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A condition for the reduction of urban unemployment in the Harris–Todaro model

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Abstract The purpose of this paper is to re-examine the Harris–Todaro model and Todaro paradox in developing countries. Specifically, we address the question of whether new job creation in urban areas always increases urban unemployment. The results of this analysis lead to the derivation of a necessary and sufficient condition under which urban unemployment does not increase when urban social infrastructure is improved and new employment is created. In short, this condition circumvents Todaro paradox. It involves the relationship between an institutionally and legally fixed urban minimum wage in the model and agricultural productivity. The condition itself is simple, but it offers significant suggestions for actual policy design.

Keywords Harris–Todaro model · Domestic migration · Domestic wage gap · Informal sector · Urban unemployment

JEL Classification J61 · J64 · O12 · O17

1 Introduction

Since the publication of two seminal papers, Todaro (1969) and Harris and Todaro (1970), the problem of underemployment and unemployment in the urban sector has long been a major focus in the economic analyses of LDCs. The Harris–Todaro model (hereafter, HT model), proposed in the two papers mentioned above, provides an interesting short-run analysis of labor migration between rural and urban areas and urban unemployment and underemployment in the urban informal sector.

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In the HT model, workers determine migration between the sectors based on their expected wages. Thus, the workers decide to migrate to the urban sector when their expected wages there are higher than those in the rural sector. It is assumed in the HT model that the urban wage is institutionally and legally fixed, so that as a result of the migration of workers, if there are more workers than the number of new jobs, some workers would necessarily be unemployed. They have to enter the urban informal sector and be unemployed or underemployed there.

In general, capital accumulation in the urban sector is indispensable for economic development in LDCs. Although they all might be lumped together as "capital", there are a lot of types and features. From the micro-perspective of a firm, machinery and equipment for production are one of the capital, capital stock such as internal reserves is also a capital. On the other hand, from the macro-perspective of an economy, social infrastructure such as airports, loading and port facilities, is also included in the capital. In this sense, industrial parks including the special economic zones (hereafter, SEZs) are one of the most important social capital. Accumulated capital, such as the SEZs in the urban industrial parks creates new job opportunities. In particular, construction of the SEZs invites many foreign companies, since in the SEZs the corporation tax is treated well. Therefore, through the exemption or discount from the corporation tax, the companies operating in the SEZs can reduce their operation costs and could become profitable.

In the process of economic development in LDCs, it has been repeatedly observed that as foreign capital creates new employment opportunities, there is an increase in worker flow from rural areas to urban areas with a concomitant decrease in per-capita income in the urban area. This phenomenon is generally referred to as the "Todaro paradox" in the field of development economics[1]

Improvements in social infrastructure, such as airports, loading and port facilities, and industrial parks including the SEZs tend to attract capital from advanced foreign countries. Still, does the improvement of social capital necessarily increase unemployment in urban areas? In other words, does new job creation in urban areas always result in the Todaro paradox?

Although much research has been devoted to the Todaro paradox, including Zarembka (1970), Blomqvist (1978), Arellano (1981), Takagi (1984), Nakagome (1989), Stark et al. (1991), Raimondos (1993), Brueckner and Zenou (1999), Brueckner and Kim (2001), most of these studies detail the conditions under which the Todaro paradox occurs. They do not, however, deal with the Todaro paradox in terms of the relation between an institutionally fixed urban wage and agricultural productivity in rural area.

If the Todaro paradox occurs, even if the urban development is carried out, per-capita income in the urban area does not increase, and the urban informal sector expands. In the previous studies, there was not an idea to promote an agricultural

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[1] This paper was inspired by an event that occurred in Metro Cebu, the Philippines, in the period from the 1980s into the 2000s. Metro Cebu locates in the central part of the Philippines and forms a major metropolitan region, next to Metro Manila. ODA projects by the Japanese Government have created industrial parks, and developed social infrastructure including airports, ports, and roads. As a result, the population in Metro Cebu has doubled, but per-capita income has nevertheless decreased. See Japan Bank for International Cooperation (2003).

development for the purpose of controlling the labor migration to the urban area. In this paper, to succeed in developing the urban area without the Todaro paradox, we develop an argument focusing on the relations between the institutional minimum wages in the urban and the agricultural productivity in the rural.

We examine this subject using the method of comparative static in the HT model. Based on this analysis, we derive a necessary and sufficient condition which concerns the relation between the urban minimum wage and agricultural productivity in the rural. Another purpose of this paper is to illustrate this condition with a diagram. The condition itself is simple, but it offers significant suggestions for policy design.

Section 2 introduces the HT model and a list of theoretical contributions applying the HT model, and Sect. 3 discusses some effects of capital accumulation in the urban sector with the institutional minimum wage (e.g., the legal minimum wages). Finally, a single necessary and sufficient condition is derived from this analysis and illustrated with a diagram.

2 Harris–Todaro model

This section briefly summarizes the theoretical model known as the HT model, and introduces representative contributions applying the HT model in the theoretical stream. The HT model is a pioneering general equilibrium model describing the labor migration mechanism from rural to urban areas due to a wage gap and the existence of urban unemployment and underemployment in developing countries. Since the publication of Todaro (1969), Harris and Todaro (1970), this model has been used as the basis for much research by mainly theoretical economists concerned with both development economics and international economics.

Early studies that apply the HT model include Bhagwati and Srinivasan (1974), Stiglitz (1974), Corden and Findlay (1975), Neary (1981), Khan (1980), (1982a), (b) and Yabuuchi (1970). More recently, Bencivenga and Smith (1997) and Lee (2008) have attempted to extend the HT model to include dynamic analysis. Other studies, Yabuuchi and Chaudhuri (2007) and Chaudhuri (2008), for example, have sought to develop a more realistic application of the HT model by dividing migrants into skilled and unskilled labor.

The most significant feature of this model is that it made it possible for analysts to deal with unemployment, within the framework of general equilibrium, by including still unemployed workers who were waiting for job opportunities in the urban sector, a factor that had previously been difficult to assess. It gave rise to a more realistic description of developing economies and helped to explain migration between urban and rural areas theoretically.

The HT model is a specific form of the "neo-classical two sectors model", represented by the "Heckscher, Ohlin and Samuelson model" (hereafter HOS model), and it can be understood as a "specific factor model" (hereafter SF model), proposed by Jones (1971). In the SF model, each sector has its own specific production factor which cannot move between sectors, and the specific factor endowments are also fixed. The HT model is a short-run model with fixed specific

capital endowment in each sector. In this paper, however, we examine the effects that the urban capital is exogenously increased by such as economic supports or development aid by advanced foreign countries.

2.1 Model and assumptions

This section outlines assumptions in the HT model and the equations that describe it. The structure of the HT model is based on the premise that a fixed wage leads to an outbreak of distortion and urban unemployment. By introducing the concept of expected wage in the urban sector, the HT model presupposes that the fixed wage in one sector is added to the assumptions of the SF model.

The economy considered in the HT model is a small open economy. In the HT model, the economy consists of two sectors, one is an agricultural rural sector, sector 1, and the other is a manufacturing urban sector, sector 2. There are three kinds of production factors, specific production factor in sector 1, K_1, specific production factor in sector 2, K_2, and labor, L, which is employed in both sectors and mobile between sectors. In this paper, the specific production factor in the urban sector, K_2, includes not only equipment and facilities for production but also social infrastructure, such as airports, roads, and industrial parks, which are related to production. Therefore, an improvement of the social infrastructure means an increase in K_2. Accordingly, those specific production factors are immobile between the sectors.

In the HOS model, the capital–labor ratio and the factor–reward ratio are in a one-to-one relation with the relative price of product. This feature is a sufficient condition for the conclusions of the "Rybczynski theorem, Rybczynski (1955)" and the "Stolper–Samuelson theorem, Stolper and Smuelson (1941)" (See Jones 1965). In the HT model, however, these relations among variables are not in a one-to-one relationship. This makes the HT model more suitable for describing developing countries. This feature also gives the impression that the HT model depends only on the supply side of the model and ignores the demand side.

If the wage in the manufacturing sector, w_2, is bound by an institutional and legal lower limit at $\overline{w}_2$ such as a legal minimum wage, then: $w_2 = \overline{w}_2$. This assumption is usually referred to as the "wage rigidity axiom"[2]. A producer's subjective equilibrium, namely profit maximization, is carried out in both sectors. Therefore, the marginal product of labor equals the real wage in each sector.

It is possible for workers to move freely due to the wage gap between sectors. In other words, workers move to the higher wage sector by comparing their expected wages in sectors 1 and 2. In both sectors, the expected wage is defined by multiplying w_i ($i = 1, 2$) by the probability of finding a job in the sector. In the HT model, the probability of finding a job is assumed to be equal to the rate of employment[3]. In the rural sector, it is assumed that wages are flexible and equal to

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[2] Although, in this paper, the urban wage, w_2, is exogenously given as the legal minimum wage, Stiglitz provides an endogenous explanation on the rural–urban wage gap using the labor turnover, see Stiglitz (1974a).

[3] For criticism and a detailed discussion of this assumption, see Mazumdar (1976).

the marginal product of labor according to profit maximization. There is, therefore, no unemployment in the rural sector. This means that in the rural sector, workers can be always employed, so that the probability of finding a job in the rural sector equals unity. In the urban sector, however, the probability of finding a job is less than unity because of the existence of unemployment.

Suppose an economy has $\overline{L}$ workers as a labor endowment, with L_1 and L_2 being the numbers of workers in the rural and urban sectors, respectively. These sectors produce X_1 and X_2 units of output. While the rural sector employs L_1, the urban sector employs only $L_e(L_e \leq L_2)$, since the urban wage is bound to a lower limit at $\overline{w}_2$. It is assumed that $\overline{w}_2$ is higher than the urban wage that would prevail if wages were flexible in the urban sector. In the urban sector, then, the number of total workers, L_2, equals $L - L_1$, with $(L - L_1) - L_e$ being unemployed.

In this paper, we assume that production functions in both sectors are neo-classical, so that the marginal product of both inputs are positive and these production functions satisfy the law of diminishing marginal product[4]. Furthermore, unlike the Harris–Todaro (1970), in this paper, we suppose that the second cross partial derivatives are positive to consider the influence that an increase in capital stocks such as the social infrastructure gives to the economy[5]. Hence, production functions in both sectors are as follows[6]:

$$X_1 = F_1(K_1, L_1) \quad \frac{\partial F_1}{\partial L_1} > 0; \quad \frac{\partial^2 F_1}{\partial L_1^2} < 0; \quad \frac{\partial^2 F_1}{\partial K_1 \partial L_1} > 0, \quad (2.1.1)$$

$$X_2 = F_2(K_2, L_e) \quad \frac{\partial F_2}{\partial L_e} > 0; \quad \frac{\partial^2 F_2}{\partial L_e^2} < 0; \quad \frac{\partial^2 F_2}{\partial K_2 \partial L_e} > 0. \quad (2.1.2)$$

Since production functions are neo-classical, they have well-behaved properties. In this paper, it is supposed that the capital in the both sectors, K_1 and K_2, increase exogenously by such as the financial supports from the advanced countries, and does not increase endogenously in the system. Therefore, K_1 and K_2 are exogenous

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[4] In the Harris-Todaro (1970), production functions are described as follows:

$X_A = q(N_A, \overline{L}, \overline{K}_A) \quad q' > 0, \ q'' < 0$

$X_M = f(N_M, \ \overline{K}_M) \quad f' > 0, \ f'' < 0$

where $\overline{L}$ is the fixed availability of land, and N_A is the rural labor used to produce the agricultural products. N_M is the total labor (urban and rural migrant) required to produce manufacturing products. $\overline{K}_A$ and $\overline{K}_M$ are capital stocks in rural and urban sectors, respectively, and because the analysis in the Harris and Todaro (1970) is short run analysis, these capital stocks are fixed.

[5] Though we assume the positive second cross partial derivatives, it does not contradict that if the production factors are substitutes, the isoquant is convex to the origin. In this paper, it is assumed that the urban capital stocks increase externally by the economic supports such as ODA from the advanced countries. Therefore, even if the labor inputs remain the same, as the urban capital stock increases the production curve shifts up.

[6] In both production functions, we also assume next features,

$F_1(K_1, \ 0) = F_1(0, \ L_1) = F_2(K_2, \ 0) = F_2(0, \ L_e) = 0.$

variables. With L_u as unemployment in the urban sector, labor constraint may be represented as below:

$$\overline{L} = L_1 + L_2 = L_1 + (L_e + L_u). \qquad (2.1.3)$$

With profit maximization in both sectors as a given, the first-order conditions are expressed as follows:

$$w_1 = \frac{\partial F_1}{\partial L_1}(K_1, L_1), \qquad (2.1.4)$$

$$\overline{w}_2 = p \frac{\partial F_2}{\partial L_e}(K_2, L_e) \qquad (2.1.5)$$

where p represents the relative price of the products, that is $p = P_2/P_1$[7] In this paper, the relative price of the products is a constant. In the SF model, the short-run responses to exogenous changes in commodity prices and endowments for employment, production factor returns, and output levels are analyzed in Mayer (1974) in detail. Thus, we do not make more analysis on the changes of relative prices of the products here. The expected wage in the urban sector, w_2^e, is expressed as

$$w_2^e = \overline{w}_2\left(\frac{L_e}{L_2}\right). \qquad (2.1.6)$$

Migration between the rural and urban sectors will cease when the urban-expected wage is equal to the rural-expected wage, which is the same as the rural real wage. This condition is, therefore, expressed as follows, and referred to as the "Harris–Todaro equilibrium" in general.

$$w_1 = \overline{w}_2\left(\frac{L_e}{L_2}\right). \qquad (2.1.7)$$

Assuming p is constant based on the assumption of a small country, (2.1.5) suggests that given $\overline{w}_2$ exogenously, the value of L_e is uniquely determined. Hence, by (2.1.7), we can determine the relation between w_1 and L_2 as a rectangular hyperbola. Given $\overline{w}_2$ and p exogenously, L_1, L_2, L_e, L_u, X_1, X_2 and w_1 are simultaneously and uniquely determined in the system, which consists of the seven (2.1.1) to (2.1.7).

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[7] In Harris and Todaro (1970), the relative price of the products is a function of the relative outputs of agricultural and manufactured goods and is expressed as follows:

$$p = \rho\left(\frac{X_2}{X_1}\right), \quad \rho' > 0$$

where X_1, X_2, are the agricultural and the manufactured outputs, respectively. It is not described clearly in Harris and Todaro (1970), however, it is easily derived that the relative price of the products is a function of the levels of outputs by assuming that the consumer's utility functions are homothetic.

3 Effects of capital accumulation with minimum wage in the urban sector

This section deals with some of the effects that capital accumulation in the urban sector has influence on the economy. In general, the improvement of social infrastructure such as securing of water for industrial uses, ports, airports and roads contributes to lowering the production cost and the transportation cost for the companies operating in the area. In addition, the creation of the SEZs where the corporation tax is treated well is effective to invite the foreign firms there.[8] The invested foreign capital forms production bases in those SEZs and creates new job opportunities there. Once new jobs are created, workers who are seeking employment emigrate from the rural area. However, if the number of workers emigrating is greater than the number of new jobs, some would necessarily have to be unemployed or underemployed in the urban informal sector. Does the creation of new jobs, therefore, lead to an increase in urban unemployment? Previous studies concerning whether the creation of new employment in urban areas that also increases urban unemployment have yielded ambiguous results (Corden and Findlay 1975; Neary 1981). In this section, using the HT model and the neo-classical production functions, we propose a necessary and sufficient condition for the unemployment fluctuation affected by the creation of the new employment in the urban area.

3.1 Effects on the number of workers in both sectors

Within the framework of the HT model, improvements of infrastructure in the urban sector may be captured as an increase in the specific factor in the production function in the manufacturing sector, K_2, in the sense that they may indirectly contribute to the efficiencies of production and the reduction of production costs.

Let us consider how an increase in the specific factor in the manufacturing sector will affect employment and wages in the rural sector. Where the minimum wage in the urban sector is assumed to be kept at the fixed, $\overline{w}_2$, we analyze the effects that the increase in the urban-specific factor, K_2, has on employment in the urban sector. The first-order condition of profit maximization in the urban sector is given by (2.1.5). As before, supposing $p = 1$, for simplicity, and differentiating (2.1.5) with regard to K_2, we obtain (3.1.1).

$$\frac{d\overline{w}_2}{dK_2} = \frac{\partial^2 F_2}{\partial K_2 \partial L_e} + \frac{\partial^2 F_2}{\partial L_e^2} \frac{dL_e}{dK_2}. \tag{3.1.1}$$

And by substituting $d\overline{w}_2/dK_2 = 0$ for (3.1.1), we determine the following (3.1.2):

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[8] In the case of Metro Cebu, the Philippines, the number of firms operating in the Mactan economic zone 1 and 2, those are the SEZs, rose approximately three times in 100 firms from 30 firms for 10 years from 1990 through 1999. And the number of workers employed in the economic zone also rose approximately in 39,000 from 11,000 in the same period. See Japan Bank for International Cooperation (2003).

$$\frac{dL_e}{dK_2} = -\frac{\partial^2 F_2}{\partial K_2 \partial L_e} \bigg/ \frac{\partial^2 F_2}{\partial L_e^2}. \tag{3.1.2}$$

According to the properties of the production function, the sign of dL_e/dK_2 is positive. Hence, the increase in the specific factor, K_2, creates additional urban employment. It is understood that, under the assumption that the improvement of social infrastructure succeeds in attracting foreign capital, new production bases built with that foreign capital will create new jobs.

How, then, does an increase in employment based on the improvement of the social infrastructure in the urban area affect labor numbers in the rural and urban sectors, respectively? By differentiating (2.1.3) and (2.1.7) with regard to the number of employed in the manufacturing sector, L_e, we obtain (3.1.3) and (3.1.4),

$$\frac{dL_1}{dL_e} = -\overline{w}_2 \bigg/ L_2 \bigg/ \left(\frac{L_e \overline{w}_2}{L_2^2} - \frac{\partial^2 F_1}{\partial L_1^2} \right) < 0, \tag{3.1.3}$$

$$\frac{dL_2}{dL_e} = \overline{w}_2 \bigg/ L_2 \bigg/ \left(\frac{L_e \overline{w}_2}{L_2^2} - \frac{\partial^2 F_1}{\partial L_1^2} \right) > 0. \tag{3.1.4}$$

As (3.1.3) and (3.1.4) indicate, it is clear that the increase in urban employment decreases the number of workers in the rural sector, and increases the number of workers in the urban sector. As the probability of urban employment increases, so does the expected wage in the urban sector. And when the expected wage in the urban sector exceeds the rural wage, migration from the rural to the urban will occur.

Alternatively, a decline in the number of workers in the rural sector pushes up the rural wage. We can illustrate these results with the diagram in Fig. 1. Let AA and BB in Fig. 1 be the marginal product curves of labor in the rural and urban sectors, respectively. For convenience, they are drawn as straight lines with origins O_1 and O_2, where the length of O_1O_2 is equal to the labor endowment in the economy. As shown in Fig. 1, urban employment is equal to O_2I, for the urban wage is fixed institutionally and legally at $\overline{w}_2$. A rectangular hyperbola through the urban wage-employment point, N, is described by the SS curve and is referred to as the "Harris–

Fig. 1 Effects of an increase in urban-specific capital
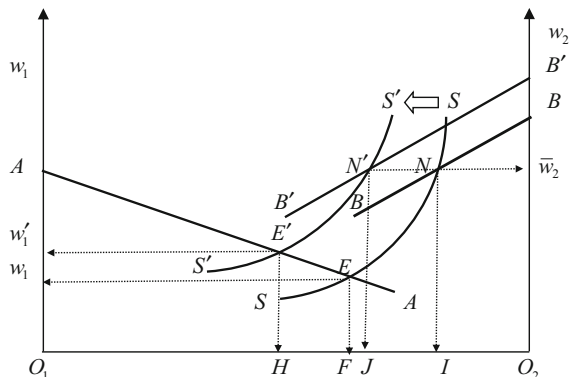
Todaro curve," which means the relation between w_1 and L_2 in (2.1.7). With wage and employment levels fixed in the urban sector, a rectangular hyperbola drawn through point N, the point of intersection of this rectangular hyperbola with the marginal product curve in the rural sector, E, gives us the level of rural employment, O_1F and the rural wage, FE.

Because of the increase in urban-specific capital, the urban marginal product of labor curve, BB, shifts up. However, the Harris–Todaro curve indicated by SS shifts to the left because the urban minimum wage has to be kept at a constant level, $\overline{w}_2$. As a result, employment in the urban sector expands by JI. According to the shift of the SS curve, the intersection point of the Harris–Todaro curve, SS, with the marginal product curve of labor in the rural area, AA, also shifts to the left on the AA curve, establishing the new equilibrium as E'. It follows, then, that the number of workers in the rural area, L_1, declines by HF, while the number of workers in the urban area rises to O_2H from O_2F to the same degree, HF. The real wage in the rural sector, w_1, rises to w_1'.

3.2 Fluctuations in urban unemployment

This section analyzes how an increase in specific factors in the urban sector affects urban unemployment. In Harris and Todaro (1970), wage subsidy policies in both the rural and urban sectors are discussed in terms of policies to reduce urban unemployment. These policy discussions are an important feature that enhances the significance of the paper. The primary policy recommendation derived in the paper is to grant both sectors a wage subsidy of the same amount. According to a proposal made by Bhagwati (1971), the first best policy for solving the distortion is to offset the distortion itself directly. In this instance, since distortion emerging in the economy is urban unemployment, the first best policy to reduce urban unemployment is to offset a wage differential between the rural and urban sectors by wage subsidy.

However, arguments on subsidy policies always face the difficult problem of how to finance them. Unless financed by income transfer, such as ODA from foreign countries, financing a subsidy would generate a new and considerable distortion, so is there any alternative to using wage subsidy as a way of reducing urban unemployment?

As discussed in the previous section, the improvement of social and industrial infrastructure attracts foreign capital and results in an expansion of urban employment. The emergence of new jobs raises the probability of finding a job as well as a rise in expected wage in the urban area. The higher expected urban wage draws workers from the rural area to the urban. As expected, the number of workers in the urban area increases relative to the period before improvements in the social infrastructure. At this stage, however, it is unclear whether the number of unemployed in the urban area increases or decreases.

On this point, Neary (1981), following Corden and Findlay (1975), concludes that the net effect which capital accumulation in the manufacturing sector has on urban unemployment is ambiguous. However, by adding the one necessary and

sufficient condition indicated below to the consideration, it is possible to derive a watershed formulation such that the number of unemployed in the urban area does not change when employment in the urban area expands in response to infrastructure improvement, including the creation of the SEZs, in the urban area.

The relationship between the increased number of newly employed in the urban area and the number of the workers leaving the rural area is given by the following equation:

$$\frac{dL_1}{dL_e} = -\frac{\overline{w}_2 L_2}{L_e \overline{w}_2 - L_2^2 \frac{\partial^2 F_1}{\partial L_1^2}}. \tag{3.2.1}$$

Here dL_1 represents the change in workers in the rural area, and dL_e represents the increase in urban employment. It is obvious that the sign of (3.2.1) is minus, which is $dL_1/dL_e < 0$, for $\partial^2 F_1/\partial L_1^2$ is negative with the assumptions of the production functions. The number of unemployed in the urban area does not change when $dL_e = -dL_1$ holds. Therefore, when the right side of (3.2.1) is equal to minus unity, we can expect a watershed such that the number of urban unemployed does not change.

By inserting the Harris–Todaro equilibrium condition, that is (2.1.7), in (3.2.1), and supposing $a(a < 0)$ to be the angle of the marginal product curve of labor in the rural sector, we can rewrite (3.2.1) as follows[9]:

$$\frac{dL_1}{dL_e} = -\frac{\overline{w}_2}{w_1 - L_2 a}. \tag{3.2.2}$$

Thus, if the number of urban unemployed decreases by the creation of new jobs in the urban sector, the next condition must hold[10]:

$$\frac{\overline{w}_2 - w_1}{L_2} < -a. \tag{3.2.3}$$

We can diagram these relations as follows in Fig. 2:

As shown in Fig. 2, and indicated in Fig. 1 above, urban employment will be equal to $O_2 I$. According to the first-order condition of profit maximization, when the urban fixed wage is given the urban employment level will also be fixed. Subsequently, to derive the level of employment in the rural sector, we draw a rectangular hyperbola, SS (the Harris–Todaro curve), through point N. The rural equilibrium is given by the point of intersection between AA and SS. The level of rural employment is given by the length of $O_1 F$. This implies that the magnitude of urban unemployment, L_u, will be given by FI.

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[9] For simplicity, the necessary and sufficient condition in this paper is derived under the condition that the marginal product curves in both the urban and the rural are linear. Needless to say, the marginal product curves are non-linear in general. When the marginal product curves are non-linear, derivation of the condition has to be done in another way. We would like to transfer the derivation of it to another opportunity.

[10] When (3.2.3) holds, by the expansion of the urban employment, not only the number of the urban unemployed, but the rate of unemployment in the urban decreases, that is $d\left(L_u/L_2\right)\big/dK_2 < 0$, since the number of urban workers increases as the urban specific capital expands, that is $\frac{dL_2}{dK_2}\left(= \frac{dL_e}{dK_2}\frac{dL_2}{dL_e}\right) > 0$.

Fig. 2 A necessary and sufficient condition in HT model
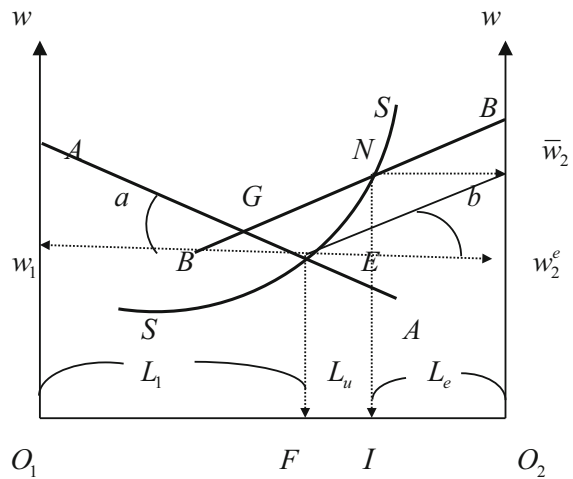
The angle of the marginal product of labor in the rural sector is illustrated as $\angle\,a$ in Fig. 2. On the other hand, the left side of (3.2.3) divides the differences between the urban-minimum wage and the urban-expected wage, which is equal to the real wage in the rural sector, by the number of the total workers in the urban sector. Accordingly, it is represented by $\angle\,b$ in Fig. 2. The condition expressed by (3.2.4) suggests that the new jobs created by the improvement of urban infrastructure increases the number of urban unemployment when $\angle\,b$ is larger than $\angle\,a$ in absolute value, and decreases when $\angle\,b$ is smaller than $\angle\,a$. In other words, if the legal minimum wage in the urban sector is established in such a way as to satisfy the following necessary and sufficient condition, the improvement of the social infrastructure including construction of the SEZs contributes to a decline in urban unemployment and an increase in per capita income in the urban sector.

$$\frac{\overline{w}_2 \; - \; w_1}{L_2} \; < \; |-a|. \tag{3.2.4}$$

We can summarize these results as a theorem:

Theorem 1 *In the Harris–Todaro model, the necessary and sufficient condition for the increase in the specific production factor in the urban sector to decrease urban unemployment is that the slope of the marginal product curve of labor in the rural sector exceeds the per-capita wage difference between the institutional minimum wage and the expected wage in the urban sector.*

4 Conclusion

For economic development in LDCs, capital accumulation in the urban sector is a crucial element. The accumulated capital forms many production bases and creates job opportunities in the urban sector. At the same time, the increase in employment

raises the wage level in the urban sector. In the Harris–Todaro model, the rising urban wage pushes up the expected wage in the urban sector and consequently encourages workers to migrate from the rural sector to the urban sector. If, in the resulting migration, there are more workers than the number of job opportunities created in the urban sector, some will necessarily be unemployed. Occasionally, the increase in unemployment lowers the per-capita income level before the capital is accumulated. This phenomenon is referred to as Todaro paradox. Previous studies have not, however, determined what effect an increase in capital stock in the urban sector has on urban unemployment.

In this paper, we have proposed a means to clarify this influence using the Harris–Todaro model and the neo-classical production functions. We have derived one necessary and sufficient condition under which the increase in capital stock does not increase unemployment in the urban area. This condition concerns the relationship between the institutionally and legally set minimum wage in the urban area and agricultural productivity in the rural area. Unsurprisingly, if agricultural productivity rises and income in the rural area increases, rural workers have no need to migrate to the urban sector to find jobs and face the risk of unemployment.

Despite the simplicity of this condition, it provides two important suggestions for economic policy. The first concerns the legal minimum wage in the urban sector: The setting of a minimum wage in defiance of the productivity of the rural sector may give rise to Todaro paradox.[11] The other relates to support for urban development: It has been observed in Asian countries that, particularly in the urban sector, concentrated improvement of social capital such as harbors, roads, and industrial parks gives rise to Todaro paradox. In the case of Metro Cebu, the Philippines, mentioned in footnote 1), the Todaro paradox occurred in the 1990s. As the Metro Cebu economy developed with ODA projects supported by the Japanese Government, workers from surrounding areas migrated to the region and increased urban unemployment. Therefore, when social infrastructure improvement is implemented, improvement of the agricultural infrastructure should be carried out simultaneously to increase agricultural productivity. By so doing, it becomes possible to avoid a disruptive influx of workers from rural to urban areas.

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[11] The legal minimum wage in Metro Cebu in 2003 when an investigation by the JBIC (Japan Bank for International Cooperation) was carried out was 200 peso per day. The current legal minimum wage in Cebu is 308–366 peso (non-agriculture) per day. On the other hand, in Manila of the capital, it is 475–512 peso (non-agriculture) per day as of Feb. 13, 2017. (Source: National Wages and Productivity Commission, Department of Labor and Employment).

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