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Open-access Renewable Resources and Urban Unemployment: Dual Institutional Failures in a Small Open Economy

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1. Introduction

Development policy targets, such as the Millennium Development Goals (MDGs), often pursue both poverty reduction and environmental preservation. The Sustainable Development Goals (SDGs), the successor of MDGs, address the compatibility of these goals explicitly (Sachs, 2015). The economics literature has explored policies to pursue these dual development goals based on the traditional dualistic economy model a la Harris and Todaro (1970: HT) by focusing on relations between reduction in urban unemployment and a decrease in pollution due to urban industrial activities (Wang, 1990; Daitoh, 2003; Beladi and Chao, 2006; Rapanos, 2007; Daitoh, 2008; Tsakiris et.al., 2008; Daitoh and Omote, 2011). These studies, with a few exceptions, have overlooked the roles of rural environmental resources and the associated institutional issues. In fact, imperfect institutions that govern rural natural resource use, along with an urban institutional failure that induces persistent urban unemployment and poverty in informal sectors, is a key challenge for many developing countries in achieving the dual SDG targets of poverty reduction and environmental preservation.

Rural natural resources play no less important economic and environmental roles than those of pollution from urban industries especially in poor developing economies. For example, as Barbier (2005) finds, the majority of low- and middle-income countries are highly dependent on primary product exports (*stylized fact one* on p.24) while resource dependency in those countries is associated with poor economic performance (*stylized fact two* on p.32). Empirical studies have found that such poor performance is the outcome of weak institutions governing natural resource use (Fischer 2010, Barma et al. 2012). The compatibility between rural resource preservation and a resolution of urban problems including unemployment has attracted keen interests among policymakers. Izquierdo, Grau and Aide (2011) explored implications of rural-to-urban migration for conservation of forest in Argentina. They found that under the future land-use-cover scenarios they created, the rural-to-urban migration and land-use planning could favor rural nature conservation with little impact on urban areas. This leads us to the question of whether rural environmental preservation could be compatible with urban poverty reduction in general given two institutional failures associated with urban labor markets and rural natural resource use. These two failures are inter-related as the relative wage is one of the key factors for rural-urban migration, which is another global trend across developing economies. In particular, while discouraging rural resource exploitation (or encouraging urban manufacturing) may mitigate resource overuse, the accompanying migration may increase urban unemployment.

This paper attempts to answer this question by taking into account the stylized fact that rural production depends highly on open-access renewable resources in poor developing economies. The crucial roles of open-access renewable resources and their dynamics have already been analyzed intensively in the trade literature. Chichilnisky (1994) found that the international difference in property right regimes on renewable resources can be a source of gains from trade in a two-country Ricardian trade model. Brander and Taylor (1997, 1998) showed that gains from trade may be lost by the dynamics of open-access renewable resource stock in the long-run. They referred to Brazil, Canada, Indonesia, Philippines and Ivory Coast as typical countries whose export substantially depends on open-access forests. While most of them are developing countries, none of these studies have considered a dualistic structure with urban unemployment a la Harris and Todaro (1970), which is specific to developing economies.

Conversely, most previous studies on trade and environment based on HT models paid no attention to the overexploitation problem concerning open-access resources. Nor did they consider renewable resource dynamics. Dean and Gangopadhyay (1997) and Chao, Kerkvliet and Yu (2000) considered deforestation problem in a small open dualistic economy with vertically-related industries. They analyzed effects of export restriction on timber produced in the rural sector. However, they considered the situation where competitive profit-maximizing firms produced a rural resource good. That is, they implicitly assumed perfect property right regime on resources, eliminating the possibility of overexploitation problem concerning open-access resources.

We bridge the gap between these two strands of research by developing a model that captures the two key institutional failures described above in a simple manner, i.e., a small open HT model with an open-access resource in the rural sector. This approach provides a number of advantages, First, this model allows us to analyze transparently when a reduction in urban unemployment can be compatible with a decrease in overexploitation of rural resource stock. In particular, we demonstrate how the traditional first-best policy by Bhagwati and Srinivasan (1974) should be modified in the presence of rural open-access resources. Second, our framework delineates the economic mechanism through which an export tax on the resource good affects urban unemployment through a reduction in rural population (and thus an increase in the number of the urban unemployed) and an increase in the number of urban manufacturing workers.

The above analysis on the export tax provides important policy insights because export tax is one of the most common policy instruments imposed on natural resource sectors in many developing countries (WTO 2010).[1] The direction of change in urban unemployment, influenced by the export taxes, determines whether a reduction in urban poverty will be compatible with a decrease in overexploitation of rural resources.[2] Abe and Saito (2016) is the

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[1] WTO (2010) notes that, while natural resources represent approximately 24 per cent of all sectors, about one-third of all export taxes recorded in WTO Trade Policy Reviews cover natural resource sectors. It also finds that export taxes occur with greater frequency in fishing and forestry (renewables) than in fuels and mining (non-renewables).

[2] The rate of urban unemployment plays a critical role in evaluating social welfare in HT models. See section 5.

novel and only existing study, which examined the effects of an export tax on the resource good on urban unemployment and welfare in a small open HT economy with rural environmental resource stock. Among other results, they showed that an increase in the export tax always *raises* the *rate* of urban unemployment but improves the environmental quality.

However, this result depends crucially on the special structure of their model. In particular, because they choose the urban manufactured good as the numeraire, an increase in the export tax does not affect the relative price of the urban manufactured good (because its price is always unity) and thus the number of urban manufacturing workers is fixed in equilibrium. The higher export tax only decreases rural production and population, which promotes migration to the city. It necessarily increases both the number of the urban unemployed and the rate of urban unemployment.[3] In other words, the possibilities of an increase in the number of urban manufacturing workers and of reducing the rate of urban unemployment are eliminated from the outset in Abe and Saito (2016). Therefore, we reexamine the direction of change in the rate of urban unemployment based on a general HT model with more price flexibility.

Our analysis generates a number of findings. First, the first-best policy given the two institutional failures in urban and rural sectors is a combination of urban wage subsidy and a *lower* rate of rural income subsidy or even a *tax*. This requires a modification of the traditional first-best policy prescription by Bhagwati and Srinivasan (1974), i.e., the combination of urban and rural wage subsidies at the same rate. In particular, a rural income *tax* constitutes the first-best policy when (i) the urban fixed wage rate is lower, and/or (ii) the domestic price of the urban manufactured good is higher (e.g., a lower world price of the resource good under free trade and/or a higher tariff rate on the manufactured goods). Second, as opposed to Abe and Saito (2016), a rise in the export tax rate on the resource good always *reduces* the *rate* of urban

[3] In the Harris-Todaro Framework, the unemployment rate is defined as the ratio of the number of the urban unemployed to the number of urban manufacturing workers.

unemployment, which improves welfare. However, even so, the *level* of urban unemployment is more likely to increase if the initial rate of export tax is lower (including free trade). Finally, an increase in the export tax rate always improves welfare if this country initially engages in free trade.

Our model captures the institutional failures related to the urban labor market and the rural resource use in a highly stylized manner (i.e., an institutionally imposed lower bound on the urban wage rate and open access resource use in the rural sector). Regarding the former assumption, many studies have generalized the original HT model by endogenizing the wage rigidity in the urban labor market (de Janvry and Sadoulet 2016, p.443; Todaro and Smith 2015, pp.361-362) and by modeling the urban informal sector formally (e.g., Gupta 1993). While generalizing our model in these directions will not change our main results about the nature of the first-best policy and the impacts of export taxes, extending the model further beyond may generate richer results. We will discuss the policy implications of our results, along with the opportunities for extending our analysis, in the last section of the paper.

2. The Model

Consider a small open two-sector Harris-Todaro (1970) economy exporting a resource good, which is produced in the rural sector, and importing a manufactured good, which is produced in the urban sector. While the resource good is assumed to be the numeraire, the price $\bar{p} > 0$ of the urban manufactured good is given in the world market. Under free trade, its domestic price p is equal to $\bar{p}$. As the simplest way to introduce an institutional failure of the urban labor market, we assume that the urban wage rate is institutionally fixed at a level $w_M > 0$ that exceeds any prevailing market clearing level, so that urban unemployment exists in equilibrium.

Let $R \geq 0$ be the output level (harvest) of the resource good, which is produced with

$L_R \geq 0$ units of rural labor and a renewable resource stock $S \geq 0$. We assume the Schaefer production function:

(1) $R = \alpha S L_R$,

where $\alpha > 0$ represents the efficiency of resource good production. To represent an institutional failure with respect to the natural resource management, we assume that the resource is subject to open access. Thus agents in the rural sector can freely use the service of S to produce R. With this assumption, the opportunity cost of labor $w > 0$ and the rural labor input L_R satisfy the zero-rent condition $R = wL_R$ in equilibrium:[4]

(2) $w = \alpha S$.

The renewable resource stock evolves over time depending on the natural growth of the resource and the harvest. We assume a logistic growth function of the renewable resource $G(S) = rS\left(1 - \frac{S}{K}\right)$ where $r > 0$ is the intrinsic growth rate of the resource and $K > 0$ the carrying capacity. At any point in time t, the resource stock S_t will grow according to $\dot{S_t} = G(S_t) - R_t$. We focus on the steady state where $\dot{S_t} = 0$:

(3) $rS\left(1 - \frac{S}{K}\right) = R$.

Equalities (1) and (3) imply the following relationship between the steady-state stock level and the associated labor input:

(4) $S = K\left(1 - \frac{\alpha}{r} L_R\right) = S(L_R)$

The associated sustainable yield satisfies $R(L_R) = \alpha S(L_R) L_R$.

The urban manufacturing output $M \geq 0$ and the labor input (i.e., the urban employment) $L_M > 0$ satisfy $M = F(L_M)$ where F is the production function with $F' > 0$ and $F'' < 0$. The representative firm of competitive urban manufacturing sector maximizes its profit,

[4] We should interpret w not as a wage rate but as an income per capita in the rural sector because rural agents produce the resource good using their own labor.

employing labor L_M up to the level where the value marginal product of urban manufacturing labor (MPL_M) in terms of domestic price p equals the institutionally fixed wage rate:

(5) $w_M = pF'(L_M)$.

As in the standard HT model, the equilibrium allocation of labor between the rural and the urban sectors induces the equalization of expected wage/income between rural and urban areas:

(6) $w = \frac{w_M}{1+\mu}$,

where $\mu \equiv L_U/L_M$ is the urban unemployment rate, and L_U the level of urban unemployment. The total population $L > 0$ in the economy is fixed and consists of rural labor, urban manufacturing employment, and urban unemployment:

(7) $L_R + (1+\mu)L_M = L$.

The general equilibrium system of (1), (2), (3), (5), (6) and (7) determines the values of six endogenous variables (R, S, w, L_R, L_M, μ). It can be solved as follows. First, substituting (4) into (2), we have:

(8) $w = \alpha K \left(1 - \frac{\alpha}{r} L_R\right)$.

To ensure that the model has a unique interior solution for the open-access general equilibrium and for the efficient resource allocation problem in the next section, we assume:

Assumption 1: $r > 2\alpha L$ holds.

Under this condition, the opportunity cost of rural labor w is always positive in equilibrium. Next, we have from (6) and (8):

(9) $w_M = (1+\mu)\alpha K \left(1 - \frac{\alpha}{r} L_R\right)$.

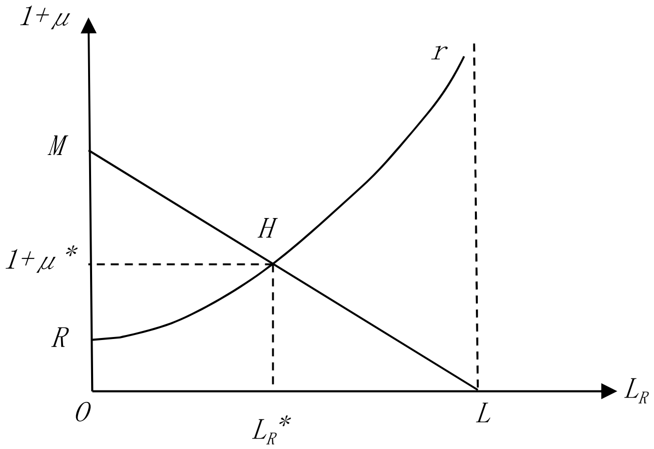
The combinations of $(L_R, 1+\mu)$ satisfying (9) are represented by the increasing convex curve

Rr in Figure 1. The intercept R on the vertical axis is $w_M/\alpha K$. Finally, given L_M^* determined by (5), the combinations of $(L_R, 1+\mu)$ satisfying (7) are represented by the decreasing line ML in Figure 1. The intercept M on the vertical axis is L/L_M^*. If M lies above R, there exists a unique equilibrium H in our model. Then, we obtain the next proposition.

Proposition 1. *Under Assumption 1, there is a unique interior equilibrium that satisfies*

(10) $\alpha KL > w_M L_M^*$.

Figure 1. Existence and Uniqueness of Equilibrium



3. First-best Policy

We now investigate the first-best policy for this economy with two kinds of distortions; open access to the rural resource and urban wage rigidity. This policy could also be interpreted as providing a theoretical prescription that makes poverty reduction and environmental resource preservation compatible in a dualistic developing economy.

On one hand, taxing the rural production may be justified because open access leads to resource overexploitation. On the other hand, a reduction in urban unemployment requires a rural subsidy that will expand rural population to hinder excessive rural-to-urban migration. Bhagwati and Srinivasan (1974) showed in the standard HT model (without rural open-access resources) that the first-best policy is the combination of rural and urban wage subsidies at the same rate. This section shows that the first-best labor allocation is attained in our model by a combination of the urban wage subsidy and a *lower* rate of rural income subsidy, or even a *tax*.[5] Then we investigate when the first-best policy combination consists of a rural income *tax*.

3.1 First-best Labor Allocation and Urban Wage Subsidy

Let us first define the first-best labor allocation. It is attained when the value marginal products of labor are equalized across the rural and the urban sectors.[6] While the value MPL_M is $pF'(L_M)$, the value of (sustainable) marginal product of rural labor (MPL_R) is given by $R'(L_R) = \alpha K\left(1 - \frac{2\alpha}{r} L_R\right)$. With the full-employment condition $L_R + L_M = L$, the efficient labor allocation (L_R^E, L_M^E) is characterized by

(11) $pF'(L_M^E) = \alpha K\left(1 - \frac{2\alpha}{r} L_R^E\right)$.

This is shown by point E in Figure 2. Because the right-hand side of (11) is positive by Assumption 1, an interior solution E exists if the value MPL_M is lower than MPL_R when $(L_R, L_M) = (0, L)$, i.e., if $pF'(L) < \alpha K$ holds.

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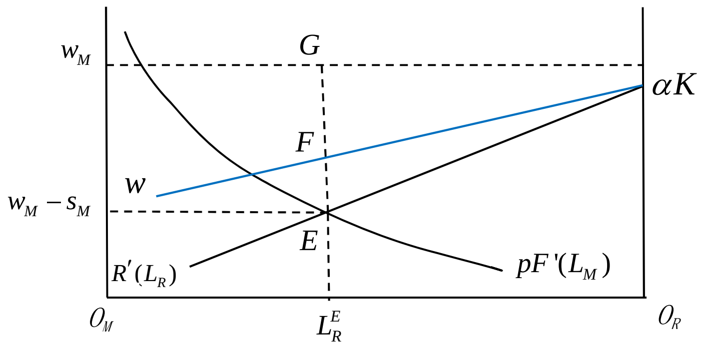
5 We assume that the subsidies are financed by a lump-sum tax levied on consumers and that tax revenues net of subsidies are distributed in a lump-sum fashion among consumers.

6 This efficient labor allocation in our "sustainable yield" model corresponds to the solution to the associated dynamic optimization problem with the discount rate close to zero. See Appendix A.

Figure 2. Rural Income Subsidy



If the government provides each urban firm with the wage subsidy $s_M = EG$, the mass $O_M L_R^E$ of workers are employed in the urban manufacturing sector. Because the urban wage rate received by the workers will be equal to the fixed urban wage rate w_M, each manufacturing worker has no incentive for migration. This urban wage subsidy will thus support the efficient labor allocation E.

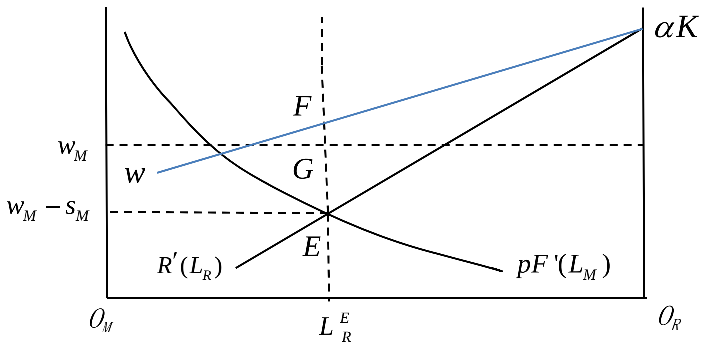
3.2 Rural Subsidy

In order to derive the first-best policy in the rural sector, we introduce the line w representing the (sustainable) average product of rural labor (8) in Figure.2. If the government provides each rural producer with the subsidy $s_R = GF$, rural income per capita w received will be equal to the fixed urban wage rate w_M. Then each rural worker has no incentive to migrate to the urban area, and thus the number $O_R L_R^E$ of people will work in the rural resource sector. Therefore, the first-best policy is the combination of the urban wage subsidy $s_M = EG$ and the rural income subsidy $s_R = GF$.

3.3 Should Rural Resource Use be Taxed?

When the domestic price p of the manufactured good is relatively high, the first-best policy in the rural sector will not be a subsidy but a *tax* on rural income per capita. Figure 3 describes this case: if the government imposes a tax $t_R = FG$ on each rural producer, the disposable income of a rural producer is represented by the height of point G, which is equal to w_M. Then he/she has no incentive for rural-urban migration.

Figure 3. Rural Income Tax



Let us now investigate when the rural first-best policy is a *tax*. Consider the benchmark case where the line w for average product of rural labor (8) passes through point G. Then the government should set the rural income subsidy at zero ($s_R = 0$). If $w_M < w$ at L_R^E holds, the rural income *tax* combined with the urban wage subsidy $s_M = EG$ gives rise to the first-best labor allocation E. From the inequality above, we obtain the necessary and sufficient condition for rural income tax:

(12) $w_M < \alpha K \left(1 - \frac{\alpha}{r} L_R^E\right)$

When is (12) likely to hold? Using Figure 2 or 3, we can examine how the efficient labor allocation is affected by exogenous parameters. First, (12) is more likely to hold when (a) the urban fixed wage rate w_M is lower and (b) p is higher. Second, the effects of the other parameters are, in general, ambiguous (see Appendix B). Thus we obtain the next position.

Proposition 2:

(i)*The first-best labor allocation is attained by a combination of the urban wage subsidy* s_M

and a lower rate of rural income subsidy s_R*, or even a tax* t_R*.*

(ii)*The rural income tax* t_R *combined with the urban wage subsidy* s_M *gives rise to the first-best labor allocation if and only if (12) holds. Thus the first-best rural policy is more likely to be a tax when (a) urban fixed wage rate (*w_M*) is lower, and/or (b) the domestic price of urban manufactured good (*p*) is higher. The relations of* K*,* r *and* α *are, in general, ambiguous.*

The reason for result (ii)-(a) to hold is that w_M is given independently of the other parameters when determining the first-best labor allocation. The reason for (ii)-(b) is as follows. When p is higher, the $pF'(L_M)$ curve lies at a higher position. The value of L_R^E (the length of $O_R L_R^E$ in the figure) is smaller and thus the first-best labor allocation corresponds to a lower level of rural population $O_R L_R^E$. Because of the diminishing returns to rural labor, the (sustainable) rural income per capita w tends to be higher than the fixed urban wage. This requires a tax that reduces disposable income of rural people so that they have no incentive for rural-to-urban migration.

Result (ii)-(b) has two important economic implications. First, under free trade, the first-best policy combination is more likely to be a rural income *tax* with urban wage subsidy when the world price $\bar{p}$ of the urban manufactured good is higher, or, equivalently, when the world price $1/\bar{p}$ of the resource good is lower. In this situation the traditional first-best policy proposed by Bhagwati and Srinivasan (1974), i.e., the combination of urban and rural wage subsidies at the same rate, will not apply to modern dualistic developing economies whose production highly depend on rural open-access resources.

Second, the first-best rural policy will be a rural income tax, not subsidy, when this country imposes a high import tariff on the urban manufactured good (which increases the domestic price p). This situation seems realistically relevant to low- and middle-income developing countries. By Lerner's symmetry theorem, when the government sets a high export tax on the rural good for preservation of environmental resource stock such as forests (see section 4 in further details), the first-best policy will be a rural income tax with urban wage subsidy. In this situation, rural residents suffer from both the export tax and the rural income tax. Domestic income inequality between rural and urban areas will be aggravated.

4. Export Tax on the Resource Good

We will now investigate the effects of a rise in the export tax rate on the resource good to compare our results with those in Abe and Saito (2016). We show that, at the steady state, preservation of rural renewable resource stock is consistent with a reduction in urban unemployment.

4.1 Open-access Equilibrium with Export Tax

Let $t > 0$ be the ad-valorem tax rate on the export of the resource good.[7] The world relative price of the resource good is higher than its domestic price, i.e., $1/\bar{p} = (1+t)(1/p)$. Then the domestic price of the urban manufactured good is $p = (1+t)\bar{p}$, with its world price $\bar{p}$ given exogenously. Recall that the open-access equilibrium is given by (5), (7) and (9). The equilibrium urban manufacturing employment will then be $L_M^*(t) = \phi\left(\frac{(1+t)\bar{p}}{w_M}\right)$, where ϕ is the inverse function of $F'(L_M)$ and $\phi' > 0$ holds. The ML line will be $1+\mu = \frac{L-L_R}{L_M^*(t)}$ with the vertical intercept $\frac{L}{L_M^*(t)}$.

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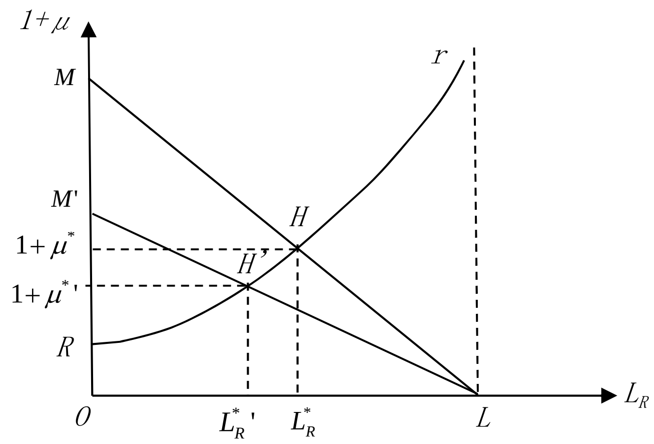
[7] In section 2 we have used t as a time variable. We focus here on the steady state and use t to represent an export tax.

Figure 4. Effect of an Increase in the Export Tax



4.2 The Effect on the Rate of Urban Unemployment

Let us first investigate the effect of a rise in t on the rate μ^* of urban unemployment, which influences the equilibrium welfare in a critical manner. When t is raised, the urban manufacturing employment $L_M^*(t)$ increases and thus the ML line shifts downward to $M' L$ in Figure 4. Because the Rr curve remains unchanged, the equilibrium moves from H to H'. Therefore the rural population L_R^* decreases while the rate μ^* of urban unemployment decreases. The rural income $w^* = w_M/(1+\mu^*)$ increases.

Proposition 3: *A rise in the export tax rate on the resource good always*

(i) reduces the rate μ^**of urban unemployment, (ii) decreases rural population* L_R^**, and (iii) increases the rural income per capita* w^*.

Result (i) is opposite to what Abe and Saito (2016) find (that a rise in the export tax rate *increases* the rate of urban unemployment) due to the following reason. Because Abe and Saito (2016) choose the urban manufactured good as the numeraire, a rise in the export tax rate on the resource good does not affect the relative price of the urban manufactured good (whose price is always unity) in their model.[8] Thus the urban manufacturing employment L_M^* remains unchanged. On the other hand, a rise in the export tax rate decreases the rural production and population, promoting the rural-to-urban migration, thereby increasing the urban population $L_U^* + L_M^*$. With L_M^* fixed, both the level L_U^* and the rate $\mu^* = L_U^*/L_M^*$ of urban unemployment increase in their model. In contrast, our model captures a change in L_M^* due to the trade policy change because we choose the resource good as the numeraire. Then a rise in the relative price p of the manufactured good expands the urban manufacturing employment and thus decreases rural population. Because of the decreasing returns to rural labor, the rural income per capita w rises and thus the rate of urban unemployment declines (see equation 6). Therefore, a rise in the export tax on the resource good will not increase but *reduce* the *rate* of urban unemployment.[9] In this sense, a reduction in urban unemployment will be compatible with the preservation of rural resource stock.[10]

However, the *level* of urban unemployment may or may not decrease as demonstrated below. If it increases, a higher export tax rate on the rural resource good could be interpreted as aggravating the urban poverty.

4.3 The Effect on the Level of Urban Unemployment

Here we derive a necessary and sufficient condition for the *level* of urban unemployment, L_U^*, to be increasing in the export tax rate. It follows from (6), (7), and (8) that the equilibrium satisfies $\alpha K \left(1 - \frac{\alpha}{r} L_R\right)(L - L_R) = w_M L_M^*(t)$. Total differentiation yields $\alpha K \left[-\frac{\alpha}{r}(L - L_R) -\right.$

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8 Other differences include (i) the number of resource users is exogenous and independent of urban-rural migration in Abe and Saito (2016) while it is endogenous and directly linked to migration in our model; and (ii) the resource dynamics is not taken into account in Abe and Saito's framework.

9 Appendix C shows that if we chose the manufactured good as the numeraire without changing the other parts of the model, the urban unemployment rate would be increasing in the export tax rate.

10 The rural-urban income gap shrinks by result (iii). The export tax tends to correct income inequality as well.

$\left(1 - \frac{\alpha}{r} L_R\right)\Big] dL_R = w_M dL_M$. Thus we obtain

(14) $\frac{dL_R^*}{dL_M^*} = -\frac{w_M}{\alpha K\left[\frac{\alpha}{r}(L - L_R) + \left(1 - \frac{\alpha}{r} L_R\right)\right]} < 0.$

It follows from $dL_R + dL_M + dL_U = 0$ that the necessary and sufficient condition for $\frac{dL_U^*}{dL_M^*} > 0$ is $-\frac{dL_R^*}{dL_M^*} > 1$. Using (14), it is equivalent to

(15) $w_M > \alpha K\left[\frac{\alpha}{r}(L - L_R) + \left(1 - \frac{\alpha}{r} L_R\right)\right].$

To find what kind of equilibrium we should focus, from (8), (15) is rewritten as:

(16) $w_M - w^* > (L - L_R^*)\alpha^2 K / r.$

This inequality implies that a rise in the export tax rate on the resource good increases the level of urban unemployment when the production of this economy depends highly on the resource good sector (L_R^* is large) and the rural-urban income gap ($w_M - w^*$) is large.

When is (15) or (16) likely to hold? Although the effects of exogenous parameters L, K, α, r and w_M on the right-hand side are ambiguous (see Appendix D), we can find unambiguous effects of the domestic price p of the urban manufactured good. When the initial value of p is lower, $L_M^*(t)$ is smaller and thus, in Figure 4, the ML line lies at a higher position. Then L_R^* is larger and w^* is lower. Therefore, (16) is more likely to hold when the initial domestic price p is lower. In light of Lerner's symmetry theorem, we obtain:

Proposition 4: *A rise in the export tax rate t on the resource good increases the level of urban unemployment if and only if this country's domestic price p of the urban manufactured good is sufficiently low. This situation occurs when (i) the world price of the manufactured good is low under free trade, (ii) an initial rate of export tax on the resource good is low, and/or (iii) an initial rate of import tariff on the manufactured good is low.*

Let us make an intuitive explanation for this proposition. When the domestic price p is low, this economy tends to have large population L_R^* in the rural resource good sector at the initial equilibrium. Then, a rise in t, which leads to a higher value of p, expands the urban manufacturing sector and induces rural-to-urban migration. The urban population will increase until the rural income per capita w is equalized to the urban expected wage $w_M/(1+\mu)$. The size of the migration depends on the elasticity of rural labor demand. Totally differentiating (8), we have $dw = -\alpha K\left(\frac{\alpha}{r}\right)dL_R$, and thus $\frac{dL_R}{dw} = -\frac{r}{K\alpha^2}$. Using (8), the elasticity of rural labor demand is:

(17) $\varepsilon = -\frac{w}{L_R}\frac{dL_R}{dw} = \frac{w}{L_R}\left(\frac{r}{K\alpha^2}\right) = \frac{K\alpha}{L_R}\left(1-\frac{\alpha}{r}L_R\right)\left(\frac{r}{K\alpha^2}\right) = \frac{r}{\alpha L_R} - 1,$

which is positive by Assumption 1. Because the rural population L_R^* is large at the initial equilibrium, the elasticity ε of rural labor demand will be small. Thus w rises more slowly when rural people migrate to the urban sector. However, because the rural population is large, the absolute number of migrants will be large.

On the other hand, when p is low, a rise in p (the size of the increment$=dp$) corresponding to the same rate of increase in gross export tax rate $T=(1+t)$ will be small (because of $\frac{dp}{p} = \frac{dT}{T}$ derived from $p = T\bar{p}$). Thus the upward shift of the value MPLM curve will be small. Then an increase in the urban manufacturing employment will be small while the number of migrants from the rural sector will be large. Therefore, the number of people unemployed in the city will increase. This tends to increase the *level* of urban unemployment.

Furthermore, we can obtain economic implications from these results. Result (i) implies that when this country initially engages in free trade and the world price $(1/\bar{p})$ of the exported resource good is high, a rise in the export tax rate tends to *increase* the level of urban unemployment. Thus restricting the export of resource intensive goods may make reducing urban unemployment and preserving rural resources incompatible.

Results (ii) and (iii) imply that an introduction of the export tax on the resource good will *decrease* the level of urban unemployment if this country initially sets a *high* import tariff rate on the urban manufacturing good. We observe such policy mix with many resource-rich developing economies. Thus preserving natural resources is compatible with a reduction in urban unemployment in these cases. However, if the tariff is reduced in the worldwide trade liberalization, these two goals may come to be incompatible.

5. Welfare Consideration

In this section we investigate whether a rise in the export tax rate on the resource good improves welfare of the entire economy. Suppose that each consumer's utility function is homothetic in the consumption of the resource good c_R and the manufactured good c_M. Let $E(1, p, u)$ represent the representative consumer's (minimum) expenditure given the domestic price $p = (1 + t)\bar{p}$ and utility level u. The aggregate consumption expenditure is equal to the aggregate revenue in terms of the domestic price, i.e., $c_R + pc_M = R + pM + t(R - c_R)$, where $t(R - c_R)$ is the tax revenue measured in the resource good. In terms of the world price, $c_R + \bar{p}c_M = R + \bar{p}M$ holds, as usual. Given $\bar{p}$, the value of export equals that of import, $R - c_R = \bar{p}(E_p - M)$, where $E_p \equiv \frac{\partial E}{\partial p} = c_M$ is the compensated demand for the manufactured good. Thus the export tax revenue $t(R - c_R)$, which is redistributed to consumers in a lump-sum fashion, can be written as $t\bar{p}(E_p - M)$. Therefore the representative consumer's budget constraint in terms of the domestic price is:

(18) $E(1, p, \bar{u}) = R + pM + t\bar{p}\big(E_p - M\big)$.

Totally differentiating (18) and rearranging the terms (see Appendix E), we obtain:

(19) $E_u \frac{du}{dt} = -\left(\frac{wL}{1+\mu}\right)\frac{d\mu}{dt} - t\bar{p}c_M\left(\varepsilon_C + \varepsilon_M \frac{M}{c_M}\right)$,

where $\varepsilon_C \equiv -E_{pp}\frac{\bar{p}}{E_p} > 0$ and $\varepsilon_M \equiv \frac{\partial M}{\partial p}\frac{\bar{p}}{M} > 0$ are the own-price elasticities of the compensated demand for and the supply of the manufactured good. A rise in t has two welfare effects. The first term on the right-hand side of (19) represents a positive effect due to a decrease in urban unemployment rate ($d\mu/dt < 0$) while the second term a negative effect due to the decrease in the import of the manufactured good, i.e., in the export of the resource good. The latter holds because small values of ε_C and/or ε_M imply that the domestic demand for the manufactured good decreases and/or its supply increases to a small extent.[11] The welfare will improve if the effect of the reduction in urban unemployment rate is sufficiently large and/or when the country's trade volume decreases to a sufficiently small extent. Furthermore, if this country initially engages in free trade ($t = 0$), the welfare necessarily improves by an introduction of the export tax on the resource good.

Proposition 5: *Taxing the export of the resource good improves welfare when it decreases the country's trade volume to a sufficiently small extent. Furthermore, starting from free trade, a marginal increase in the export tax necessarily improves the welfare.*

Now we summarize the policy implications regarding the compatibility between urban poverty reduction and rural resource preservation in a small open dualistic economy. Let us focus on the realistically relevant situation where a developing country, which is highly dependent on rural renewable resources, sets a high import tariff rate on the urban manufactured good. First, from Proposition 2, the first-best policy consists of a rural income *tax* t_R combined with an urban

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[11] See Appendix E for an explicit expression relating the second term on the right-hand side of (19) to the corresponding change in trade volume.

wage subsidy s_M, because the domestic price p of the urban manufactured good is high. This is in a sharp contrast to the traditional policy prescription by Bhagwati and Srinivasan (1974) that the first-best policy is the combination of the urban and rural wage subsidies at the same rate. Second, a rise in the export tax rate on the resource good will decrease not only the rate (Proposition 3) but also the level of urban unemployment (Proposition 4), thereby improving welfare (Proposition 5).

Hence, the developing country under consideration tends to have an incentive to restrict resource-good exports, which can contribute to preservation of resource stock. Conversely, suppose that a developing country sets low tariffs on the urban manufactured goods initially. Then it will likely experience an increase in the level of urban unemployment when an export tax on the resource good is introduced. Under such circumstances, urban poverty reduction and rural resource preservation will not be compatible.

6. Concluding Remarks

This paper explores when poverty reduction and resource preservation can be compatible in modern developing economies whose production highly depends on open-access renewable resources. By applying a small open dualistic economy model with urban unemployment and a rural open-access renewable resource, we characterize the first-best policy combination. We also investigate whether reducing urban unemployment is compatible with a decrease in the overexploitation of rural resources when an export tax rate on the resource good rises. At the steady state, the first-best policy consists of a combination of urban wage subsidy and a *lower* rate of rural income subsidy or even a *tax*. This requires a modification of the well-known first-best policy combination by Bhagwati and Srinivasan (1974). In particular, the first-best policy is more likely to include rural income *tax* when (i) the urban fixed wage rate is lower and/or (ii) the domestic price of urban manufactured good is higher (e.g., a lower world price of the resource good under free trade and/or a higher import tariff on the manufactured good). In contrast to Abe and Saito (2016), a rise in the export tax rate generally *reduces* the *rate* of urban unemployment, which improves welfare. However, the *level* of urban unemployment is more likely to increase if the initial rate of export tax is lower. Finally, a rise in the export tax rate always improves welfare if this country initially engages in free trade.

Our analysis could be extended in several directions. First, we assume that harvesting from a renewable resource is the only production activity in the rural sector. This assumption rules out other activities such as agriculture in the rural sector. On one hand, labor reallocation from direct resource use to agriculture may alleviate resource overuse. On the other hand, agriculture might accelerate resource overuse in some cases (e.g., land conversion for agriculture that contributes to deforestation).[12] Taking into account such multiple rural activities may result in richer findings on rural-urban migration, resource use, and poverty reduction. Second, we assume that labor is the only primary factor of production (except for the resource stock) and rule out endogenous investment in (physical) capital. Third, our analysis does not consider environmental externalities associated with the rural resources. Finally, we concentrated on the steady state of the renewable resource stock. Further studies could investigate the properties of equilibrium and welfare along non-stationary transition paths.

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[12] Jinji (2006) studies how international trade influences deforestation when the resource's carrying capacity is endogenous.

Appendix A: Sustainable Yield and Dynamically Efficient Outcome

In section 2 we derived the first-best labor allocation using (5) and $w_M = w$:

$$\text{(11)} \quad \alpha K \left(1 - \frac{2\alpha}{r} L_R^E\right) = w.$$

This corresponds to the first order condition for the problem of deriving the efficient sustainable yield L_R that maximizes the rent $R(L_R) - wL_R$. Solving (11), we have:

$$L_R^E = \frac{r(\alpha K - w)}{2\alpha^2 K} = \frac{r}{2\alpha}\left(1 - \frac{w}{\alpha K}\right).$$

The above efficient outcome for the "sustainable yield" model is the (dynamically) efficient outcome, i.e., the solution to the associated dynamic optimization that maximizes the present value of rents over time if the discount rate is (close to) zero. To see this, consider the following dynamic optimization problem:

$$\max_{\{E_t\}_{t\geq 0}} \int_0^\infty e^{-\rho t}[\alpha S_t E_t - wE_t]dt$$

$$s.t. \quad \dot{S}_t = rS_t(1 - S_t/K) - \alpha S_t E_t \quad t \geq 0,$$

given S_0 where $\rho > 0$ is the discount rate. (Here we let $E_t \equiv L_{Rt}$.) Let H be the associated current-value Hamiltonian:

$$H_t = \alpha S_t E_t - wE_t + \lambda_t\{rS_t(1 - S_t/K) - \alpha S_t E_t\}.$$

The condition for optimality is given by

$$\frac{\partial H_t}{\partial E_t} = \alpha S_t - w - \lambda_t S_t = 0$$

(at the singular solution) and the following adjoint equations:

$$\dot{\lambda}_t - \rho\lambda_t = -\frac{\partial H_t}{\partial S_t} = -\left\{\alpha E_t + \lambda_t(r - \frac{2rS_t}{K} - \alpha E_t)\right\}.$$

At the steady state, we have $\dot{S}_t = 0$ and harvest equal to natural resource growth: $\alpha SE = rS(1 - S/K)$. (The time subscript t is omitted here.) It then follows form the adjoint equation that

$$\rho\lambda = \alpha E + \lambda(-rS/K).$$

As $\rho \to 0$ we have

$$\alpha E = \frac{\lambda r S}{K}, \quad i.e., \quad \lambda = \frac{\alpha E K}{rS}.$$

Plug this into the first order condition (for the singular solution) and we have

$$\alpha S - w - \frac{\alpha^2 E K}{r} = 0.$$

Because harvest equals natural resource growth at the steady state, we have $\alpha E = r(1 - S/K)$, i.e., $S = K - \frac{\alpha E K}{r}$. Substitute this into the last expression and we have

$$\alpha K\left(1 - \frac{2\alpha}{r}L_R\right) = w.$$

Therefore,

$$E = \frac{r(\alpha K - w)}{2\alpha^2 K} = \frac{r}{2\alpha}\left(1 - \frac{w}{\alpha K}\right).$$

This is the same as the efficient outcome for the sustainable yield model derived from (11).

Appendix B: Effects of Parameters on the Efficient Labor Allocation

This appendix shows that the effects of changes in K, r and α on L_R^E are, in general, ambiguous. Totally differentiating (11), we get:

$$\left\{\alpha K\left(\frac{2\alpha}{r}\right) - pF''(L_M)\right\} dL_R$$

$$= \alpha\left(1 - \frac{2\alpha}{r}L_R\right) dK + \alpha K\left(\frac{2\alpha}{r^2}L_R\right) dr - F'(L_M)dp + K\left(1 - \frac{4\alpha}{r}L_R\right) d\alpha.$$

Under Assumption 1, we have $1 - \frac{2\alpha}{r}L_R^E > 0$, the relations of exogenous parameters to the efficient labor allocation are:

$$\frac{dL_R^E}{dK} > 0, \quad \frac{dL_R^E}{dr} > 0, \quad \frac{dL_R^E}{dp} < 0.$$

However, $\frac{dL_R^E}{d\alpha} > 0$ holds if and only if $1 - \frac{4\alpha}{r}L_R^E > 0$ is satisfied. Therefore, as shown in the text, the first-best rural policy is more likely to be a *tax* when the domestic price of urban manufactured good (p) is higher.

However, an increase in K and in r raises the value of L_R^E, but does not always raises the right-hand side of (12). An increase in α has an ambiguous effect on the value of L_R^E and thus on the right-hand side of (12). Therefore the relations of K, r and α are, in general, ambiguous.

Appendix C: The Model with Manufactured Good as the Numeraire

This appendix shows that the urban unemployment rate would increase by a rise in the export tax rate as in Abe and Saito (2016) if we chose the manufactured good as the numeraire. As demonstrated below, the choice of the numeraire plays a crucial role in determining the direction of change in μ^*.

Let us denote the domestic relative price of the resource good as q. In this revised model, given (q, w_M, L), the system of the six equations determines the same six unknowns as in the text. Note that w_M is fixed in terms of the manufactured good.

$R = \alpha S L_R,$ (1)

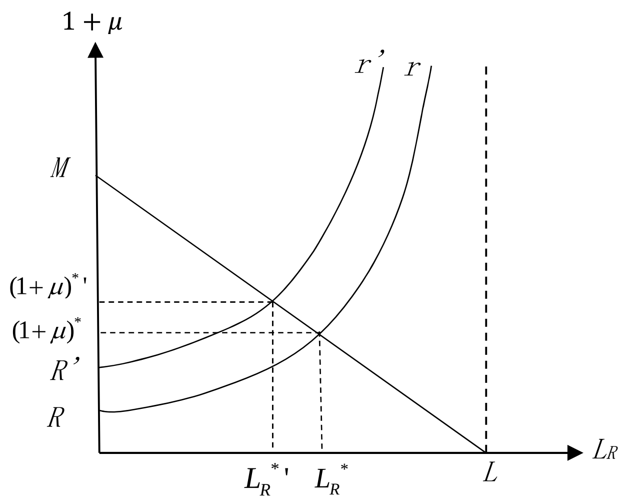
$w = \frac{qR}{L_R} = q\alpha S,$ (2')

$rS\left(1 - \frac{S}{K}\right) = R,$ (3)

$w_M = F'(L_M),$ (5')

$w = \frac{w_M}{1+\mu},$ (6)

$L_R + (1+\mu)L_M = L.$ (7)



Let us explain how to solve it. First, L_M^* is pre-determined by (5'). Then the ML line (7) $L_R + (1+\mu)L_M^* = L$ remains unchanged. Consider how the Rr curve is revised.

Substituting (1) into (3) yields (5) $S(L_R) = K\left(1 - \frac{\alpha}{r}L_R\right)$ in the text. Substituting this into (2') and eliminating w by using (6), we get the revised *Rr* curve:

(11') $w_M = (1+\mu)q\alpha K\left(1 - \frac{\alpha}{r}L_R\right)$.

Observe that the slope of the revised *Rr* curve, $\frac{d(1+\mu)}{dL_R} = \frac{(\alpha/r)(1+\mu)}{1-(\alpha/r)L_R}$, does not directly depend on q.

A higher export tax rate implies a lower domestic price of resource good q. Then the revised *Rr* curve shifts upward. However, the *ML* line remains unchanged because L_M^* does not change in this model (see equation 5'). Thus, L_R^* decreases while $(1+\mu^*)$ increases in equilibrium. The *rate* μ^* of urban unemployment would *increase* in our model if we chose the manufactured good as the numeraire as in Abe and Saito (2016). For the reason explained in the main text, we argue that the resource good should be taken as the numeraire.

Appendix D: Effects of Parameters on Open-access Equilibrium L_R^*

First, total differentiation of $\alpha K\left(1 - \frac{\alpha}{r}L_R\right)(L - L_R) = w_M L_M^*(t)$ in section 4.3 yields

$$\alpha K\left\{-\frac{\alpha}{r}(L - L_R) - \left(1 - \frac{\alpha}{r}L_R\right)\right\}dL_R + \alpha K(L - L_R)\left(\frac{\alpha L_R}{r^2}\right)dr$$

$$+\alpha K\left(1 - \frac{\alpha}{r}L_R\right)dL + \alpha\left(1 - \frac{\alpha}{r}L_R\right)(L - L_R)dK + (L - L_R)K\left\{1 - \frac{2\alpha}{r}L_R\right\}d\alpha$$

$$= w_M dL_M^* + L_M^* dw_M.$$

Rearranging the terms, we obtain:

$$\alpha K\left\{\frac{\alpha}{r}(L - L_R) + \left(1 - \frac{\alpha}{r}L_R\right)\right\}dL_R = \alpha K(L - L_R)\left(\frac{\alpha L_R}{r^2}\right)dr$$

$$+\alpha K\left(1 - \frac{\alpha}{r}L_R\right)dL + \alpha\left(1 - \frac{\alpha}{r}L_R\right)(L - L_R)dK + (L - L_R)K\left\{1 - \frac{2\alpha}{r}L_R\right\}d\alpha$$

$$-w_M dL_M^* - L_M^* dw_M.$$

Under Assumption 1, $1-\frac{2\alpha}{r}L_R^*>0$ holds. Then we have:

$$\frac{dL_R^*}{dL}>0, \frac{dL_R^*}{dK}>0, \frac{dL_R^*}{d\alpha}>0, \frac{dL_R^*}{dr}<0, \frac{dL_R^*}{dL_M^*}<0.$$

The effect of a change in w_M on L_R^* is ambiguous because a rise in w_M directly decreases L_R^* but increases it through a reduction in L_M^*.

Appendix E: *Derivation of Welfare Formula (19)*

Total differentiation of (18) yields;

$$E_u du = dR + pdM + (M - E_p)dp + \{\bar{p}(E_p - M)dt + t\bar{p}(E_{pp} - M_p))dp\}.$$

Using $dp = \bar{p}dt$, $dM = F'(L_M)dL_M$ and $dR = wdL_R + L_R dw$ from the zero-rent condition $R = wL_R$, we get ;

$$E_u du = wdL_R + L_R dw + pF'(L_M)dL_M + \bar{p}(M - E_p)dt + \bar{p}(E_p - M)dt + t\bar{p}^2(E_{pp} - M_p)dt.$$

$$E_u du = wdL_R + L_R dw + pF'(L_M)dL_M + t\bar{p}^2(E_{pp} - M_p)dt.$$

Remembering (6) and (7), we have $dw = -\left(\frac{w}{1+\mu}\right)d\mu$ and $dL_R = -(1+\mu)dL_M - L_M d\mu$. Substituting them, we get;

$$E_u du = w\{-(1+\mu)dL_M - L_M d\mu\} - L_R\left(\frac{w}{1+\mu}\right)d\mu + pF'(L_M)dL_M + t\bar{p}^2(E_{pp} - M_p)dt.$$

Using (5) and (7), and rearranging the terms, we obtain

$$E_u \frac{du}{dt} = -\left(\frac{wL}{1+\mu}\right)\frac{d\mu}{dt} + t\bar{p}^2(E_{pp} - M_p).$$

The second terms on the right-hand side satisfies

$$t\bar{p}^2(E_{pp} - M_p) = -t\bar{p}E_p\left(\varepsilon_C + \varepsilon_M \frac{M}{E_p}\right),$$

Thus we obtain (19) in the text.

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