University of Hawai`i at Mānoa
Department of Economics
Working Paper Series

Saunders Hall 542, 2424 Maile Way,
Honolulu, HI 96822
Phone: (808) 956 -8496
www.economics.hawaii.edu

Working Paper No. 19-6

Open Access Renewable Resources, Urban Unemployment, and the Resolution of Dual Institutional Failures

By
Ichiroh Daitoh
Nori Tarui

March 2019

Open Access Renewable Resources, Urban Unemployment, and the Resolution of Dual Institutional Failures[*]

March 2, 2019

Ichiroh Daitoh[†]
Faculty of Business and Commerce, Keio University
Nori Tarui[‡]
Department of Economics, University of Hawaii at Manoa
University of Hawaii Economic Research Organization (UHERO)

This paper investigates how poverty reduction and environmental resource preservation can be simultaneously achieved in a small open dual economy with urban wage rigidity, rural open access resources, and rural-urban migration. An increase in the export tax rate on the rural resource good increases urban unemployment in both the short and long run with resource dynamics. We find that the first-best policy, which makes the two goals compatible, is an urban wage subsidy combined with either a rural wage subsidy at a *lower* rate or, if the urban output price is sufficiently high, a rural *tax*. An increase in the export tax on the resource good could induce rural institutional change away from open access, but protection of urban manufacturing through a tariff hinders such rural institutional change.

JEL Classification Codes: O13; Q27; F18

Keywords: open access; renewable resource; urban unemployment; rural-urban migration; export tax on the resource good; institutional change

---

[*] Declarations of Interest: none

[†] *Correspondence*: Ichiroh Daitoh, Faculty of Business and Commerce, Keio University: 2-15-45, Minato-ku, Tokyo, 108-8345, Japan; E-mail: idaitoh@fbc.keio.ac.jp; Tel & Fax: +81-3-5418-6707.

[‡] Nori Tarui, Department of Economics, University of Hawaii at Manoa: 2424 Maile Way, 518 Saunders Hall, Honolulu, HI 96822, USA; nori@hawaii.edu; Tel: +1-808-956-8427 & Fax: +1-808-956-4347.

1. Introduction

Poverty reduction and environmental preservation are fundamental challenges for many developing economies. The United Nations' Sustainable Development Goals emphasize the importance of engaging in public and private activities to address these two challenges (Sachs, 2015). The economics literature has explored policies to address these dual goals by applying the traditional dual economy model in Harris and Todaro (1970; HT model hereafter) (Wang, 1990; Daitoh, 2003; Beladi and Chao, 2006; Rapanos, 2007; Daitoh, 2008; Tsakiris et al., 2008; Daitoh and Omote, 2011).[1] These studies, with few exceptions, have focused on simultaneous reductions in urban industrial pollution and urban unemployment due to the institutionally fixed high wage rate and rural-urban migration.

However, rural environmental resources also play important economic and environmental roles in low-income economies. As Barbier (2005) documents, the majority of low-income countries are highly dependent on primary product exports (*stylized fact one* on p.24), while their resource dependency is associated with poor economic performance (*stylized fact two* on p.32). The compatibility of rural resource

[1] The HT model, despite its simplicity, is still used today in the frontier of research attempting to focus on urban unemployment in a dual developing economy because there are no other rural-urban models that can explain urban unemployment as an equilibrium phenomenon. Indeed, spatial economics has provided more elaborate and interesting models that explain the endogenous formation of rural-urban configurations. However, to the best of our knowledge, the spatial economics literature does not consider urban unemployment in equilibrium.

preservation and the resolution of urban problems, including unemployment, has attracted keen interest from policymakers. Some studies have discussed the association between land-use dynamics and rural-urban migration in the developing world today (e.g., Aide and Grau, 2004, for Latin American countries). Other studies indicate the linkages between rural outmigration resulting from drought and environmental degradation on the one hand and the urban poverty and health issues faced by urban migrants on the other (Simms and Reid 2006, p.39).[2] Izquierdo et al. (2011) found that under the future land-use/cover scenarios they considered, rural-to-urban migration and land-use planning could enhance forest conservation with little impact on urban areas in Argentina. These studies indicate that continued rural-to-urban migration may reduce pressures on rural resource use without aggravating urban poverty.

This paper considers whether rural resource preservation could be compatible with urban poverty reduction in general in a dual economy. For this purpose, we extend a small open HT model by incorporating renewable resource dynamics into the rural sector: while discouraging rural resource exploitation (or encouraging urban manufacturing) mitigates resource overuse, the accompanying rural-to-urban migration may increase urban unemployment. Empirical studies have found that the poor

[2] Grau and Aide (2008) note that in recent decades, forest expansion or the recovery of degraded forests has been reported for several Caribbean and Central American areas in association with the strong impact of rural outmigration and economic modernization.

economic performance of resource-dependent economies is the outcome of weak institutions governing natural resource use (Fischer 2010, Barma et al. 2012). In fact, imperfect rural institutions that lead to the overexploitation of natural resources and urban institutional failure that induces persistent urban unemployment and poverty in informal sectors pose key challenges for many developing countries. Thus, we investigate whether and how rural resource preservation and a reduction in urban unemployment could be compatible in a small open dual economy with an institutionally fixed high urban wage and open access rural resources due to an imperfect property rights system.

This study applies the following three analyses. First, we investigate the effect of an export tax on the output from the natural resource because it is one of the most common policy instruments imposed on natural resource sectors in developing countries (WTO 2010).[3] Abe and Saito (2016), based on a small open HT model in which rural resources are common property, found that an increase in the export tax rate on the rural resource good *always increases* the rate of urban unemployment in the short run when the resource

[3] The World Trade Organization (WTO) (2010) notes (on p.116) that while natural resources represent less than one-quarter of all tradable sectors, fully one-third of all export taxes recorded in the WTO's Trade Policy Reviews are imposed on natural resource sectors. The WTO also finds (in Fig.28) that export taxes occur with greater frequency in the fishing and forestry (renewables) industries than in the fuels and mining (non-renewables) industries.

stock level is fixed. Our study confirms that while the rate of urban unemployment decreases in the subsequent transition path as the resource stock recovers, the steady-state unemployment rate stays above the initial level. Because an increase in the rate of urban unemployment tends to deteriorate welfare in HT models, this finding indicates that the export restrictions on the harvest from resources under incomplete regulation—such as the export restrictions that were adopted by Southeast Asian countries in the 1970s and 1980s on timber from tropical forest —lead to negative impacts for the economy as whole in the long run.

Next, we proceed to derive the first-best policy, a policy prescription for attaining the two goals simultaneously. We find that the first-best policy is an urban wage subsidy combined with a rural wage subsidy at a *lower* rate. This recommendation requires a modification of the traditional first-best policy proposed by Bhagwati and Srinivasan (1974), i.e., a combination of urban and rural wage subsidies at the same rate. In particular, a rural *tax* (instead of a subsidy) will be the rural first-best policy when (a) the urban fixed wage rate is lower, (b) 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 good), (c) the productivity of rural technology is higher, or (d) the rural resource's carrying capacity is larger. Although we assume that the urban wage rate is institutionally fixed, generalizing our model by endogenizing the urban wage rate (de Janvry and Sadoulet 2016, p.443; Todaro and Smith 2015, pp.361-362) and by formally modeling the urban informal sector (e.g., Gupta 1993) does not change our main results about the nature of the first-best policy and the impacts of export taxes.

Third, taking the possibility of endogenous institutional change into account, we explore conditions under which the trade policies commonly observed among developing countries with natural resources induce institutional change (such that, at some cost, restricted access to the resource is enforced). We find that an increase in the export tax rate on the rural good will enhance the incentive for rural institutional change from open access when the relative share of labor in the rural resource good sector is sufficiently high or if the resulting decrease in the opportunity cost of rural labor is sufficiently large. A tariff protection on urban manufacturing necessarily reduces the incentive for rural institutional change, maintaining open access. We also investigate how institutional failure in the urban labor market may be endogenously resolved by these trade policies in section 6.

2. Relation to the Literature

In this section, we explain the relationship between the present paper and previous studies addressing rural environmental resources in two-sector models of international trade.

The literature on trade and natural resources has investigated the gains from trade under open access renewable resources and resource dynamics. Chichilnisky (1994) found that international differences in the property rights regimes imposed on renewable resources can be a source of gains from trade in a two-country Ricardian trade model. The model demonstrates that trade by a country with ill-defined property rights with another with well-defined rights leads to apparent gains but actual losses. Brander and Taylor (1997, 1998) showed that gains from trade may be lost in the long run due to the dynamics of open access renewable resource stocks. These scholars claim that Brazil, Canada, Indonesia, the Philippines and the Ivory Coast are typical countries where exports substantially depend on open access forests. Although most of these are developing countries, existing studies have not considered a dual economy with urban unemployment, which is a key characteristic of developing economies. A recent study by Noack et al. (2018) is an exception: this study uses a dynamic model of a dual economy to consider the income differences between a rural sector with an open access renewable resource and an urban sector given costly migration. The authors find that implementing a policy to regulate resource use allows rents from the resource to accumulate, thereby enhancing the efficiency of labor allocation between the rural and the urban sectors. Our study investigates a similar dual aspect in a developing economy; our approach allows us to study not only the rural-urban wage gap but also the extent of urban unemployment (which could be interpreted as the size of the urban informal sector) and the impacts of other types of policies such as trade interventions.

Another strand of literature on trade and the environment considers the effect of trade policies on unemployment. For example, Dean and Gangopadhyay (1997) and Chao et al. (2000) considered deforestation in a small open dual economy with vertically related industries. They analyzed the effects of export restrictions on timber produced in the rural sector. However, they considered a situation in which competitive profit-maximizing firms produce a rural resource good. In other words, these studies assume a perfect property rights regime imposed on resources, eliminating the possibility that resources are overexploited as occurs under imperfect property rights systems.

The present paper bridges the gap between these two strands of research by developing a simple but formal model incorporating an open access resource and resource dynamics. Our small open HT model with a zero-rent equilibrium in the rural sector has the advantage of clearly identifying the economic mechanism through which an export tax on a rural resource good does not affect the number of urban manufacturing workers but increases urban unemployment through rural-urban migration.

3. The Model

3.1 Small Open Dual Economy with Rural Open Access Resources in the Steady State

Consider a small open dual economy with a rural sector producing a resource good R and an urban sector producing a manufactured good M. Good R is assumed to be the numeraire, and the price in the world market $\bar{p} > 0$ of good M is given. Under free trade, the good's domestic price p is equal to $\bar{p}$. Because it is the simplest way to introduce an institutional failure of the urban labor market, we assume that the urban wage rate is institutionally fixed at the level $w_M > 0$, which exceeds any prevailing market clearing level, to ensure that urban unemployment exists in equilibrium. In what follows, we consider a range of parameter values such that the economy exports the resource good and imports the manufactured good in equilibrium.

We assume that $R \geq 0$ units of a resource good (harvest) are produced with $L_R \geq 0$ units of rural labor and a renewable resource stock $S \geq 0$ under the Schaefer production specification:

$$R = \alpha S L_R, \tag{1}$$

where $\alpha > 0$ represents the productivity of resource good production. To incorporate an institutional failure with respect to natural resource management, we assume that the resource is subject to open access. Thus, rural agents can freely use S to produce R. Under 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; hence,

$$w = \alpha S. \tag{2}$$

We interpret w not as a wage rate but as income per capita because rural agents produce the resource good using their own labor.

At any point in time *t*, the resource stock S_t increases according to $\dot{S_t} \equiv dS_t/dt = G(S_t) - R_t$. We assume that the logistic growth function of the renewable resource is $G(S) = rS\left(1 - \frac{S}{K}\right)$, where $r > 0$ represents the intrinsic growth rate of the resource, and $K > 0$ represents its carrying capacity. In the steady state where $\dot{S_t} = 0$, we have:

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

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

$$S(L_R) = \begin{cases} K\left(1 - \frac{\alpha}{r} L_R\right) & if\ 0 \leq L_R \leq \frac{r}{\alpha}; \\ 0 & if\ L_R > \frac{r}{\alpha}. \end{cases} \tag{4}$$

The associated output level, which is called the "sustainable yield" in resource economics, satisfies $R(L_R) = \alpha S(L_R) L_R$.

The urban manufacturing production function $F(L_M)$ has a positive and decreasing marginal product of labor $(F'(L_M) > 0,\ F''(L_M) < 0)$ and satisfies the Inada conditions ($\lim_{L_M \to 0} F'(L_M) = \infty,\ \lim_{L_M \to \infty} F'(L_M) = 0$), where $L_M \geq 0$ is the labor input for manufacturing. A representative firm in the competitive urban manufacturing sector maximizes its profit $pF(L_M) - w_M L_M$ by employing L_M at the level where the value of the marginal product of urban manufacturing labor in terms of domestic price p equals the institutionally fixed wage rate:

$$w_M = pF'(L_M). \tag{5}$$

Let $L_M(w_M/p)$ represent the urban employment level that satisfies (5). As in the standard HT model, the equilibrium allocation of labor between the rural and urban sectors equalizes the expected wage rate or income levels between rural and urban areas:

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

where $\mu \equiv L_U/L_M \geq 0$ is the urban unemployment rate, and $L_U \geq 0$ denotes the level of urban unemployment.[4] The total population $L > 0$ in the economy is fixed and consists of rural labor, urban manufacturing employment, and urban unemployment:

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

[4] In the HT framework, the unemployment rate is defined as the ratio of the number of urban unemployed people to the number of urban manufacturing workers. This ratio always moves in the same direction as the standard urban unemployment rate $L_U/(L_M + L_U) = 1/\{1 + (1/\mu)\}$.

Given p, w_M and L, equations (1), (2), (3), (5), (6) and (7) determine the steady-state equilibrium values of six endogenous variables R, S, w, L_R, L_M, and μ. In the present model, the equilibrium on the production side is independent of that on the consumption side, as in the neoclassical competitive general equilibrium models. Therefore, social welfare is maximized when gross domestic product (GDP) $R + pM$ is maximized.

We can prove the existence of a unique interior general equilibrium solution under some mild conditions.[5] If we use only equations to explain the properties of our HT equilibrium and the intuitions behind our analytical results, we must use complicated analytical procedures. Instead, we apply the graphical analysis by Corden and Findlay (1975), which is a standard method used in the study of HT models.

3.2 Properties of an HT Equilibrium with Rural Open Access Resources

We will elucidate the properties of our HT equilibrium with rural open access resources. In Fig.1, urban manufacturing employment $L_M^* = L_M(w_M/p)$, which is determined by (5), is shown by $O_M J$, with origin O_M. Given L_M^*, we draw the expected urban wage rate curve $w^e = w_M L_M^*/L_C$ with the city population $L_C (= L_M^* + L_U)$ measured from origin O_M to the right. This curve, usually called the Harris-Todaro (HT) curve, is a

[5] Section 3.2 explains that an interior general equilibrium solution exists under Assumption 1 (presented later). Appendix A shows how to solve the model with an export tax on the resource good under the same assumption.

rectangular hyperbola passing through point T (because $w^{\mathrm{e}} = w_M$ holds at $L_C = L_M^*$).

At the HT equilibrium point H where the rural income line $w = \alpha S(L_R)$, which originates at O_R, intersects the HT curve, the city and rural populations are $O_M Q$ and $O_R Q$, respectively. The equilibrium level of urban unemployment μL_M^* is shown by JQ. In our HT equilibrium, $w^* = \alpha S(L_R^*)$ is always positive, and thus $1 > \frac{\alpha}{r} L_R^*$ holds.[6] Under the following assumption, the equilibrium labor allocation is an interior solution.

Assumption 1. $w_M \frac{L_M(w_M/p)}{L} < \alpha K$.

This inequality means that the height of point $N(= \alpha K)$ exceeds the expected urban wage rate w^{e} at $L_C = L$ (i.e., when the total population lives in the urban area).

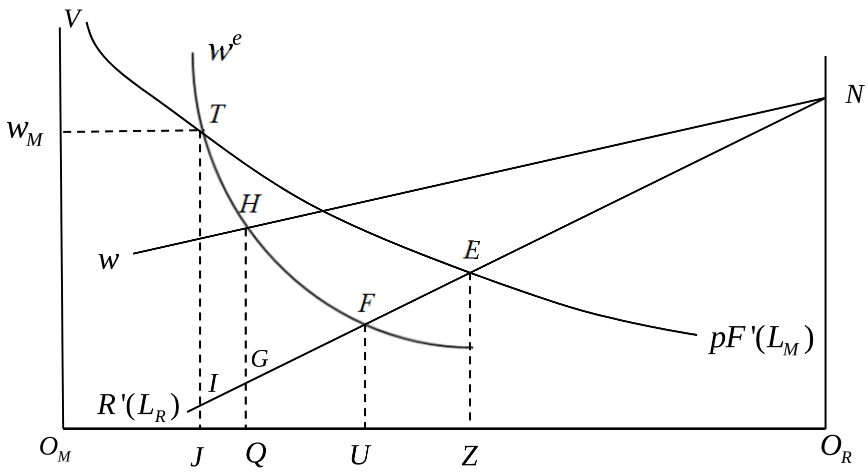

Fig.1. Harris-Todaro Equilibrium with Rural Open Access Resources

[6] When $\mathrm{R}'(L_R^*) < 0$ holds at the equilibrium point H, the rural population is larger than the level corresponding to the "maximum sustainable yield" at which $\mathrm{R}'(L_R^*) = 0$ holds.

The equilibrium H is associated with two distortions, which we call “dual institutional failures.” The first institutional failure is the institutionally fixed high urban wage rate, while the second is open access to the rural resource. We explain the consequences of these institutional failures in terms of losses in GDP. First, the first-best resource allocation is shown by point *E*, where the value of marginal product $pF'(L_M)$ is equal to the value of marginal product $R'(L_R)$. GDP is shown by $O_M VENO_R$.

The institutionally fixed high wage rate w_M induces GDP losses for two reasons. First, this wage rate reduces manufacturing employment $(O_M J)$ to a level below the first-best level $O_M Z$. The value of urban manufacturing production is $O_M VTJ$, and thus, the corresponding GDP loss will be $EZJT$. If the remaining population $(O_R J)$ lived in the rural area, then rural production would increase by $EZJI$, and thus the net GDP loss would be EIT. However, people tend to migrate to a distance at which the expected urban wage rate is higher than their rural income. *Without open access* to the resource stock, the rural population would be represented by the intersection *F* of the rural marginal product curve $R'(L_R)$ and the *HT* curve. Population JU would move from rural to urban areas, resulting in urban unemployment (of the same size, JU). Thus, the value of rural production would decrease by $FUJI$. This process is the second reason for GDP loss.

The second institutional failure—which is specific to our HT model—is overuse of the rural resource stock, or equivalently, excess rural production due to open access; this is captured by the divergence between the average ($w = \alpha S(L_R)$) and the marginal ($R'(L_R)$) products of labor in the resource good sector. In our HT equilibrium, the rural population is $O_R Q$ (corresponding to H) instead of $O_R U$ (corresponding to F), reducing excess rural-to-urban migration. Then, the level of urban unemployment (JQ) is less than the length of JU, which increases the value of rural production by $FUQG$ (the value of rural production is $O_R NGQ$). Hence, resource overuse in the rural sector tends to reduce urban unemployment. Taking these effects together, the overall GDP loss in our HT economy is shown by $EGQJT$.

4. Export Tax on the Resource Good

In this section, we investigate how an increase in the export tax rate on the resource good may affect resource good production, urban unemployment and welfare.[7] Under the ad-valorem export tax rate $\tau \geq 0$, the value of the rural resource good in terms of its domestic price $q = \bar{q}/(1+\tau)$ is $R^{\tau} = \frac{R}{1+\tau}$, where its world price is $\bar{q} = 1$. Each rural producer's revenue (2) is replaced with

[7] We thank Kenzo Abe for his useful discussion on the analysis in this section.

$$w^{\tau} = \frac{\alpha S}{1+\tau}, \tag{2'}$$

and w in (6) is replaced with w^{τ}.

4.1 *Steady-State Effects*

An increase in the export tax rate τ shifts the rural income line w down to $w^{\tau} = \alpha S(L_R)/(1+\tau)$, as seen in Fig.2. Because the HT equilibrium moves from H to H^{τ}, rural income per capita w^*, rural population L_R^* and production R^* decrease, mitigating the resource overuse. More importantly, given manufacturing employment L_M^*, an increase in τ always increases both the rate μ^* and level L_U^* of urban unemployment.

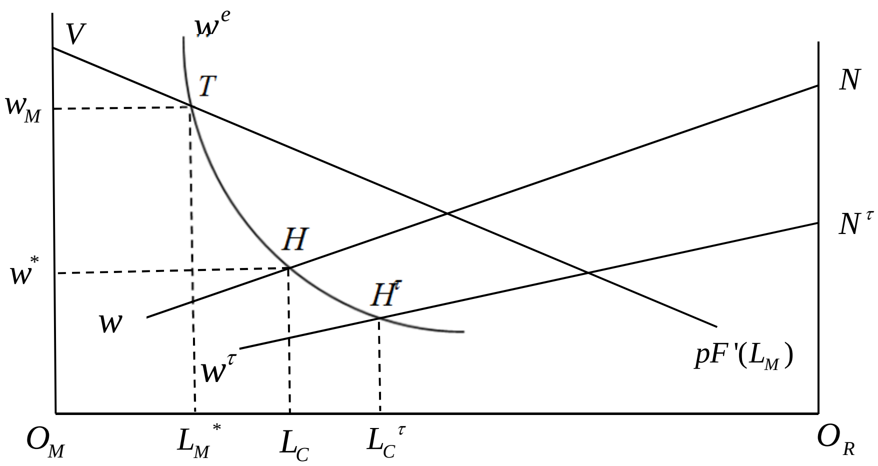

Fig.2. Effect of an Increase in the Export Tax Rate on the Rural Resource Good

Steady-state social welfare will deteriorate because real GDP decreases.[8] To put it more precisely, assume that each consumer's utility function is homothetic in the consumption of the resource good c_R and the manufactured good c_M. Let $E\left(\frac{1}{1+\tau}, p, u\right)$ denote the representative consumer's expenditure function, where $q = 1/(1+\tau)$ is the domestic price of the resource good and u is the utility level. The aggregate consumption expenditure is equal to the aggregate revenue in terms of the domestic price, i.e.,

$$E\left(\frac{1}{1+\tau}, p, u\right) = \frac{R}{1+\tau} + pM + \frac{\tau}{1+\tau}\left[R - E_q\left(\frac{1}{1+\tau}, p, u\right)\right], \tag{8}$$

where $E_q\left(\frac{1}{1+\tau}, p, u\right) = \frac{\partial E}{\partial q} = c_R$ is the domestic (compensated) demand for the resource good.[9] The export tax revenue (the third term on the right-hand side) is assumed to be distributed to consumers in a lump-sum fashion. Totally differentiating (8) with $dp = dM = 0$, we obtain:

$$\left[E_u + \frac{\tau}{1+\tau}E_{qu}\right]\frac{du}{d\tau} = \frac{dR}{d\tau} + \frac{\tau}{1+\tau}\frac{E_{qq}}{(1+\tau)^2} \quad . \tag{9}$$

This equality indicates that the total equilibrium welfare decreases ($\frac{du}{d\tau} < 0$) because the compensated demand for a good is decreasing in its price ($E_{qq} < 0$), and the rural output falls due to an increase in the export tax rate ($\frac{dR}{d\tau} < 0$). Therefore, as indicated in the introduction, policies to restrict the export of harvests from resource-intensive

[8] GDP decreases because rural output decreases while urban manufacturing output remains unchanged.
[9] From this expression, we can derive $c_R + \bar{p}c_M = R + \bar{p}M$ in terms of the world price. We also have $E_{qu} > 0$ because E_q is linear in u if the utility function is homothetic.

sectors under institutional failure (e.g., timber export restrictions in Malaysia and the Philippines in the 1970s and the 1980s) impose negative welfare impacts in the long run given the dual institutional failures and the associated resource misallocation in these economies.

4.2 Effects along the Transition Path

We can also investigate the effects on the transition path after an export tax is imposed. At each instant, given S, w_M, p and L, the general equilibrium system of (1), (2’), (5), (6) and (7) determines the values of five endogenous variables $R, \mathrm{w}^{\tau}, L_R, L_M,$ and μ, while the resource dynamics equation determines the change in S over time.

Suppose that the economy is initially at the steady state. An increase in τ has two opposing effects on urban unemployment. First, an increase in τ decreases rural income per capita $w^{\tau *}$ by (2’) and thus increases the rate of urban unemployment μ^* by (6) at the initial steady state. This is qualitatively the same as what Abe and Saito (2016) identify as the instantaneous impact of an export tax on unemployment. Then, because the resource good output decreases, S increases along the transition path. Thus, $w^{\tau *}$ increases and μ^* declines. Because L_M^* remains unchanged, the level L_U^* of urban unemployment moves in the same direction as the rate μ^*. Despite these adjustments on the transition path, the new steady state is associated with higher unemployment, as indicated by the previous analysis on the steady state.

We summarize the results from 4.1 and 4.2 in the next proposition.

Proposition 1: *An increase in the export tax rate* τ *on the resource good (i) decreases the rural population* L_R^* *and production* R^**, (ii) decreases rural income per capita* w^**, and (iii) increases the rate* μ^* *and level* L_U^* *of urban unemployment in the short run when the resource stock size is fixed. Along the transition path, these variables move in the opposite direction, but the steady-state effect works in the same direction as the short-run effect. The welfare decreases in the long run.*

Thus, Proposition 1 demonstrates that the short-run effect of the export tax on the rural resource good and urban unemployment (derived by Abe and Saito, 2016) becomes smaller in magnitude (but in the same direction) in the long run.

The rest of the paper focuses on the results for the steady state.

5. First-Best Policy

In this section, we derive the first-best policy for an economy with rural open access resources and urban wage rigidity. On the one hand, taxing 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 increase the rural population to limit excessive rural-to-urban migration. Bhagwati and Srinivasan (1974) used a standard HT model (without rural open access resources) to show that the first-best policy is a combination of rural and urban wage subsidies at the same rate. In contrast, in our model, the first-best policy is a combination of an urban wage subsidy and a rural income subsidy at a *lower* rate or even a *tax*.[10] We investigate when the first-best policy combination includes a rural income *tax*.

5.1 First-Best Allocation and Urban Wage Subsidy

The first-best allocation is attained at point E in Fig.3, where the value of marginal product in the urban sector, $pF'(L_M)$, and the value of marginal product in the rural sector associated with a sustainable harvest, $R'(L_R) = \alpha K\left(1 - \frac{2\alpha}{r} L_R\right)$, are equalized.[11]

[10] We assume that these 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.

[11] Appendix B shows that this efficient labor allocation in our "sustainable yield" model corresponds to the solution of the associated dynamic optimization problem with the discount rate close to zero. If the discount rate is larger, we could apply the analysis below by choosing associated subsidy/tax rates that

With the full-employment condition $L_R + L_M = L$, the efficient labor allocation (L_R^E, L_M^E) is characterized by

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

In what follows, we assume

Assumption 2. $pF'(L) < \alpha K$.

This inequality means that the average product (αK) of rural labor at $L_R = 0$ exceeds the value of marginal product $pF'(L_M)$ when the total population works in urban manufacturing ($L_M = L$). The first-best steady-state allocation E exists as an interior solution because of Assumption 2 and the Inada condition on F.

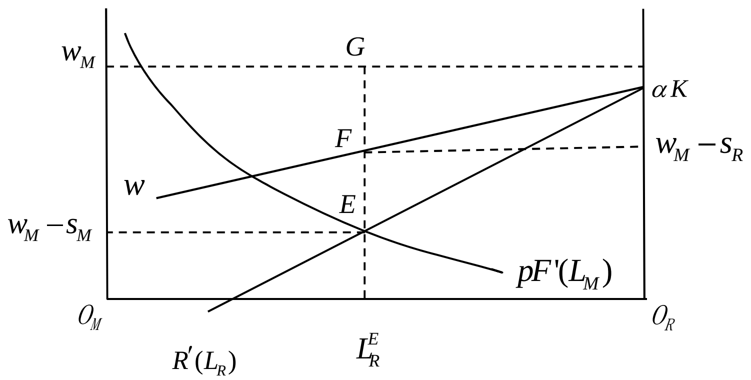

Fig.3. Rural Income Subsidy

support dynamically efficient resource allocation.

If the government provides each urban firm with the wage subsidy $s_M = EG$, then the available workers $O_M L_R^E$ are employed in the urban manufacturing sector at a wage rate equal to the urban fixed wage rate w_M. This urban wage subsidy will ensure the full employment of urban labor $O_M L_R^E$ at the efficient level.

5.2 Rural Income Subsidy

To derive the first-best policy in the rural sector, in Fig.3, we apply the line $w = \alpha S(L_R)$ representing the (sustainable) average product of rural labor, which lies above the marginal product $R'(L_R) = \alpha S(L_R) + \alpha S'(L_R) L_R$ because $S'(L_R) = -\alpha K/r < 0$. If the number $O_R L_R^E$ of people work under zero rent in the rural resource sector, rural income per capita will be shown by the height of point F, which is lower than the urban fixed wage rate w_M. To eliminate the incentive for rural-to-urban migration, the government could provide each rural producer with a subsidy $s_R = GF$. Therefore, the first-best policy is the combination of an urban wage subsidy $s_M = EG$ and a rural income subsidy $s_R = GF$ at a lower rate.

5.3 Should Rural Resource Use be Taxed?

The first-best rural policy is not necessarily a subsidy: under some conditions, a *tax* on rural income constitutes the first-best policy. In Fig.4, the rural income per capita w under zero rent at the efficient level of rural labor $O_R L_R^E$ exceeds the urban fixed wage rate w_M. Then, the government should impose a tax $t_R = FG$ on each rural producer to eliminate the incentive for excessive urban-to-rural migration.

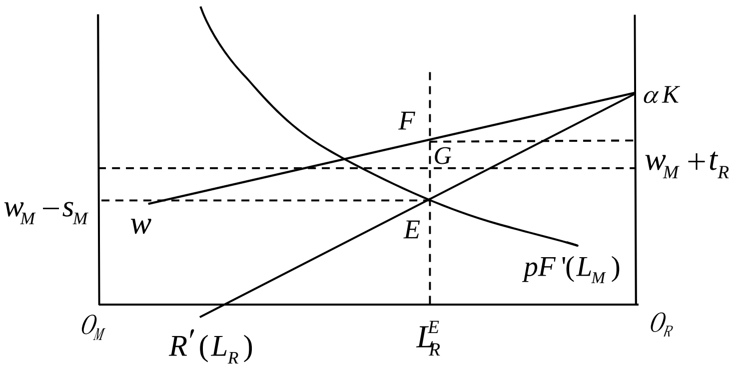

Fig.4. Rural Income Tax

We obtain the necessary and sufficient condition for the rural policy to involve an income tax (instead of a subsidy) by the inequality $w_M < w$ at L_R^E:

$$s_R = w_M - \alpha K \left(1 - \frac{\alpha}{r} L_R^E\right) < 0. \tag{12}$$

When is (12) likely to hold? Using either Fig.3 or 4, we can examine how the efficient allocation is affected by exogenous parameters. Inequality (12) is more likely to hold when (a) w_M is lower or (b) p is higher. Intuitively, result (a) holds because the lower

w_M is, the smaller the urban labor market distortion would be. In such situations, the tax rate required to correct resource overuse would exceed the subsidy rate necessary to address urban labor market imperfections. Thus, the rural optimal policy is a tax rather than a subsidy.

The reason for (b) is as follows. An increase in p shifts the $pF'(L_M)$ curve upward. The first-best allocation corresponds to a smaller 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. To eliminate the incentive for urban-to-rural migration, the government could impose a tax $t_R = FG$ on each rural producer to ensure that their disposable income, represented by the height of point G, is equal to w_M.

Inequality (12) is also more likely to hold when (c) α is higher or (d) K is larger because in these cases, the sustainable yield of the rural resource good is larger, and hence the rural distortion due to open access is relatively more significant than the urban labor market distortion. These factors thus tend to justify a tax on rural income (see Appendix C for rigorous analyses).

Proposition 2: (*i*) *The first-best allocation is a combination of an urban wage subsidy* s_M *and a rural income subsidy* s_R *at a lower rate or even a tax* t_R*. (ii) A rural income* *tax* t_R *combined with an urban wage subsidy* s_M *represents the first-best allocation if and only if (12) holds. Thus, the first-best rural policy is more likely to be a tax when (a) the urban fixed wage rate* w_M *is lower; (b) the domestic price* p *of the urban manufactured good is higher; (c) the productivity of rural technology* α *is higher; or (d) the rural resource's carrying capacity* K *is higher.*

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 an 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. Under these circumstances, the traditional first-best policy proposed by Bhagwati and Srinivasan (1974), i.e., a combination of urban and rural wage subsidies at the same rate, should be modified for modern dual developing economies in which production highly depends on rural open access resources.

Second, when a country imposes a high import tariff on the urban manufactured good (which leads to a high domestic price *p*), the first-best rural policy is a rural income tax instead of a subsidy. In this situation, which is relevant for low- and middle-income developing countries, urban manufacturing firms are protected by the tariff, while rural producers must pay the income tax. This gives rise to domestic income inequality between rural and urban producers. In the absence of rural institutional failure, the first-best policy for addressing urban labor market institutional failure will not induce income inequality between rural and urban areas because the urban and rural wage subsidies are set at the same rate. However, when there is institutional failure in the rural sector, the first-best policy includes a trade-off between efficiency and the rural-urban equity.

6. Resolution of Institutional Failures

We have thus far considered the effects of policies on resource allocation given the institutional failures associated with the urban labor market and rural resource use. Recent studies have shown that such institutional failures might be resolved through changes in market conditions such as capital accumulation, technological change, and changes in the terms of trade (e.g., Copeland and Taylor 2009). In what follows, taking the possibility of endogenous institutional change into account, we explore when the policies can resolve these institutional failures.

A number of studies involving rural resource use have indicated that institutional change that restricts resource use may be introduced when the relative price of the harvested (resource) good increases due to trade liberalization (Bulte and Barbier 2005; Copeland 2005, Copeland and Taylor 2009, Margolis and Shogren 2009; Fischer 2010). The "threshold model" of institutional change (e.g., Copeland 2005 p.10) indicates that an improvement in the terms of trade for the harvested good may induce institutional change (away from open access) for the following reason. The maximum sustainable rent, which is equal to the profit of competitive firms producing the harvested good in the steady state, is a function of the rural labor inputs: $\pi(L_R) = R(L_R) - w_{\mathrm{R}} L_R$, where w_{R} is the wage rate in the competitive rural labor market. Suppose that the cost of avoiding open access and enforcing resource management, $C > 0$ per unit of time, exceeds the maximum sustainable rent under autarky: $C > \max_{L_R} \pi(L_R)$. As trade liberalization improves the terms of trade (i.e., increases the price of the exported resource good), the maximum sustainable rent will increase and may exceed C. If this occurs, then trade liberalization will induce institutional change.

In this paper, let us focus on an export tax on the rural resource good and an import tariff on the urban manufactured good, which are both commonly observed in many developing countries with natural resources. We will consider the export tax because institutional change may occur if rural resource rent under restricted access is sufficiently large (de Meza and Gould 1992, Margolis and Shogren 2009). An import tariff on the urban good could make the institutionally fixed urban wage rate flexible (i.e., endogenously determined) by increasing the demand for urban labor.

6.1 Institutional Changes under an Export Tax on the Rural Resource Good

How would an increase in the export tax rate influence the prospect of institutional change in our model? Consider the hypothetical situation in which rural firms that owned the resource stock chose their labor input to maximize profit $\pi(L_R) = \frac{R(L_R)}{1+\tau} - w_R L_R$. The labor input L_R^* would be determined by:

$$w_R = \frac{R'(L_R^*)}{1+\tau}. \tag{13}$$

The change in the maximized sustainable rent $\pi^* = \frac{R(L_R^*)}{1+\tau} - w_R L_R^*$ is:

$$\frac{d\pi^*}{d\tau} = -\frac{R(L_R^*)}{(1+\tau)^2} + \left[\frac{R'(L_R^*)}{1+\tau} - w_R\right]\frac{dL_R}{d\tau} + \frac{w_M L_R^*}{(1+\mu)^2}\frac{d\mu^*}{d\tau}. \tag{14}$$

Using (13) and $w_R = \frac{w_M}{1+\mu}$, the above formula becomes:

$$\frac{d\pi^*}{d\tau} = -\frac{R(L_R^*)}{(1+\tau)^2} + \frac{w_R L_R}{1+\mu}\frac{d\mu^*}{d\tau}. \tag{15}$$

With $\frac{d\mu^*}{d\tau} > 0$, the sign of this term is ambiguous. Defining the *gross* urban unemployment rate as $\lambda = 1 + \mu$, the necessary and sufficient condition for an increase in τ to increase π^* is:

$$\frac{R(L_R^*)}{w_R L_R} < (1+\tau)^2 \frac{d\lambda/d\tau}{\lambda} \tag{16}$$

In contrast, an export tax on the rural resource good does not affect the incentive to resolve urban labor market failure because it has no effects on the equilibrium of the urban manufacturing sector.

This establishes the next proposition.

Proposition 3: *(i) An increase in the export tax rate on the rural resource good may or may not enhance the incentive for rural institutional change away from open access to a perfect private property system. The necessary and sufficient condition for increasing this incentive is that (16) holds at the initial equilibrium. (ii) An increase in the export tax rate on the rural good does not affect the incentive to resolve urban labor market failure.*

From (*i*), an increase in the export tax rate strengthens the incentive for rural institutional change to a perfect private property system under free trade ($\tau = 0$) when the relative share of labor ($w_R L_R / R(L_R^*)$) in the rural sector is larger or the rate of increase (decrease) in the gross urban unemployment rate (rural wage rate) is higher at the initial equilibrium. Note that a rapid increase in λ is associated with a rapid decrease in the rural wage rate (because $w_R = w_M / \lambda$).

6.2 Effects of an Import Tariff on the Urban Manufactured Good

Next, we consider how an import tariff rate on the urban manufactured good may induce an institutional change in the urban labor market and affect the incentive for rural institutional change from open access to the perfect private property system. We will first investigate the effects of this policy in 6.2 and then discuss the incentive for institutional change in 6.3.

Under the ad-valorem tariff rate $t \geq 0$,[12] the domestic price of the urban manufactured good is $p = (1+t)\bar{p}$, with its world price $\bar{p}$ given in the world market. We first show that the rate of urban unemployment μ^* always decreases and then explain when social welfare will improve.

An increase in t increases urban manufacturing employment L_M^*, and thus the HT curve shifts upward to $H'T'$ in Fig.5. Because the rural income line (w) remains unchanged, the equilibrium moves from H to H'. The rural population L_R^* and production R^*decrease. Therefore, the import tariff on the urban manufactured good mitigates rural resource overuse due to open access. Because rural income w^* increases, by (6), the rate of urban unemployment μ^* decreases.[13]

---

[12] In section 2, we used *t* as a time variable. Here, we focus on the steady state and use *t* to represent an import tariff rate.

[13] The *level* of urban unemployment may increase or decrease. It can be shown that an increase in the export tax rate t on the resource good decreases the *level* of urban unemployment if and only if the country's initial domestic price p of the urban manufactured good is sufficiently high. The proof is

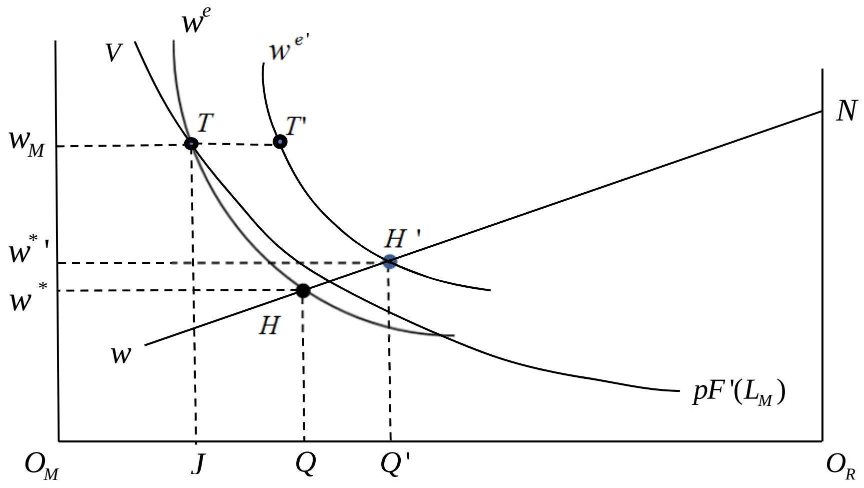

Fig.5. Effect of an Import Tariff on the Urban Manufactured Good

Proposition 4: *An increase in the import tariff rate on the urban manufactured good always (i) reduces the rate of urban unemployment* μ^*, *(ii) increases the rural income per capita* w^*, *and (iii) decreases the rural population* L_R^* *and production* R^* *in the steady state*.

For the welfare analysis, we follow the same procedure as in section 4. Given the domestic price of the urban manufactured good $p = (1 + t)\bar{p}$, the representative consumer's budget constraint in terms of the domestic price is:

available on request.

$$E(1, p, \bar{u}) = R + pM + t\bar{p}\big(E_p - M\big). \tag{17}$$

where $E_p \equiv \frac{\partial E}{\partial p} = c_M$ is the (compensated) demand for the manufactured good.[14] The tariff revenue $t\bar{p}(E_p - M)$ is distributed to consumers in a lump-sum fashion. By differentiating (17) and rearranging the terms (see Appendix D), we obtain:

$$E_u \frac{du}{dt} = -\left(\frac{wL}{1+\mu}\right)\frac{d\mu}{dt} + t\bar{p}^2\big(E_{pp} - M_p\big), \tag{18}$$

where $E_{pp} \equiv \frac{\partial E_p}{\partial p} = \frac{\partial c_M}{\partial p}$, $M_p \equiv \frac{\partial M}{\partial p}$, and $E_{pp} - M_p$ represents the change in the quantity of imports. Social welfare will improve if the effect from reducing the urban unemployment rate is sufficiently large and/or when the country's trade volume $(E_p - M)$ decreases to a sufficiently small extent. Furthermore, if this country initially engages in free trade ($t = 0$), then welfare unambiguously improves from introducing an import tariff on the urban manufactured good.

Proposition 5: *An increase in the import tariff rate of the urban manufactured good improves the steady-state welfare if the effect of reducing the urban unemployment rate is sufficiently large and/or when the tariff increase reduces the country's trade volume to a sufficiently small extent. Furthermore, if the country initially engaged in free trade, a marginal increase in the import tariff rate will improve welfare in the steady state.*

[14] In terms of the world price, $c_R + \bar{p}c_M = R + \bar{p}M$ holds. Here we assume away the export tax on the resource good to concentrate on the effects of the tariff.

6.3 Institutional Change under an Import Tariff on the Urban Manufactured Good

Given the effects of the import tariff derived above, we now discuss the possible resolution of urban labor market failure. An increase in t shifts the value of marginal product $pF'(L_M)$ upward in Fig.6 (the curves and points after the tariff increase are shown with a tilde). With a sufficiently large shift, the equilibrium wage level at $\widetilde{H}$ will exceed w_M. Then, urban labor market failure will be resolved because the urban labor market equilibrium in which $w \geq w_M$ is not binding occurs when the demand for urban and rural labor are equalized. Therefore, the import tariff could resolve urban labor market failure.

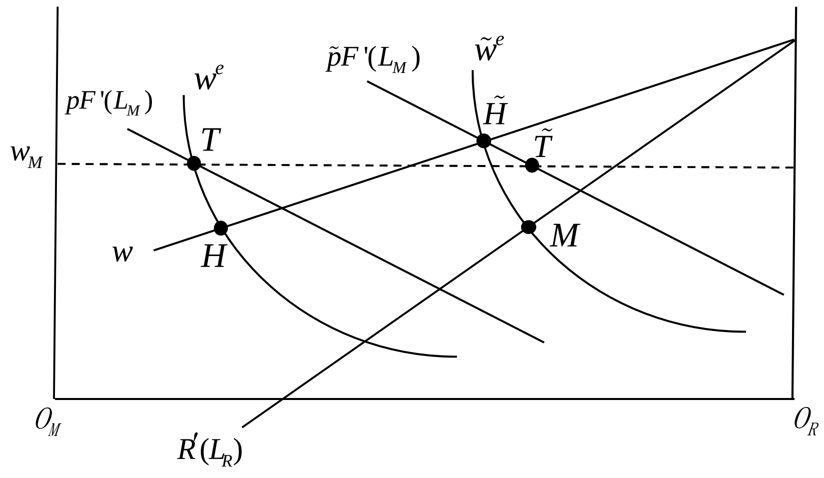

Fig.6. Resolution of Urban Labor Market Failure with Rural Open Access Resources

Another remark on the resolution of urban labor market failure with or without rural institutional failure is in order regarding resource use. For both sectors, inputs other than labor, resources and technology are assumed to be fixed. Not only the increase in the tariff rate analyzed above but also an increase in either the capital stock or productivity in the course of development increases the value of the marginal product $pF'(L_M)$. If the rural resources were private property, then rural labor demand would be given by the $R'(L_R)$ curve. Then, as Fig.6 shows, the *HT* equilibrium would still exist at point M. Therefore, in a situation where the upward shift in the value of the marginal product $pF'(L_M)$ continues in the manufacturing sector, an increase in the tariff rate resolves urban labor market failure *earlier* when the rural resource is subject to open access than when it is private property. This rural-urban nexus is a new finding of our paper.

Finally, we investigate whether rural institutional change from open access to a perfect private property system may occur through an increase in the tariff rate on the urban good. In the same hypothetical situation as presented in section 6.1, except that there is no export tax, the first-order condition for rural firms' profit maximization would be $w_R = R'(L_R^*)$. By substituting L_R^*, we obtain the maximum sustainable rent as $\pi^* = R(L_R^*) - w_R L_R^*$. By considering the HT equilibrium condition $w_R = \frac{w_M}{1+\mu}$, we derive the change in π^* that is due to an increase in the tariff rate:

$$\frac{d\pi^*}{dt} = [R'(L_R^*) - w_R]\frac{dL_R}{dt} + \frac{w_M}{(1+\mu)^2}\frac{d\mu}{dt}. \tag{19}$$

Using $w_R = R'(L_R^*)$ and $\frac{d\mu}{dt} < 0$, we obtain:

$$\frac{d\pi^*}{dt} = \frac{w_M}{(1+\mu)^2}\frac{d\mu}{dt} < 0. \tag{20}$$

That is, the maximum sustainable rent decreases. The import tariff on the urban manufactured good *necessarily reduces* the net benefit of institutional change to shift rural institutions away from open access to the perfect private property system.

The results regarding endogenous institutional change can be summarized as follows:

Proposition 6: *(i) An increase in the tariff rate on the urban manufactured good reduces the net benefit of institutional change to shift rural institutions away from open access to the perfect private property system. However, (ii) an increase in the import tariff rate or in the capital stock or productivity of the urban manufacturing sector may induce the resolution of urban labor market failure due to the institutionally fixed high wage rate. (iii) Urban labor market failure is resolved earlier when the rural resource is subject to open access than when it is under a perfect private property system.*

This finding of our paper, combined with proposition 5, might have important implications for small open developing countries that are highly dependent on open access natural resources. While governments of those countries will have an incentive to introduce import restrictions to protect the urban manufacturing sector, this industrialization policy tends to hinder rural institutional change to the perfect private property system, maintaining open access.

7. Concluding Remarks

This paper has investigated how urban poverty reduction and rural resource preservation can be simultaneously achieved in a small open dual economy with urban wage rigidity and rural open access resources. Both in the short run (when the rural resource stock is fixed) and in the long run (where rural resource dynamics are considered), an increase in the export tax rate on the rural resource good *necessarily increases* the rate and level of urban unemployment. We then proceed to derive the first-best policy, which makes the dual goals compatible, showing that it is a combination of an urban wage subsidy with a rural wage subsidy at a *lower* rate. A rural *tax* (instead of a subsidy) is the first-best policy if the domestic price of the urban manufactured good is sufficiently high. Furthermore, taking the possibility of endogenous institutional change into account, we have investigated whether and when an export tax on the rural good and an import tariff on the urban good will enhance the incentive to resolve the dual institutional failures.

Our analysis could be extended in several directions. First, we assume that harvesting a renewable resource is the only production activity in the rural sector. This assumption rules out other activities, such as agriculture. While labor reallocation from direct resource use to agriculture may alleviate resource overuse, agriculture might accelerate resource overuse in some cases (e.g., land conversion for agriculture that contributes to deforestation).[15] Considering 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 the environmental externalities associated with rural resources. These suggest important directions for future research exploring the compatibility of poverty reduction and environmental resource management in modern developing countries.

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

Appendix A: Existence Condition of the Harris-Todaro Equilibrium

This appendix shows how to solve the HT equilibrium under the export tax τ on the resource good. First, the urban manufacturing employment L_M^* is predetermined by (5). Then, rural income per capita in the steady state is $w^\tau = \frac{\alpha S(L_R)}{1+\tau}$. Combining this with (6), we have:

$$(1+\mu)\alpha S(L_R) = (1+\tau)w_M \tag{A.1}$$

Another relation between $(1+\mu)$ and L_R is the labor constraint (7) $L_R + (1 + \mu)L_M^* = L$. By simultaneously solving these two equations, we can obtain the HT equilibrium. The figure below shows the loci of $(1+\mu)$ and L_R that satisfy (A.1) and (7). If the vertical axis intercept of (7) is higher than that of (A.1), the HT equilibrium exists as an interior solution. This existence condition can be written as $(1+\tau)\left(\frac{w_M}{\alpha K}\right) < \frac{L}{L_M^*}$, which is equivalent to Assumption 1 under $\tau = 0$.

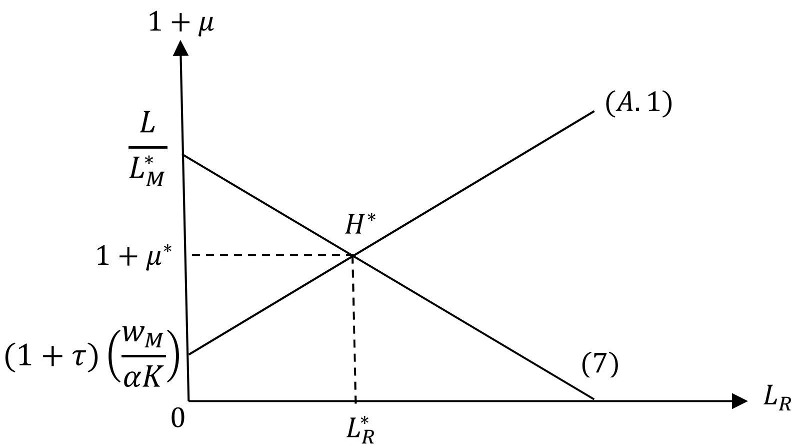

Fig.A.1 Existence of the Harris-Todaro Equilibrium

Appendix B: Sustainable Yield and the Dynamically Efficient Outcome

In section 5, we derived the first-best labor allocation in (11), where we apply:

$$\alpha K\left(1-\tfrac{2\alpha}{r}L_R^E\right)=w. \qquad (11')$$

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') for rural labor, 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 E_t is labor effort and $\rho>0$ is the discount rate (we let $E_t\equiv L_{Rt}$). Let H be the associated current-value Hamiltonian:

$$H_t=\alpha S_t E_t-wE_t+\lambda_t\left\{rS_t\left(1-\frac{S_t}{K}\right)-\alpha S_t E_t\right\},$$

where λ_t is the co-state variable associated with S_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 a harvest equal to natural resource growth: $\alpha SE = rS(1 - S/K)$ (the time subscript t is omitted here). It then follows from 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 the harvest equals natural resource growth in 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 C: Effects of the Parameters on the First-Best Rural Policy

This appendix investigates the effects of changes in K, r and α on the right-hand side of equation (12). By differentiating (11), we obtain:

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

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

It follows that $\frac{dL_R^E}{dr}>0$, $\frac{dL_R^E}{dp}<0$, and $\frac{dL_R^E}{dK}$ >0 (because $1-\frac{2\alpha}{r}L_R^E>0$). The sign of $\frac{dL_R^E}{d\alpha}$ is ambiguous. We now return to the expression for the optimal rural subsidy rate $s_R=w_M-\alpha K\left(1-\frac{\alpha}{r}L_R^E\right)$. The derivation above indicates that

$$\frac{ds_R}{dw_M}>0,\frac{ds_R}{dp}=\frac{\alpha^2K}{r}\frac{dL_R^E}{dp}<0.$$

Hence, the condition $s_R<0$ holds if w_M is low enough or if p is high enough. In both cases, the institutional failure of the urban labor market is small relative to the distortions due to rural resource open access, and hence, the first-best rural policy is to tax rural income. We also have

$$\frac{ds_R}{d\alpha}=-K\left(1-\frac{2\alpha}{r}L_R^E\right)+\frac{\alpha^2K}{r}\frac{dL_R^E}{d\alpha}=-K\left(1-\frac{2\alpha}{r}L_R^E\right)+\frac{\alpha^2K}{r}\frac{K\left(1-\frac{4\alpha}{r}L_R^E\right)}{\alpha K\left(\frac{2\alpha}{r}\right)-pF''(L_M^E)}$$

$$= \frac{-rK\left(1-\frac{2\alpha}{r}L_R^E\right)\left\{\alpha K\left(\frac{2\alpha}{r}\right)-pF"(L_M^E)\right\}+\alpha^2K^2\left(1-\frac{4\alpha}{r}L_R^E\right)}{r\left\{\alpha K\left(\frac{2\alpha}{r}\right)-pF"(L_M^E)\right\}}$$

$$= \frac{-2\alpha^2K^2+\frac{4\alpha^3K^2L_R^E}{r}+rK\left(1-\frac{2\alpha}{r}L_R^E\right)pF"(L_M^E)+\alpha^2K^2-\frac{4\alpha^3K^2L_R^E}{r}}{r\left\{\alpha K\left(\frac{2\alpha}{r}\right)-pF"(L_M^E)\right\}}$$

$$\frac{-\alpha^2K^2+rK\left(1-\frac{2\alpha}{r}L_R^E\right)pF"(L_M^E)}{r\left\{\alpha K\left(\frac{2\alpha}{r}\right)-pF"(L_M^E)\right\}} < 0.$$

Similarly, we have

$$\frac{ds_R}{dK} = -\alpha\left(1-\frac{\alpha}{r}L_R^E\right)+\frac{\alpha^2K}{r}\frac{dL_R^E}{dK} = -\alpha\left(1-\frac{\alpha}{r}L_R^E\right)+\frac{\alpha^2K}{r}\frac{\alpha\left(1-\frac{2\alpha}{r}L_R^E\right)}{\alpha K\left(\frac{2\alpha}{r}\right)-pF"(L_M^E)}$$

$$= \frac{-\alpha r\left(1-\frac{\alpha}{r}L_R^E\right)\left\{\alpha K\left(\frac{2\alpha}{r}\right)-pF"(L_M^E)\right\}+\alpha^3K\left(1-\frac{2\alpha}{r}L_R^E\right)}{r\left\{\alpha K\left(\frac{2\alpha}{r}\right)-pF"(L_M^E)\right\}}$$

$$= \frac{-2\alpha^3K+\frac{2\alpha^4K}{r}L_R^E+r\left(1-\frac{\alpha}{r}L_R^E\right)pF"(L_M^E)+\alpha^3K-\frac{2\alpha^4K}{r}L_R^E}{r\left\{\alpha K\left(\frac{2\alpha}{r}\right)-pF"(L_M^E)\right\}}$$

$$= \frac{-\alpha^3K+r\left(1-\frac{\alpha}{r}L_R^E\right)pF"(L_M^E)}{r\left\{\alpha K\left(\frac{2\alpha}{r}\right)-pF"(L_M^E)\right\}} < 0.$$

An intuition behind these two results is that as α or K increases, the sustainable yield of the rural resource good increases, and thus, the distortion due to open access increases. If these parameters have sufficiently large values, taxing rural income is part of the first-best policy. The effect of a change in r is ambiguous:

$$\frac{ds_R}{dr} = -\frac{\alpha^2K}{r^2}L_R^E+\frac{\alpha^2K}{r}\frac{dL_R^E}{dr} = -\frac{\alpha^2K}{r^2}L_R^E+\frac{\alpha^2K}{r}\frac{\alpha K\left(\frac{2\alpha}{r^2}L_R^E\right)}{\alpha K\left(\frac{2\alpha}{r}\right)-pF"(L_M^E)}$$

$$= \frac{-\frac{\alpha^2 K}{r}\left\{\alpha K\left(\frac{2\alpha}{r}\right) - pF"(L_M^E)\right\} L_R^E + \frac{\alpha^2 K}{r}\frac{2\alpha^2 K}{r^2} L_R^E}{r\left\{\alpha K\left(\frac{2\alpha}{r}\right) - pF"(L_M^E)\right\}}$$

$$= \frac{-\frac{2\alpha^4 K^2}{r^2} L_R^E + \frac{\alpha^2 K}{r} pF"(L_M^E) L_R^E + \frac{2\alpha^4 K^2}{r^3} L_R^E}{r\left\{\alpha K\left(\frac{2\alpha}{r}\right) - pF"(L_M^E)\right\}}$$

$$= \frac{\frac{2\alpha^4 K^2}{r^3} L_R^E (1-r) + \frac{\alpha^2 K}{r} pF"(L_M^E) L_R^E}{r\left\{\alpha K\left(\frac{2\alpha}{r}\right) - pF"(L_M^E)\right\}}.$$

If $r \geq 1$, then the denominator is negative, and hence $\frac{ds_R}{dr} < 0$. Otherwise, the sign is indeterminate.

Appendix D: Derivation of Welfare Formula (18)

Total differentiation of the budget constraint (17) 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 $dR = wdL_R + L_R dw$ derived from the zero-rent condition $R = wL_R$, we obtain:

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

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

Recall from (6) and (7) that $dw = -\left(\frac{w}{1+\mu}\right)d\mu$ and $dL_R = -(1+\mu)dL_M - L_M d\mu$.

Substituting them and using (5), we obtain:

$$E_u du = w\{-(1+\mu)dL_M - L_M d\mu\} - L_R\left(\frac{w}{1+\mu}\right)d\mu + pF'(L_M)dL_M$$

$$+t\bar{p}^2(E_{pp} - M_p)dt$$

$$= -\left(\frac{w}{1+\mu}\right)[L_R + (1+\mu)L_M]d\mu + t\bar{p}^2(E_{pp} - M_p)dt$$

By substituting (7), we obtain (18) in the text:

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

We can also write it as follows:

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

The right-hand side of this expression represents three welfare effects of the import tariff. The first term is the "resource overuse effect" due to open access, the second is "the (pure) urban unemployment effect," and the third is the "trade reducing effect" (negative due to the decrease in the import of the manufactured good $E_{pp} - M_p < 0$).

Acknowledgements

The previous version of this paper, entitled "Open-Access Renewable Resources and Urban Unemployment: Dual Institutional Failures in a Small Open Economy," was presented at the following meetings: the Kanto Branch Meeting of the Japan Society of International Economics (2015), the 12th Asia Pacific Trade Seminars (2016), Kobe University (2016), Kyoto University (2017), the 76th Annual Meeting of the Japan Society of International Economics (2017), Winter International Trade Seminar (2018), the 2018 Spring Meeting of the Japanese Economics Association, the 2018 Asian

Meeting of the Econometric Society, and the 6th World Congress of Environmental and Resource Economists (2018). Discussions by Kenzo Abe, Scott Barrett, and Keisaku Higashida, as well as comments by James Brander, Ngo Van Long, Kazuo Nishimura, Jota Ishikawa, Taiji Furusawa and Naoto Jinji helped us improve the draft. Daitoh is grateful to financial supports by JSPS KAKENHI Grant Numbers JP16K03654 and JP24530241 (Grant-in-Aid for Scientific Research(C)) and Keio Gijuku Academic Development Funds (2013, 2018).

References

Abe, K., Saito, M., 2016. "Environmental Protection in the Presence of Unemployment and Common Resources," *Review of Development Economics,* Vol.20, No. 1, pp.176–188.

Aide, T.M., Grau, H.R., 2004. "Globalization, migration, and Latin American ecosystems," *Science*, 305(5692), pp.1915-1916.

Barbier, E., 2005. *Natural Resources and Economic Development*, Cambridge University Press.

Barma, N.H., Kaiser, K., Le, T.M., Vinuela, L., 2012. *Rents to Riches? The Political Economy of Natural Resource-led Development.* World Bank.

Beladi, H., Chao, C., 2006. "Environmental Policy, Comparative Advantage, and Welfare for a Developing Country," *Environment and Development Economics* 11, pp.559-68.

Bhagwati, J.N., Srinivasan, T.N., 1974. "On Reanalyzing the Harris-Todaro Model: Policy Rankings in the Case of Sector-Specific Sticky Wages," *American Economic Review* Vol.64, No.3, pp.502-08.

Brander, J.A., Scott, M.T., 1997. "International Trade and Open-Access Renewable Resources: The Small Open Economy Case," *Canadian Journal of Economics* Vol.30, No.3, pp.526-552.

Brander, J.A., Scott, M.T., 1998. "Open Access Renewable Resources: Trade and Trade Policy in a Two-country Model," *Journal of International Economics* 44, pp.181-209.

Bulte, E.H., Barbier, E.B., 2005. “Trade and Renewable Resources in a Second Best World: An Overview,” *Environmental and Resource Economics*, 30, pp.423-463.

Chao, C., Kerkvliet, J.R., Yu, E.S.H., 2000. “Environmental Preservation, Sectoral Unemployment, and Trade in Resources,” *Review of Development Economics*, 4(1), pp.39-50.

Chichilnisky, G., 1994. “North-South Trade and the Global Environment,” *American Economic Review* Vol.84, No.4, pp.851-874.

Copeland, B.R., 2005. “Policy Endogeneity and the Effects of Trade on the Environment,” *Agricultural and Resource Economics Review, 34*(1), pp.1-15.

Copeland, B.R., Taylor, M.S., 2009. “Trade, Tragedy, and the Commons,” *American Economic Review*, *99*(3), pp.725-749.

Corden, M.W., Findlay, R., 1975. “Unemployment, Intersectoral Capital Mobility and Development Policy,” *Economica*, Vol. 42, No. 165, pp.59-78.

Daitoh, I., 2003. “Environmental Protection and Urban Unemployment: Environmental Policy Reform in a Polluted Dualistic Economy,” *Review of Development Economics* 7（3）, pp.496-509.

Daitoh, I., 2008. “Environmental Protection and Trade Liberalization in a Small Open Dual Economy,” *Review of Development Economics* 12(4), pp.728-736.

Daitoh, I., Omote, M., 2011. “The Optimal Environmental Tax and Urban Unemployment in an Open Economy,” *Review of Development Economics* 15(1), pp. 168-179.

de Janvry, A., Sadoulet, E., 2016. *Development Economics: Theory and Practice*. Routledge.

Dean, J.M., Gangopadhyay, S., 1997. “Export Bans, Environmental Protection, and Unemployment,” *Review of Development Economics* 1(3), pp.324-336.

Grau, H.R., Aide, T.M., 2008. “Globalization and Land-Use Transitions in Latin America,” *Ecology and Society*, 13(2).

Gupta, M.R., 1993. “Rural-Urban Migration, Informal Sector and Development policies: A Theoretical Analysis,” *Journal of Development Economics* 41, pp.137-151.

Fischer, C., 2010. “Does Trade Help or Hinder the Conservation of Natural Resources?,” *Review of Environmental Economics and Policy, 4* (1), pp.103-121.

Harris, J.R., Todaro, M.P., 1970. “Migration, Unemployment and Development: A Two-Sector Analysis,” *American Economic Review* Vol.60, pp.126-42.

Izquierdo, A.E., Grau, H,R., Aide, T.M., 2011. ”Implications of Rural-Urban Migration for Conservation of the Atlantic Forest and Urban Growth in Misiones, Argentina (1970–2030),” *AMBIO* 40, pp.298-309.

Jinji, N., 2006. “International Trade and Terrestrial Open-Access Renewable Resources in a Small Open Economy,” *Canadian Journal of Economics* Vol. 39, No. 3, pp.790-808.

Margolis, M., Shogren, J.F., 2009. “Endogenous Enclosure in North‐South Trade,” *Canadian Journal of Economics*, *42*(3), pp.866-881.

Noack, F., Riekhof, M.C., Quaas, M., 2018. “Development in a Dual Economy: The Importance of Resource-Use Regulation,” *Journal of the Association of Environmental and Resource Economists*, *5*(1), pp.233-263.

Rapanos, V.T., 2007. “Environmental Taxation in a Dualistic Economy,” *Environment and Development Economics* 12, pp.73-89.

Sachs, J.D., 2015. *The Age of Sustainable Development*, Columbia University Press, New York.

Simms, A., Reid, H., 2006. “Up in Smoke? Latin America and the Caribbean: The Threat from Climate Change to the Environment and Human Development,” *Oxfam Policy and Practice: Climate Change and Resilience*, *2*(1), pp.1-48.

Todaro, M.P., Smith, S.C., 2015. *Economic Development*, 12th edition. Pearson Education Limited.

Tsakiris, N., Hatzipanayotou, P., Michael, M.S., 2008. “Pollution, Capital Mobility and Tax Policies with Unemployment,” *Review of Development Economics* 12, pp.223-36.

Wang, L., 1990. “Unemployment and the Backward Incidence of Pollution Control,” *Journal of Environmental Economics and Management* 18, pp.292-98.

World Trade Organization, 2010. *World Trade Report 2010: Trade in natural resources*.