Tariff-Financed Public Inputs in the Mobile Capital Harris-Todaro Model

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Introduction

It has been widely recognised that encouraging public investment on infrastructure (e. g., transport and communication systems and irrigation facilities) is a key to enhancing domestic production possibilities in LDCs and solving various problems involving underdevelopment. Of course the consequences of spending on infrastructure depend not only on the impact of spending itself but also on the source of funds for this expenditure. Empirical studies by Greenaway (1984) and Burgess and Stern (1993) have shown that taxes on trade activities, such as tariffs, play an important role in financing public spending in LDCs. This is because of administrative feasibility, political problems, and poorly developed domestic markets. So it may be important to clarify how infrastructure is provided and operated using tariff revenues. From this viewpoint, with an approach similar to that of Feehan (1992), I examined in a previous paper [Matsumoto (1995)] the optimal tariff-financing rule for public inputs that are independent variables in firms' production functions. Both of these studies were based on the work of Komiya (1967) in which a non-traded good sector is incorporated into the Heckscher-Ohlin-Samuelson (H-O-S) model.

This paper extends the study of tariff-financed public input provision by introducing the Harris-Todaro (H-T) type of sector-specific unemployment. The basis for this paper is the well-known mobile capital H-T model, which was developed by Corden and Findlay (1975). Originally, Harris and Todaro (1970) explained labourers' locational choices between urban and rural areas in terms of their expected income-maximising behaviour. This, combined with the rigidity of the urban wage rate, captures a significant feature of LDCs. That is, despite persistent urban unemployment, there is mass migration from rural to urban areas. Although the H-T framework has been used to examine the impact of public policies in LDCs,[1] public input provision has seldom been considered in the literature. Exceptions are Jones and O'Neill (1994, 1995). However, their analyses were confined to the comparative statics of the impact of public input provision.[2]

By deriving the optimal supply rule for a tariff-financed public input, this paper focuses its attention on the economic cost of the additional provision of the public input in the mobile capital H-T model. Ideally, when there is no distortion, a public input should be supplied such that the sum of the values of its marginal products is equal to the marginal physical cost of producing the public input, which amounts to the cost measure of public input provision.[3)] By contrast, besides the marginal physical cost, the cost measure in this paper includes the distortionary impacts of public input provision resulting from both the use of a tariff to provide the public input and the presence of the H-T type of labour market imperfection. The second-best cost measure is examined in detail. In particular, whether the cost of public input provision in a tariff-distorted H-T economy exceeds that in a first-best economy is considered according to the Pigovian tradition.

This paper also examines second-best shadow factor prices in the presence of tariff distortion. It is shown that in the mobile capital H-T model, the shadow price of labour (capital) under tariff distortion is greater (lower) than that when the introduction of lump-sum taxes is possible. As a result, public production in this paper is capital intensive relative to that in the case with non-distortionary taxes.

This paper is organised as follows. The next section describes the model. Section II considers the impact of public input provision and tariff policy on private production. Based on the results obtained in that section, the optimal rule for public input provision is derived and examined in Section III. Concluding remarks are made in Section IV.

I. The model

Consider a small open economy with an urban manufacturing sector and a rural agricultural sector, which are denoted by M and A respectively. In both sectors, private production is carried out using labour, capital, and a public input. The public input is produced by the public sector using labour and capital. The public sector is located in urban areas.[4)] Production functions are

(1a) $X^i = g^i(G) f^i(L^i, K^i)$, $(i = M, A)$

(1b) $G = f^G(L^G, K^G)$,

where X^i is the output of sector i, L^i and K^i are, respectively, the amount of labour and capital employed in sector i, and G is the amount of the public input. It is assumed that $dg^i / dG \geqq 0$. Let good M (A) be an importable (exportable) good. The costs of producing the public input are paid for with the revenue raised by a tariff imposed on good M. f^i and f^G are well-behaved and linearly homogeneous. This means that the public input is of the factor-augmenting type, which has an impact equivalent to Meade's (1952) atmosphere externality.

Following H-T, throughout this paper the urban wage is fixed above its market-clearing level, whereas the rural wage is competitively determined. Labourers migrate from rural to urban areas until the rural wage equals the expected urban wage, which is equal to the urban wage times the probability of finding a job in the urban sector:

(2) $W^M/(1+\lambda)=W^A$,

where W^i is the wage rate in sector i and λ is the ratio of the level of urban unemployment to the level of urban employment $[(L-L^M-L^G-L^A)/(L^M+L^G)$, where L is the endowment of labour]. In the H-T framework, $1/(1+\lambda)$, which is the ratio of the urban employed to the urban labour force, represents the probability of finding a job in the urban sector.[5] The capital market is competitive and the rate of return on capital is equalised between the urban and rural sectors. Given market prices and the amount of the public input, private firms maximise their profits. The zero-profit conditions for private production are

(3a) $q=P+t=C^M(W^M, r, G)$,

(3b) $1=C^A(W^A, r, G)$,

where q (P) is the domestic (world) price of good M in terms of good A (good A is chosen as a numeraire). t is the tariff rate, C^i is the unit-cost function, and r is the rate of return on capital. Since P remains fixed in this paper, I will consider q rather than t to be a choice variable. From (1), C^i is linearly homogeneous in factor prices. Publicly-employed labour and capital receive W^M and r, respectively, since the public input is produced in urban areas. However, unlike Matsumoto (1995), the public sector in this paper is not constrained to minimise its production costs evaluated at market factor prices.[6]

Solving (2) and (3) gives

(4) $W^A=W^A(q, G)$, $r=r(q, G)$, $\lambda=\lambda(q, G)$.

Using (4) the conditions for factor market equilibrium are

(5a) $[1+\lambda(q, G)]\,[C^M{}_w(W^M, r(q, G), G)X^M+L^G]+C^A{}_w(W^A(r, G), r(q, G), G)X^A=L$,

(5b) $C^M{}_r(W^M, r(q, G), G)X^M+C^A{}_r(W^A(r, G), (q, G), G)X^A+K^G=K$,

where subscripts denote partial derivatives and K is the economy's endowment of capital. Note that $\lambda\,(C^M{}_wX^M+L^G)$ represents the level of urban unemployment. Solving (5a, b) for X^M and X^A yields

(6) $X^M=X^M(q, G, L^G, K^G)$, $X^A=X^A(q, G, L^G, K^G)$.

From (6), public production affects private production through both the direct impact of G and a Rybczynski effect arising from changes in L^G and K^G.

All residents have identical preferences and identical factor endowments. This assumption and the risk-neutrality assumption in H-T [see (2)] allow me to describe the consumption side of the economy aggregatively. The Marshallian demand for good i is denoted by $D^i(q, I)$ where

(7) $I = I(q, G) = W^A(q, G)L + r(q, G)K$
$= qX^M(q, G, L^G, K^G) + X^A(q, G, L^G, K^G) + W^M L^G + r(q, G)K^G$

is the economy's aggregate income. Although the RHS of (7) includes L^G and K^G, they do not influence the aggregate income since $qX^M{}_{L^G} + X^A{}_{L^G} = W^M$ and $qX^M{}_{K^G} + X^A{}_{K^G} = r$. I denote the indirect welfare function by V (q, I). Utility maximisation implies that

(8a) $qD^M{}_I + D^A{}_I = 1,$
(8b) $qD^{CM}{}_q + D^{CA}{}_q = 0,$

where D^{ci} is the Hicksian demand function for good i ($D^{ci}{}_q = D^i{}_q + D^M D^i{}_I$).
The equilibrium condition for the economy is given by

(9) $P[X^M(q, G, L^G, K^G) - D^M(q, I(q, G))] + X^A(q, G, L^G, K^G) - D^A(q, I(q, G)) = 0,$

which is the balance of trade condition. Walras' law implies that the public budget constraint, $t\ (D^M - X^M) = W^M L^G + rK^G$, is balanced when (9) holds. The government sets the level of q, G, L^G, and K^G to maximise V (q, I) subject to (1b) and (9) :

(10) $\mathrm{Max}_{q,G,L^G,K^G} V(q, I(q, G))$, s. t. (1b) and (9).

II. Effects of public input provision and tariff policy on private production

This section examines the effects of changing the amount of the public input and the tariff rate on private production, that is, the partial derivatives of (6) with respect to G and q.[7] This examination is essential for the analysis of the optimal rule for public input provision in this paper. I begin with a consideration of the effect of the public input. Differentiating (5) with respect to G yields the partial derivative of (6) with respect to G :

(11a) $X^M{}_G = X^M \eta^M - \{(1+\lambda)\alpha^M(r^G / r) - \alpha^A[(W^A{}_G / W^A)$
$- (r_G / r)]\} / \Delta - C^A{}_r(L^M + L^G)\lambda_G / \Delta,$
(11b) $X^A{}_G = X^A \eta^A + q\{(1+\lambda)\alpha^M(r_G / r) - \alpha^A[(W^A{}_G / W^A)$
$- (r_G / r)]\} / \Delta + C^M{}_r(L^M + L^G)\lambda_r / \Delta,$

where $\eta^i = (dg^i\ /\ dG)\ /\ g^i$, $\alpha^M = C^M{}_{W_r}X^M$, $\alpha^A = C^A{}_{W_r}X^A$, and $\Delta = (1+\lambda)\, C^M{}_W C^A{}_r - C^M{}_r C^A{}_W$.[7]
Differentiating (2) and (3) yields the partial derivatives of (4) :

(12a) $r_G / r = q\eta^M / rC^M{}_r = \eta^M / \theta^{MK},$
(12b) $W^A{}_G / W^A - r_G / r = [\eta^A - (q\eta^M / rC^M{}_r)] / W^A C^A{}_W$

$$=[\eta^{A}-(\eta^{M}/\theta^{MK})]/\theta^{AL},$$

(12c) $$-W^{A}_{G}/W^{A}=\lambda_{G}/(1+\lambda)=[q\eta^{M}(C^{A}_{r}/C^{M}_{r})-\eta^{A}]/W^{A}C^{AW}$$
$$=[\eta^{M}(\theta^{AK}/\theta^{MK})-\eta^{A}]/\theta^{AL},$$

where θ^{ij} is the income share of factor j in sector i [e. g., $\theta^{MK}=rC^{M}_{r}/q$]. To derive (12), $C^{iG}=-C^{i}\eta^{i}$ is used (see footnote 8). Regarding (12c), (2) implies that $-d\lambda/(1+\lambda)=dW^{A}/W^{A}$.

Neary (1981) showed that an equilibrium in the mobile capital H-T model is locally, asymptotically stable if and only if the urban sector is capital intensive relative to the rural sector in the value sense [see also McCool (1982)]. This means that $\eta<0$, or equivalently, $\theta^{AK}/\theta^{MK}<1$. This condition is assumed in this paper. In the mobile capital H-T model, the ranking of factor-intensities in the value sense is relevant to the effect of public policies on production.

According to (11), the impact of the public input on production can be decomposed into three parts. The first term on the RHS of (11) is the marginal product of the public input. The second term corresponds to the factor substitution effect in Matsumoto (1995) [see his (11)]. The third term, which is endemic to the H-T economy, captures the impact on urban unemployment. I call this the unemployment effect.

The factor substitution effect is the result of the impact of the public input on the wage-rental ratios in both sectors, which are represented by W^{M}/r and W^{A}/r respectively. As usual, a rise (fall) in the wage-rental ratios induces an intersectoral substitution towards the labour (capital) intensive good A (M) since $\Delta<0$. However, (12a, b) show that the direction of the changes in the urban and rural wage-rental ratios caused by public input provision may be different. Whereas W^{M}/r falls, W^{A}/r may increase or decrease depending on the difference in η^{i}. Thus, the induced direction of substitution is uncertain. A substitution towards good M occurs if $\eta^{M}\geqq\eta^{A}$. The opposite direction of substitution happens only if $\eta^{M}<\eta^{A}$. Unlike the H-O-S model of Matsumoto (1995), the factor substitution effect in this paper appears even if the public input has an equiproportional impact on private industries where $\eta^{M}=\eta^{A}$. This is because of the fixity of the urban wage.

The unemployment effect can be considered to be an example of Rybczynski's effect of public input provision. With a fixed level of urban employment, an increase in the public input changes the magnitude of the employed labour force available to private industries by $(L^{M}+L^{G})\lambda_{G}$. Taking the wage-rental ratios as given, this change in factor allocation affects private production in a Rybczynski fashion since (4) implies that factor prices and λ are independent of factor endowments as in the H-O-S model. As a result, the output of the capital intensive good M (the labour intensive good A) increases if $\lambda^{G}>(<)0$. Recalling that stability implies that $\theta^{AK}/\theta^{MK}<1$, (12c) shows that λG is negative (positive) if (only if) $\eta^{A}\geqq(<)\eta^{M}$.

Next, the impact of the tariff on production, Xiq, is investigated. From (4) and (5), I have

(13a) $$X^{M}_{q}=-\{(1+\lambda)\alpha^{M}(r_{q}/r)-\alpha^{A}[(W^{A}_{q}/W^{A})-(r_{q}/r)]\}/\Delta-C^{A}_{r}(L^{M}+L^{G})\lambda_{q}/\Delta,$$

(13b) $$X^{A}_{q}=q\{(1+\lambda)\alpha^{M}(r_{q}/r)-\alpha^{A}[(W^{A}_{q}/W^{A})-(r_{q}/r)]\}/\Delta+C^{M}_{r}(L^{M}+L^{G})\lambda_{q}/\Delta,$$

where

(14a) $r_q / r = 1 / rC^M_r = 1 / (q\theta^{MK})$,

(14b) $W^A_q / W^A - r_q / r = -1 / (W^A C^{AW} r C^M_r) = -1 / (q\theta^{AL}\theta^{MK})$,

(14c) $-W^A_q / W^A = \lambda_q / (1+\lambda) = C^A_r / (W^A C^{AW} C^M_r) = \theta^{AK} / (q\theta^{ML}\theta^{MK})$.

The literature on the mobile capital H-T model has demonstrated that, under the Neary stability condition, a rise in the tariff rate increases the output of the private good that is subject to the tariff (good M in this paper). This effect can be identified using (13) and (14). Since (14a, b) imply that the wage-rental ratios fall with a tariff increase, a substitution towards the capital intensive good M arises. Moreover, from (14c), the decrease in the available employed labour force increases the output of good M, as in the unemployment effect in (11). As a result of this effect on λ, a tariff change alters the value of private production[9]:

(15) $qX^M_q + X^A_q = -W^A(L^M + L^G)\lambda_q$.

This equation has appeared frequently in the previous studies on the mobile capital H-T model [see, for example, (11) in Batra and Naqvi (1987)].

III. The optimal rule for tariff-financed public input provision

Using the results obtained in Section II, this section derives and examines the optimal rule for tariff-financed public input provision. From (10), the Lagrangian for the problem is as follows:

$$\Omega = V(q, I(q, G)) + \beta\,[f^G(L^G, K^G) - G]$$
$$+ \gamma\{P[X^M(q, G, L^G, K^G) - D^M(q, I(q, G))] + X^A(q, G, L^G, K^G) - D^A(q, I(q, G))\},$$

where β and γ are Lagrangian multipliers associated with (1b) and (9), respectively. γ represents the social marginal utility of income. β / γ is the shadow price of the public input in terms of the numeraire, which amounts to its marginal physical cost, as shown by (16) below. In what follows, I denote β / γ by C^{SG}.

Using (5), the first-order conditions for choosing the amount of publicly-employed factors are

(16a) $W^S = C^{SG} f^G_{LG} = -PX^M_{LG} - X^A_{LG} = (1+\lambda)(PC^A_r - C^M_r) / \Delta$
$= W^M - [t(1+\lambda)C^A_r / \Delta]$,

(16b) $r^S = C^{SG} f^G_{KG} = -PX^M_{KG} - X^A K_{KG}[(1+\lambda)(C^M_W - PC^A_W) / \Delta$
$= r + (tC^A_W / \Delta)$,

where W^S (r^S) is the shadow price of labour (capital)[10]. As in the H-O-S model with tariff distortion [see Section I in Srinivasan and Bhagwati (1978)], the shadow price of a factor equals the change in the value of private production, evaluated at world prices, as a result of the increase in that factor available to private industries. (16a, b) show that $W^S > W^M > 0$ and $r > r^S > 0$ since $\Delta < 0$.[11] Noting that $W^S = W^M$ and $r = r^S$ when $t = 0$, this result implies that, for producing the public input, the public sector chooses technology that is more capital intensive than the case where there is no tariff distortion.

Using Roy's identity and Slutsky's decomposition and noting (8b) and (15). the first-order condition for choosing the tariff rate becomes

$$(17)\quad [(V_I/\gamma)-(PD^M_I+D^A_I)]=[t(X^M_q-D^{CM}_q)+W^A(L^M+L^G)\lambda_q]/(I_q-D^M).$$

The qualitative result derived from (17) is similar to that derived from Matsumoto (1995). It can be shown that Iq-DM, which is the welfare impact of changing the tariff rate in terms of the numeraire, is negative in the presence of normality in consumption and the absence of the Laffer effect of the tariff.[12] This implies that the social marginal utility of income (γ) is greater than its private marginal utility (V_I) at the optimum since the RHS of (17) is negative and $PD^M_I + D^A_I < 1$. This result reflects the fact that using a tariff to raise the government's revenue restricts transfer possibilities between the private and public budgets. In the mobile capital H-T model, this distortion deteriorates because of the impact of the tariff on urban unemployment.

By (17), the first-order condition for choosing the amount of the public input is

$$\begin{aligned}(18)\quad PX^M_G+X^A_G&=C^{SG}-[(V_I/\gamma)-(PD^M_I+D^A_I)]I_G\\ &=C^{SG}+[t(X^M_q\text{-}D^{CM}_q)+W^A\,(L^M+L^A)\lambda_q]\,[I_G/(D^M\text{-}I_q)].\end{aligned}$$

Making use of (11) and (16a) yields

$$\begin{aligned}(19)\quad PX^M_G+X^A_G=PX^M\eta^M+X^A\eta^A+t\{(1+\lambda)\alpha^M(r_G/r)-\alpha^A[(W^A_G/W^A)\\ -(r_G/r)]\}/\Delta-W^S(L^M+L^G)[\lambda_G/(1+\lambda)].\end{aligned}$$

Substituting (19) into (18) and using (12) yield the optimal supply rule for the public input:

$$\begin{aligned}(20)\quad PX^M\eta^M+X^A\eta^A=C^{SG}+[t(X^M_q\text{-}D^{CM}_q)+W^A(L^M+L^G)\lambda_q]\,[I_G/(D^M\text{-}I_q)]\\ -t\{(1+\lambda)\alpha^M(\eta^M/\theta^{MK})-\alpha^A[\eta^A-(\eta^M/\theta^{MK})]/\theta^{AL}\}/\Delta\\ +W^S(L^M+L^G)[\eta^M(\theta^{AK}/\theta^{MK})-\eta^A]/\theta^{AL}.\end{aligned}$$

Since replacing λ_q with (14c) does not give any insight into the analysis, it is left intact in (20).

The RHS of (20) measures the economic cost of the additional provision of the public input, which must be equalised with the sum of the values of its marginal products at the optimum. In a first-best setting, the economic cost of providing one more unit of a public input is its marginal physical cost, or equivalently, the shadow price of the public input CSG. Compared with this setting, the distortionary impacts arising from the rigidity of the tax system and the presence of urban unemployment are incorporated into the cost measure of public input provision in this paper. These impacts are captured by the second, third, and fourth terms on the RHS of (20).

The second term on the RHS of (20) is the result of impact of a change in the tariff rate to finance the additional public expenditure. As in Matsumoto (1995), I call this the tariff effect. The term $I_G / (I_q\text{-}D^M)$ captures the change in the tariff rate when the amount of the public input is raised.[13] This tariff change affects the cost of the public input through its impact on the tariff revenue and urban unemployment. The sign of the tariff effect coincides with that of I_G since $[t(X^M{}_q\text{-}D^{CM}{}_q)+W^A(L^M+L^G)\lambda_q] / (\text{D徐}\text{-}I_q)>0$. From (7) and (11), the formula of I_G is as follows:

$$
\begin{aligned}
(21)\quad I_G &= qX^M\eta^M + X^A\eta^A - W^A(L^M+L^G)\lambda_G + r_G K^G \\
&= (\eta^A / CA_W)L + q\eta^M[-X^M\Delta + K^G C^M{}_W - C^A{}_r(1+\lambda)L^G] / C^A{}_W C^M{}_r.
\end{aligned}
$$

The second expression in (21) is derived using (12a, c). The first expression implies that $I_G > 0$ if $\eta^A \geqq \eta^M$ (recall that $\lambda_G<0$ in this case).

The third and fourth terms on the RHS of (20) are the factor substitution effect and the unemployment effect of public input provision, respectively. These effects were examined in Section II. The factor substitution effect gives rise to substitution between private goods by altering the wage-rental ratios in both sectors. This changes the tariff revenue and influences the cost of public input provision. The unemployment effect means that public input provision generates a welfare impact by changing the level of urban unemployment, which is evaluated at the shadow price of labour. As a matter of course, this effect arises even if the introduction of lump-sum taxation is possible.

Table 1

Signs of the distortionary effects in (20) under different conditions of ηi *

	$\eta^M=\eta^A$	$\eta^M>0,\ \eta^A=0$	$\eta^M=0,\ \eta^A=0$
tariff effect	+	±	+
factor substitution effect	+	+	−
unemployment effect	−	+	−

* The ± sign regarding the tariff effect indicates that the sign cannot be determined with certainty.

These arguments cast light on the cost structure of tariff-financed public input provision in the mobile capital H-T model. The sign of each effect in (20) is uncertain. Table 1 summarises the sign in three cases, each being associated with a particular condition of η^i, although this does not intend to say that other possible cases are not important. Any clear-cut result regarding whether the economic cost of the public input exceeds its shadow prices cannot be easily obtained in this paper. In the H-O-S model of Matsumoto (1995), the tariff-financing cost of a pure public input exceeds its shadow price when this input has an equiproportional impact ($\eta^A=\eta^M$ in this paper). This result does not apply to the mobile capital H-T model because of the unemployment effect. Based on the notion that LDCs' governments typically overinvest in manufacturing facilities, Jones and O'Neill (1995) stated that the cost of providing an urban public input ($\eta^M > 0$, $\eta^A = 0$) in a H-T economy would be less than that in a first-best economy. However, this statement of Jones and O'Neill was made without deriving the optimal rule for public input provision, and it would not be true at least under the conditions specified in this paper.[14] From (20) and (21), the cost of the urban public input is below its shadow price only if the rural sector is more capital intensive than the public sector in the value sense. This would be implausible in LDCs where rural production uses technology that is very labour intensive. By contrast, the rural specific case ($\eta^M = 0$, $\eta^A > 0$) does not yield any lucid results since the tariff effect may act contrary to other effects in influencing the cost of public input provision.

Lastly, the analysis of public input provision in this paper has a bearing on the H-T literature on tax-subsidy policies. For example, Batra and Naqvi (1987) have argued that public policies that raise (reduce) the volume of trade are beneficial (detrimental) to welfare in the mobile capital H-T model. In this paper, (11) and (20) imply that the distortionary effect of public input provision that encourages the production of the exportable (importable) good is profitable (harmful) in the sense that it decreases (increases) the cost of this provision. The positive (negative) signs in Table 1 correspond to this situation.

IV. Concluding remarks

This paper has examined the implication of earmarking tariff revenues for public input provision in the mobile capital H-T model. This study may have practical importance since a dependence on tariffs for raising tax revenues and the presence of urban unemployment are common characteristics of LDCs. It has been clarified how these distortions affects the optimal rule for public input provision.

The tariff-financing constraint implies that the cost of public input provision is influenced by the tariff effect and the factor substitution effect. Although the ideas behind these effects are similar to those in the H-O-S model of Matsumoto (1995), they are complicated in the mobile capital H-T model with labour market imperfection. Regardless of the source of tax revenues, the unemployment effect, which captures the impact of public input provision on urban unemployment, also distorts the cost structure of this provision. These three effects would be expected to increase the substantial cost of public inputs provided to the urban manufacturing sector. However, their signs and magnitudes could not be seen without detailed information on production and consumption parameters. In prescribing policies for spending on infrastructure in LDCs, the economic consequences of each effect and of their total effect should be carefully considered.

By deriving second-best shadow factor prices, this paper has also shown how public production is distorted by the use of tariffs to pay for publicly-employed factors. The presence of tariff distortion increases (decreases) the shadow price of labour (capital) in the mobile capital H-T model. This result implies that the capital-labour ratio in the public sector in the presence of tariff distortion is greater than that which is required to minimise production costs when the costs are financed by non-distortionary taxes.

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Notes

1) The policy analyses in the H-T literature have mainly dealt with subsidy policies or trade interventions such as tariffs and quotas. Examples are Bhagwati and Srinivasan (1974), Stiglitz (1974), Corden and Findlay (1975), Calvo (1978), Basu (1980), Khan (1980b), Khan and Lin (1982), McCool (1982), Batra and Naqvi (1987), Chao and Yu (1990), Marjit (1991), Chen and Choi (1994) and Gupta (1995).

2) By incorporating a Thunen-like rural sector into the H-T framework, Jones and O'Neill examined the impact of public input provision on rural land use.

3) This first-best supply rule for public input provision was derived by Kaizuka (1965). Although the Kaizuka rule does not necessarily apply to all types of public inputs [see, with respect to this point, Feehan (1989)], it is appropriate to factor-augmenting public inputs in which production functions are linearly homogeneous in all inputs excluding public inputs. As in Feehan (1992) and Matsumoto (1995), this paper investigates this type of public input.

4) The qualitative results obtained in this paper are valid irrespective of the location of the public sector.

5) As will be seen, public input provision may reduce the wage gap between both sectors. In this case, there is the possibility that the H-T aspect of the model vanishes. This paper assumes that the wage gap is so large that it is not eliminated when the economy is at its equilibrium with tariff distortion.

6) In the presence of tariff distortion, the public sector should minimise its production costs evaluated at second-best shadow factor prices set by the government. This will be confirmed in Section III. The difference in the specification of public production between Matsumoto (1995) and this paper has an important implication for the sign of the shadow prices of primary factors and the public input. See, with respect to this point, footnote 11.

7) The effects on production of public employment of factors, i. e., X^i_{LG} and X^i_{KG}, are clarified in the next section. These effects are related to second-best shadow prices and correspond to the generalised Rybczynski effect in Matsumoto (1995).

8) By the separability of the production functions, I have $C^i_G=-C^i\eta^i$, $C^i_{wG}=-C^i_w\eta^i$ and $C^i_{rG}=-C^i_r\eta^i$. Furthermore, the linear homogeneity of the unit-cost functions implies that $W^iC^i_{ww}+rC^i_{rw}=W^iC^i_{wr}+rC^i_{rr}=0$. Based on these results, differentiating (5a, b) gives

$$(1+\lambda)C^M_w dX^M+C^A_w dX^A=\{(1+\lambda)C^M_w X^M\eta^M+C^A_w X^A\eta^A-r\{(1+\lambda)\alpha^M(r_G/r)-\alpha^A[(W^A_G/W^A)-(r_G/r)]\}\}-(C^M_w X^M+L^G)\lambda_G\}dG,$$

$$C^M_r dX^M+C^A_r dX^A=\{C^M_r X^M\eta^M+C^A_r X^A\eta^A+W^A\{(1+\lambda)\alpha^M(r_G/r)-\alpha^A[(W^A_G/W^A)-(r_G/r)]\}\}dG.$$

Solving these equations yields (11). In that process, $W^MC^M_w+rC^M_r=q$ and $W^AC^A_w+rC^A_r=1$ are used. Ordinarily, α^i can be expressed in terms of the substitution elasticity between factors and so forth. However, this complicates my equations and does not give any insight into the qualitative analysis in this paper. Therefore, I will use αi for convenience.

9) Using (2), I have $(C^M{}_r\text{-}qC^A{}_r)\ /\ \Delta=[C^M{}_r(W^AC^A{}_w+rC^A{}_r)-C^A{}_r(W^MC^M{}_w+rC^M{}_r)]\ /\ \Delta=-WA$. This, combined with (13), yields (15).

10) Note that $PC^A{}_r\text{-}C^M{}_r=(W^MC^M{}_w+rC^M{}_r-t)C^A{}_r-(W^AC^A{}_w+rC^A{}_r)C^M{}_r=W^A\Delta-tC^A{}_r$. This gives (16a). In a similar way, (16b) can be derived.

11) The positivity of r^S and C^{SG} may not be sustained if, as in Matsumoto (1995), the public sector minimises its production costs evaluated at market factor prices. The reason is that, in this case, the marginal products of publicly-employed factors are related to W^M and r rather than W^S and r^S. Along the lines of Srinivasan and Bhagwati (1978) and Bhagwati and Srinivasan (1980), a similar issue was examined by Matsumoto (1995) in the H-O-S framework.

12) Denoting the government's budget surplus, $t\,(D^M-X^M)-(W^ML^G+rK^G)$, by T, I have $\partial T\ /\ \partial t=t\,(D^{CM}{}_q-X^M{}_q)+tD^M{}_I(I_q-D^M)+(D^M-X^M)-r_qK^G$. Moreover, (7) and (15) give

$$I_q-D^M=X^M-D^M+r_qK^G-WA(L^M+L^G)\lambda_q,$$

which, combined with (8a), implies that

$$\partial T\ /\ \partial t=t(D^{CM}{}_q\text{-}X^M{}_q)-W^A(L^M+L^G)\lambda_q-(PD^M{}_I+D^A{}_I)\ (I_q-D^M).$$

Since the first and second terms of this equation are negative, I_q-D^M must be negative if $\partial T\ /\ \partial t>0$ and $D^i{}_I>0$. This paper assumes that $I_q-D^M<0$.

13) Differentiating (9) with respect to q and G, and using Slutsky's decomposition and (8a) give

$$[t(D^{CM}{}_q-X^M{}_q)-W^A(L^M+L^G)\lambda_q+(I_q\text{-}D^M)(PD^M{}_I+D^A{}_I)]dq+[PX^M{}_G+X^A{}_G-(PD^M{}_I+D^A{}_I)I_G]dG=0.$$

Substituting (17) and (18) into this equation, I have $dq\ /\ dG=I_G\ /\ (D^M-I_q)$.

14) There are two important differences between Jones and O'Neill and this paper. First, in their (1995) paper, public inputs are financed by wage taxes [taxes on agricultural output in their (1994) paper]. Second, intersectoral capital mobility is not introduced into the Jones and O'Neill framework. Given these differences, it cannot be concluded in this paper whether the statement of Jones and O'Neill (1995) regarding the cost measure of urban public inputs is appropriate.

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