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FACTOR ENDOWMENTS AND REGIONAL LOCATION OF PRODUCTION: EVIDENCE FROM VIETNAM

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Abstract

This paper uses inter-regional input-output data and factor endowments of Vietnam to examine the relationship between factor endowments and production patterns. We present a multi-sectoral integrated activity analysis model to examine that if labor and capital could reallocate across sectors and regions, what would be in a competitive benchmark the optimal output allocation across the three regions and from there to test various theories on the reasons for the directions of inter-regional trade in goods and/or factors of production. Using the results from the model that would indicate the interregional exchanges of intermediate inputs, final demand and value added, we examine the relationship between inter-regional flows of trade on endowments at the observed and optimal levels to test Heckscher-Ohlin theory. Are regional specializations due to differences in endowments, technologies or demand? We found that the Heckscher-Ohlin factor abundance specialization hypothesis is only supported by the data of regions stay in relative extreme level of factor abundance (Hanoi and Rest of Vietnam) but not holds true in case of Ho Chi Minh.

Keywords: international trade, Heckscher-Ohlin, factor endowments, location of production, general equilibrium, input-output model.

JEL code: F12, D58, R15

1. Introduction

The fundamental theory of trade analysis is the factor proportions theory cored by Heckcher-Ohlin (HO) model and its extension (Heckcher-Ohlin-Vanek model). Heckcher-Ohlin-Vanek (HOV) model shows that countries will export the services of

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relatively abundant factors and import the services of relatively scarce factors. Over the years, there are many studies which have tried to test the factor proportion theory (Bowen *et al.*, 1987; Trefler, 1993, 1995 and Davis *et al.*, 1997). The HOV model is rejected in most of these tests. According to ten Raa and Mohnen (2001), there are two main problems encountered in those studies "either their do not use the independent data on trade, endowments and technologies, in which case the test is largely invalidated, or they are counterfactual by assuming common technologies and/or preferences (ten Raa and Mohnen, 2001, p. 93).

Bernstein and Weinstein (2002) point out that in order to the HOV model holds true, the assumptions are as follows:

1. There are equal numbers of goods (N) and factors (F). If N>F: even in cases where the HOV model holds, it should not be possible to predict output on the basic of endowments. 'Factor-endowment driven model' fails for traded goods, but holds for non-traded goods (Bernstein and Weinstein, 2002).
2. Technology is identical across regions and exhibits constant returns to scale.

This prompts the question that whether or not the HO model holds given:

1. The number of goods exceeds the number of factors
2. Production techniques are different across regions.
3. Different in preferences (structure of domestic final demand)
4. Increasing return to scale and imperfect competition
5. Regional historical perspectives are matter.

This paper uses inter-regional input-output data and factor endowments of Vietnam to examine the relationship between factor endowments and production patterns. We present a multi-sectoral integrated activity analysis model to examine that if labor and capital could reallocate across sectors and regions, what would be in a competitive benchmark the optimal output allocation across the three regions and from there to test various theories on the reasons for the directions of inter-regional trade in goods and/or factors of production.

Main contributions of our analysis are threefold. First, using the results from the model that would indicate the interregional exchanges of intermediate inputs, final demand and value added, we examine the relationship between inter-regional flows of trade on endowments at the observed and optimal levels to test theories of interregional trade such as the HO model. Are regional specializations due to differences in endowments, technologies or demand? What could explain interregional trade of goods and factors of production? Second, we propose a specific pattern of trade between regions of Vietnam, and hence the results allow the local governments to choose the relevant trade policies. Third, the study also contribute to the literature of general equilibrium by applying new technique, which was first developed by ten Raa and Mohnen (2001), and its variant by ten Raa and Mohnen (2002).

The paper is organized as follows. Section 2, we present the model used to setup the competitive benchmark. In section 3, we determine the comparative advance of the three regions and compare the factor contents of the net bilateral trade flows with the factor endowments. We conclude by summarizing the main features of the model and results in section 4.

2. The Model

2.1. The Input-Output Model

A simple Input-Output Model is used to calculate the factor contents of production from the IRIO table. The model is as follows:

The simple Leontief equation indicates that:

$$X = \left(I - A\right)^{-1} Y \tag{1}$$

where:

- X Vector of gross output
- Y Vector of final demand
- I Identity matrix
- A Direct input coefficient matrix

Let k_i^r and l_i^r denote direct factor contents of capital and labor of sector *i* of region *r*, respectively, where:

$$k_i^r = \frac{K_i^r}{X_i^r} \qquad\qquad l_i^r = \frac{L_i^r}{X_i^r} \tag{2}$$

Hence, equation (1) can be rewritten as:

$$\begin{bmatrix} \left(l_i^1\right) & \left(l_i^2\right) & \left(l_i^3\right) \\ \left(k_i^1\right) & \left(k_i^2\right) & \left(k_i^3\right) \end{bmatrix} X = \begin{bmatrix} \left(l_i^1\right) & \left(l_i^2\right) & \left(l_i^3\right) \\ \left(k_i^1\right) & \left(k_i^2\right) & \left(k_i^3\right) \end{bmatrix} \left(I - A\right)^{-1} Y \tag{3}$$

and hence we have:

$$\begin{bmatrix} L \\ K \end{bmatrix} = \begin{bmatrix} \left(l_i^1\right) & \left(l_i^2\right) & \left(l_i^3\right) \\ \left(k_i^1\right) & \left(k_i^2\right) & \left(k_i^3\right) \end{bmatrix} \left(I - A\right)^{-1} Y \tag{4}$$

Equation (1) and (4) return the total factor contents of production is follows:

$$\begin{bmatrix} \left(l_i^1\right) & \left(l_i^2\right) & \left(l_i^3\right) \\ \left(k_i^1\right) & \left(k_i^2\right) & \left(k_i^3\right) \end{bmatrix} \left(I - A\right)^{-1} \tag{5}$$

2.2. The multi-sectoral integrated activity analysis model

As indicated in section 1, We use a variant of the multi-sectoral integrated activity analysis model as proposed by ten Raa and Mohnen (2001) to examine that if labor and capital could reallocate across sectors and regions, what would be in a competitive benchmark the optimal output allocation across the three regions and from there to test various theories on the reasons for the directions of inter-regional trade in goods and/or factors of production. To check the HO model, we find that the observed factor contents of the net trade with those predicted by the theory are not totally confronted. Hence we check whether the endowment alone determine factor movement of free trade which is the endogenous inter-regional trade flows within the model, controlling for regional taste (final demand) and technology.

For illustration we take three economies, namely Hanoi, Ho Chi Minh and rest of Vietnam. The choice of these three economies is totally opportunistic, based on the availability of IRIO table.

The model works with fixed domestic endowments, fixed input coefficient and fixed proportions of final consumption and investment in each region. We assume that all commodities are tradeable for inter-region. The efficient allocation of resources is obtained by maximizing level of domestic final demand (including consumption and investment) in all three regions. Thus let c denote the vector of activity level of final demands in Hanoi, Ho Chi Minh City and the rest of Vietnam (c is a column vector with dimensions # of regions).

In our model, we posit c to be such that the outcomes preserve the actual inter-regional balance of payment for each region. The model has some support from ten Raa and Mohnen (2000) and Sikdar et all (2006). However, rather than trying to get a handle on the way used by ten Raa and Mohnen (2000) and Sikdar et all (2006), we give up the use of vector scanner, γ which are the final consumption ratios ($\gamma_i = c^i / c^j \quad i \neq j$ and variable c of region j acts as an expansion factor). Hence we don't have to use the Newton algorithm to find the fixed point at which the consequence vector of regional surpluses for all economies equal to the observed surplus. In our model we construct an inter-regional trade-balance constraint (see equation 9 below). Hence the competitive benchmark is determined just by solving a linear programme for only one time and the difference between the computed and actual deficits was zeros.[2]

Apart from c itself, the variables are the activity level s for Hanoi, Ho Chi Minh and rest of Vietnam production sectors (s is a column vector with dimensions of # of sectors times # of regions).

All prices are endogenous. Prices of commodities are shadow prices associated with the constraint (7), prices of labor and capital are determined by shadow prices associated with constraint (8).

[2] In ten Raa and Mohnen (2001), algorithm stopped after six iterations and the difference between the computed and actual deficit was a small fraction of deficit.

The linear program is:

$$\max_{s,c} e^{\mathrm{T}} fc \tag{6}$$

subject to the following constraints:

(i) for the production balance:

$$-\left(V^{'} - U\right)s + fc \le -g \tag{7}$$

It is noted that we use the IRIO table is a non-competitive type [3] wherein a distinction is made between domestically and imported products consumed in production and consumption. Hence in the production balance equation there is no appearance of import (see appendix A.1 for details).

(ii) for the factor inputs, we assume that labor can move across sector but stay in their region. In terms of capital stock, it is sectoral specific but capital, itself, can be allocated across region:

$$\begin{pmatrix} L^1 & & 0 \\ & \ddots & \\ 0 & & L^3 \end{pmatrix} s \le N \qquad \text{and} \qquad \left(K^{*} \sim I(n)\right)s \le M \tag{8}$$

(iii) and for control of the inter-regional trade balance:

$$\left(I(3)^{*} \sim ones(3,44)\right)\left\{\begin{array}{l}\left(\left(\begin{bmatrix} 0 & e^{w,1-2} & 0 \\ 0 & 0 & e^{w,2-3} \\ e^{w,3-1} & 0 & 0 \end{bmatrix} - \begin{bmatrix} m^{w,2-1} & 0 & 0 \\ 0 & m^{w,3-2} & 0 \\ 0 & 0 & m^{w,1-3} \end{bmatrix}\right) Xs \\ + \left(\begin{bmatrix} 0 & e^{f,1-2} & 0 \\ 0 & 0 & e^{f,2-3} \\ e^{f,3-1} & 0 & 0 \end{bmatrix} - \begin{bmatrix} m^{f,2-1} & 0 & 0 \\ 0 & m^{f,3-2} & 0 \\ 0 & 0 & m^{f,1-3} \end{bmatrix}\right) Fc\end{array}\right\} = D_{observed} \tag{9}$$

[3] There are two types of IO table, the competitive IO table and the non-competitive one. In the former type, imports are considered as perfect substitutes. Hence, there are no distinguish between imported goods and goods produced domestically. All imports are viewed to be consumed by domestic final demands. Intermediate demands are assumed to be satisfied by only domestically produced goods/services. In the non-competitive type IO table, imports are not group in the final demand block, but considered as a non-produced input of production. Reason is goods are imported not only for domestic final demands but also for intermediate demands.

The inter-regional trade balance is controlled in a way that the endogenous import of each region within the model should not exceed the observed import level.

The program features the following parameters [with dimensions in brackets]:

g vector of international export [# of commodities times # of regions]

e unit vector of all components one [# of commodities times # of regions]

T transposition symbol

f domestic final demand [# of commodities times # of regions by # of regions]

X diagonal matrix of gross output [# of commodities times # of regions by # of commodities times # of regions]

F diagonal matrix of domestic final demand [# of regions by # of regions]

V make table [# of sectors times # of regions by # of commodities times # of regions]

U use table [# of commodities times # of regions by # of sectors times # of regions]

K capital stock [# of sectors by # of regions],

L^r where $r = (1..3)$ row vector of regional labor employment [# of sector]

M capital endowment [# of sectors]

N labor force [# of regions]

$e^{w,i-j}$ where $i, j = (1..3)$ matrix of export coefficients from region i to region j for the purpose of intermediate use [# of commodities by # of sectors]

$e^{f,i-j}$ vector of export coefficients from region i to region j for the purpose of final use [# of commodities]

$m^{w,i-j}$ matrix of import coefficients of region j from region i for the purpose of intermediate use [# of commodities by # of sectors]

$m^{f,i-j}$ vector of import coefficients of region j from region i for the purpose of final use [# of commodities]

$D_{observed}$ vector of observed regions' bilateral balance of payment [# of regions]

By definition, domestic exports from the first and second regions to the third one should equal to the third's imports from the other two. So we have:

$e^{w,i-j} = m^{w,j-i}$ and $e^{f,i-j} = m^{f,j-i}$ where $i, j = (1..3), \forall i \neq j$

$I(n)$	identify matrix [n by n, where n is the # of sectors]
$ones(m,n)$	unity matrix [m by n]
$*\sim$	horizontal-direct-product matrix operator. If $z = x *\sim y$ then the input matrices x and y must have the same number of rows. The result will have cols(x) * cols(y) columns[4].

The sign pattern of inter-regional trade balance locates the comparative advantages of the three regional economies. It is noted that it is accomplished solely on the basis of parameters for the three regions, namely, Hanoi, Ho Chi Minh and the rest of Vietnam. The parameters represent taste (f), technology (V, U, k) and endowment (M, N), and fixed the rest of the world (g). By comparing the expansion of final demand under autarky and free trade scenarios we can assess the gains from free trade.

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[4] If $x = \begin{pmatrix} 1 & 2 \\ 3 & 4 \end{pmatrix}$ and $y = \begin{pmatrix} 5 & 6 \\ 7 & 8 \end{pmatrix}$

$$z = x*\sim y = \begin{pmatrix} 5 & 6 & 10 & 12 \\ 21 & 24 & 28 & 32 \end{pmatrix}$$

Hence, by definition, in the equation (8):

$$K*\sim I(n) = \begin{pmatrix} k_1^1 & \dots & k_n^1 & 0 & \dots & 0 & 0 & \dots & 0 \\ 0 & \dots & 0 & k_1^2 & \dots & k_n^2 & 0 & \dots & 0 \\ 0 & \dots & 0 & 0 & \dots & 0 & k_1^3 & \dots & k_n^3 \end{pmatrix}_{3x3n}$$

and in equation (9):

$$I(3)*\sim ones(3,44) = \begin{pmatrix} ones(1,44) & & 0 \\ & \ddots & \\ 0 & & ones(1,44) \end{pmatrix}_{3x132}$$

3. The results

Table 1 presents factor endowment for Hanoi, Ho Chi Minh and rest of Vietnam. The HO hypothesis states that a region exports the commodity of which uses intensively its relatively abundant resource. As showed by table 1, Hanoi has highest capital-labor ratio, followed by Ho Chi Minh and the lowest is Rest of Vietnam. According to HO theorem, Hanoi and Ho Chi Minh should export commodities of which capital factor contents are relatively higher than others. Rest of Vietnam should export commodities, where there are relatively high labor factor contents. Hence, if the factor contents of net inter-regional trade is predicted by the HO model, Hanoi and Ho Chi Minh will be a net exporter of capital stock and Rest of Vietnam will be exporter of labor.

TABLE 1 Factor endowments of Hanoi, Ho Chi Minh and the rest of Vietnam (labor in person and capital stock in million of VND)

Factor	Hanoi	Ho Chi Minh	Rest of Vietnam
Labor	2,140,146	4,662,419	32,159,943
Capital stock	53,307,510	65,836,822	252,200,304
Capital-labor ratio	24.91	14.12	7.84

Table 2 presents the observed, free total factor content of the trade flows. Observed data shows that Hanoi (net) export capital and import labor when Rest of Vietnam stays in the opposite side (import capital and export labor). Hence HO model holds true in case of Hanoi and Rest of Vietnam. Interestingly, Ho Chi Minh is an importer of both labor and capital whereas predicted by HO model, it should be an exporter of capital. If bilateral trade were completely free and the regional economy were perfectly competitive, total factor content of the trade flows under free trade is presented in the next column to the observed level. As we want to test the HO model, it is expected that the three regions would follow the HO hypothesis. In such way, Ho Chi Minh would change the side of it net-export. However, as shown in table 2, the test rejects HO model for Ho Chi Minh city.

TABLE 2 Observed, free total factor content of the trade flows

Factor	Hanoi		Ho Chi Minh		Rest of Vietnam	
	Observed Domestic Net-export	Free Domestic Net-export	Observed Domestic Net-export	Free Domestic Net-export	Observed Domestic Net-export	Free Domestic Net-export
Labor (person)	-693482	-769706	-1303458	-1385059	1996941	2154765
Capital (mill. VND)	19008526	20482268	-5770337	-6107025	-13238189	-14375243

The results in presented in table 2 reveal an interesting thing. As shown in table 1, Hanoi is endowed with relatively highest capital and Rest of Vietnam is endowed with relatively highest labor. This lead us to a conclusion that in case of region, where there is a extreme level of factor endowment, HO factor abundance specification hypothesis is support by the data. However, in case of Ho Chi Minh city, where HO model is rejected, factor endowments could not solely determine the factor movements of trade. This means taste and technology along with the factor endowment control the flow of trade in this region.

Table 3 shows observed (actual) and free export (EX) and import (IM) of Hanoi, Ho Chi Minh and Rest of Vietnam. Free trade emerged if we ignore the ramifications of the trade with the rest of the world. The first 4 columns of each region contract the actual and the optimum trade figures. By modeling, the observed inter-regional trade deficit between any of two regions is exactly same with the optimum levels. This means each region cant import from the other two regions more than its actual level. The result shows that there is change in the volume of trade but region doesn’t change much its comparative advantages. This mean, there is a consistence between the observed and optimal endogenous trade within the model.

TABLE 3 Observed, free trade exports minus import from one region to the other two (million of VND)

Code	Hanoi				Ho Chi Minh				Rest of Vietnam			
	Actual EX	Actual IM	Free EX	Free IM	Actual EX	Actual IM	Free EX	Free IM	Actual EX	Actual IM	Free EX	Free IM
1	0	429219	0	448379	0	1330461	0	1391419	1759681	0	1839798	0
2	0	932445	0	995909	0	3667019	0	3948904	4599463	0	4944813	0
3	0	1021244	0	1082657	0	2478557	0	2675105	3499801	0	3757762	0
4	0	0	0	0	100333	0	108120	0	0	100333	0	108120
5	0	617189	0	1123819	0	2034425	0	2146371	2651614	0	3270190	0
6	0	59247	0	61044	77000	374063	81636	404357	433310	77000	465401	81636
7	0	243029	0	257566	0	1171967	0	1263798	1414996	0	1521364	0
8	8800	367186	9540	420390	0	340256	0	365174	707441	8800	785563	9540
9	9399	103893	10321	109732	0	59710	0	64526	162992	8788	173598	9661
10	2969	81453	3155	89388	0	89023	0	96086	170283	2776	185266	2947
11	118685	143472	122188	603256	0	110509	0	116342	253981	118685	719598	122188
12	8356	310518	9133	329361	0	1302949	0	1407789	1612255	7145	1735841	7824
13	13196	2940345	14517	3229181	0	2761527	0	2968609	5700624	11948	6196449	13175
14	1326	222167	1459	234858	527598	71278	576641	77038	191945	427424	204596	470800
15	1005	151358	1109	159964	703965	0	770468	0	22677	576290	23967	635579
16	0	1089971	0	1125447	0	1652103	0	1704320	2742074	0	2829767	0
17	0	76112	0	79851	140000	2323397	143557	2480819	2399509	140000	2560670	143557
18	0	412158	0	425895	324507	0	337301	0	185471	97820	191653	103059
19	0	67561	0	72754	898393	102200	977776	110269	161992	890623	174656	969409
20	0	245665	0	271519	1236409	1490775	1332487	1602783	1732728	1232696	1870198	1328383

21	141184	0	151150	0	0	819710	0	876527	814399	135873	870847	145470
22	188340	0	201968	0	1418244	0	1520865	0	0	1606584	0	1722833
23	0	438878	0	463617	150000	543304	158672	588389	836900	4718	898534	5200
24	376773	0	404432	0	1876434	0	2014183	0	0	2253207	0	2418615
25	844957	0	918388	0	1513	568168	1645	613537	538770	817072	581791	888288
26	66416	0	70638	0	0	521488	0	559626	521488	66416	559626	70638
27	243056	0	263036	0	4508790	703000	4879434	757024	703000	4751846	757024	5142470
28	1038833	0	1117331	0	150000	872067	161408	931896	803788	1120554	858933	1205776
29	1341275	0	1467390	0	235284	0	257407	0	0	1576559	0	1724797
30	487752	0	533439	0	78000	368024	85347	396597	352636	550364	380014	602203
31	3264438	0	3525679	0	0	1451044	0	1559506	1243080	3056474	1335998	3302171
32	132906	0	141980	0	15000	0	16024	0	0	147906	0	158004
33	0	317370	0	338373	200000	1213239	213300	1296479	1338844	8235	1430397	8845
34	0	204417	0	221738	0	2996130	0	3216769	3200547	0	3438508	0
35	0	18322	0	19603	321896	80291	342581	86427	83264	306547	89608	326159
36	1622584	0	1795680	0	0	0	0	0	0	1622584	0	1795680
37	1710620	0	1843331	0	3329545	0	3587852	0	0	5040165	0	5431183
38	365043	0	393994	0	19222	0	20746	0	0	384265	0	414741
39	1516257	0	1639910	0	0	0	0	0	0	1516257	0	1639910
40	2112864	0	2206912	0	299284	4000	312606	4297	4000	2412148	4297	2519518
41	1094494	0	1165605	0	3393823	273528	3611803	292941	153003	4367792	163862	4648329
42	1152374	0	1273645	0	5462300	44072	6037130	47654	44072	6614674	47654	7310776
43	1602920	0	1761627	0	2419926	0	2659525	0	0	4022846	0	4421152
44	904384	0	994734	0	0	1093027	0	1180984	960645	772002	1037949	851699

TABLE 4 Gross output gained from free trade for Hanoi, Ho Chi Minh and the rest of Vietnam (million of VND)

	Hanoi		Ho Chi Minh		Rest of Vietnam	
	Observed	Free	Observed	Free	Observed	Free
c	1.0000	1.0541	1.0000	1.0810	1.0000	1.1067
Gross output	65,317,627	72,540,703	160,641,147	171,520,938	722,382,986	768,128,922

Table 4 presents gain from free trade. Perfect competition and free trade would boost the Hanoi, Ho Chi Minh and Rest of Vietnam economy (activity level of domestic final demand) by 5.4%, 8.1% and 10.7% respectively. Consequently, gross output would increase. The difference reflects the relative importance of inter-regional trade of the three economies. Gains are obtained by elimination of the domestic waste of resources from misallocation and less than full utilization of resources.

4. Discussion of the Model

No scenario is tested about the shift of comparative advantages of free access to the technology (such as Hanoi and Ho Chi Minh using Rest of Vietnam technology). The shift in this scenario might be a good explanation for the location of production. It is particularly noteworthy that one region's technology is superior in some sectors hence the technologies then adopted by the other region.

Each region would have three set of activity level, corresponding to three alternative choices of technology. Activity vector s now will be s_1, s_2 and s_3. Concerning the activity level of domestic final demand c, now we have also three set namely, c_1, c_2 and c_3.

It is note that A can be written as follows:

$$A_1 = \begin{pmatrix} A_{11} & A_{12} & A_{13} \\ A_{21} & A_{22} & A_{23} \\ A_{31} & A_{32} & A_{33} \end{pmatrix} \tag{10}$$

In order to examine the impact of technology, we could assume there is a free access to technology. In such case, two alternative A matrices, namely A_2 and A_3 are constructed by circulating technologies of 3 regions as follows:

$$A_2 = \begin{pmatrix} A_{12} & A_{13} & A_{11} \\ A_{22} & A_{23} & A_{21} \\ A_{32} & A_{33} & A_{31} \end{pmatrix} \text{ and } A_3 = \begin{pmatrix} A_{13} & A_{11} & A_{12} \\ A_{23} & A_{21} & A_{22} \\ A_{33} & A_{31} & A_{32} \end{pmatrix} \quad (11)$$

- first n columns of A_2 now represent technology of Ho Chi Minh and next n columns are Rest of Vietnam and last n columns are Hanoi.
- first n columns of A_3 now represent technology of Rest of Vietnam and next n columns are Hanoi and last n columns are Ho Chi Minh.

In order to test the free access to technology scenario, the model can be rewritten as follows.

The objective function is:

$$\max_{s_1,s_2,s_3,c_1,c_2,c_3} e^{\mathrm{T}} f(c_1 + c_2 + c_3) \quad (12)$$

subject to the following constraints:

for the production balance: (13)

$$-(I - A_1)Xs_1 - (I - A_2)Xs_2 - (I - A_3)Xs_3 +$$
$$+ f_1 c_1 + \left(e^T f_1 ./ e^T f_2\right).* f_2 c_2 + \left(e^T f_1 ./ e^T f_3\right).* f_3 c_3 \le -g$$

for the factor inputs: (14)

$$\begin{pmatrix} L^1 & 0 & 0 \\ 0 & L^2 & 0 \\ 0 & 0 & L^3 \end{pmatrix} s_1 + \begin{pmatrix} L^2 & 0 & 0 \\ 0 & L^3 & 0 \\ 0 & 0 & L^1 \end{pmatrix} s_2 + \begin{pmatrix} L^3 & 0 & 0 \\ 0 & L^1 & 0 \\ 0 & 0 & L^2 \end{pmatrix} s_3 \le N$$

$$\left\{\begin{pmatrix} K^1 & K^2 & K^3 \end{pmatrix}* \sim I(n)\right\} s_1 + \left\{\begin{pmatrix} K^2 & K^3 & K^1 \end{pmatrix}* \sim I(n)\right\} s_2 + \left\{\begin{pmatrix} K^3 & K^1 & K^2 \end{pmatrix}* \sim I(n)\right\} s_3 \le M$$

and for control of the inter-regional trade balance:

$$\left(I(3)^{*} \sim ones(3,44)\right)\left\{\begin{array}{l}\left(\left(\begin{bmatrix} 0 & e^{w,1-2} & 0 \\ 0 & 0 & e^{w,2-3} \\ e^{w,3-1} & 0 & 0 \end{bmatrix}-\begin{bmatrix} m^{w,2-1} & 0 & 0 \\ 0 & m^{w,3-2} & 0 \\ 0 & 0 & m^{w,1-3} \end{bmatrix}\right)Xs\right. \\ \left.+\left(\begin{bmatrix} 0 & e^{f,1-2} & 0 \\ 0 & 0 & e^{f,2-3} \\ e^{f,3-1} & 0 & 0 \end{bmatrix}-\begin{bmatrix} m^{f,2-1} & 0 & 0 \\ 0 & m^{f,3-2} & 0 \\ 0 & 0 & m^{f,1-3} \end{bmatrix}\right)Fc\right\}=D_{observed}$$

(15)

Hence, the constraint (15) should be rewritten by applying inter-regional import/export coefficients from (11).

$$\left(I(3)^{*} \sim ones(3,44)\right)\left\{\begin{array}{l}\left(\left(\begin{bmatrix} 0 & A_{12} & 0 \\ 0 & 0 & A_{23} \\ A_{31} & 0 & 0 \end{bmatrix}-\begin{bmatrix} A_{21} & 0 & 0 \\ 0 & A_{32} & 0 \\ 0 & 0 & A_{13} \end{bmatrix}\right)Xs\right. \\ \left.+\left(\begin{bmatrix} 0 & e^{f,1-2} & 0 \\ 0 & 0 & e^{f,2-3} \\ e^{f,3-1} & 0 & 0 \end{bmatrix}-\begin{bmatrix} m^{f,2-1} & 0 & 0 \\ 0 & m^{f,3-2} & 0 \\ 0 & 0 & m^{f,1-3} \end{bmatrix}\right)Fc\right\}$$

(16)

5. Conclusion

In this paper by computing the competitive benchmark the optimal output allocation across the three regions, we examine the relationship between inter-regional flows of trade on endowments at the observed and optimal levels to test HO model. The results shows that HO factor abundance specialization hypothesis is only supported by the data of regions stay in relative extreme level of factor abundance (Hanoi and Rest of Vietnam) but not holds true in case of Ho Chi Minh. This lead us to the conclusion that location of production is not merely determined by factor endowment but also by the difference in technology and preference.

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APPENDIX A Framework of non-competitive IO table[5]

TABLE A-1 non-competitive IO table

		INTERMEDIATE DEMAND	FINAL DEMAND				Total
		Industry	Domestic final demand			International trade	
Commodity		1… j … n	C	I	G	E M	X
Domestically produced commodities	1	X_{11} X_{1j} X_{1n}	C_1	I_1	G_1	E_1	X_1
	i	X_{i1} X_{ij} X_{in}	C_i	I_i	G_i	E_i	X_i
	n	X_{n1} X_{nj} X_{nn}	C_n	I_n	G_n	E_n	X_n
Imported commodity	1	M_{11}^f M_{1j}^f M_{1n}^f	M_{1c}^f	M_{1I}^f	M_{1G}^f	(M_1)	
	i	M_{i1}^f M_{ij}^f M_{in}^f	M_{iC}^f	M_{iI}^f	M_{iG}^f	(M_i)	
	n	M_{n1}^f M_{nj}^f M_{nn}^f	M_{nC}^f	M_{nI}^f	M_{nG}^f	(M_n)	
Total intermediate use		W_1 W_j W_n	C	I	G	E (M)	GDP
Value added		V_1 V_i V_n					
Total		X_1 X_i X_n					

Symbols:

i	Commodity	j	Industry sector
C_i	Private consumption	X_{ij}	Commodity i used by sector j
I_i	Capital formation	$W_i = \sum_i X_{ij}$	
G_i	Government consumption	V_i	Value added
E_i	Export	X_i	Gross Input/Output
M_i	Import	M_{ij}^w	Imported commodity i used by sector j

$M_{C,I,G}^f$ Imported commodity *i* used by type of final demand (C, I, G)

[5] This appendix is mainly based on Ngoc (2007)

Table A-1 shows the sample of non-competitive type IO table. The disadvantages of using competitive type IO table is that we have to assume that all intermediate demand are satisfied by domestically produced commodities and goods are imported only for satisfying final demand. This assumption is no-longer hold in the non-competitive type IO. The starting point for derivation of non-competitive IO tables is the material balance equation of the input-output account:

$$X_i = W_i + D_i + E_i - M_i \tag{A.1}$$

where:

X_i = gross output of sector i

W_i = intermediate domestic demand for the output of sector i 1

D_i = domestic demand final of product i

E_i = export demand of product i

M_i = total import of commodity classified in sector i

Import of commodity *i*, M_i, consists of M^w for intermediate demand and M^f for final demand. They appear in the total import supply and as part of both intermediate and final demand in equation (A.1). Let u_i^w and u_i^f stand for the domestic supply ratios (the proportion of intermediate and of final demand produced domestically).

Hence we have:

$$X_i = u_i^w \sum_j a_{ij} X_j + u_i^f D_i + E_i \tag{A.2}$$

$$M_i = m_i^w W_i + m_i^f D_i \tag{A.3}$$

where the import coefficients are define as $m_i = (1 - u_i)$ for both intermediate and final goods.

According to Kubo et al (1986), we assume that: first, there is no direct re-export of imports; second, imports and domestic goods with the same sector classification are alternative sources of supply and are perfect substitutes in all uses; third, the domestic supply ratio for intermediate use, u_i^w, is assumed to be same for all sectors using commodity *i* as an input.

Equation (2) and (3) can be conveniently restated in matrix notation as:

$$X = \hat{u}^w AX + \hat{u}^f D + E \tag{A.4}$$

$$M = \hat{m}^w AX + \hat{m}^f D \tag{A.5}$$

In this study, however, it was imperative that a national imports table be generated that could adequately serve as the basis in regionalizing the import transaction. For this purpose, a direct estimation methodology was developed to build the import coefficient matrices. The approximation of diagonal matrix of import coefficients for intermediate use $\hat{m}^w$ can be calculated as follows:

The import coefficient of sector i, $\hat{m}_{ii}^w$, can be estimated by the equation:

$$\hat{m}_{ii}^w = \frac{M_i}{TDD_i} \tag{A.6}$$

where TDD_i is total domestic demand for sector i [6].

Equation (A.1) can be conveniently rewritten in matrix notation as:

$$X = (I - A)^{-1}(D + E - M) = (I - A)^{-1} Y \tag{A.7}$$

where:

$Y = D + E - M$	Total domestic final demand (excluding imports)
A	Direct input coefficient matrix and represents the technology of inter-industry relations. A consists of two components: the domestic component and the imported one.

A can be written as follows:

$$A = A^d + A^m \tag{A.8}$$

where:

$A^d = \hat{u}^w A$	domestic direct input/output coefficient matrix
$A^m = \hat{m}^w A$	import coefficient matrix for intermediate use

[6] By definition $TDD_i = W_i + D_i = X_i - E_i + M_i$ (which is can be calculated with the data can be extracted from competitive IO table).

Replace $A^d = \hat{u}^w A$, equation (A.4) can be rewritten as follows:

$$X = A^d X + \hat{u}^f D + E \tag{A.9}$$

Hence we have:

$$X = (1 - A^d)^{-1}(\hat{u}^f D + E) \tag{A.10}$$

Equation (A.10) shows the new material balance of the non-competitive type input-output table. They show that in an economy, a part of intermediate demand and final demand (including export) are satisfied by all domestically produced commodities. Compared to the original material balance described by (A.1), advantage of using non-competitive type IO is that in its material balance there is no appearance of imported commodities. Hence material balance accounts are not been biased by assume that all intermediate demand are satisfied by domestically produced commodities and goods are imported only for satisfying final demand.

APPENDIX B Data

The study requires data complied from several sources.

In order to test theories of interregional trade we use inter-regional input-output (IRIO) data and factor endowments of Vietnam in 2000: the inter-regional input-output (IRIO) table of Hanoi, Ho Chi Minh and rest of Vietnam 2000 was compiled by the author in corporation with research team from General Statistic Office of Vietnam (GSO of Vietnam). Data required for the compilation of these IRIO table are: national input-output table of 2000 is published by GSO of Vietnam; input-output tables of Ho Chi Minh and Hanoi in 2000 is unpublished, compiled research team from GSO of Vietnam; inter-regional trade data in 2000 is published by GSO of Vietnam.

Labor and capital stock data are taken from the enterprise census 2000 which is published by GSO of Vietnam. The data on capacity utilization are from the Statistical Year Books published by the General Statistic Office (GSO) of Vietnam in 2000.

Table B-1 presents the description of IRIO table used in this study.

Symbols:

i	Commodity	*j*	Industry sector
C	Consumption	CF	Capital formation
EX	Exports	IM	Imports
HCM	Ho Chi Minh	ROV	Rest of Vietnam
ID	Intermediate demand	FD	Final demand
VA	Value added	GI	Gross input
Produc-Tax	Tax on production	Op.Surplus	Operating surplus

TABLE B-1 IRIO table of Hanoi, Ho Chi Minh and Rest of Vietnam

		INTERMEDIATE DEMAND			FINAL DEMAND			Foreign Import	Total Gross Output
		Hanoi	HCM	ROV	Hanoi	HCM	ROV		
		1 … j … n	1 … j … n	1 … j … n	C CF EX	C CF EX	C CF EX		
Hanoi	1 : i : n	Hanoi commodities consumed by Hanoi industries	Hanoi commodities consumed by HCM industries	Hanoi commodities consumed by ROV industries	Hanoi commodities consumed by Hanoi Final Demand	Hanoi commodities consumed by HCM Final Demand	Hanoi commodities consumed by ROV Final Demand	0 : 0 : 0	Hanoi Gross Output
HCM	1 : i : n	HCM commodities consumed by Hanoi industries	HCM commodities consumed by HCM industries	HCM commodities consumed by ROV industries	HCM commodities consumed by Hanoi Final Demand	HCM commodities consumed by HCM Final Demand	HCM commodities consumed by ROV Final Demand	0 : 0 : 0	HCM Gross Output
ROV	1 : i : n	ROV commodities consumed by Hanoi industries	ROV commodities consumed by HCM industries	ROV commodities consumed by ROV industries	ROV commodities consumed by Hanoi Final Demand	ROV commodities consumed by HCM Final Demand	ROV commodities consumed by ROV Final Demand	0 : 0 : 0	ROV Gross Output
Rest of World	1 : i : n	Imported commodities consumed by Hanoi industries	Imported commodities consumed by HCM industries	Imported commodities consumed by ROV industries	Imported commodities consumed by Hanoi Final Demand	Imported commodities consumed by HCM Final Demand	Imported commodities consumed by ROV Final Demand	(FIM)	
Total		Hanoi ID	HCM ID	ROV ID	Hanoi FD	HCM FD	ROV FD		
Wages									
Produc-Tax									
Op.Surplus									
Depreciation									
Total VA		Hanoi VA	HCM VA	ROV VA					
Total GI		Hanoi GI	HCM GI	ROV GI					

APPENDIX C Sectoral code

Code	Description
1	Paddy
2	Other crops
3	Livestock and poultry
4	Agricultural services
5	Fishery
6	Forestry
7	Mining and quarrying
8	Processed, preserved meat, animal oils and fats
9	Milk, butter & other dairy products
10	Processed, preserved fruits and vegetable products
11	Processed seafood and by products
12	Sugar (all kinds), coffee and tea, processed
13	Rice, processed and other food manufactures
14	Alcohol, beer and liquors, non-alcohol water and soft drinks
15	Cigarettes and other tobacco products
16	Textiles
17	Garment
18	Manufacture of leather tanneries
19	Processed wood and wood products
20	Paper pulp and paper products Printing and publishing
21	Basic chemicals and by-products; petroleum products
22	Fertilizer, pesticides, veterinary
23	Health medicine
24	Processed rubber and by products, plastic and by-products
25	Non-metallic mineral products
26	Ferrous metals and products
27	Non-ferrous metals and products
28	General & special-purpose machinery; office, accounting & computing machines
29	Electrical machinery and equipment
30	Home appliances and its spare parts
31	Motor vehicles, transport means and spare parts
32	Health instruments, precise equipment & apparatus
33	Other manufactured products
34	Electricity and gas
35	Water and water supply
36	Construction
37	Trade
38	Passenger transport services
39	Goods transport services
40	Communication services
41	Financial services, insurance, real estate, business services, science & technology
42	State management, defence and compulsory social security Education and training; health care; culture and sport
43	Hotels, restaurants
44	Other services, not elsewhere classified