Open-Access Renewable Resources and Urban Unemployment:

Dual Institutional Failures in a Small Open Economy

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This paper investigates how poverty reduction and environmental resource preservation can be compatible in a small-open dualistic economy with urban wage rigidity and rural open-access resources, where rural-urban migration occurs endogenously. At the steady state, the first-best policy calls for an urban wage subsidy with a rural wage subsidy at a *lower* rate. A rural *tax* constitutes the first-best policy when the domestic price of urban manufactured good is sufficiently high. Thus the policy prescription by Bhagwati and Srinivasan (1974) does not apply when the world price of the resource good is low and/or a tariff on the manufactured good is high. Export tax on the resource good reduces the unemployment rate unlike what existing literature indicates. The number of the unemployed also decreases if the domestic price of manufactured good is high enough. A small export tax always improves welfare by mitigating the two institutional failures. Along a transition path, rural resource preservation is compatible with urban poverty reduction.

JEL Classification Codes: O13, Q27, F18

Keywords: open access; renewable resource; urban unemployment; export tax on the resource good; Harris-Todaro model

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1. Introduction

Poverty reduction and environmental preservation constitute fundamental challenges to many developing economies. As indicated in the United Nations' Sustainable Development Goals (Sachs, 2015), international development agencies including the World Bank and non-governmental organizations advocate policies to overcome these dual challenges. The economics literature has explored policies to pursue these dual goals based on the traditional dualistic economy model a la Harris and Todaro (1970). These applications focus on the 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, pose a key challenge for many developing countries in achieving the dual 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) documents, 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 on forest conservation in Argentina. They found that under the future land-use-cover scenarios they considered, 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 behind rural-urban migration, which is another global trend across developing economies (Todaro and Smith, 2015, Chapter 7). In particular, while discouraging rural resource exploitation (or encouraging urban manufacturing) may mitigate resource overuse, the accompanying rural-to-urban 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, which is a key characteristic of developing economies. A recent study by Noack, et al. (2018) is an exception: by using a dynamic model of a dualistic economy, it takes into account the income differences between a rural sector with an open-access renewable resource and an urban sector given costly migration. The authors find that a policy to regulate resource use allows rents from resource to accumulate, thereby enhancing efficiency of the labor allocation between the rural and the urban sectors. Our study investigates a similar dualistic aspect of a developing economy, where our approach allows us to study not only the rural-urban wage gap but the extent of urban unemployment (or the size of the urban informal sector, depending on the interpretation) as well as the impacts other types of policies such as trade liberalization.

Conversely, most previous studies on trade and environment with labor-market imperfection have paid no attention to the overexploitation problem concerning open-access resources. Nor have they considered renewable resource dynamics. Dean and Gangopadhyay (1997) and Chao, Kerkvliet and Yu (2000) considered deforestation 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 a perfect property right regime on resources, eliminating the possibility that open-access resources are overexploited.

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 but stylized manner, i.e., a small open Harris-Todaro (HT) model with an open-access resource in the rural sector.[1] 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, as discussed 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—a policy instrument frequently used by many resource-rich countries as described below—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 an export tax is one of the most common policy instruments imposed on natural resource sectors in many developing countries (WTO 2010).[2] The direction of change in urban unemployment, influenced by the export taxes, determines whether a reduction in urban

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

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

poverty will be compatible with a decrease in overexploitation of rural resources.[3] Abe and Saito (2016) is the 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; given the institutionally-fixed urban wage, the export tax does not affect the equilibrium number of urban manufacturing workers. Thus, in Abe and Saito (2016), 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.[4] We reexamine the direction of change in the rate of urban unemployment based on the general HT model in which the export tax can change both the number of urban manufacturing workers and the rural population. We derive our main results from the "sustainable yield" model that focuses on the steady state of rural resource stock, and explore the results along a transition path as well.

[3] The rate of urban unemployment plays a critical role in evaluating social welfare in HT models. See section 5.
[4] In the Harris-Todaro framework, the unemployment rate is defined as the ratio of the number of urban unemployed people to the number of urban manufacturing workers.

Our analysis generates a number of findings. First, in the “sustainable yield” model, 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 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. Besides, along a transition path, rural resource preservation is compatible with urban poverty reduction. However, the export tax does not affect the rate of urban unemployment but aggravates the level of it along the transition path.

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 possibility of endogenous resolution of institutional failures in section 5 of the paper.

2. The Model

2.1 Small Open Dualistic Economy with Rural Open-Access Resources in the Steady State

Consider a small open economy with two sectors: a rural sector producing a resource good and an urban sector that produces a manufactured good. 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. 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.

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:

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

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 rural agents 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:[5]

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

[5] 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.

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 $\dot{S_t} = 0$:

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

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

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

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

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

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:

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

where $\mu \equiv L_U/L_M \geq 0$ is the urban unemployment rate, and $L_U \geq 0$ 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:

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

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). 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 the gross domestic product (GDP) $R + pM$ is maximized.

Although one can prove easily the existence of a unique interior general equilibrium solution under some mild conditions[6] we will have to get into complicated analytical procedures if we only use equations. Fortunately, however, by making use of the

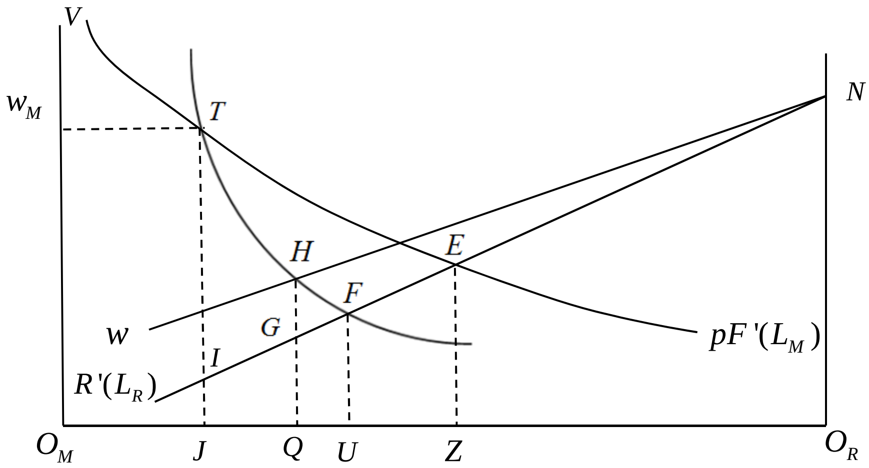
[6] Appendix B shows how to solve the general equilibrium system in which the manufactured good is the numeraire. The present model could be solved in the same way.

well-known diagram originated by Corden and Findlay (1975), we can clearly explain the properties of our HT equilibrium and derive our results.

2.2 Properties of HT Equilibrium with Rural Open-Access Resources

We will elucidate the properties of our HT equilibrium with open-access resources in the rural sector. In Figure 1, given the urban manufacturing employment L^*_M determined by (5) which is shown by $O_M J$, we draw the curve representing the relation between the expected urban wage rate $w^{\mathrm{e}} = w_M L^*_M / L_C$ and the city population L_C. It is a rectangular hyperbola passing through point T with the origin O_M. This is usually called the Harris-Todaro (HT) curve in development economics. Because the rural income line $w = \alpha S(L_R)$ with the origin O_R crosses the HT curve at point H, the city and rural populations are $O_M Q$ and $O_R Q$, respectively. The 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.

Figure 1. Equilibrium of HT Economy with Rural Open-Access Resources



The equilibrium H of our HT model suffers from two kinds of distortions, which we could call “dual institutional failures”. The first institutional failure is the institutionally-fixed high wage rate in the urban sector while the second the open-access renewable resources in the rural sector. We will explain the consequences of these institutional failures in terms of losses in gross domestic product (GDP). As a starting point, the first-best resource allocation is shown by point E, where the value of marginal product of labor (MPL_M) in urban manufacturing $pF'(L_M)$ is equal to the marginal product of labor (MPL_R) in the rural sector $R'(L_R)$. The GDP is shown by O_MVENO_R.

First, the institutionally-fixed high wage rate w_M induces GDP losses for two reasons. It makes the manufacturing employment (O_MJ) less than the first-best urban employment O_MZ. Then the value of urban manufacturing production is O_MVTJ and thus the corresponding GDP loss will be $EZJT$. If all the remaining population (O_RJ) lived in the rural area, the rural production would increase by $EZJI$. Therefore the net loss of GDP will be EIT. In this sense, the institutionally-fixed high urban wage rate, which induces the less-than-optimal manufacturing employment, is one reason for the GDP loss. However, people intend to migrate as far as their urban expected wage rate is higher than the rural income. Because, *without the open access* of resource stock, the rural population would be determined at the intersection F of the rural MPL_R curve $R'(L_R)$ and the HT curve, the population JU would move from rural to urban area and thus the value of rural production would be lost by $FUJI$. This shows another reason for the GDP loss: the emergence of urban unemployment (JU) caused by excess rural-to-urban migration due to the equalization of expected wage rates.

The second institutional failure, which is specific to our HT model, is over-use of the rural resource stock, or equivalently, excess rural production due to the open access of resource stock. This can be captured by the divergence between the average ($w = \alpha S(L_R)$) and marginal ($R'(L_R)$) products of labor in the resource good sector. Because in our HT equilibrium the rural population turns out to be $O_R Q$ (corresponding to H) instead of $O_R U$ (corresponding to F), the excess rural production leads to more rural population, hindering the excess rural-to-urban migration. Then the level of urban unemployment (JQ) is less than the length of JU. This increases the value of rural production by $FUQG$ (the value of rural production itself is $O_R NGQ$). To sum up, the over-use of resource stock in the rural sector helps decreasing the urban unemployment.

From the explanations above, the overall GDP loss in our HT economy is shown by $EGQJT$.

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 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*.[7] Then we investigate when the first-best policy combination consists of a rural income *tax*.

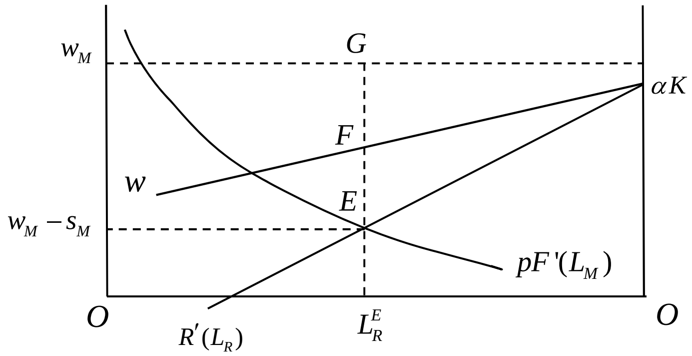
3.1 First-best Allocation and Urban Wage Subsidy

Let us first define the first-best allocation. It is attained when the value marginal products of labor are equalized across the rural and the urban sectors. 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

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

This is shown by point E in Figure 2. An interior solution E exists because the manufacturing production function $F(L_M)$ satsfies $F'(0) = \infty \; and \; F'(\infty) = 0$.

Figure 2. Rural Income Subsidy



[7] 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.

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 wage rate received by the urban 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 allocation E.

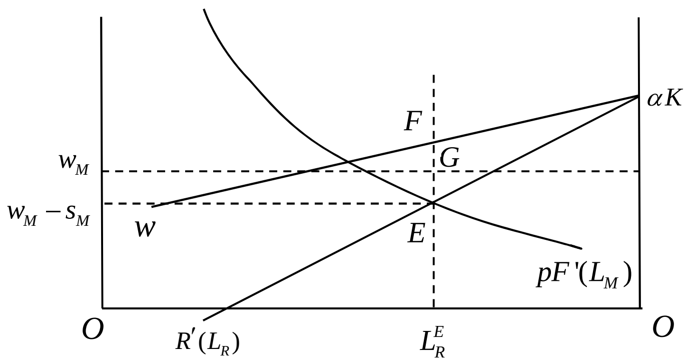
3.2 Rural Income Subsidy

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. The line $w = \alpha S(L_R)$ lies above $R'(L_R) = \alpha S(L_R) + \alpha S'(L_R) L_R$ because of $S'(L_R) = -\alpha K/r < 0$. 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 agents have no incentive for further 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 passes through point *G*. Then the government should set the rural income subsidy at zero ($s_R = 0$). If $w_M < w$ holds at L_R^E, the rural income *tax* $t_R = FG$ 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:

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

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

Proposition 1:

Consider the "sustainable yield" model of a small open HT economy with rural open-access renewable resources.

(i)*The first-best 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 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 p of the urban manufactured good is higher. The relations to K, r and α are ambiguous.*

Result (ii)-(a) holds because w_M is given independently of the other parameters when determining the first-best allocation. Intuitively, the lower w_M is, the smaller the urban labor market distortion is. In such situations, the size of the tax rate to correct resource overuse would exceed the size of the subsidy rate necessary to address the labor market imperfection in the urban sector. Thus the optimal policy calls for a rural tax rather than a rural subsidy.

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 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. Under these circumstances, 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, should be modified for modern dualistic developing economies whose production highly depends on rural open-access resources.

Second, the first-best rural policy will be a rural income tax, instead of a subsidy, when this country imposes a high import tariff on the urban manufactured good (which leads to the high 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. Thus domestic income inequality between rural and urban areas will be aggravated. In the absence of the rural institutional failure, the first-best policy to address the urban labor-market institutional failure will not aggravate income inequality between rural and urban residents because it consists of the same rates of rural and urban wage subsidies. With the additional institutional failure in the rural sector, however, the first-best policy gives rise to a trade-off between efficiency and equity between rural and urban areas.

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. 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 $t \geq 0$ be the ad-valorem tax rate on the export of the resource good.[8] The world relative price of the resource good is higher than its domestic price, i.e., $\frac{}{\bar{p}} = (1 + t)\left(\frac{1}{p}\right) > \frac{1}{p}$. Then the domestic price of the urban manufactured good is $p = (1 + t)\bar{p}$, with its world price $\bar{p}$ given exogenously.

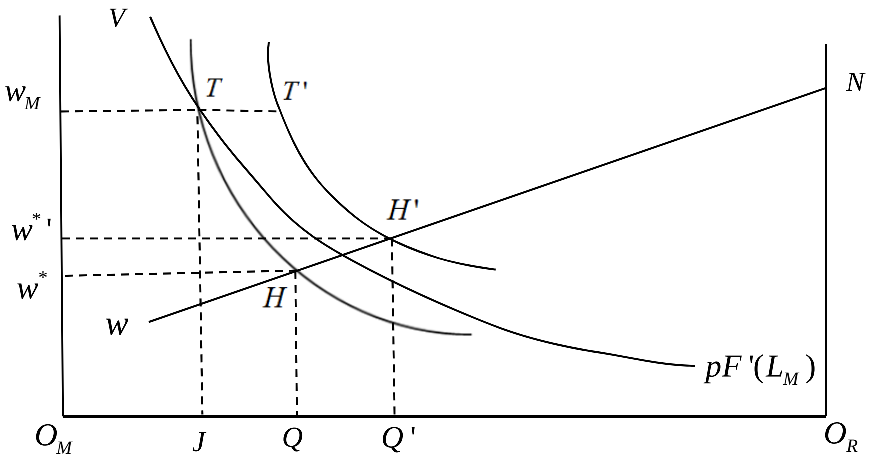
4.2 Steady-State Effect on the Rate of Urban Unemployment

We will 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. A rise in t increases the urban manufacturing employment L_M^* and thus the HT curve shifts upward to $H'T'$ in Figure 4. Because the rural income curve (w) remains unchanged, the equilibrium moves from H to H'. Therefore the rural population L_R^* decreases while the rural income w^*

[8] 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.

increases. Therefore the rate μ^* of urban unemployment decreases by (6) $w^* = w_M/(1+\mu^*)$.

Figure 4. Effect of an Increase in the Export Tax



Proposition 2:

In the "sustainable yield" model, 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.[9] 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 rate on the resource good will not increase but *reduce* the *rate* of urban unemployment.[10] In this sense, a reduction in urban unemployment will be compatible with the preservation of rural resource stock.[11]

[9] Other differences include (i) the number of resource users is exogenous and thus 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.

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

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

However, the *level* of urban unemployment may or may not decrease as demonstrated below. In what follows, we will say that urban poverty reduction and rural resource preservation are “compatible” if an increase in the resource stock accompanies decreases in both the rate and the level of urban unemployment. If it accompanies only the decrease in the unemployment rate, we will say that they are “less compatible”.

4.3 Steady-State 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 decreasing in the export tax rate. It follows from (6), (7), and (8) that the equilibrium satisfies $\alpha K\left(1-\frac{\alpha}{r}L_R\right)(L-L_R)=w_M L_M^*$. Total differentiation yields $\alpha K\left[-\frac{\alpha}{r}(L-L_R)-\left(1-\frac{\alpha}{r}L_R\right)\right]dL_R=w_M dL_M$. Thus we obtain

$$\frac{dL_R^*}{dL_M^*}=-\frac{w_M}{\alpha K\left[\frac{\alpha}{r}(L-L_R)+\left(1-\frac{\alpha}{r}L_R\right)\right]}>0. \qquad (13)$$

Note that $\frac{dL_U^*}{dt}=\frac{dL_U^*}{dL_M^*}\frac{dL_M^*}{dt}$ where $\frac{dL_M^*}{dt}>0$ as discussed above. It follows from $dL_R+dL_M+dL_U=0$ that the necessary and sufficient condition for $\frac{dL_U^*}{dL_M^*}<0$ (and hence $\frac{dL_U^*}{dt}<0$) is $-\frac{dL_R^*}{dL_M^*}<1$. Using (13), it is equivalent to

$$w_M<\alpha K\left[\frac{\alpha}{r}(L-L_R)+\left(1-\frac{\alpha}{r}L_R\right)\right]. \qquad (14)$$

It then follows from (8) that

$$w_M-w^*<(L-L_R^*)\alpha^2 K/r. \qquad (15)$$

This inequality implies that a rise in the export tax rate on the resource good decreases the level of urban unemployment when the resource good sector has a small proportion in the economy's total production (L_R^* is small) and the rural-urban income gap ($w_M - w^*$) is small.

When is (14) or (15) 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 C), we can find unambiguous effects of the domestic price p of the urban manufactured good. When the initial value of p is higher, L_M^* is larger and thus, in Figure 4, the *HT* curve lies at a higher position of $H'T'$. Then L_R^* is smaller and w^* is higher. Therefore, (15) is more likely to hold when the initial domestic price p is higher. In light of Lerner's symmetry theorem, we obtain:

Proposition 3: In the "sustainable yield" model, a *rise in the export tax rate t on the resource good decreases the level of urban unemployment if and only if the country's domestic price p of the urban manufactured good is sufficiently high. This situation occurs when (i) the world price of the manufactured (resource) good is high (low) under free trade, (ii) an initial rate of export tax on the resource good is high, and/or (iii) an initial rate of import tariff on the manufactured good is high.*

Let us make an intuitive explanation for this proposition. When the domestic price p is high, this economy tends to have small rural population L_R^* at the initial equilibrium. Then, a rise in t, which leads to a higher value of p, expands the urban manufacturing employment 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 $w = \alpha K\left(1 - \frac{\alpha}{r}L_R^*\right)$, we have $dw = -\alpha K\left(\frac{\alpha}{r}\right)dL_R$, and thus $\frac{dL_R}{dw} = -\frac{r}{K\alpha^2}$. The elasticity of rural labor demand is:

$$\varepsilon = -\frac{w}{L_R}\frac{dL_R}{dw} = \frac{w}{L_R}\left(\frac{r}{K\alpha^2}\right) = \frac{K\alpha}{L_R}\left(1 - \frac{\alpha}{r}L_R\right)\left(\frac{r}{K\alpha^2}\right) = \frac{r}{\alpha L_R} - 1, \quad (16)$$

which is positive by $1 > \frac{\alpha}{r}L_R^*$. Because the rural population L_R^* is small at the initial equilibrium, the elasticity ε of rural labor demand will be large. This implies that a larger rural-to-urban migration is needed until the rural income per capita is equal to the urban expected wage rate. However, because the rural population is small, the absolute number of migrants will be small.

On the other hand, when p is high, 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 large (because of $\frac{dp}{p} = \frac{dT}{T}$ derived from $p = T\bar{p}$). Thus the upward shift of the value

MPL_M curve will be large. Then an increase in the urban manufacturing employment will be large while the number of migrants from the rural sector will be small. Therefore, the number of people unemployed in the city (the *level* of urban unemployment) will decrease.

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, an introduction of the export tax 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 less compatible.

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 less compatible.

5. Welfare and Endogenous Institutional Changes

5.1 Steady-State Welfare

In this subsection 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 $E(1, p, u)$ denote the representative consumer's (minimum) expenditure function 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:

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

Totally differentiating (17) and rearranging the terms (see Appendix D), we obtain:

$$E_u \frac{du}{dt} = -\left(\frac{wL}{1+\mu}\right)\frac{d\mu}{dt} - t\bar{p}c_M\left(\varepsilon_C + \varepsilon_M \frac{M}{c_M}\right), \tag{18}$$

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 (18) 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.[12] 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 4: *In the "sustainable yield" model, 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.*

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[12] See the last equality in Appendix D for an explicit expression relating the second term on the right-hand side of (18) to the corresponding change in trade volume.

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 case where the domestic price p of the urban manufactured good is high. A corresponding realistically relevant situation for a developing country which is highly dependent on rural renewable resources may be the one in which the world price of a resource intensive good is low under free trade and /or the government imposes 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 wage subsidy s_M. 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, an introduction of the export tax rate on the resource good will decrease not only the rate (Proposition 2) but also the level of urban unemployment (Proposition 3), thereby improving welfare (Proposition 4).

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 chooses low tariffs on the urban manufactured goods in the world wide trend for trade liberalization. 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 be less compatible.

5.2 Resolution of Institutional Failures

The analysis so far takes the institutional failures associated with the urban labor market and rural resource use as given. Previous studies have shown that such market failures might be resolved due to changes in the market conditions such as capital accumulation, technological change, and changes in the terms of trade. Here we discuss how the preceding policy analysis changes if such induced institutional changes are taken into account.

We start with the possibility of changes in institutions involving rural resource use. A number of studies indicate that policy reforms (or institutional change in general) to restrict resource use may be introduced when the relative price of the harvested good increases due to trade liberalization (Copeland 2005, Copeland and Taylor 2009, Margolis and Shogren 2009). 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 would be equal to the profit of competitive firms producing the harvested good in the steady state, is a function of the rural labor input:

$\pi(L_R) = R(L_R) - w_R L_R$, where w_R is the wage rate given in the competitive rural labor market. Suppose that the cost of avoiding open access and enforcing resource management is given by $C > 0$ per unit of time. Further assume that, under autarky, C exceeds the maximum sustainable rent: $C > \max_{L_R} \pi(L_R)$. This inequality implies that the benefit of introducing institution does not justify the cost. However, as the terms of trade change in favor of the output from the resource sector due to trade liberalization, the maximum sustainable rent would increase and may exceed C. If it does, then trade liberalization would induce institutional change.

How would an increase in the export tax rate influence the prospect of institutional change in our model? The first order condition for maximizing the sustainable rent from resource use is $w_R = R'(L_R^*)$. Substituting L_R^*, we obtain the maximum sustainable rent as $\pi^* = R(L_R^*) - w_R L_R^*$. Taking account of the HT equilibrium condition $w_R = \frac{w_M}{1+\mu}$, we derive the change in π^* due to an increase in the export tax:

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

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

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

Then the export tax works in the direction opposite to trade liberalization, and hence will not increase the maximum sustainable rent. This fact implies that the results that are obtained in the previous sections are robust against the possibility of endogenous institutional change.

We turn to the possible resolution of labor-market frictions in the course of development. An increase in t shifts the value of marginal product of labor in the manufacturing sector upward (Figure 4). With a sufficiently large shift, the equilibrium wage level will exceed w_M. Then the labor market failure will be resolved because the labor market equilibrium where $w \geq w_M$ is not binding occurs when the inverse demands for labor in the urban and the rural areas are equalized. Therefore, an export tax on rural natural resource use may induce the resolution of the urban labor market failure.

Another remark regarding the resolution of the labor market failure with or without institutional failure in resource use is in order. Factors that are implicitly assumed to be fixed in the previous analysis include inputs, other than labor and resource, for production and technology used in both sectors. An increase in the capital stock or productivity in the manufacturing sector shifts the value of marginal product of labor upward. Looking at Figure 1 again, we could observe that the labor market failure will be resolved earlier when the resource is under open access than when its use is regulated. Again, the labor market equilibrium where $w \geq w_M$ is not binding occurs when the inverse demands for labor in the urban and the rural areas are equalized. While the inverse demand for labor in the rural sector is given by its marginal product when the resource is used under private property, under open access it is given by its average product, which lies above the marginal product curve. Hence it is possible that the minimum wage constraint $w \geq w_M$ is binding when the resource is under private property while it is not when the resource is open access. Therefore, in a situation where the marginal product curve for labor in the manufacturing sector shifts upward continuously, the labor-market friction is resolved earlier when the resource is open access.

6. Compatibility along a Transition Path

Until now we have concentrated on the compatibility problem in the steady state. In this section we investigate the effects along the transition path from one steady state to another by slightly modifying the "sustainable yield" model. We will consider the model in which the migration equilibrium is determined at a point in time and the rural resource stock S is adjusted over time. This short-run equilibrium model consists of five equations (1), (2), (5), (6) and (7), and determines the values of five variables (R, w, L_R, L_M, μ), given $S, w_M, p \; and \; L$.

First, when the resource stock S increases exogenously, the urban manufacturing employment L_M^* remains unchanged by (5). The rural income per capita w^* increases by

(2), promoting urban-to-rural migration. Because the level of urban unemployment L_U^* decreases and thus the rate of urban unemployment $\mu^* = L_U^*/L_M^*$ declines. This implies that the rural resource preservation is "compatible" with urban poverty reduction in the short-run equilibrium. These two goals turn out to be "compatible" along a transition path.

Second, a rise in the export tax on the rural resource good increases the domestic price p of urban manufactured good. It does not affect the rural income per capita w^* and the rate of urban unemployment μ^* because neither (2) nor (6) include p. However, the urban manufacturing employment L_M^* increases and therefore the level of urban unemployment $L_U^* = \mu^* L_M^*$ increases. In the short-run equilibrium, the export tax will have no effects on the rate of urban unemployment but aggravate the level of it. Welfare always decreases because (18) is valid and $\frac{d\mu}{dt} = 0$ holds. However, when S increases along a transition path, the rate of urban unemployment declines ($\frac{d\mu^*}{dS}$ 0) and thus welfare tends to improve along it.

Proposition 5: *Consider the short-run equilibrium model in which the migration equilibrium is determined at a point in time, given the rural resource stock* S *. An increase in* S *(i) has no effects on the urban manufacturing employment* L_M^* *and (ii)* *leads to a reduction in the rate and level of urban unemployment. (iii) An export tax on the rural resource good does not affect the rate of urban unemployment while it increases the level of it. (iv)* When S *increases along a transition path, welfare tends to improve along it*

7. Concluding Remarks

This paper explores when poverty reduction and resource preservation can be compatible in a developing economy 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 or export tax on the resource 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. Furthermore, the *level* of urban unemployment is more likely to decrease if the domestic price of the urban manufactured good is higher. Finally, an introduction of the export tax always improves welfare if this country initially engages in free trade. Besides, rural resource preservation is “compatible” with urban poverty reduction along a transition path. However, the export tax does not affect the rate of urban unemployment but aggravates the level of it along the transition path.

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).[13] 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

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

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. These must be important directions for future research exploring the compatibility between poverty reduction and environmental resource management in modern developing countries.

Appendix A: Effects of Parameters on the Efficient Labor Allocation

This appendix shows that the effects of changes in K, r and α on the right-hand side of inequality (12) are ambiguous. Totally differentiating (11), we get:

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

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

The relations of the exogenous parameters to the efficient allocation are:

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

The signs of $\frac{dL_R^E}{dK}$, and $\frac{dL_R^E}{d\alpha}$ are ambiguous. An increase in K and α has an ambiguous effect on the value of L_R^E and thus on the right-hand side of (12). Therefore the relations to K, r and α are ambiguous.

Appendix B: The Model with Manufactured Good as the Numeraire

This appendix shows that the rate of urban unemployment 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 the urban wage, rural income per capita, *domestic* prices of the urban manufactured good and the rural resource good in *nominal* terms be W_M,W,P_M and P_R, respectively. Then equilibrium conditions (2), (5) and (6) will be written as:

$$W = \frac{P_R R}{L_R} = P_R \alpha S, \qquad (2')$$

$$W_M = P_M F'(L_M), \qquad (5')$$

$$W = \frac{W_M}{1+\mu}\ , \qquad (6')$$

We proceed to the model in which the urban manufactured good is the numeraire, i.e. $P_M = 1$. We get $\frac{W}{P_M} = \left(\frac{P_R}{P_M}\right)\alpha S$ from (2') and $\frac{W_M}{P_M} = F'(L_M)$ from (5'). Define the urban wage rate, which is fixed in terms of the manufactured good, as $\widetilde{w_M} = \frac{W_M}{P_M}$. Denoting $\widetilde{w} = \frac{W}{P_M}$ and $q = \left(\frac{P_R}{P_M}\right)$, we have the system of the six simultaneous equations below.

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

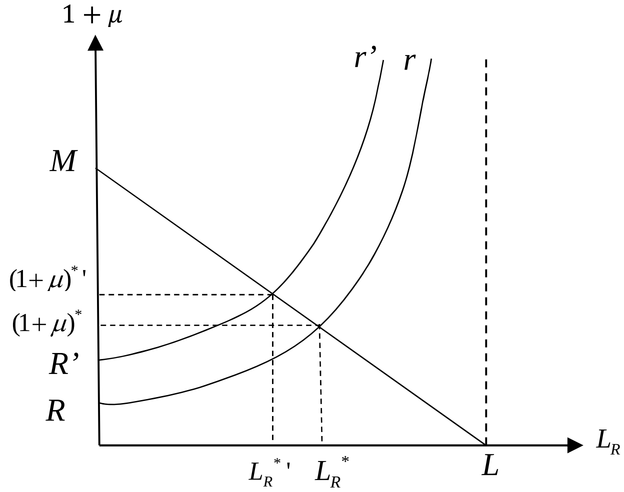
$\widetilde{w} = \frac{qR}{L_R} = q\alpha S,$ (2")

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

$\widetilde{w_M} = F'(L_M),$ (5")

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

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



Given $(q, \widetilde{w_M}, L)$, this system determines the six unknowns $(R, S, \widetilde{w}, L_R, L_M, \mu)$. It can be solved as follows. First, L_M^* is pre-determined by (5'). Then (7) $L_R + (1+\mu)L_M^* = L$ determines the *ML* line with the vertical intercept M of L/L_M^*. On the other hand, substituting (1) into (3) yields (5) $S(L_R) = K\left(1 - \frac{\alpha}{r}L_R\right)$ in the text. Plugging this into (2') and eliminating $\widetilde{w}$ by using (6), we get $\widetilde{w_M} = (1+\mu)q\alpha K\left(1 - \frac{\alpha}{r}L_R\right)$. This determines the *Rr* curve. The general equilibrium is determined at the intersection of the *ML* and *Rr* curves.

A higher export tax rate lowers the domestic price q of resource good relative to its world price. To see this, an export tax makes the nominal world price of resource good equal to $\overline{P_R} = (1+t)P_R$. The nominal world price of manufactured good equals its domestic price, $\overline{P_M} = P_M$. Thus, using $\overline{P_R}/\overline{P_M} = (1+t)P_R/P_M$, we get $q = \left(\frac{\overline{P_R}}{\overline{P_M}}\right)/(1+t)$. Therefore a higher export tax rate shifts the *Rr* curve upward. However, because L_M^*

does not change in this model (see equation (5’)), the *ML* line remains unchanged. Thus, L_R^* decreases while $(1+\mu^*)$ increases in equilibrium. The *rate* μ^* of urban unemployment would *increase* if we chose the manufactured good as the numeraire as in Abe and Saito (2016).

By contrast, if we choose the resource good as the numeraire, i.e. $P_R = 1$, the domestic relative price of urban manufactured good is $p = \frac{P_M}{P_R} = \frac{\overline{P_M}}{\overline{P_R}/(1+t)} = (1+\mathrm{t})\bar{p}$. A higher export tax rate increases p and thus increases L_M^* by (5) in the text, where $w_M = W_M/P_R$ is fixed. In order to obtain sufficiently general results, the resource good should be taken as the numeraire.

Appendix C: Effects of Parameters on Open-Access Equilibrium L_R^*

This appendix shows that the relations of L, K, α, r and w_M to the right-hand side of (14) or (15) are ambiguous. 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:

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

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

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

Then we have:

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

You can easily see the overall effects of L, K, α and r on (14) or (15) are ambiguous.

Furthermore, 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 D: Derivation of Welfare Formula (18)

Total differentiation of (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 $dR = wdL_R + L_R dw$ from the zero-rent condition $R = wL_R$, we get;

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

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

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, 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 term on the right-hand side satisfies

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

Thus we obtain (18) in the text.

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