n = \frac{i^* f_{k\ell}}{D}[U_{\ell x} + f_\ell U_{xx}] < 0 \tag{A.4b}$$

$$\frac{\partial\beta}{\partial z_0} \equiv \beta_z = -\frac{i^*}{D}[f_\ell^2 U_{xx} - 2f_\ell U_{x\ell} - (U_{\ell\ell} + \lambda f_{\ell\ell})] > 0 \tag{A.4c}$$

$$\frac{\partial\alpha}{\partial k_0} \equiv \alpha_k = -\frac{\Omega_1}{i^* - \mu_1}[\beta_k - 1] \tag{A.4d}$$

$$\frac{\partial\alpha}{\partial n_0} \equiv \alpha_n = 1 - \beta_k \tag{A.4e}$$

$$\frac{\partial\alpha}{\partial z} \equiv \alpha_z = -\frac{\Omega_1}{i^* - u_1}\beta_z < 0 \tag{A.4f}$$

where D, the Jacobian of (A.1) > 0.

The dynamic adjustments of the state variables k, q and n over the initial phase $(0, T)$ are given by the equations

$$k = \tilde{k}_1 + A_1 e^{u_1 t} + A_2 e^{u_2 t} \tag{A.5a}$$

$$q = \tilde{q}_1 + A_1 \frac{u_1}{I}, e^{u_1 t} + A_2 \frac{u_2}{I_q} e^{u_2 t} \tag{A.5b}$$

$$n = \tilde{n}_1 + \left[n_0 - \tilde{n}_1 - \frac{A_1\Omega_1}{u_1 - i^*} - \frac{A_2\Omega_2}{u_2 - i^*}\right] e^{i^* t} + \frac{A_1\Omega_1}{u_1 - i^*} e^{u_1 t} + \frac{A_2\Omega_2}{u_2 - i^*} e^{u_2 t} \tag{A.5c}$$

where $u_2 > 0$, is the unstable eigenvalue, $\Omega_2 \equiv f_k + f_l \ell_k - x_k - u_2$, and the constants A_1, A_2 are yet to be determined. Observe that equations (A.5a) - (A.5c) describe time paths that in the absence of a future disturance would be ultimately unbounded.

For the period after time T, when the temporary policy is removed, the steady state is now determined by the set of equations

$$U_x(\tilde{x}_2, \tilde{\ell}_2) = \overline{\lambda}_2 \tag{A.6a}$$

$$U_\ell(\tilde{x}_2, \tilde{\ell}_2) = -\overline{\lambda}_2 f_\ell(\tilde{k}_2, \tilde{\ell}_2) \tag{A.6b}$$

$$\tilde{q}_2 = 1 - z_0 \tag{A.6c}$$

$$f_k(\tilde{k}_2, \tilde{\ell}_2) = i^*(1 - z_0) \tag{A.6d}$$

$$f(\tilde{k}_2, \tilde{\ell}_2) - \tilde{x}_2 + i^* \tilde{n}_2 = 0 \tag{A.6e}$$

$$\tilde{n}_2 - n_T = -\frac{\Omega_1}{i^* - u_1}(\tilde{k}_2 - k_T) \tag{A.6f}$$

where the subscript 2 now denotes the second regime, and k_T, n_T, denote the stocks of k, n at time T, the instant the ITC is restored to its initial level. Solving these equations for $\tilde{k}_2, \tilde{n}_2$ yields the solutions

$$\tilde{k}_2 = \beta(k_T, n_T, z_0) \tag{A.7a}$$

$$\tilde{n}_2 = \alpha(k_T, n_T, z_0) \tag{A.7b}$$

where the functions β, α are of the same form as in (A.2).

In order for the transversality conditions to be met, the dynamics over this latter period must be stable and are given by

$$k = \tilde{k}_2 + A_1' e^{u_1 t} \tag{A.8a}$$

$$q = \tilde{q}_2 + A_1' \frac{u_1}{I_q} e^{u_1 t} \tag{A.8b}$$

$$n = \tilde{n}_2 + A_1' \frac{\Omega_1}{u_1 - i^*} e^{u_1 t} \tag{A.8c}$$

where A_1' is yet to be determined.

The three constants A_1, A_2, A_1' are determined by: (i) an initial condition on k_0, together with continuity conditions on k and q at time T. Thus setting $t = 0$ in (A.4a) and equating the solutions for (A.4a), (A.7a) and (A.4b) and (A.7b) at time T yields

$$A_1 + A_2 = -(\tilde{k}_1 - k_0) \tag{A.9a}$$

$$A_1 e^{u_1 T} + A_2 e^{u_2 T} - A_1' e^{u_1 T} = \tilde{k}_2 - \tilde{k}_1 \tag{A.9b}$$

$$A_1 \frac{u_1}{I_q} e^{u_1 T} + A_2 \frac{u_2}{I_q} e^{u_2 T} - A_1' \frac{u_1}{I_q} e^{u_1 T} = \tilde{q}_2 - \tilde{q}_1. \tag{A.9c}$$

In order to evaluate these constants, we must first determine the changes in the relevant steady–state equilibria. Letting $dz \equiv (z_1 - z_0)$ equations (A.1c), (A.6c) immediately imply

$$\tilde{q}_2 - \tilde{q}_1 = dz \tag{A.10a}$$

while (A.2a), (A.3a), together with (A.4) imply

$$\tilde{k}_1 - k_0 = \beta_z dz. \tag{A.10b}$$

The evaluation of $\tilde{k}_2 - \tilde{k}_1$ is more complicated. From (A.7a), (A.2a), and (A.4) we obtain

$$\tilde{k}_2 - \tilde{k}_1 = \beta_n \left[\frac{\Omega_1}{i^* - u_1}(k_T - k_0) + (n_T - n_0) \right] - \beta_z dz.$$

Using equations (A.5a), (A.5c) to determine k_T, n_T, and (A.1f), this last equation may be rewritten as

$$\tilde{k}_2 - \tilde{k}_1 = \beta_n \left[A_2 e^{u_2 T} \left[\frac{\Omega_2}{u_2 - i^*} - \frac{\Omega_1}{u_1 - i^*} \right] + \left[n_0 - \tilde{n}_1 - \frac{A_1 \Omega_1}{u_1 - i^*} - \frac{A_2 \Omega_2}{u_2 - i^*} \right] e^{i^* T} \right] - \beta_z dz.$$

Noting further that

$$\tilde{n}_1 - n_0 = \frac{\Omega_1}{u_1 - i^*} \beta_z dz$$

we obtain

$$\tilde{k}_2 - \tilde{k}_1 = -\beta_n \left[\frac{\Omega_1}{u_1 - i^*} - \frac{\Omega_2}{u_2 - i^*}\right] A_2 e^{u_2 T} - \beta_n \left[\frac{A_1\Omega_1}{u_1 - i^*} + \frac{A_2\Omega_2}{u_2 - i^*}\right] e^{i^* T} - \beta_z \left[1 + \frac{\beta_n \Omega_1}{u_1 - i^*} e^{i^* T}\right] dz \quad (A.10c)$$

Substituting (A.10a) - (A.10c) into (A.9a) - (A.9c) we may solve for the constants A_1, A_2, A_1'. In particular, we may establish

$$A_1 = -\beta_z dz - A_2$$

$$A_2 = (\beta_z u_1 + I_q)\frac{dz}{D'}$$

where

$$D' \equiv (u_2 - u_1)e^{u_2 T} + u_1 \beta_n \left[\frac{\Omega_1}{u_1 - i^*} - \frac{\Omega_2}{u_2 - i^*}\right]\left[e^{i^* T} - e^{u_2 T}\right] > 0.$$

In evaluating this expression for D', we are using the result, immediate from (11) that $\mu_2 = i^* - \mu_1 > i^*$.

Having thus obtained the solutions for k, q and n, the following relationships may be further established:

$$(i) \quad \tilde{q}_1 - \frac{u_1}{I_q}, \tilde{k}_1 < q_T - \frac{u_1}{I_q}, k_T < q_0 - \frac{u_1}{I_q} k_0$$

$$(ii) \quad n_0 + \frac{\Omega_1}{i^* - u_1} k_0 < n_T + \frac{\Omega_1}{i^* - u_1} k_T.$$

The first of these implies that both the lines $X''X''$ and $X'X'$ lie below XX, with $X''X''$ lying in between, as drawn in Fig. 1A. The second implies that the line $Z'Z'$ lies above ZZ, as drawn in Fig. 1B. The shapes of the adjustment paths BC and LH can also be established from the solutions for k, q and n.

Note that in order for the consumer optimality conditions to hold, λ must be constant at all times, other than time 0, but including time T. It therefore jumps instantaneously at time 0 to its new value $\bar{\lambda}_2$. It can be shown that a temporary increase in z implies a permanent reduction in $\bar{\lambda}_2$.

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