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A THEORETICAL JUSTIFICATION FOR THE USE OF LOCATION QUOTIENTS

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1. Introduction

The ability to identify export industries of a given region is important to any predictions concerning regional short-run income analysis.[1] Since statistical data on trade between different regions are either not available or of rather low quality, indirect methods must be applied to determine whether a given industry can be classified as an exporting, importing, or local (non-basic) activity. The most frequently used indirect method of identification is the use of location quotients. Although they are widely criticized for being based on very restrictive assumptions, the relative ease of computation still makes them a very attractive tool of regional analysis.

Most users of location quotients are fairly explicit in listing the underlying assumptions;[2] however, nowhere can we find a rigorous analysis which examines the theoretical basis for the use of this technique. It is the objective of this paper to construct a general equilibrium model which explicitly relates the trade- (export- or import-) orientation of a given industry to its location quotient making use of employment as the measurement unit. In addition, we will demonstrate that the common assumption that average income of each region must be the same is inconsistent. Not only is this assumption inconsistent but it is unnecessary; even allowing for differences in average income the location quotient is still a correct indicator of an industry's trade orientation as long as there are no differences in tastes and in production techniques. As a side result we will show how the existence of local (non-basic) industries affects the trade orientation of basic industries.

[1]As Lane (1966) correctly points out, the base-multiplier analysis as used by regional economists concerns itself solely with short-run economic fluctuations. Economic growth, on the other hand, is a long-run phenomenon which requires changes in the resource base.

[2]For a statement of those assumptions, see Isard (1963) or Greytak (1969).

2. The model

Before we go to the actual construction of the model, first let us define the location quotient. Consider an economy which consists of j ($j = 1, 2, \ldots, J$) regions each of which produces and consumes i ($i = 1, \ldots, n$) final commodities. Using superscripts for the region and subscripts for the commodity, we define the amount of labor employed by industry i in region j by L_i^j and total employment of labor in region j by L^j, i.e., $L^j = \sum_{i=1}^n L_i^j$. Similarly, total employment of labor in the whole economy is denoted by $L^0 = \sum_{j=1}^J L^J$, and that part of the economy's labor force that works in industry i is $L_i^0 = \sum_{j=1}^J L_i^j$. As we call $L_i^j/L^j = \lambda_i^j$ the fraction of region j's total labor force used in industry i, and $L_i^0/L^0 = \lambda_i^0$ the fraction of the whole economy's labor force employed in industry i, we can define the location quotient (q_i^j) of industry i in region j as

$$q_i^j = \lambda_i^j/\lambda_i^0. \tag{1}$$

Depending on whether q_i^j is greater or less than one, region j will export or import commodity i.

The relationship between the value of the location quotient and the trade orientation of a given industry can be investigated by specifying a simple general equilibrium trade model which is based on the following set of assumptions. The whole economy consists of two regions, which are defined as areas between which factors of production are immobile. Each region produces and consumes three commodities; two are tradables which move between regions without any artificial or natural trade impediments, the third cannot be traded between regions because of excessive transport costs – it is called a non-tradable commodity. As is commonly assumed in location quotient analysis, the whole economy serves as a benchmark and, therefore, is assumed to be closed, neither exporting nor importing from other countries. Each region is endowed with a fixed stock of capital ($K^j; j = 1, 2$) and labor ($L^j; j = 1, 2$). Factor resources are perfectly mobile within a region but cannot move between regions. In each region perfect competition prevails and all resources are fully employed.[3] For a given commodity the two regions have identical production functions which exhibit the following properties: they are homogeneous of the first degree in inputs, at least twice differentiable, and strictly quasi-concave; factor-intensity reversal does not occur. Consumer demand for a given commodity depends on relative prices, income, and tastes. Neither of the commodities is an inferior good.

After having stated the assumptions we proceed with the construction of a

[3]To determine whether an industry is exporting or importing we assume full employment. In the application of base-multiplier analysis it is implicitly assumed that the same trade pattern will prevail at a given level of unemployment.

general equilibrium trading model for region j. To make the notation simpler we delete the superscript j indicating the jth region.

The production function for commodity i is

$$X_i = X_i(L_i, K_i), \qquad i = 1, 2, 3, \tag{2}$$

where X_i is output of the ith final commodity and L_i and K_i are the amount of labour and capital, respectively, used in industry i. Homogeneity of degree one in the inputs allows us to rewrite (2) as

$$X_i = L_i f_i(k_i), \tag{2'}$$

where $k_i = K_i/L_i$ is the capital–labor ratio in industry i. Dividing (2′) by L, the total labor force of the region, and letting $x_i = X_i/L$ the per worker production of commodity i we obtain

$$x_i = \lambda_i f_i(k_i), \qquad i = 1, 2, 3. \tag{2''}$$

The assumption of perfect competition ensures that the value of the marginal product of each respective factor is the same in all three industries of the region,

$$r = p_1 f_1' = p_2 f_2' = p_3 f_3', \tag{3}$$

where r is the money rate of return on capital, p_i is the price of the ith commodity, and $f_i' = \partial f_i/\partial k_i$ the marginal physical product of capital;

$$w = p_1(f_1 - k_1 f_1') = p_2(f_2 - k_2 f_2') = p_3(f_3 - k_3 f_3'), \tag{4}$$

w being the money wage rate. Finally, on the production side we have two resource constraints which state that the total available supply of labor and capital is fully employed,

$$L_1 + L_2 + L_3 = L, \tag{5}$$

$$K_1 + K_2 + K_3 = K, \tag{6}$$

K and L being the total endowment of capital and labor, respectively. Eqs. (5) and (6) can be expressed in a slightly different way by writing

$$\lambda_1 + \lambda_2 + \lambda_3 = 1, \tag{5'}$$

$$k_1\lambda_1 + k_2\lambda_2 + k_3\lambda_3 = k = K/L. \tag{6'}$$

With this system of eleven equations contained in (2″), (3), (4), (5′), and (6′) we have fully specified the production sector of the region.

The consumption sector can be expressed by the three demand equations of (7),

$$d_i = d_i(p_1, p_2, p_3; y, \alpha_i) \qquad i = 1, 2, 3, \tag{7}$$

d_i being per capita demand for commodity i, and y being the region's per capita or average income which is defined as

$$y = p_1x_1 + p_2x_2 + p_3x_3. \tag{8}$$

α_i is a taste parameter for commodity i, the introduction of which enables us to incorporate regional demand differences that are not based on differences in per capita income or prices. Finally, we define each region's net per capita exports (e_i) as

$$e_i = x_i - d_i, \qquad i = 1, 2, 3, \tag{9}$$

whereby for the third commodity, which is non-tradable, $e_3 = 0$ implying that

$$x_3 = d_3. \tag{10}$$

From eq. (9) we can see that regional exports depend on the difference between regional production and consumption, both measured in per unit of worker terms. Taking eq. (9) and substituting (2″) and (7) into it, we obtain

$$e_i = \lambda_i f_i(k_i) - d_i(p_1, p_2, p_3; y, \alpha_i). \tag{11}$$

Examining the variables in eq. (11) that exert an influence on the exports of commodity i from this region we exclude p_1 and p_2. Since we have assumed no impediments exist to the flow of final commodities among regions, these prices must be the same in all regions. In addition we can show that both k_i and p_3 must be the same due to factor price equalization.[4] To prove this assertion let us go back to (3) and (4) and state the condition that under perfect competition the value of the marginal product of a given factor must be the same in both industries,

$$p_1 f_1'(k_1) = p_2 f_2'(k_2),$$

and

$$p_1[f_1(k_1) - k_1 f_1'(k_1)] = p_2[f_2(k_2) - k_2 f_2'(k_2)].$$

[4]The proof of factor-price equalization with non-traded goods is borrowed from Komiya (1967).

These two equations must hold for each region as well as the economy as a whole, since production functions of a given commodity were assumed to be the same in each region. For given values of p_1 and p_2 we can solve the two equations in the two unknowns k_1 and k_2; since we excluded the possibility of factor price reversal this solution must be unique. But as p_1 and p_2 are the same for each region and the whole nation, the regional and national values of k_1 and k_2 must be the same as well. As we look at the eqs. (3) and (4) we also can see that the regional values of factor returns (r, w) will not differ from the national values of those returns. And finally, as we state the equations

$$r = p_3 f_3'(k_3),$$

and

$$w = p_3[f_3(k_3) - k_3 f_3'(k_3)],$$

we solve uniquely for p_3 and k_3 in terms of w and r; since it was shown already that w and r are the same in each region, p_3 and k_3 must be the same in each region as well. This proves that the assumption of unimpeded movements of tradables between regions, which guarantees that p_1 and p_2 are the same in each region, is sufficient to ensure that k_i ($i = 1, 2, 3$), w, r, and p_3 are the same in each region as well.

Differentiating (11) totally and remembering the constancy of the above variables, the variables influencing the trade orientation of the region can be given by

$$\mathrm{d}e_i = f_i\,\mathrm{d}\lambda_i - (c_i/p_i)\,\mathrm{d}y - (\partial d_i/\partial\alpha_i)\,\mathrm{d}\alpha_i, \qquad i = 1, 2, \tag{12}$$

where $c_i = p_i\,\partial d_i/\partial y$ is the marginal propensity to consume commodity i.

Each of these variables takes on a specific value for a given region, whereby the regional value may not be the same as the value of the same variable for the whole economy. If they are not the same, such a deviation of the regional from the national value of a particular variable can be denoted by the differential 'd'; e.g., if the regional per worker income exceeds the national per worker income, $y^j - y^0 > 0$, then $\mathrm{d}y > 0$ expresses this positive deviation of the regional value. The proposition of the users of location quotients is that if $\lambda_i^j/\lambda_i^0 \gtreqless 1$ then $e_i^j \gtreqless 0$; in terms of differentials we can write if $\mathrm{d}\lambda_i \gtreqless 0$ then $e_i = \mathrm{d}e_i \gtreqless 0$, where it may be noted that $\mathrm{d}e_i = e_i$ since $e_i^0 = 0$, by the assumption of the whole economy being closed. Eq. (12), however, shows that the trade orientation of industry i in a given region depends not only on the value of the location quotient ($\mathrm{d}\lambda_i$) but also on the differences in per capita income, and differences in taste.

In the location quotient analysis of most writers the influence of the second ($\mathrm{d}y$) and third factor ($\mathrm{d}\alpha_i$) on exports is eliminated by assuming them away. For instance, Greytak (1969, p. 388) writes in his discussion of the location quotient: '. . ., the basic assumption of this approach is that the proportion of local activity for local use is equal to that of the benchmark economy. The implication of this assumption is that the propensity to consume and the average income (or some combination of the two) are equal in the two economies. In addition, community preference patterns for individual consumer commodities must be the same in the two areas.' Translated into our notation, the assumption of community preference patterns being the same in the two areas implies that all $\mathrm{d}\alpha_i$ are equal to zero. Although this assumption seems to be fairly unrealistic, it is quite legitimate. A much more severe problem arises with respect to the other assumption, namely that all regions have the same average income; i.e., $\mathrm{d}y = 0$. Not only is this assumption unrealistic, but it is inconsistent with the rest of the analysis. We will prove that, assuming there are no taste differences, a location quotient which is not equal to one implies differences in per capita income between the nation and a particular region.

As we know, λ_i and y are both endogenous variables and, therefore, cannot be assumed to take on certain desirable values. On the contrary, their values must be determined within the system which has α_i $(i = 1, 2, 3)$, p_1, p_2, and k as its exogenous variables. Let us demonstrate how the endogenous variables y and λ_i $(i = 1, 2, 3)$ respond to regional differences in those exogenous variables. Immediately we can disregard the influence of p_1 and p_2 since they are the same in each region. First, we take eqs. (5'), (6'), and (8) as well as the equilibrium condition for the non-tradable commodity, $x_3 = d_3$ or $\lambda_3 f_3 = d_3(p_1, p_2, p_3; y, \alpha_3)$, and differentiate them totally,

$$\mathrm{d}\lambda_1 + \mathrm{d}\lambda_2 + \mathrm{d}\lambda_3 = 0, \tag{13}$$

$$k_1 \mathrm{d}\lambda_1 + k_2 \mathrm{d}\lambda_2 + k_3 \mathrm{d}\lambda_3 = \mathrm{d}k, \tag{14}$$

$$\mathrm{d}y = p_1 f_1 \mathrm{d}\lambda_1 + p_2 f_2 \mathrm{d}\lambda_2 + p_3 f_3 \mathrm{d}\lambda_3, \tag{15}$$

$$f_3 \mathrm{d}\lambda_3 = (\partial d_3/\partial y)\,\mathrm{d}y + (\partial d_3/\partial \alpha_3)\,\mathrm{d}\alpha_3. \tag{16}$$

Performing the above differentiations we immediately set $\mathrm{d}k_i = \mathrm{d}p_i = 0$ because they do not differ between regions as final good and factor prices are equalized. (13) to (16) represent a system of four equations in the four endogenous variables $\mathrm{d}\lambda$ $(i = 1, 2, 3)$ and $\mathrm{d}y$. The next step is to take (13) and (14) and solve for $\mathrm{d}\lambda_1$ and $\mathrm{d}\lambda_2$ in terms of $\mathrm{d}\lambda_3$ and $\mathrm{d}k$,

$$\mathrm{d}\lambda_1 = [(k_3 - k_2)\,\mathrm{d}\lambda_3 - \mathrm{d}k]/[k_2 - k_1], \tag{17}$$

$$\mathrm{d}\lambda_2 = [-(k_3 - k_1)\,\mathrm{d}\lambda_3 + \mathrm{d}k]/[k_2 - k_1]. \tag{18}$$

Now we substitute the solutions for $\mathrm{d}\lambda_1$ and $\mathrm{d}\lambda_2$, (17) and (18), into (15) to obtain

$$\mathrm{d}y = \{[p_1f_1(k_3-k_2)-p_2f_2(k_3-k_1)+p_3f_3(k_2-k_1)]\,\mathrm{d}\lambda_3 \\ -[p_1f_1-p_2f_2]\,\mathrm{d}k\}/\{k_2-k_1\}. \tag{19}$$

Although eq. (19) looks highly complicated it reduces to a very simple expression after we realize that

$$(p_if_i-p_jf_j) = (p_ik_if_i'-p_jk_jf_j') \\ = (k_i-k_j)r, \quad i \neq j,$$

which can easily be seen from eqs. (3) and (4). As we substitute the appropriate expressions, e.g.,

$$(k_3-k_2) = (p_3f_3-p_2f_2)/r,$$

into (19) we obtain

$$\mathrm{d}y = r\,\mathrm{d}k. \tag{19'}$$

This is the well-known result that a unit increase of the capital–labor ratio of a certain area increases the value of its output per worker by an amount equal to the value of the marginal product of capital. This relationship between income and endowments is unique and not affected by differences in tastes on the side of consumers.

Now it is an easy matter to solve for all $\mathrm{d}\lambda_i$ as well. We take eq. (16) and substitute $\mathrm{d}y = r\,\mathrm{d}k$, which yields

$$\mathrm{d}\lambda_3 = [(c_3r)/(f_3p_3)]\,\mathrm{d}k+(1/f_3)(\partial d_3/\partial\alpha_3)\,\mathrm{d}\alpha_3, \tag{20}$$

where $c_3 = p_3(\partial d_3/\partial y)$, which is the marginal propensity to consume the non-traded commodity. It requires only one more step to solve for $\mathrm{d}\lambda_1$ and $\mathrm{d}\lambda_3$ after substituting (20) into (17) and (18), respectively. For instance, if we solve for $\mathrm{d}\lambda_1$ we get

$$\mathrm{d}\lambda_1 = \{[(k_3-k_2)(c_3r)/(p_3f_3)-1]\,\mathrm{d}k \\ +[(k_3-k_2)(1/f_3)(\partial d_3/\partial\alpha_3)]\,\mathrm{d}\alpha_3\}/\{k_2-k_1\}. \tag{21}$$

The value of the location quotient of a given industry depends on the difference in endowments and on the taste parameter with respect to the non-traded commodity. Only the taste parameter of the non-traded commodity and not those of all commodities affect λ_1. A change in taste for non-traded commodities cannot be satisfied by importing more or less of this good, but will cause a reallocation of resources which affects the employment ratio in all industries using the same factors of production as inputs.

If there are no differences in tastes between regions or we just assume them away, then λ_1 is uniquely related to k as factor-intensity reversal has been excluded. This means that if the endowment ratio of the region is different from that of the whole economy, there will also be differences in the fraction of labor employed in a given industry (λ_i) as well as in income per worker (y). In other words, whenever the location quotient of a given industry is not equal to one average income of the people living in this region must be different from that of the national average. Therefore, it is not possible to work with location quotients and at the same time assume that average income differences between regions are zero. This assumption is inconsistent.

Immediately the question arises whether the whole location quotient analysis breaks down once we are not able to assume that income per worker is the same in each region. Fortunately enough, this is not the case: the location quotient being greater or less than one still correctly indicates whether an industry is exporting or importing as long as no taste differences between regions exist. To prove this proposition let us take (12) and restate if for commodity 1,

$$\mathrm{d}e_1 = f_1\,\mathrm{d}\lambda_1 - (c_1/p_1)\,\mathrm{d}y - (\partial d_1/\partial\alpha_1)\,\mathrm{d}\alpha_1. \tag{12'}$$

The location quotient analysis is based on observing $\mathrm{d}\lambda_1$. In eq. (12′) we have in addition the terms $\mathrm{d}y$ and $\mathrm{d}\alpha_1$. While the taste parameter is exogenously given and therefore never can be expressed in terms of $\mathrm{d}\lambda_1$, we can rewrite $\mathrm{d}y$ in terms of the location quotient ($\mathrm{d}\lambda_1$) and the taste parameters. To accomplish that we substitute for $\mathrm{d}k = \mathrm{d}y/r$ into (21) and solve for $\mathrm{d}y$,

$$\mathrm{d}y = \{[(k_2-k_1)r]\,\mathrm{d}\lambda_1 - [r(k_3-k_2)(\partial d_3/\partial\alpha_3)]\,\mathrm{d}\alpha_3/f_3\}/\Delta, \tag{22}$$

where

$$\Delta = [(k_3-k_2)(c_3 r)/(p_3 f_3) - 1],$$

which must be negative; this can be seen after we substitute for

$$r(k_3-k_2) = (p_3 f_3 - p_2 f_2),$$

and rewrite Δ as

$$\Delta = [-(1-c_3) - (c_3 p_2 f_2)/(p_3 f_3)];$$

this expression must be negative since by assumption none of the three goods are inferior and $c_1+c_2+c_3 = 1$.

Finally, we substitute (22) into (12') to obtain our final expression relating exports of the first industry to the location quotient and differences in tastes,

$$\begin{aligned} de_1 = \{&[\Delta f_1-(c_1/p_1)(k_2-k_1)r]\,d\lambda_1 \\ &+[(1/f_3)(c_1/p_1)r(k_3-k_2)(\partial d_3/\partial\alpha_3)]\,d\alpha_3\}/\Delta-(\partial d_1/\partial\alpha_1)\,d\alpha_1. \end{aligned} \tag{23}$$

Now we can verify our proposition that even with differences in average income the location quotient indicates the trade orientation of an industry quite correctly as long as there are no taste differences. We take (23) and set $d\alpha_3 = d\alpha_1 = 0$; then our proposition is correct if the term $[\Delta f_1-(c_1/p_1)(k_2-k_1)r]/\Delta$ is positive. To determine the sign of this term let us go back to the definition of Δ and substitute it, as well as $(k_2-k_1)r = (p_2f_2-p_1f_1)$, into the numerator of above expression. This yields $[-(1-c_3)f_1-(c_3p_2f_2f_1)/(p_3f_3)-(c_1p_2f_2)/p_1+c_1f_1]/\Delta$; the first and the last term of the numerator add up to a negative value since $(1-c_1-c_3) = c_2 > 0$ and, therefore, the whole numerator is negative. Since the denominator is negative as well, the whole expression relating de_1 to $d\lambda_1$ must be positive. This proves that, even though we allow for differences in average income, a location quotient greater (less) than one correctly indicates that a given industry is exporting (importing). The differences in average income are due to differences in endowment. Hence, endowment affects the level of per capita demand through the level of average income. On the other hand, endowment differences are also the cause of the divergence of the regional from the national production pattern or, stated differently, of the location quotient not being one. However, although the endowment ratio affects supply and demand, the supply effect can never be outweighed by the demand effect.

The assumption of the absence of differences in taste is very crucial for the location quotient analysis. As can clearly be seen from (23), the presence of deviations of the values of taste parameters makes it impossible to draw conclusions concerning trade-orientation of a given industry if we know nothing but the value of the location quotient. That differences in taste for the commodity in question affect its exports is quite obvious. However, what has not been recognized so far is the fact that differences in taste for local, non-traded, commodities affect the trade orientation of traded goods as well. A change in demand for a non-traded good can be satisfied only through a corresponding adjustment in local production of this commodity, since exports or imports are by definition excluded. But with a given stock of factor resources the production adjustment of one industry will also affect production of all other industries. Hence, differences in taste for non-traded commodities have an impact on exports of a traded good through the supply side.

In addition to the absence of taste differences, some other assumptions are very crucial for the validity of location quotient analysis. Within the specification of our model it is of great importance that factor price equalization is established. This requires: identical production functions with the usual properties for each region, no transport costs for traded goods, perfect competition, immobility of factors between regions, and perfect mobility of factors within each region.

3. Operationalizing the model

Having established the theoretical basis for the use of location quotients, our objective in this section is to correct the naive formulation for the biases resulting from income and taste differences. Eq. (12) expresses the trade orientation of a region as

$$de_i = f_i \,d\lambda_i - (c_i/p_i)\, dy - (\partial d_i/\partial \alpha_i)\, d\alpha_i .$$

Recalling that differentials indicate differences from a national average, and that e_i is per capita exports, we can rewrite eq. (12) as

$$E_i = Lf_i[\lambda_i - \bar{\lambda}] - L(c_i/p_i)[y_j - \bar{y}] - L(\partial d_i/\partial \alpha_i)[\alpha_i - \bar{\alpha}]. \tag{12''}$$

The bars in (12″) denote national averages while $\bar{E} = 0$ based on our assumption of a closed national economy. Noting from eq. (2′) that $f_i = X_i/L_i$, the first term on the right-hand side of (12″) can be expressed as $X_i[(q_i-1)/q_i]$, the traditional method of determining the percentage of local production exported.

The second term on the right-hand side of (12″) represents the export bias resulting from per capita income differences. Letting $y^* = y_j/\bar{y}$, $y_j - \bar{y}$ can be rewritten as $[(y^*-1)/y^*]y_j$, with $y_j = Y_j/L$ we have $(Y_jc_i/P_i)[(y^*-1)/y^*]$. With c_i the marginal (equal to the average) propensity to consume commodity i, and p_i its price, Y_jc_i/P_i represents the number of units of commodity i purchased locally. Assuming that the region does not both import and export the same commodity, the second term reduces to $(X_i - E_i)$ $[(y^*-1)/y^*]$. Ignoring for the moment the influence of taste differences, the expression determining export orientation becomes

$$E_i = X_i\left\{\left[\frac{q_i-1}{q_i} - \frac{y^*-1}{y^*}\right]\Big/\left[1 - \frac{y^*-1}{y^*}\right]\right\}. \tag{12'''}$$

In trying to incorporate tastes into this analysis we encounter a significant problem, that is, defining exactly what we mean by differences in tastes. Regional variations in consumption could result from income differences, individual preferences that are not 'averaged out', or the presence of a third factor like climate, topology or cultural influences. If we concentrate on consumption patterns and correct for income differences, we could attribute the 'unexplained' or residual differences to differences in tastes. Essentially we could calculate income elasticities of demand for each product in each region. Comparing national consumption with regional consumption using the national distribution as a reference point, differences in consumption patterns could be attributed to tastes. Unfortunately, sufficiently detailed budget studies that would allow you to quantify the taste parameter are definitely scarce. If such data were available, it could be incorporated into our model as follows: Let the marginal change in consumption due to a change in tastes be equal to the average, such that $\partial d_i/\partial\alpha_i = d_i/\alpha_i$. Since $d_i = x_i - e_i$ and $Ld_i = X_i - E_i$, the third term on the right-hand side of (12) can be expressed as $(X_i - E_i)\,[(\alpha^* - 1)/\alpha^*]$, where $\alpha^* = \alpha_i/\bar{\alpha}_i$. The trade orientation for commodity i in region j, incorporating variations in income and tastes, would then be indicated by

$$E_i = X_i\left\{\left[\frac{q_i - 1}{q_i} - \frac{y^* - 1}{y^*} - \frac{\alpha^* - 1}{\alpha^*}\right]\Big/\left[1 - \frac{y^* - 1}{y^*} - \frac{\alpha^* - 1}{\alpha^*}\right]\right\}.$$

4. The assumptions of the model revisited

The theoretical analysis presented in this paper was based upon a simple two-sector, three-good general equilibrium model. In general, the model assumed that: (1) both regional and national economies are perfectly competitive and initially at a point of long-run equilibrium, (2) commodity production functions are homogeneous of degree one with respect to inputs, (3) no productivity differences exist among factors employed in different regions, (4) factors of production are always fully employed, (5) factor endowments are fixed within each region – that is, regional factor flows do not exist, and (6) transportation costs for commodities are zero.

The introduction of monopoly elements into the model will not change the basic conclusions of the analysis. If one of the sectors, for example, sector 1, were monopolistic, we would need to replace the competitive price in our equations by $p_1(1+M)$ where M represents the monopoly markup. We would also have to introduce another factor of production, monopoly profits, that would exhaust the income earned in sector 1. Assuming that the monopoly markup is small due either to some firms in sector 1 being competitive, the threat of potential entry, or through the existence of substitute goods, the basic relationship between e_i and λ_i will be effected, although in a relatively minor way. If our production function is Cobb–Douglass with α and $\beta = 0.5$ in the competitive case and α and $\beta = 0.4$ in the case of monopoly (the monopoly markup being 20%), then a 10% increase in the amount of labor will lead to a 1% difference in production in the two cases.[5]

If we allowed for transport costs on traded goods, final commodity prices, factor returns, and optimal capital–labor ratios in the three industries would differ as between regions. In the absence of transport costs, as we have seen, the regional values of e_1 and λ_1 move in the same direction whenever the regional and national endowment ratios differ. With transport cost, however, the same relation may not hold any more; the existence of price differentials could affect e_1 and λ_1 in opposite directions. When transport costs of a substantial magnitude exist, use of location quotient analysis becomes a tenuous matter; however, to the extent that transport costs are relatively minor, the relationship between e_1 and λ_1 will only be altered slightly.

Since the incentive for factor migration will be based upon differences in factor and output prices, incorporating interregional migration into our model could only be justified if the initial position of the economy were one of disequilibria. If significant differences in output prices, factor returns, and optimal capital labor ratios existed between regions, then our qualifications concerning transport costs would be applicable here also. No clear relationship between e_i and λ_i would exist, and location quotients would be invalid. However, if the economy could be characterized as initially in an equilibrium position, an assumption of no factor migration would not be unreasonable, especially since location quotients are primarily used to provide short-run income and employment projections.

5. Conclusions

Location quotients are one of the most widely used measures of export specialization and an important tool of regional scientists. Yet even with its widespread use and the recognition of its inherent weaknesses, no theoretical justification for its use exists to our knowledge. Without a specification of the theoretical underpinnings of the technique there is little room for modification and improvement. This paper has attempted to correct this deficiency by deriving the location quotient with employment as the measurement unit from a three commodity general equilibrium model.

From this simple model some interesting conclusions are reached. Although it is generally assumed that average income in all regions must be the same in order to employ location quotients this assumption is illegitimate. Under the model's assumptions a location quotient greater than one is tantamount to a different than national average income. Even if incomes differ in regions, location

[5]Harberger (1962) also investigated the implications of introducing monopoly elements in a general equilibrium model concerning the incidence of the corporate income tax. He concluded that '... (the monopoly case) differs only in minute detail from that which determines the incidence of the corporation income tax in the competitive case'. (p. 240)

quotient analysis can still correctly indicate the export orientation of the region provided that there are no taste differences. However, the procedure of attributing a percentage of the total employment in that industry to exports will be biased, the amount and direction of the bias being a function of the income differences. Further, this model emphasizes the importance of the non-traded commodity (or local services) to the trade orientation of the community. With fixed factor endowments, resources diverted to the production of local services effects the production of the other commodities and consequently, trade patterns.

These findings have been adopted to the existing techniques. It is believed that the ease and inexpensiveness of calculating location quotients is not severely modified while an improvement in the predictive ability of location quotients will surely result.

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