Evolutionary and Institutional Economics Review (2024) 21:321–347
https://doi.org/10.1007/s40844-024-00291-1

ARTICLE

Impacts of international trade on the SMT view of the economy

Tosihiro Oka[1]

Received: 10 June 2024 / Accepted: 24 September 2024 / Published online: 15 October 2024

Abstract

Shiozawa, Morioka and Taniguchi (2019)'s Microfoundations for Evolutionary Economics (Springer Japan) provided an alternative view (SMT view) of the economy to the orthodox equilibrium view of the economy. According to the SMT view, demand and supply are matched by quantity adjustment under fixed prices, and prices function as a transmitter of cost information downstream as well as a guide for choice and development of techniques. This paper examines the impacts of international trade on the SMT view based on the new theory of international values (NTIV). In a closed economy, prices are uniquely determined even if there are many choices of techniques by the minimal price theorem. With international trade, due to the multiplicity of wages, prices are not uniquely determined. Whether this fact allows demand to participate in the determination of prices is examined, and it is clarified that because of the disparity of real production possibility set from the hypothetical one, which is effective in determining prices, demand loses the power of equilibration. This fact opens up the possibility and even necessity of production taking place below the maximal boundary, which is accompanied by unemployment. Individual firms' behavior in the choice and development of techniques and the process of price conversion that are consistent with the SMT view and the NTIV is formulated. A residual unsolved question of wage adjustment following technological changes is identified.

Keywords New theory of international values · Quantity adjustment · Minimal price theorem · Maximal boundary of production possibility set

Mathematics Subject Classification B510 · B520 · F190

✉ Tosihiro Oka
oka@econ.kyoto-u.ac.jp

[1] School of Government, Graduate School of Economics, Kyoto University, Yoshida-honmachi, Sakyo-ku, Kyoto 606-8501, Japan

1 Introduction

Shiozawa, Morioka and Taniguchi (2019, henceforth SMT) provided microfoundations for evolutionary economics. It presented a view on economy that demands and supplies are matched mainly by quantity adjustment not by price adjustment in short periods, and that prices have other roles than to adjust demands and supplies, rather to transmit information about production costs downstream of production networks finally toward consumption stages, and to provide a guide to choice of production techniques and to technological development. As a result, this view is characterized by the independence of prices from demands. Morioka's theorem on the stability of quantity adjustment is located at the center of their framework. Let us call this view of economy as the SMT view of economy.

The new theory of international values (NTIV), which was put forward by Shiozawa (2014) and Shiozawa et al. (2017), is regarded as an extention of the SMT view to the economy with international trade. However, the economy with international trade is different from a closed economy in that wages are diverse. Owing to this diversity, prices are not determined uniquely for a given set of techniques. In the present paper, I will examine what this difference brings about for the SMT view.

SMT declared to provide microfoundations for evolutionary economics, and mainly formulated firms' behavior in quantity adjustment. While the focus of the present study will also be on the behavior of individual firms, more careful attention must be paid to firms' technology choice and pricing decisions, since prices and techniques are not uniquely determined in the economy with international trade. Because of the greater importance of what is given historically (or institutionally), it will be important to identify the working domain of individual behavior and the constraints that historical conditions impose on it. In addition, it is important to identify matters that belong to the realm of government policy.

In this paper, the following will be found:

1. Disparity between demand and supply can not be regarded as a driving force for changes in prices, even though mutiple admissible international values (consisting of prices and wages) are possible; independence of prices from demand is held in such a profound sence for the economy with international trade.
2. When an admissible international value is historically given, any firm cannot alter the prices and the wages consisting this value, as long as the firm does not find a new technique that has not belonged to the existing set of techniques.
3. The set of the techniques (which contains a particular division of labor among countries) that corresponds to the existing admissible international value can produce non-negative net outputs, but there are cases where unemployment of labor in some countries is required to produce net outputs.
4. When a firm finds a new technique, it is possible for the firm to lower the price of its product or to raise the wage rate of its employees, which can bring about changes in international value. What is the final international value depends on firms' behavior.

5. Alteration in wages through changes in exchange rates belongs to the realm of govenment policy.

In Sects. 2 and 3, the SMT view and the NTIV are described respectively. In Sect. 4, whether demand influences the choice among the admissible international values is examined. In Sect. 5, the cases where unemployment is required to produce non-negative net outputs are identified. In Sect. 6, behaviroral foundations are given for technological changes, and the pathways through which they spill over into the economy and change prices are presented. In Sect. 7, mention of governmental policy to lower wage rates is given.

2 The SMT view of the economy

2.1 The minimal price theorem

Let us assume there are T techniques and N commodities, each technique producing a single commodity by using labor and inputs of commodities. Let c_j^t denote the amount of commodity j $(j = 1, 2, \cdots, N)$ as input per unit of labor for technique t, and b_j^t denote the amount of gross output of commodity j under technique t per unit of labor. We assume single product production, that is, if $b_n^t > 0$ for a commodity n, then $b_k^t = 0$ for all $k \neq n$. Under this assumption, the industry that produces commodity j can be called 'industry j'. Let us define a_j^t as $a_j^t = b_j^t - (1 + \rho_n)c_j^t$ $(j = 1, 2, \cdots, N)$, where ρ_n is the markup rate of industry n, which is produced by technique t. Let us define the row vector $\boldsymbol{a}^t$ as $\boldsymbol{a}^t = (a_1^t, a_2^t, \cdots, a_N^t)$, which is the net output vector of technique t. Arranging net output vectors vertically, we have a matrix $\boldsymbol{A}$:

$$\boldsymbol{A} = \begin{bmatrix} a_1^1 & a_2^1 & \cdots & a_N^1 \\ a_1^2 & a_2^2 & \cdots & a_N^2 \\ \vdots & \vdots & & \vdots \\ a_1^T & a_2^T & \cdots & a_N^T \end{bmatrix}.$$

Let w denote the wage rate. The minimal price theorem asserts that there is a price vector $\boldsymbol{p} = (p_1, p_2, \cdots, p_N)'$ that satisfies $\langle \boldsymbol{a}^h, \boldsymbol{p} \rangle = w$[1] for a technique h that belongs to S, which can produce any product, and $\langle \boldsymbol{a}^k, \boldsymbol{p} \rangle < w$, for $k \notin S$. Since S produces any commodity under the assumption of single-commodity production, at least as many techniques as N constitute S. Let us choose N techniques from S to produce all the products, and construct a square matrix by arranging the N net output vectors vertically. Letting it be denoted $\boldsymbol{A}(S)$, we have $\boldsymbol{A}(S)\boldsymbol{p} = \mathbf{1}w$, where $\mathbf{1}$ is an N-dimensional column vector with all the elements being unity. When this economy is productive, $\boldsymbol{A}(S)$ is nonnegatively invertible, and we have $\boldsymbol{p} = \boldsymbol{A}(S)^{-1}\mathbf{1}w$. If S' is a

[1] $\langle \boldsymbol{a}^h, \boldsymbol{p} \rangle$ represents the scalar product of $\boldsymbol{a}^h$ and $\boldsymbol{p}$.

subset containing N techniques which cover production of all the products, and at least one of which does not belong to S, then $\boldsymbol{A}(S')\boldsymbol{p} \leq \mathbf{1}w$. If $\boldsymbol{A}(S')$ is productive, there is a $\boldsymbol{p}'$ that satisfies $\boldsymbol{A}(S')\boldsymbol{p}' = \mathbf{1}w$. Therefore, $\boldsymbol{A}(S')(\boldsymbol{p}' - \boldsymbol{p}) \geq \mathbf{0}$. Since $\boldsymbol{A}(S')$ is nonnegatively inversible, $\boldsymbol{p}' \geq \boldsymbol{p}$. If there are more than one techniques to produce commodity j all of which belong to S, the price of j that allows no extra profit must be unique. For if there are techniques h and h' for the production of commodity j, and their correspondent prices $\boldsymbol{p}$ and $\boldsymbol{p}'$ satisfy $\langle \boldsymbol{a}^h, \boldsymbol{p} \rangle = \langle \boldsymbol{a}^{h'}, \boldsymbol{p}' \rangle = w$ while $p_j < p'_j$, then the production with h will earn an extra profit, that is, $\langle \boldsymbol{a}^h, \boldsymbol{p}' \rangle > w$, because $p'_j - p_j \geqq p'_i - p_i$ for a given set of techniques for $i \, (i \neq j)$. As a result, the price vecor $\boldsymbol{p}$ that satisfies $\boldsymbol{A}(S)\boldsymbol{p} = \mathbf{1}w$ and $\langle \boldsymbol{a}^k, \boldsymbol{p} \rangle < w$ for $k \notin S$ is unique and minimal.

2.2 Quantity adjustment

SMT (2019) provided a foundation concerning the adjustment process for the disparity between demand and supply that is alternative to the adjustment in the general equilibrium theory. In the general equilibrium theory, a tâtonnement is assumed, in which prices are adjusted so as to bring about equality between demands and supplies. This process is, however, not realistic except for rare cases where organized markets exist. Most commodities produced by capitalistic firms are supplied and demanded without such an organized markets, but based on behaviors by individual firms and households using locally obtainable information. SMT formulated this realistic adjustment process.

SMT views that demand is the primary constraint for individual firms who are supplying commodities under the capitalistic production system. That is because hard budget constraints (Kornai 1980) are imposed on firms. Under hard budget constraints, firms cannot continue business with negative profits; if profits are continuously negative, firms will not be able to pay for the inputs and face the danger of default and bankrupcy. To earn profits, firms have to sell sufficient amounts of their products at the prices not lower than the level that covers the full costs of production. Lack of demand may cause deficits when there are fixed costs or sunk costs of inputs, but they can only sell what is demanded. Therefore, they try to meet demand, and adjust their production to demand.

Morioka (2023) formulated the process of quantity adjustment, which is called 'demand-satisfying supply' (Morioka 2023, p. 372). The following assumptions have been made.

1. During an adjustment process, prices do not change. The mimimal price theorem gives a basis of this assumption. Furthermore, firms face various risks if they change prices frequently, and do not try to alter prices.
2. Since production takes time, it is planned and has to be carried out on the basis of demand forecast. Therefore, actual demand may be different from the forecast. Any deviations from the forecast are adjusted by incearsing or decreasing inventory.

3. Consequently, there must be some buffer inventory of products. The costs from possible stockout and the costs of maitaining inventory will determine the desirable amount of buffer inventory.
4. Production requires raw materials, which must be ordered and purchased before production takes place. Buffer inventory of raw materials is needed to prepare for the risk of failure to obtain them.
5. Demand forecast is revised based on the actual demands.

In addition to these assumptions, an industrial sector is assumed to be as if it were a firm, although multiple firms in a sector can be treated similarly by assuming a fixed sales share of each firm within a sector (Morioka 2023, p. 379). Based on these assumptions, decision on the product amount is formulated as

$$\boldsymbol{x}(\tau) = (1 + k)\boldsymbol{s}^e(\tau) - \boldsymbol{z}(\tau),$$

where $\boldsymbol{x}(\tau) = (x_1(\tau), x_2(\tau), \cdots, x_N(\tau))$ denotes the outputs from the production of period τ, which are obtained at the end of period τ, k represents the ratio of desirable buffer inventory to demands, $\boldsymbol{s}^e(\tau) = (s^e_1(\tau), s^e_2(\tau), \cdots, s^e_N(\tau))$ is the demand forecast, which is to be met by the supply at the end of period τ, and $\boldsymbol{z}(\tau) = (z_1(\tau), z_2(\tau), \cdots, z_N(\tau))$ denotes the product inventory at the end of period τ. The inventory $\boldsymbol{z}(\tau)$ must satisfy

$$\boldsymbol{z}(\tau) = \boldsymbol{z}(\tau - 1) + \boldsymbol{x}(\tau - 1) - \boldsymbol{s}(\tau - 1),$$

where $\boldsymbol{s}(\tau - 1)$ represents the actual demand of period $\tau - 1$. Combining these two equations with the firms' decision formula for period $\tau - 1$:

$$\boldsymbol{x}(\tau - 1) = (1 + k)\boldsymbol{s}^e(\tau - 1) - \boldsymbol{z}(\tau - 1),$$

we obtain

$$\boldsymbol{x}(\tau) = (1 + k)(\boldsymbol{s}^e(\tau) - \boldsymbol{s}^e(\tau - 1)) + \boldsymbol{s}(\tau - 1). \tag{1}$$

On the other hand, firm (industry) i's decision to order raw materials is formulated as

$$\boldsymbol{m}_i(\tau) = (1 + l)s^e_i(\tau)\boldsymbol{c}_i - \boldsymbol{v}_i(\tau),$$

where $\boldsymbol{m}_i(\tau) = (m_{i1}(\tau), m_{i2}(\tau), \cdots, m_{iN}(\tau))$ is firm i's raw materials order, l is the ratio of desirable raw material buffer inventory to demand, $\boldsymbol{c}_i = (c_{i1}, c_{i2}, \cdots, c_{iN})$ represents input coefficients (per unit of output) of firm i, and $\boldsymbol{v}_i(\tau) = (v_{i1}(\tau), v_{i2}(\tau), \cdots, v_{iN}(\tau))$ is the raw material inventory at the end of period τ. Combining this equation with the one for period $\tau - 1$ and with the equation for the raw material inventory that must be satisfied:

$$\boldsymbol{v}_i(\tau) = \boldsymbol{v}_i(\tau - 1) + \boldsymbol{m}_i(\tau - 1) - x_i(t)\boldsymbol{c}_i,$$

we obtain

$$\boldsymbol{m}_i(\tau) = (1 + l)(s^e_i(\tau) - s^e_i(\tau - 1))\boldsymbol{c}_i + x_i(\tau)\boldsymbol{c}_i. \tag{2}$$

Defining $\boldsymbol{C} = (\boldsymbol{c}_1, \boldsymbol{c}_2, \cdots \boldsymbol{c}_N)'$ and using (1), (2), and the definition of demand:

$$\boldsymbol{s}(\tau) = \sum_{i=1}^{N} \boldsymbol{m}_i(\tau) + \boldsymbol{d},$$

where $\boldsymbol{d} = (d_1, d_2, \cdots, d_N)$ represents final demand, we obtain

$$\boldsymbol{s}(\tau) = (2 + k + l)(\boldsymbol{s}^e(\tau) - \boldsymbol{s}^e(\tau - 1))\boldsymbol{C} + \boldsymbol{s}(\tau - 1)\boldsymbol{C} + \boldsymbol{d}$$

Morioka (2023) identified conditions to guarantee that $\boldsymbol{s}(\tau)$ stably converges. It depends on the desirable rates of buffer inventory, k and l, the manner of forecast fomation—how $\boldsymbol{s}^e$ is formed—, and the spectral radius of $\boldsymbol{C}$. Morioka confirmed that under the plausible assumption of $k = l = 0.2$, and a realistic spectral radius of $\boldsymbol{C}$, formation of forecast for demand from moderate averaging of past actual values, such as simple moving average of past 6 or 7 periods will be sufficient to guarantee stability (ibid., pp. 383–384).

The minimal price theorem has provided a basis for the stability of prices, and the theory of quantity adjustment has provided a framework to understand how disparities between demand and supply are adjusted on the basis of individual firms' behavior of seeking profit using local information. Stable prices give a foundation for the quantity adjustment process, whereas price becomes free from the function of equilibrating demand and supply, and is given an important function of transmitting cost information and of providing a guide for choice and development of techniques. Is this SMT view for a closed single-country economy also valid to the global economy with international trade? Does it have to be changed?

3 The new theory of international values

Shiozawa (2014, 2017) established the new theory of international values (NTIV). It describes the economy with international trade characterized by the existence of a combination of prices and wages that enables a set of production techniques competitively utilized and under which producers do not have incentive to switch to other techniques.

This economy is constituted by M countries and N commodities. Technique t is identified by the vectors of net output and labor input coefficients:

$$\boldsymbol{a}^t = (a_1^t, a_2^t, \cdots, a_N^t),\ \boldsymbol{u}^t = (u_1^t, u_2^t, \cdots, u_M^t),$$

where a_j^t represents the net output of commodity $j\,(j = 1, 2, \cdots, N)$ and u_k^t represents the labor input of country $k\,(k = 1, 2, \cdots, M)$ for technique $t\,(t = 1, 2, \cdots, T)$. Net output is gross output minus input. 'Input' here again includes markup for advanced capital; thus provided that technique t produces n and b_j^t, c_j^t and ρ_n denote the output of j, the input of j (not including markup) and the markup rate of product n respectively, a_j^t is equal to $b_j^t - (1 + \rho_n)c_j^t$ ($b_j^t = 0$ for $j \neq n$). Each technique is assumed to belong to a country. If technique t belongs to country m, $u_m^t > 0$ and $u_{m'}^t = 0$ for $m' \neq m$. Since any scalar multiple of a technique is feasible, we can assume $u_m^t = 1$ if $u_m^t > 0$ without loss of generality.

Arranging the vectors $\boldsymbol{a}^t$ and $\boldsymbol{u}^t$ for $t = 1, 2, \cdots, T$ vertically, we have

$$\boldsymbol{A} = \begin{bmatrix} a_1^1 & a_2^1 & \cdots & a_N^1 \\ a_1^2 & a_2^2 & \cdots & a_N^2 \\ \vdots & \vdots & & \vdots \\ a_1^T & a_2^T & \cdots & a_N^T \end{bmatrix}, \ \boldsymbol{J} = \begin{bmatrix} u_1^1 & u_2^1 & \cdots & u_M^1 \\ u_1^2 & u_2^2 & \cdots & u_M^2 \\ \vdots & \vdots & & \vdots \\ u_1^T & u_2^T & \cdots & {}_M^T \end{bmatrix}.$$

Assuming the scale of production of technique t is represented by s^t, and that $\boldsymbol{s} = (s^1, s^2, \cdots, s^T)$, $\boldsymbol{y} = \boldsymbol{sA}$ is an N-dimensional vector representing net procucts of the economy. Each country has its endowment of labor. Let $\boldsymbol{l} = (l_1, l_2, \cdots, l_M)$ be the vector representing labor endowments.

If the set of technique is productive, we have non-negative net products $\boldsymbol{y}$ that meet $\boldsymbol{y} = \boldsymbol{sA}$ and $\boldsymbol{sJ} \leqq \boldsymbol{l}\, (\boldsymbol{s} \geqq \boldsymbol{0})$. The production possibility set is defined as

$$\mathcal{P} = \left\{ \boldsymbol{y} \in R^N \mid \boldsymbol{y} = \boldsymbol{sA}, \boldsymbol{sJ} \leqq \boldsymbol{l}, \boldsymbol{s} \geqq \boldsymbol{0}, \boldsymbol{s} \in R^T \right\},$$

where R^N and R^T represent the sets of all the vectors with dimention N and T respectively. When there is no vector $\boldsymbol{z}$ that meets $\boldsymbol{z} \geq \boldsymbol{y}\, (\boldsymbol{z} \in \mathcal{P})$, $\boldsymbol{y}$ is a maximal element. The set of all the maximal elements is the maximal boundary of the production possibility set. Since the net output coefficient a_j^t is defined assuming input coefficients include markup $(1 + \rho_n)c_j^t$ (when t produces n), the maximal boundary means a set of maximal consumptions that enable growth of each product with the rate equal to the markup rate. This means that the maximal boundary as well as the production possibility set are hypothetical ones, for actual growth rate of each commodity may not be equal to the markup rate in its production and also it is rather usual to regard final demands including investments as net products. Shiozawa called this economy as 'equivalent economy' (Shiozawa 2014, p. 110).

The following is the principal theorem of the new theory of international values.[2]

Theorem 1 *Provided that* $\mathbf{y}$ *is a maximal element of the production possibility set, there exists a positive vector of commodity prices,* $\boldsymbol{p} = (p_1, p_2, \cdots, p_N)'$, *and a positive vector of wages,* $\mathbf{w} = (w_1, w_2, \cdots, w_M)'$, *under which no technique obtains extra profit* ($\boldsymbol{Jw} \geqq \boldsymbol{Ap}$), *the total value of the net products is equal to the total sum of wages* ($\langle \boldsymbol{y}, \boldsymbol{p} \rangle = \langle \boldsymbol{l}, \boldsymbol{w} \rangle$), *and every country has at least one competitive technique and its labors are fully employed. Conversely, if there is a set of* $\mathbf{p}$ *and* $\mathbf{w}$ *that satisfies* $\langle \boldsymbol{y}, \boldsymbol{p} \rangle = \langle \boldsymbol{l}, \boldsymbol{w} \rangle$ *and* $\boldsymbol{Jw} \geqq \boldsymbol{Ap}$, *then* $\mathbf{y}$ *is a maximal element.*

A vector $\boldsymbol{v} = (\boldsymbol{p}', \boldsymbol{w}')'$ is called an 'international value'. An international value that satisfies $\boldsymbol{Jw} \geqq \boldsymbol{Ap}$ and $\langle \boldsymbol{y}, \boldsymbol{p} \rangle = \langle \boldsymbol{l}, \boldsymbol{w} \rangle$ is called an 'admissible value' (Shiozawa 2017, p. 20). For any admissible value $(\boldsymbol{p}', \boldsymbol{w}')'$, for its corresponding maximal element $\boldsymbol{y}$ and for any element of the production possibility set z, $\langle \boldsymbol{z} - \boldsymbol{y}, \boldsymbol{p} \rangle \leqq 0$ (Shiozawa 2014, p. 353). The maximal boundary consists of facets of the polytope that represents the production possibility set. The internal area of a facet was called a

[2] This theorem includes the contents of theorems 10, 11, and 17(b) in Shiozawa (2014; pp. 331,332,339).

'regular domain' (Shiozawa 2017, p. 18), and the admissible value corresponding to a maximal element on a regular domain was called a 'regular international value' (ibid. p. 20). The regular international value corresponding to a facet of the production possibility set is unique without scalar multiple, because $\langle \boldsymbol{z}-\boldsymbol{y},\boldsymbol{p}\rangle \leqq 0$ for any $\boldsymbol{z} \in \mathcal{P}$ and $\boldsymbol{y}$ exists on a regular domain.

Shiozawa (SMT, 2019, p. 108) provided an alternative definition for 'regular international value', according to which an admissible international value is defined as 'regular' when (a) a set of techniques S, which is a subset of the technique set T, is productive, (b) the technology graph S is a spanning tree, and (c) $\langle \boldsymbol{u}(h),\boldsymbol{w}\rangle = \langle \boldsymbol{a}(h),\boldsymbol{p}\rangle$ for a positive international value $(\boldsymbol{p},\boldsymbol{w})$, where $\boldsymbol{u}(h)$ and $\boldsymbol{a}(h)$ represent the vectors of labor input coefficients and net output coefficients, respectively, of any technique h belonging to S. This definition is said to be equivalent to the former one (ibid.), but it utilizes graph theory and dispenses with the notion of production possibility set or the notion of labor endowments, thus effectively showing that the existence of the regular international values is not dependent on such notions. The former definition of regular value is, however, intuitively understandable and useful to investigate the relation between demands and prices, and thus is suitable for the present study.

For a closed economy, the minimal price theorem guarantees the existence of a unique set of prices independent of demands, and provides the basis for stability of prices and dominance of quantity adjustment during a change in demands. For the economy with international trade, this property cannot be held. There are multiple wage rates each of which belongs to a country. This generates the possibility of multiple international values. This multiplicity may bring about the possibility of some effects of demand on the determination of values.

4 Demands and international values

For a closed economy, the minimal price vector is unique. This corresponds to the fact that the maximal boundary of the production possibility set consists of only one facet. For the global economy with international trade, the maximal boundary consists of multiple facets, and thus there are multiple regular international values. The number of maximal facets for M-country, N-commodity case is

$$\frac{(M+N-2)!}{(M-1)!(N-1)!}$$

for the economy with no intermediate commodity (Shiozawa 2014, p. 372). For the case of two-country, three-commodity, the number is three, and for the case of two-country, two-commodity, the number is two.

When N commodities are produced in a closed economy, an admissible value is determined under a single wage rate. When a second country appears and trade between the two countries is opened, a different wage rate of the second country enables a technique of the second country, which produces the same product as in the first country, to exist competitively. In that case the product is produced

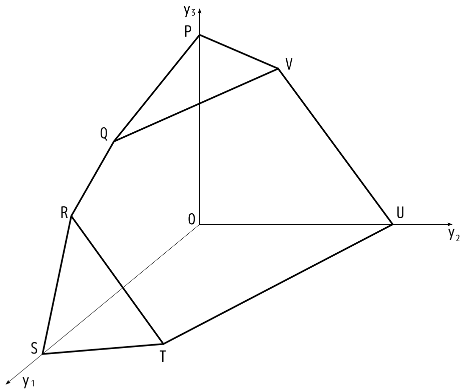


Fig. 1 A maximal boundary for 2-country, 3-commodity case

in both countries by different techniques. This commodity has been called a ‘link commodity’, and this case has been called a ‘linkage case’ (Sato 2017, pp. 294–296, Graham 1948, p. 332). In a two-country situation, only one commodity can be a link commodity in general except by chance. In general, n commodities are produced in a country while $N-n+1$ commodities are produced in the other country in the linkage case. It is possible for a country to produce n commodities while for the other country to produce only residual $N-n$ commodities, and for no commodity to be produced commonly by both countries. This case, with no link commodity, has been called a ‘limbo case’ (Graham 1948; Sato 2017). An international value of a linkage case corresponds to a regular domain of the maximal boundary, that is, the internal area of a facet of the production possibility set. A value of a limbo case corresponds to a face belonging to two different facets, which is a face with the dimension $N-2$. There cannot be an ($N-3$)-dimensional face on the positive domain of the maximal boundary, because n commodities produced by a country and $N-n-1$ commodities produced by the other country cannot satisfy positive demands; net output of at least one commodity must become nonpositive, because it is not produced by any country.

Figure 1 represents an example of the maximal boundary for 2-country 3-commodity case. The triangles PQV, RST and the pentagon QRTUV constitute the nonnegative part of the maximal boundary, the regular domain of which corresponds to the linkage cases. The ridges QV and RT correspond to the limbo cases.

When a third country joins to the two-country, N-commodity economy with a third wage rate, an additional link commodity can emerge, and $N+2$ techniques coexisist competitively. There can be the cases where $N+2$, $N+1$, and N techniques coexist competitively to satisfy positive demands. However, just $N-1$ techniques cannot supply positive net products for all commodities. Therefore, there can be faces with $N-1$ dimension, that is facets, faces with $N-2$ dimension, and faces with $N-3$ dimension within the positive domain of the maximal boundary. In general, there can be faces with up to $N-M$ dimension within the positive domain of the maximal boundary; in Fig. 1 there cannot be any face with dimension $0(=3-3)$, which is a point in the positive domain.

Anyway, there are multiple facets constituting the maximal boundary. Hence, international value cannot be uniquely determined only by the minimal price constraint based on technological conditions, in contrast to the case of a closed economy. This opens up the question whether there is room for demands to influence the determination of prices. This question arises because the NTIV seems to have the same strucuture as the rent theory since Ricardo, and demand plays a role in determination of prices in the rent theory.

Ricardo (1951) explained rent to agricultural lands based on the scarcity of land relative to crop demand; when the demand becomes large and is not met by using the most fertile land, less fertile land will be introduced into production, causing the crop price to rise to be equal to the higher production cost on the less fertile lands, with the difference between the price and the lower production costs on the fertile land becoming rents to landowners. Sraffa (1960, pp. 75–76) introduced a different type of rent that can emerge for the scarcity of land. He argued that rent can emerge on a land of the same quality; two techniques, either of which costs more without rent, can be utilized simultaneously through generating rent to the land if it is scarce. What tecniques are used depends on the demands for crop, because land scarcity is relative to the demands for crop. Price evidently depends on the demands as well as on the techniques. Can it also be argued that demands play a role in determining prices in international trade in a similar way with the case of rent?

Shiozawa (2014) emphasized firstly the magnitudes of the areas of the facets compared with those of the other parts of the maximal boundary. As is evident from Fig. 1, the ratio of the latter to the former is zero. Therefore, it will be much more likely that the demand vector is in the internal area of some of the facets than on the faces with lower dimensions. If the demand vector is in the internal area of a facet, even when it moves, as far as it belongs to the same area, the price cannot change. Secondly, he pointed out even if the demand vector is located on one of the faces with the dimension of $N - 2$, say RT in Fig. 1, the degree of freedom for prices is only one, in the sense that the price vector can move as long as it is normal to the ridge. When the demand is on the face of $N - m$ dimension, the degree of freedom of prices is $m - 1$. Therefore, the degree of freedom cannot be greater than $M - 1$. In the demand and supply theory of prices, the degree of freedom is considered as many as $N - 1$. Compared to this degree, the degree of freedom under the NTIV is up to $M - 1$, which is extremely small, probably smaller than 10 to the minus fifth power of $N - 1$. In these senses, prices are regarded as almost stable during a change in demands.

As far as the demand vector is on a facet, prices do not need to change, and even on other faces than facets of the maximal boundary, the degree of freedom of prices is very small. In these senses, independence of prices from demands may be considered as maintained. However, dependence of prices on demands in the sense referred to in relation to rent theory of Ricardo and Sraffa was different from them. A choice among facets or shift from a facet to another was referred to in relation to the scarcity of land, the scarcity being evidently relative to the demand for crop. In this sense, the demand for crop influences the choice of technique and, in turn, the prices.

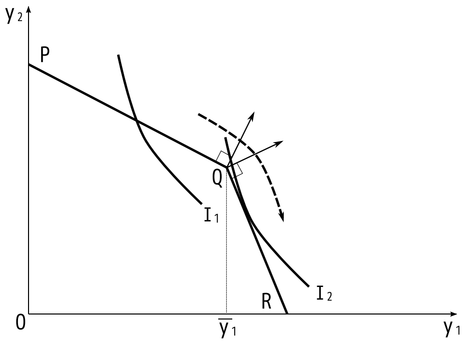


Fig. 2 Crop demand and technique

The situation is illustrated in Fig. 2 for a 2-commodity case. In this figure, y_1 denotes the demand and supply for crop, while y_2 that for another commodity. As far as the demand for crop is not large, and is met by the net product on PQ, it is produced with the least cost method, whose relative price is lower, but the demand exceeds $\bar{y_1}$, the method with higher cost is introduced and the relative price rises, with rent to the land being generated.

Can prices be said to be influenced by demands in the NTIV in this sense? Two points are relevant to this question. First, in the rent theory of Ricardo and Sraffa, scarcity of land was essential. Labor in their theory was never regarded as a scarce resource. In fact, wages always exist while rents emerge as far as land is scarce. Foreign products may be imported even when domestic demand is sufficiently met by domestic production capacity, in contrast to the case of Ricardo–Sraffian land, where production methods with higher cost are introduced only when demand cannot be met with the least cost technique. Endowments of labor is assumed in the NTIV, and quantities of labor endowments have relation to the position of the maximal boundary, but there is no reason to assume actual production takes place on the boundary. Second, as mentioned above, the production possibility set and its maximal boundary are defined for an economy each sector of which grows at the same rate as its markup rate. Since this assumption has, however, no basis in reality, the maximal boundary as well as the production possibility set are hypothetical ones. To investigate what these two points imply for the issue of the influence of demand in the determination of international value, let us use a numerical example for a minimal economy.

An example of a minimal economy with two countries—A and B—and two commodities—1 and 2—is shown in Table 1, in which input, output and net output coefficients per unit of labor input are represented. Here only two techniques are assumed to exist for each industry, although more techniques can exit. Under the assumption that all the markup rates are unity, the input and net output coefficients will be as shown in Table 2.

The markup rate can take various values, and it is not necessary to assume a uniform rate for all the sectors or all the countries. The uniform unity rate is only an example.

Table 1 Coefficients for a 2-country 2-commodity economy

Country	Commodity	Input		Output		Net output	
		1	2	1	2	1	2
A	1	0	5/2	10	0	10	−5/2
	2	5/2	45/2	0	50	−5/2	55/2
B	1	9/2	5/2	10	0	11/2	−5/2
	2	1/2	0	0	10	−1/2	10

Under the assumption of $l_A = 1$ and $l_B = 5$ (this is also an example, and various other values are possible), the production possibility set of the equivalent economy is represented by the parallelogram PQRS in Fig. 3.

PQ and QR are the maximal boundary. PQ (excluding point Q) corresponds to the division of labor where country A specializes in the production of commodity 1 and country B produces both commodities. Let 'A1B12' denote this division of labor. Similarly, QR (excluding point Q) corresponds to the division of labor A12B2. An international value $(p_1, p_2; w_A, w_B) = (3/28, 1/70; 1, 1/28)$ (assuming the labor in country A is numéraire) represents an admissible value corresponding to A1B12. Under this value, industry 2 of country A cannot emerge, because its production suffers losses $((3/28) \times (-5) + (1/70) \times 5 = -13/28 < 1)$. The value for A12B2 is $(p_1, p_2; w_A, w_B) = (2/5, 3/5; 1, 28/5)$, under which industry 1 of country B suffers losses $((2/5) \times 1 - (3/5) \times 5 = -13/5 < 28/5)$. Point Q corresponds to the division of labor A1B2, that is a perfect specialization case. Any international value $(p_1, p_2; w_A, w_B)$ that meets $p_1 = (w_B/w_A + 2)/19$, $p_2 = (10w_B/w_A + 1)/95$ and $1/28 \leqq w_B/w_A \leqq 28/5$ can be the admissible value corresponding to A1B2, with $(p_1, p_2; w_A, w_B) = (3/28, 1/70; 1, 1/28)$ and $(p_1, p_2; w_A, w_B) = (2/5, 3/5; 1, 28/5)$ being the two extreme cases for $w_A = 1$.

The international value $(p_1, p_2; w_A, w_B) = (3/28, 1/70; 1, 1/28)$, for example, satisfies $\boldsymbol{Jw} \geqq \boldsymbol{Ap}$, three components of which (for A1, A2 and B2) are satisfied with equality, and one of which (for B1) is satisfied with strict inequality. $\langle \boldsymbol{y}.\boldsymbol{p} \rangle = \langle \boldsymbol{l}, \boldsymbol{w} \rangle = 33/28$, which represents line PQ. When $\boldsymbol{y}$ is on PQ, for any vector $\boldsymbol{z}$ belongs to the production possibility set PQRS, $\langle \boldsymbol{z} - \boldsymbol{y}, \boldsymbol{p} \rangle \leqq 0$, because $\boldsymbol{p}$ is normal to PQ.

The other patterns of the division of labor, that is A2B12, A12B1 and A2B1, which are indicated by RS, PS, and S respectively, cannot generate admissible international values (allowing the residual industries to earn extraprofits). There is no

Table 2 Coefficients for a 2-country 2-commodity equivalent economy with all the markup rates being 1

Country	Commodity	Input		Output		Net output	
		1	2	1	2	1	2
A	1	0	5	10	0	10	−5
	2	5	45	0	50	−5	5
B	1	9	5	10	0	1	−5
	2	1	0	0	10	−1	10

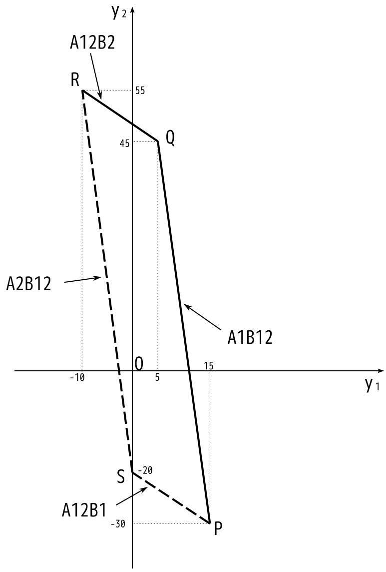


Fig. 3 Production possibility set for a 2-country 2-commodity equivalent economy

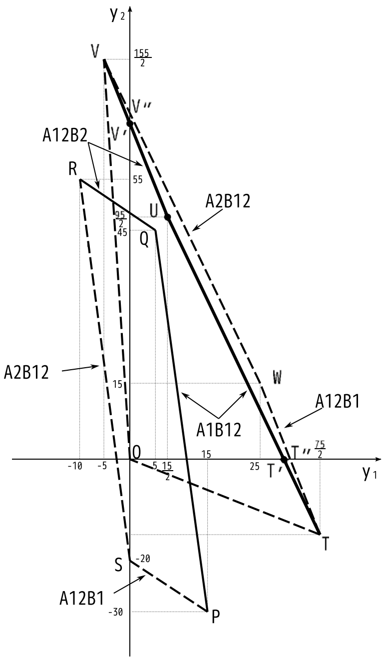
international value satisfying $\boldsymbol{Jw} \geqq \boldsymbol{Ap}$, where the components for A2 and B1 are satisfied with equality.

The maximal boundary PQR corresponds to the possible admissible values, but it is a hypothetical one, the maximal boundary for the equivalent economy. The real maximal boundary can be drawn for various interpretations of final demands. It can be thought of as the sum of final consumptions and investments, or as the final consumptions that is the net outputs subtracted by investments. In the former case, the real maximal boundary is equivalent to the maximal boundary constructed by the net output coefficients without markup. In the latter case, the maximal boundary will be obtained by the net output coefficients based on augmented input coefficients with the demand growth rates of products. Here let us assume the former assumption and consider the net outputs (including consumptions and investments) as a whole to constitute the maximal boundary. The observations under this assumption are also valid when the latter assumption is adopted as far as the growth rate of a sector is not equal to the markup rate for the sector.

Based on this concept of final demands, the real production possibility set is constructed based on the net output coefficients listed in Table 1 and the assumption of $l_A = 1$ and $l_B = 5$. Points T, U, V and W in Fig. 4 represent the net output for A1B1, A1B2, A2B2 and A2B1 respectively.

Since any convex combination of these points and the origin can be produced, the area of the quadrilateral OTWV is the production possibility set in the physical sense. However, under the constraint that only productions with non-negative profits can be carried out, divisions of labor A2B12 or A12B1 will not appear. Under the relative price p_1/p_2 that makes the two industries in country B equally competitive, that is $p_1/p_2 = 15/2$, industry 2 of country A cannot earn non-negative profit under any non-negative wage rate, and only industry 1 survives with the wage rate

Fig. 4 Production possibility sets for a 2-country 2-commodity economy



of $w_A = 28w_B$. Similarly, under p_1/p_2 that makes the two industies in country A equally competitive, that is $p_1/p_2 = 2/3$, only industy 2 of country B survives with the wage rate $w_B = (28/5)w_A$. As a result, any net output on TW or VW cannot be produced competitively. Therefore, capitalistically feasible maximal boundary is TUV, and the production possibility set is the area of quadrilateral OTUV, which is a non-convex set.

Whether TUV or TWV is the capitalistically feasible maximal boundary depends on the markup rate. We have been assuming a common rate of unity in our example. As the mark-up rate decreases, P, Q, R, and S approach to T, U, V, and W. On the way of decreasing, there is a value of the mark-up rate at which A12B1 becomes equally competitive with A12B2, where P, Q, R and S are on a same straight line. That mark-up rate is $(121 - 52\sqrt{5})/59 \approx 0.08$.[3] When the rate is lower than $(121 - 52\sqrt{5})/59$, TWV will become the capitalistically feasible maximal boundary.

In Fig. 2, increase in the intensity of crop demand brought about a change in the relative prices. In the framework of the equilibrium theory, this is explained as

[3] Under mark-up rate ρ, in order for the two industries of country A to be competitive, the prices p_1 and p_2 must satisfy $10p_1 - (5/2)(1+\rho)p_2 = w_A$ and $-(5/2)(1+\rho)p_1 + [50 - (45/2)(1+\rho)]p_2 = w_A$, which implies $p_2/p_1 = (\rho + 5)/(8\rho - 12)$. In order for the two industries of country B to be competitive, p_1 and p_2 must satisfy $10p_1 - (9/2)(1+\rho) - (5/2)(1+\rho)p_2 = w_B$ and $-(1/2)(1+\rho)p_1 + 10p_2 = w_B$, which implies $p_2/p_1 = (8\rho - 12)/(5\rho + 25)$. The non-negative ρ which satisfies both equations is $(121 - 52\sqrt{5})/59$.

follows. Increase in the intensity of crop demand makes the marginal rate of substitution $-dy_2/dy_1$ greater than the marginal rate of transformation represented by the slope of PQ, which moves the equilibrium point to Q. If the marginal rate of substitution is still greater than the slope of QR at Q, the equilibrium point will move to a point on the internal area of QR where the both rates coincide.

In Fig. 4, when production takes place under the relative price of $p_1/p_2 = 2/3$, corresponding to QR, increase in the intensity of demand for commodity 1 would generate a marginal rate of substitution greater 2/3, but it may not be greater than the slope of UV, which is the actual maximal boundary. This magnitude of marginal rate of substitution does not move the equilibrium point toward U or further to UT. Rather the rate of substitution which is smaller than the rate of transformation would move the point toward V. If the marginal rate of substitution is as large as 15/2, which is equal to the relative price p_1/p_2 on PQ but greater than the slope of TU, the point will move to T. Any equilibrium, if it exists, will not be stable, and it will move toward V or toward T. Even if it is at the point U, it will not be stable, because at point U the maximal boundary is convex to the origin in this case. Therefore, we cannot imagine any equilibrium in its usual sense, and cannot imagine the function of prices equlibrating demand and supply.

Figure 4 illustrates a case where the capitalistically feasible maximal boundary is convex to the origin. However the instability of equilibrium occurs as long as the marginal rate of substitution is greater than the existing ratio of prices but smaller than the marginal rate of transformation, or as long as the the marginal rate of substitution is smaller than the existing ratio of prices but greater than the marginal rate of transformation. Therefore, the validity for the impossibility of imagining equilibrating function of prices is not confined to the convex case.

This consideration is valid also for the cases with more than two commodities. Each facet or face with lower dimensions of the real maximal boundary has a normal vector or normal vectors whose direction is different from that of the price vectors. Therefore, we cannot imagine equilibrating function of prices to bring about equality between marginal rate of substitution and the marginal rate of transformation.

If the marginal rates of transformation are not equal to the relative prices, the necessity that production takes place on the maximal boundary will be weakened. A point below the maximal boundary will be produced either with unemployment of labor in some countries or by a less procudtive set of techniques with full employment. Production below the boundary allows other combinations of techniques than a specific combination corresponding to a face of the maximal boundary, and allows existence of unemployment.[4]

Fig. 5 shows under what divisions of labor a particular point in the production possibility set can be produced. Point U is produced only by the perfectly specialized

[4] Keynes (1936) posited the principle of effective demand to explain an equilibrium with unemployment. He defined the effective demand as the value of the aggregate demand function at the point, ‘where it is intersected by the aggregate supply funcion’ (Keynes 1936, p. 25). Since it is assumed that entrepreneurs ‘expect to maximise the excess of the proceeds over the factor cost’ (ibid) on each point of the aggregate supply function, ‘the effective demand’ means the value of the aggregate demand which is compatible with the entrepreneurs’ behavior of profit maximization, which implies that prices are equal to marginal costs, that wage is equal to marginal products of labor, and that relative prices are equal to marginal rates of transformation. Keynes posited the aggregate demand is determined by the propensity to consume and

division of labor A1B2 with full employment. Point X represents the net output that is produced solely by industry 1 of country A with full employment, with no production in country B. Therefore, the line segment UX is the locus of points representing the net products while the employment in country B moves from full employment to zero employment at the perfectly specialized division of labor A1B2 with full employment in country A, of which UM is the non-negative part. Similarly, UZ is the locus of points representing the net products while the employment in country A moves from full employment to zero employment at the division of labor A1B2 with full employment in country B, of which UN is the non-negative part. Consequently, all the points on line segments UM and UN can be produced by the division of labor A1B2; UM can also be produced by A1B12, and UN by A12B2. Points in the triangle TUM except for line segment UM can be produced only under the division of labor A1B12, and points in VUN except for UN only under A12B2; the points on TU and UV are produced with full employment, while the points below them are produced with unemployment in either country. The points in the area of the quadrilateral OMUN except for line segments UM and UN can be produced under any division of labor. The production in the area OMUN (including segments UM and UN) is compatible with any admissible international value, which can be expressed as $(p1, p2; w_A, w_B)$ meets $p_1 = (w_B/w_A + 2)/19$, $p_2 = (10w_B/w_A + 1)/95$ and $1/28 \leqq w_B/w_A \leqq 28/5$, with an extreme case $(p1, p2; w_B) = (2w_A/5, 3w_A/5; 28w_A/5)$ and another extreme case $(p1, p2; w_B) = (3w_A/28, w_A/70; w_A/28)$.

For a closed economy, price vector is determined uniquely no matter what the demand conditions are. This can be a basis of refusal of the equilibrium view of economy, in the sense that prices are determined solely by the conditions of production techniques. However, from the perspective of equilibrium theory, it may be arugued that it is a special case of equilibrium, and that it is compatible with the equilibrium view (Dorfman et al. 1958, pp. 224, 249). The impossibility of equality between the marginal rate of substitution and the marginal rate of transformation can

Footnote 4 (continued)
the inducement to invest. It is not clear whether marginal rates of substitution are equal to the relative prices or not, but this equaltiy for the demand-side did not seem to be denied. Keynes opposed only the equality between the marginal utility of wage and the marginal disutility of labor. He, therefore, seems to have accepted the equality between the marginal rate of substitution and the marginal rate of transformation for each commodity. Unemployment in relation to the inequality of them seemed to be classified into ‘frictional unemployment’, which was considered as admitted by ‘the classical theory’ (ibid., pp. 6–7). He mentioned the effects of international trade on employment only as far as it may increase or decrease aggregate demand (ibid, pp. 262–263). Pasinetti (1997b) proposed to liberalize the principle of effective demand from any behavioral hypotheses, and opposed the concepts of propensity to consume and the aggregate supply function. Pasinetti (1981) posited a vision of economy with independence of prices from demands, where there is no necessity of the demand for labor being equal to its supply for an economy as a whole (Pasinetti 1981, p. 96), and argued that the growth rate of labor productivity for a sector is usually not equal to the growth rate of the demand for the product of the sector, and thus cyclical unemployment is inevitable in an economy that is constantly undergoing structural change. This type of unemployment can be called ‘technological unemployment’. Since international trade is a cause for structural change, it has a risk to generate technological unemployment. Hence, he attached to the gains from international trade the reservation that invested capital can be transferred without causing a fall in the level of employment (ibid., pp. 254–255).

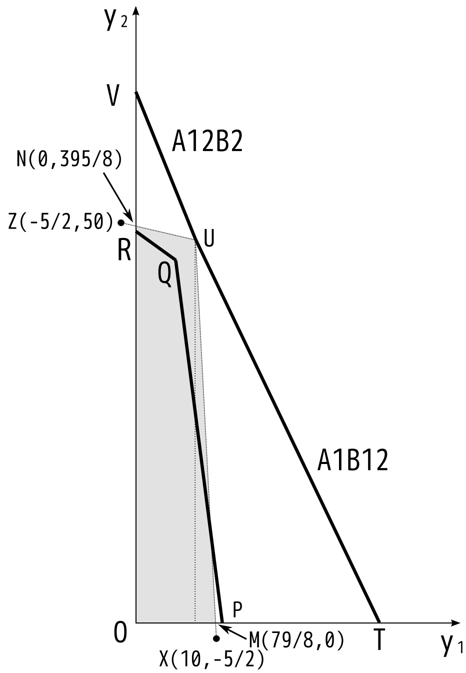


Fig. 5 Points that can be produced by divisions of labor

provide a more solid basis for refusal of equilibrium view of economy. This makes meaningless the assumption that production takes place on the maximal boundary, and gives a more solid basis to the possibility that production is carried out in the internal areas of the production possibility set, which will loosen the combination of the point of production and the selection of admissible international values.

If demand has no relation to the choice among various admissible international values, some degree of freedom emerges there. Shiozawa (2019, p. 110) pointed out ‘we are in an economy where history matters’. He also expressed this situation as ‘always already given’, citing Althusser (1965), and argued that it is at this point that ‘path dependence’, which is often referred to concerning technical change, is important. The above fact that demand does not have relation to choice among the possible international values reinforce the importance of path dependence.

Once an admissible international value is historically given, the value is stable in the sense that no other values can emerge as far as the set of techniques and markup rates does not change, because techniques that are not competitive under the given international value cannot enter the economy with non-negative profits. The value becomes free from the directions of the facets of the real maximal boundary, which allows the existence of unemployed labor. Demand becomes free from the idea of equality between the rate of marginal substitution and relative prices, and can be satisfied by the techniques that are competitive under a historically given value, which allows ways for more realistic demand theory, such as emphasizing dynamics of demand growth (Pasinetti 1981) or focusing on the dependency of demand on production (Galbraith 1998).

5 Necessity of unemployment

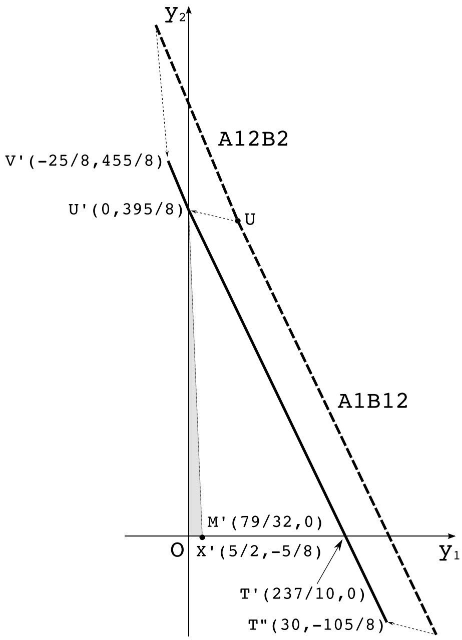
The location of the facets constituting the maximal boundary depends on labor endownments. The real maximal boundary TU and UV in Fig. 5, for example, are drawn under the assumption $l_A = 1$, $l_B = 5$. They translate along the line UN when the endowment of labor of country A changes, for example; as it decreases to 1/4, line segmants TUV translate to where U overlaps N. As shown in Fig. 6, the maximal boundary corresponding to A12B2 (U′V′ here) has disappeared from the positive quadrant. Consequently, positive net products can not be produced by this division of labor A12B2 as long as full employment is maintained in both countries. However, if unemployment is allowed, positive net production is possible within the area OU′M′ under A12B2. Of course, under the division of labor A1B12, any points in OU′T′ can be produced, but if A12B2 is historically given, technique B1 cannot emerge as a result of free choice of firms and unemployment is required in country B in order to produce positive net output. If unemployment is permitted, any division of labor corresponding to an admissible international value can produce postive net output, because the conbination of techniques is productive.

A line segment representing a division of labor can disappear from the positive quadrant as well when the labor endowment of a country increases. If the labor endowment of country B increases to 20, point U in Fig. 5 moves along the line UM to the direction of U, and when it reaches (0, 395/2), the maximal boundary correspoinding to A12B2 disappears from the positive quadrant, but this division of labor can produce some positive net outputs by permitting unemployment in country B.

The same argument can be applied to the cases where the line segment TU disappears from the positive quadrant, due to a decrease in labor endowment in country B or an increase in labor endowment in country A. The line segments TUV will translate along UM to the direction of M as labor endowment of country B decreases, and along UN to the direction of U as the labor endowment of country A increases.

This argument is held for the cases with more than 2 commodities. Let us illustrate a 2-country, 3-commodity case by Fig. 7. PQRSTUV is the positive quadrant part of a real maximal boundary drawn for some labor endowments of the two countries. Changes in labor endowments will translate the facets. It is possible that some facets disappear from the positive quadrant, as shown in the maximal boundary P′Q′R′U′V′, where original RST has disappeared from the positive quadrant. Nevertheless, as far as the international value that corresponds to RST is admissible, the division of labor that corresponds to this international value will be established. However, full employment with this division of labor produces net outputs only on facet RST, which is non-positive. Positive net outputs can, nevertheless, be produced somewhere below the facet (in the shaded tetrahedron, for example), because this division of labor is productive (since the corresponding international value is admissible). Therefore, unemployment is required to produce positive net outputs with this division of labor. If the admissible value corresponding to this division of labor is historically given, no firm can

Fig. 6 Effect of the change in labor endowments



adopt techniques that do not belong to this division of labor without deficit. As a result, the economy will not move to other division of labor, and unemployment is required.

The observation here is important, because it shows the necessity of the existence of unemployment, when it is not possible to produce net output by fully employing labor under the division of labor that corresponds to an existing admissible international value. It is a theoretical requirement for unemployment in the NTIV.

6 Technological changes

6.1 Shift of the maximal boundary

Demand does not have power to change the international value from an admissible one to another admissible one, and firms also do not have incentive to change the value, as far as the set of techniques is given. For firms, the only effective measure to change interational values is to develop new techniques. This means alteration of the production possibility set. In international economic relationships, an effective way of changing technique is to learn existing foreign techniques. Pasinetti (1981) emphasized knowledge transfer is the main source of gains from international economic relationship. He disregarded gains from trade as of a transitory nature (Pasinetti 1981, pp. 260, 271, 273). He analyzed the influence of productivity change on terms of trade, competitive status of a country, and real income of a country by comparing countries' relative productivity change of specialized products to linkage

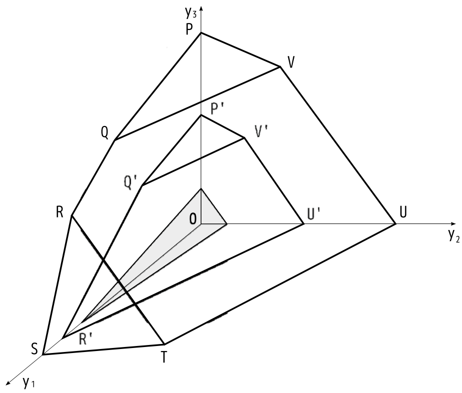


Fig. 7 Effect of the change in labor endowments: 3-commodity case

products, but he left the question of principles to determine what become specialized products and what become linkage products unanswered, which is the main question to be answered by the NTIV.

Taking our example, country B can learn from country A and introduce the technique of the production of commodity 1. When the same tachnique is available for commodity 1 to B, the international value for A1B12 will change to $(p_1, p_2; w_A, w_B) = (3/19, 11/95; 1, 1)$, with the maximal boundary shifting to T′UV in Fig. 8.

The wage rate of country B has increased to 1, and B will be able to consume more share of the world products. The expansion of the production possibility set to OT′UV will enable increase in real income of both countries, although it is possible for country A to suffer decreases in real incomes because its relative wage rate has decreased.

In this example of a technological change, an admissible international value has changed, but the set of divisions of labor that are competitive has not changed, still being A12B2 and A1B12. Firms of industry 1 in country B can further improve its technique.

When the technique has changed as shown in Table 3, the maximal boundary with markup becomes PSR in Fig. 9. Point S represents a division of labor A2B1. PS and SR represents A12B1 and A2B12 respectively. These divisions of labor have replaced the previous ones, A1B12 and A12B2.

Line segment PS is entirely in the negative area with respect to y_2, but A12B1 can produce positive net outputs, as shown above, although in the present case a part of the correspondent real maximal boundary TW is in the positive domain, and thus full employment is possible. Division of labor A12B1 has an international value $(p_1, p_2; w_A, w_B) = (2/5, 3/5; 1, 6)$, under which the production of commodity 2 in country B suffers losses (-2/5 per worker). This value is, therefore, admissible. Another admissible value is $(p_1, p_2; w_A, w_B) = (8/23, 63/115, 1, 118/23)$ (corresponding to A2B12), under which the production of commodity 1 in country A suffers losses (-6/23 per worker).

Whether the preceeding division of labor was A1B12 (with $w_B = 1/28$) or A12B2 (with $w_B = 28/5$), the technological improvement in industry 1 in

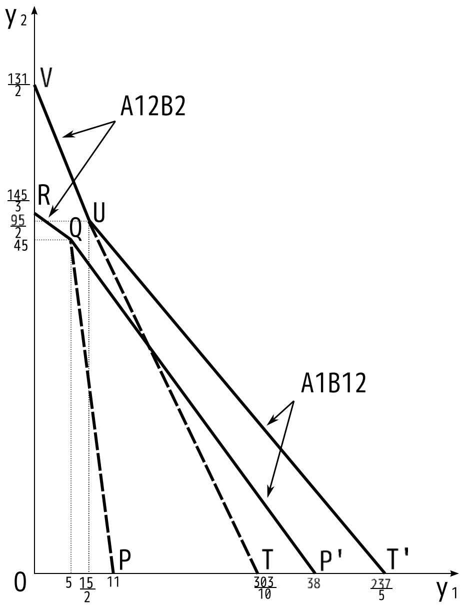


Fig. 8 Introduction of foreign technique

country B will deprive employment from industry 1 of country A (in A2B12 with $w_B = 118/23$) or industry 2 of country B (in A12B1 with $w_B = 6$).

6.2 Firms' behavior

Improvements in technique occur by the activities of individual firms. It is plausible that profit-seeking firms are looking for techniques that produce their products at cheaper costs under the prevailing international value. If they have found or developed such a technique, they will adopt it. What happens next is important for the NTIV.

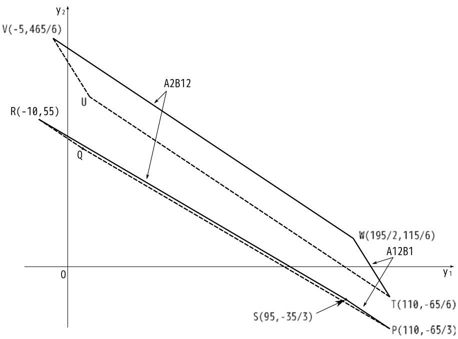
It has been thought that firms who have found advantageous techniques earn extra-profits under the prevailing prices. This means the firms adopting advantageous techniques sell their products with an increased markup rate, but this situation is thought to be temporary. The price of their products will finally be reduced to the level that does not generate extra markup rate. What brings about this final situation?

According to classical ways of thinking, like Ricardo (1817), as more and more entrepreneurs come to know the existence of extra profits with using the new

Table 3 Improvement in industry 1, country B technique

	Country	Commodity	Input		Output		Net output	
			1	2	1	2	1	2
Before markup	B	1	0	5/3	20	0	20	−5/3
After markup	B	1	0	10/3	20	0	20	−10/3

Fig. 9 Technological development



technique, they will enter this industry and the supply will increase. Increased supply will lower the price of the product until it does not allow extra profits. The lowered price will enter the production of other commodities, which will lower their prices. At each stage of this process, there must be the mechanism that the price decreases when there is excess supply. The mechanism, however, assumes a price adjustment that functions when supply exceeds demand.

SMT posits that quantity adjustment dominates in the short term. Short term means the period when techniques and capital equipment are given. The situation we are treating is that where a new technique has been found and has become known to many entrepreneurs; the situation can be regarded as a short-term one. Therefore, in order for the present reasoning to be consistent with the SMT view, quantity adjustment has to be assumed, that is, supply has to be reduced to just satisfy demand. If such an adjustment is assumed, the increased markup rate should remain for all firms in the industry. That means the price of the product will not decrease and remain at the previous level. The old international value will continue to exist in spite of the new technique, with the increased markup rate of the industry. This result is, however, not consistent with a presumption of the NTIV, that markup rates are exogenously given.

Is there a way of reasoning which is consistant with the SMT view that in the short-term quantitative adjustment is dominant, and with the NTIV presumption that markup rates are exogenously given? To earn extra profit by selling at the existing price is not the only way to increase profit by using a new technique. A firm with a new technique can increase its profit through increasing the share of its product in the market, by lowering the selling price, or by raising the wage payment to workers. The latter measure contributes to increasing the share by attracting more workers. Firms are free to lower their selling prices, and free to raise their wage payments, but it will only result in deficits without new techniques. New techniques make lowering prices or raising wages profitable.

As the new technique becoms known by other firms, the sales share competition will result in the price that is equal to the full cost under the given markup rate of the industry. The new price will enter the costs of other commodities and the sales share competition will occur in the industries of those commodities, which will bring about a new admissible international value, under which there is no incentive to switch techniques or to change the prices. Alternatively, the increased wage rate will prevail not only to the industry where the new technique has been adopted but also to all the other industries in the country, which may cause price changes and may make some industries uncompetitive under the wage rate.

Morioka (2023) assumed a fixed sales share of each firm within a sector in formulating the demand-satisfying supply of firms (Morioka 2023, p. 379). Shiozawa assumed a firm 'which represents an industry' Shiozawa et al. (2019, p. 82) in formulating the process of the conversion of prices to the minimal ones. These assumptions may be valid in investigating processes where an admissible value is given and does not change, but when examining what occurs when the value changes owing to technological change, introduction of the sales share competition seems necessary.

Does indudidual firms' behavior to seek profit lead to a new admissible value? First, let us look at the case where firms lower their selling prices. Let the existing divition of labor have been A12B2, where $(p_1, p_2; w_A, w_B) = (2/5, 3/5; 1, 28/5)$ under the previous techniques. A firm in industy 1 of country B who has found the technique shown in Table 3 will adopt it and begin production, lowering his selling price, and seeking to increase his sales share. The competition among the firms in the industry will bring about a full-cost price of commodity 1, $p_1 = 19/50$, under $p_2 = 3/5, w_B = 28/5$. This lowered price brings about extra profit to industy 2 in country B, which will cause competition among firms in the industy and will reduce the price of commodity 2. Competition in both industries in country B will bring about the new prices, $p_1 = 112/295 \approx 0.3797, p_2 = 882/1475 \approx 0.5980$. When these prices are introduced into country A, industry 1 will suffer losses while industry 2 will enjoy extra profits. Industry 1 will cease operation and industry 2 will lower its price till $p_2 = 171/295 \approx 0.5797$. This price brings about deficit to industy 2 in country B, and surplus to industy 1 in country B. Industry 2 in country B will cease operation, and industry 1 will lower its selling price. Consequently, the division of labor A2B1 will be established with $(p_1, p_2; w_A, w_B) = (47/125, 72/125; 1, 28/5)$. This is a limbo case and the value is admissible.

What will occur if the initial division of labor was A1B12 with $(p_1, p_2; w_A, w_B) = (3/28, 1/70; 1, 1/28)$? Industy 1 in country B, who has found a new technique, can earn extra profit under this value. They will lower their selling price, which will generate surplus for industry 2 in country B, which will lower the price of commodity 2. This process will bring about the prices that generate no extra profit to both industries, that is $(p_1, p_2) = (1/413, 9/2360)$. If these prices are introduced to country A, both industries there suffer losses. There is no other way for the industries in country A to run business than lowering the wage rate of the country. If the wage rate is reduced to 23/3304, industry 2 there will recover competitiveness, while industry 1 remains in deficits. Consequently, the international value $(p_1, p_2; w_A, w_B) = (1/413, 9/2360; 23/3304, 1/28)$ will be established, which is equivalent to $(p_1, p_2; w_A, w_B) = (8/23, 63/115; 1, 118/23)$. Division of labor A2B12 is established.

However, the reason why wage rate in country A is reduced has not been specified. There is no reason why the decrease in wage rate in country A stops at 23/3304. If it decreases further to 17/3304, industry 1 of country A recovers competitiveness. The existing prices will generate extra profits to industry 2 in country A, which will lower both prices to such levels as provide no profits for both industries in A. The resulting prices—$(p_1, p_2) = (17/8260, 51/16520)$—will throw both industries in country B into deficit. If the wage rate in country B is reduced to 51/1652, industry 1 will become able to run operation, while industry 2 will still be in deficit. As a result the division of labor A12B1 will be established. Therefore, if lowering wage rates is allowed, it becomes indeterminate what division of labor a technological change leads to. However, the logic of lowering wage rates has not been specified.

Next, let us look at the case where firms raise wage rate when new techniques are found. Let us start with the division of labor A12B2 with the value $(p_1, p_2; w_A, w_B) = (2/5, 3/5; 1, 28/5)$. When the new technique shown in Table 3 is known to a firm in industry 1 of country B, it can raise the wage rate up to 6 under the existing prices and mark-up rate. Under this value for w_B, any firm in industry 1 of country B is forced to employ the new technique, and industry 2 will not be able to exist in country B. An international value $(p_1, p_2; w_A, w_B) = (2/5, 3/5; 1, 6)$ will be established, which is admissible and brings about the division of labor A12B1.

Under the other previous division of labor A1B12 with the international value $(p_1, p_2; w_A, w_B) = (3/28, 1/70; 1, 1/28)$, industry 1 of country B can raise the wage rate to 44/21 by adopting the new technique. Under this wage rate, industry 2 loses competitiveness. At this stage, commodity 2 is not produced in either country. If this commodity is required, its price must be increased. When p_2 increases to 66/295, while p_1 becomes 176/1239, implying an increase in the relative price of commodity, industry 2 in country B becomes to supply its product. However, under these prices, no industry in country A operates without deficit with the existing wage rate of 1. If w_A is lowered to 506/1239, industry 2 in country A acquires competitiveness, resulting an admissible international value $(p_1, p_2; w_A, w_B) = (176/1239, 66/295; 506/1239, 44/21)$, with the division of labor A2B12. However, if country A can reduce its wage rate, there is no reason why it cannot reduce it further. If w_A reaches 374/1239, industry 1 in country A acquires competitiveness. Under this wage rate, industy 2 in country A enjoys surplus, which will cause a decrease in p_2 or re-increase in w_A. In the former event, the division of labor will change to A12B1, and in the latter event, the division of labor will return to A2B12.

By adopting new techniques, an individual firm can reduce its selling price or raise the wage rate. The reduced price prevails throughout the world, while the raised wage rate prevails in the country. A new international value will be established, but which one is established depends on the route chosen by firms, whether price is reduced or wage is raised. Firms cannot raise its selling price or reduce the wage rate. However, wage reduction may become necessary when no industry in a country gets competitiveness under the existing international prices and the wage rate of the country. Until this stage of argument, however, we have no logic for wage decrease in the realm of micro-behavior. We will deal with it briefly in the next section.

7 Reduction in wage rates as a governmental policy

For at least one industry in a country to have competitiveness, the wage rate of the country must be sufficiently low. Since it is difficult to imagine the situation where no industry exists in a country, we may just assume the wage rate is sufficiently low, and may think the extent is historically given.

Broadening our perspective to the policy area, it is plausible that government takes a policy to reduce wage rate of the country. It can take a measure to directly lower wages, but the policy to change exchange rates may be an easier measure. The balance of trade is often considered to have relation with exchange rates. However, effects of trade balance on exchange rates are not obvious. Current account surplus means increase in the net financial foreign asset. If the preference to foreign asset of the owners decreases, the domestic currency will appreciate. Preference to foreign asset depends on difference in the domestic and the foreign interest rates, and on the risk of depreciation of foreign currencies. The latter depends on expectations.

When the currency of a country depreciates at the same rate as the inflation rate of the country, the international values will be kept unchanged. In this sense, the price level can be thought as a fundamental factor for exchange rates. However, given that the preference for foreign assets depends on expectations, foreign exchange rates are fundamentally speculatively determined. The multiplicity of admissible international values strengthens this arbitrariness of exchange rates. This character enables govenment interventions to be effective. Any government can intervene foreign exchange markets with the intention to depreciate its currency and to lower its wage rate, when the other countries allow it.

For example, let us suppose that the admissible value $(p_1, p_2; w_A, w_B) = (2/5, 3/5; 1, 28/5)$ prevails, with which the division of labor A12B2 is established. When productions take place at a point on UV in Fig. 5, workers of both countries are fully employed. However, if the intensity of demand is relatively large for commodity 1, and production takes place at a point on UM, country B can produce only commodity 2, and some of its workers will be unemployed.

If country B intends to depreciate its currency and country A allows it, through the depreciation B can reduce its wage rate. If the wage rate w_B is successfully reduced to 1/28, B becomes to produce commodity 1 competitively. Under this wage rate, the international value will be $(p_1, p_2; w_A, w_B) = (3/28, 1/70; 1, 1/28)$, and the division of labor becomes A1B12, which enables production in the area TUM to take place. As the production point move toward TU, unemployment will be mitigated.

8 Conclusion

I have examined what occurs to the SMT view of economy when international trade is introduced. The following are the main findings:

1. Demand is not able to influence the choice among facets of the maximal boundary, because of the discrepancies between the real boundary of production and the hypothetical boundary that has relation to values.
2. Unemployment is not only possible but also required when no part of the facet appears in the positive quadrant which corresponds to an admissible international value that is actually established.
3. An admissible value can be given historically, but technological improvement, which is caused by firms' profit-seeking behavior, can cause a shift from one admissible value to another accompanied by a change in the division of labor.
4. The firms' behavior and the process of change in values and division of labor are formulated, which are compatible with the SMT view and the NTIV. There are cases where a change in relative wage rates must accompany the process to enable at least one industry to exist in any country, which would require policy responses.

Any mechanism of the change in relative wage rates based on individual behavior has not been formulated. Whether it is possible to give such behavioral foundations that are consistent with the SMT view and the NTIV has not yet answered. It requires further investigation.

Acknowledgements This work was supported by JSPS KAKENHI Grant Number JP21K01417.

Declarations

Conflict of interest The corresponding author states that there is no conflict of interest.

References

Althusser L (1965) Pour Marx, François Maspero (For Marx, translated by Ben Brewster, Penguin Books 1969)

Dorfman R, Samuelson PA, Solow RM (1958) Linear programming and economic analysis. McGraw-Hill, New York

Galbraith JK (1998) The affluent society (Fortieth, Anniversary). Houghton Mifflin, Boston

Graham FD (1948) The theory of international values. Princeton, Princeton University Press

Keynes JM (1936) The general theory of employment, interest and money: the corrected writings of John Maynard Keynes. vol. 7 the Macmillan Press, 1973

Kornai J (1980) Economics of shortage. New York, Oxford, North-Holland Publishing Company, Amsterdam

Morioka M (2023) Quantity adjustment theory as a basis of evolutionary economics. Evol Inst Econ Rev 20:367–399. https://doi.org/10.1007/s40844-023-00264-w

Pasinetti LL (1977) Lectures on the theory of production. Columbia University Press, New York

Pasinetti LL (1981) Structural change and economic growth: a theoretical essay on the dynamics of the wealth of nations. Cambridge University Press

Pasinetti LL (1997) The principle of effective demand. In: Harcourt GC, Riach PA (eds) A "Second Edition" of the general theory. Routledge, London, pp. 93–106

Ricardo D (1951) On the principles of political economy and taxation (The works and correspondence of David Ricardo). Vol I, edited by Piero Sraffa with the collaboration of Dobb MH, Cambridge University Press, Cambridge

Sato H (2017) An overview of research into international values in Japan. In: Shiozawa et al. (2017), pp. 281–303

Shiozawa Y (1981) Sūri-Keizaigaku no Kiso. Asakura-syoten, Tokyo

Shiozawa Y (2014) Ricardo Bōeki-Mondai no Saisyū-Kaiketu. Iwanami-syoten, Tokyo

Shiozawa Y (2017). The new theory of international values: an overview. In: Shiozawa et al. (2017), pp. 3–73

Shiozawa Y, Oka T, Tabuchi T (2017) A new construdtion of Ricardian theory of international values: analytical and historical approach. Springer Japan KK, Tokyo

Shiozawa Y, Morioka M, Taniguchi K (2019) Microfoundations of evolutionary economics. Springer Japan KK, Tokyo

Sraffa P (1960) Production of commodities by means of commodities: prelude to a critique of economic theory. Cambridge University Press, Cambridge